

# Session 6

## Aircraft Maintenance and Airports

# Aircraft Maintenance On-Condition Plan

- No aircraft is so tolerant of neglect that it is safe in the absence of an effective inspection and maintenance program
- The processes that affect an aircraft are deterioration with age (e.g. fatigue, wear and corrosion) as well as chance failures (e.g. tire burst, excess structural loads, etc).
- Up until the mid 1970's most Airlines Maintenance operated under a process called "**HARD TIME**"
- That would result in limited fixed approved hours or cycles of an engine on wing and other components depending on the airplane and the airlines operating the aircraft/engines
- The process of "**On-Condition**" maintenance is applied to items on which a determination of their continued airworthiness can be made by visual inspection, measurements, tests (chip detectors), gauge monitoring of engine **Exhaust Gas Temperatures (EGT)**, oil pressure, etc, or other means without disassembly inspections or overhaul
- The condition of an item is monitored either continuously or at specified periods
- The item's performance is compared to an appropriate standard to determine if it can continue in service
- These appropriate standards may relate to, but are not limited to, cleanliness, cracks, deformation, corrosion, wear, pressure or temperature limits, looseness or even missing fasteners
- These standards or limits are published in the applicable approved data for the aircraft or aircraft component
  - **Aircraft Maintenance Manual (AMM)**
- This approach is supported by an extensive international industry study
  - 90% of items can benefit from "**on-condition**" maintenance tasks
- The majority of maintenance tasks listed in the manufacturer's maintenance schedules/checks are "**on-condition**" tasks.

# Aircraft Maintenance- On-Condition Plan-Aircraft Checks

- Aircraft maintenance checks are periodic inspections that have to be done on all commercial/civil aircraft after a certain amount of time or usage
- Under **FAA** oversight, each operator prepares a **Continuous Airworthiness Maintenance Program (CAMP)** under its Operations Specifications or “Op Specs”
- The **CAMP** includes both routine and detailed inspections
- Airlines and airworthiness authorities casually refer to the detailed inspections as “**checks**”, commonly one of the following:
  - A check
  - B check
  - C check
  - D check
  - A and B checks are lighter checks
  - C and D are considered heavier checks
- **A CHECK**
  - Performed approximately every 400-600 flight hours or 200–300 cycles. (takeoff and landing is considered an aircraft “cycle”), depending on aircraft type
  - It needs about 20–60 man-hours and is usually performed overnight at an airport gate
  - The actual occurrence of this check varies by aircraft type, the cycle count, or the number of hours flown since the last check
  - The occurrence can be delayed by the airline if certain predetermined conditions are met
- **B CHECK**
  - This is performed approximately every 6-8 months
  - It needs about 120-150 man-hours, depending on the aircraft, and is usually completed within 1–3 days at an airport hangar
  - A similar occurrence schedule applies to the B check as to the A check
  - B checks may also be incorporated into successive A checks, i.e.: Checks A-1 through A-10 complete all the B check items

# Aircraft Maintenance- On-Condition Plan-Aircraft Checks

- **C CHECK**

- This is performed approximately every 20–24 months or a specific amount of actual **flight hours (FH)** or as defined by the manufacturer
- This maintenance check is much more extensive than a **B** check, requiring a large majority of the aircraft's components to be inspected
- This check puts the aircraft out of service and until it is completed, the aircraft must not leave the maintenance site
- It also requires more space than **A** and **B** checks
- It is, therefore, usually carried out in a hangar at a maintenance base
- The time needed to complete such a check is generally 1–2 weeks and the effort involved can require up to 6,000 man-hours
- The schedule of occurrence has many factors and components as has been described, and thus varies by aircraft category and type

- **D CHECK**

- This is by far the most comprehensive and demanding check for an airplane. It is also known as an IL or “**heavy maintenance visit**” (**HMV**)
- This check occurs approximately every 6 year
- It is a check that more or less takes the entire airplane apart for inspection and overhaul
- Even the paint may need to be completely removed for further inspection on the fuselage metal skin
- Such a check can generally take up to 50,000 man-hours and 2 months to complete, depending on the aircraft and the number of technicians involve
- It also requires the most space of all maintenance checks, and as such must be performed at a suitable maintenance base
- The requirements and the tremendous effort involved in this maintenance check make it by far the most expensive, with total costs for a single visit ending up well within the million-dollar range

# Aircraft Maintenance- On-Condition Plan-Aircraft Checks

- Because of the nature and the cost of such a check, most airlines — especially those with a large fleet — have to plan **D** checks for their aircraft years in advance
- Often, older aircraft being phased out of a particular airline's fleet are either stored or scrapped upon reaching their next D check, due to the high costs involved in comparison to the aircraft's value
- On average, a commercial aircraft undergoes three **D** checks before being retired
- Many **maintenance, repair and overhaul (MRO)** shops claim that it is virtually impossible to perform a **D** check profitably at a shop located within the United States
  - Only a few of these shops offer **D** checks
- Many airlines use D checks as an opportunity to make major cabin modifications on the aircraft
- This may include new seats, entertainment systems, carpeting, etc.
- In the United States, initial aircraft maintenance requirements are proposed in a **Maintenance Review Board (MRB)** report based on **Air Transport Association (ATA)** publication **MSG-3 (Maintenance Steering Group – 3rd Task Force)**
- **Maintenance Review Board (US)**  
Modern transport category airplanes with **MSG-3**-derived maintenance programs employ usage parameters for each maintenance requirement such as flight hours, calendar time, or flight cycles
- Maintenance intervals based on usage parameters allow more flexibility in scheduling the maintenance program to optimize aircraft utilization and minimize aircraft downtime

Emirates A380 3C check

[https://www.youtube.com/watch?v=3hLXP1R8y6o&feature=emb\\_logo](https://www.youtube.com/watch?v=3hLXP1R8y6o&feature=emb_logo)

2 Minutes

# Engine Maintenance

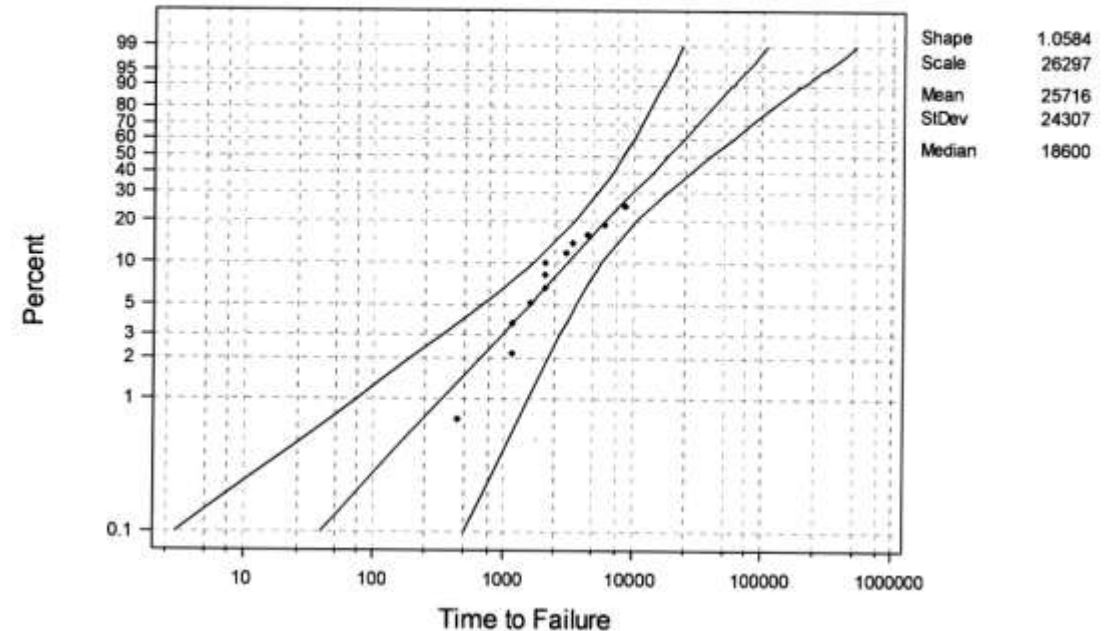
- Engines are not subject to fixed time between overhauls-  
"Hard Times"
- Engines follow "On Condition" Maintenance" plans
- This is NOT fly to failure
- It is based on results of scheduled inspections
- As long as the engine is performing within limits and various inspections are satisfactory, the engine may remain in service
- Eventually components wear or deteriorate and must be replaced or repaired to return the engine to serviceable condition
- Most of the engine internal components must be replaced during an "**engine shop visit**" where the engine is entirely or partially disassembled
- Manufacturers' engine shop manuals specify inspection limits and repair procedures for engine components



# Analysis of Failure/Wear Data

- System and component “failure” data is used to predict “failures”
- Used to establish maintenance plans
  - Maximize operating life
  - Minimize operation disruptions
  - Optimize costs
- “Failure” can be defined as any condition to be observed and judged
- Percent of components that “fail” plotted against age of part or system
- Age is number of time or cycles to “failure”
- Actual “failure” data can be used to predict probability of “failure” at given time or cycles
- Examples:
  - Engine time on wing
  - Turbine blade “life”
  - Sensor failures
  - Compressor vane bushing failure

## The Weibull Distribution Provides a Good Fit to the Data



# Aircraft Maintenance- On-Condition Plan-Line Maintenance

- **Line Maintenance**
- Inspecting things like wheels, brakes and fluid levels (oil, hydraulics) are done during transit checks
- Plus, any running repairs that the aircraft tells us it needs through thousands of on-board sensors
- Most aircraft could receive about 12 hours of line maintenance per week
- These happen around the world and around the clock



Line Maintenance      5 Minutes

[https://www.youtube.com/watch?v=OkG\\_NvNuaws](https://www.youtube.com/watch?v=OkG_NvNuaws)





# Aircraft Maintenance- On-Condition Plan-Shop Maintenance

- **Shop or Component Maintenance:**
- Can be termed as “Workshop” or just **Shop** maintenance
- This covers maintenance on components when removed from the aircraft e.g. engines, APU, seats
- Sometimes this is carried out within the same organization as the **Base Maintenance**, but sometimes special companies carry out this work separately
- **Units for Maintenance Intervals:**
- **Flight Hours (FH)**, for items that are in constant operation e.g. Fuel Pumps, Electric Generators.
- **Flight Cycles (FC)**, for items operated once or twice per flight e.g. Landing gear, air starter, brakes, hull pressurizations’
- **Calendar Time (Cal)**, for items exposed whether operated or not e.g. Fire Extinguishers, Corrosion to Structure.
- **Operating hours**, for items not operated every flight, or otherwise independent of FH or FC e.g. APU operation



# Aircraft Maintenance– Repair Stations

- **Federal Aviation Regulation Part 145, or FAR 145** describes how to obtain a repair station certificate from the **Federal Aviation Administration (FAA)**.
- It also contains the rules a certificated repair station must follow in the performance of maintenance or alterations of an aircraft, airframe, aircraft engine, propeller, appliance, or component part to which **FAR Part 43** applies.
- The regulation is broken into five subparts:
  - Subpart A - General
  - Subpart B - Certification
  - Subpart C - Housing, Facilities, Equipment, Materials, and Data
  - Subpart D - Personnel
  - Subpart E - Operating Rules
- Each repair station is required to appoint a person as the accountable manager. That person is responsible for all repair station activities and is the focal point in communications with the FAA.
- All Maintenance plans are based on manufacturer recommendations
- To apply for a repair station certification, there is an extensive list of requirements that must be followed
- This includes submitting a description of the repair station housing facilities, a list of maintenance functions, an acceptable training program, and a list of all equipment, personnel, and technical data that require certifications and ratings
- The rating system applies to the types and parts of aircraft that a certified repair station and its mechanics and technicians are authorized to work on
- The primary ratings all contain different class types, including airframe (4 classes), power plant/engine (3 classes), propeller (2 classes), radio (3 classes), instrument (4 classes), and accessory (3 classes)

Repair Stations

7.5 Minutes

<https://www.youtube.com/watch?v=00Et6SkdA4M>

[https://www.youtube.com/watch?v=-BfZ1g\\_x8wA](https://www.youtube.com/watch?v=-BfZ1g_x8wA)

Not recommended

2:11 Minutes

# Aircraft Maintenance - Parts

**Aircraft maintenance:** is the performance of tasks required to ensure the **continuing airworthiness** of an aircraft or aircraft part including overhaul, inspection, replacement, defect rectification, and the embodiment of modifications, and compliance with **Airworthiness Directives**

**Life limited parts:** are parts that, as a condition of their type certificate, may not exceed a specified time, or number of operating cycles, in service

Engine major rotating parts

**Flight critical parts:** are usually regulated by the FAA and the European Union. These include, navigation systems, communication systems, avoidance systems, etc.

**Repairable parts:** are some high value parts that can be repaired using re-manufacturing processes such as machining, welding, plating, etc.

The techniques described in **Advisory Circular 43.13-1B** are generally used as guidance for repair processes that are not specifically described by the manufacturer

High Pressure Turbine Blades & Nozzles are examples where safe repair can be very effective

- **Used Parts:** their market will grow from \$4.5 billion in 2016 to \$7.7 billion in 2026.
- Demand for aircraft recycling is growing with 9,300 retirements in the decade ahead including 4,000 narrow bodies.
- The most prized are Life Limited Parts from **CFM56** engines
- **Suspected unapproved parts:** are those parts that should be deemed un-airworthy and are therefore not eligible for installation on an aircraft or another aeronautical product because their design, manufacture or distribution is in conflict with aviation regulations
- This means that such a part may not have an approved design, may be manufactured by an unapproved manufacturer, distributed by an unapproved distributor, possibly even taken from scrap aircraft while bypassing mandatory and costly shop inspection and recertification processes



# Delta Airlines Maintenance Facility



**Delta TechOps** is a full-service aviation  
**Maintenance, Repair and Overhaul (MRO)**  
provider

Including engine **MRO**

Many large airlines offer **MRO** services to  
smaller airlines



# Airports

Every day, (7 Days a week) the FAA's **Air Traffic Organization (ATO)** provides service to more than 44,000 flights and 2.7 million airline passengers across more than 29 million square miles of airspace



<https://www.youtube.com/watch?v=OykXhUK2S04>

**Top 10 most dangerous airports in the world 2019 10:22**

# Airports-Compliance

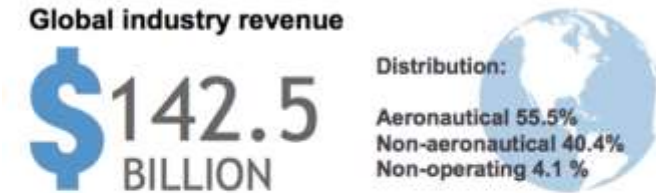
- The **FAA** retains maximum flexibility to consider unique circumstances during this public health emergency
- The **FAA** separately has published frequently asked questions (FAQs) related to the approximately \$10 billion in grants for airports under the **Corona virus Aid, Relief, and Economic Security (CARES) Act**
- Airport sponsors agree to certain obligations when they accept Federal grant funds or Federal property transfers for airport purposes
- The **FAA** enforces these obligations through its **Airport Compliance Program**
- The **FAA** develops engineering, design, and construction standards for civil airports, heliports, and seaplane bases
- This includes:
  - Standards for airfield pavement
  - Airport lighting
  - Marking, signs, and other visual aids
  - Safety during construction
  - Surveying and Graphical Information Systems(GIS) data
  - Deicing
  - Aircraft Rescue and Fire Fighting( ARFF), and other facilities
  - Bird radar and foreign object detection systems
  - And more



# Airports-Really Busy Places

- Every day (7 days a week) the FAA Air Traffic Organization (ATO) provides service to:
  - More than 44,000 flights
  - 2.7 million passengers
  - Across 29 million square miles of airspace
- Airports provide the location for infrastructure that supports airline operations:
  - Runways , lighting, radar
  - Air traffic control
  - Fire and rescue
  - Security
  - Customs/immigration
  - Fuel
  - Maintenance facilities
  - Passenger Terminals
  - Retail business
  - Baggage handling
  - Cargo Terminals
  - Passenger parking
  - Car Rentals /taxi stands/busses/train stations

## Airport economics at a glance\*



**Global aeronautical revenue per passenger**

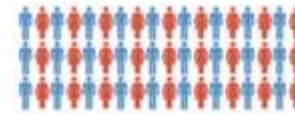
**\$11.78**

**Global non-aeronautical revenue per passenger**

**\$ 8.58**

**Total cost per passenger**

**\$ 16.82**



**Industry net profit margin**



**Global return on invested capital**



**Distribution of non-aeronautical revenue by key source:**

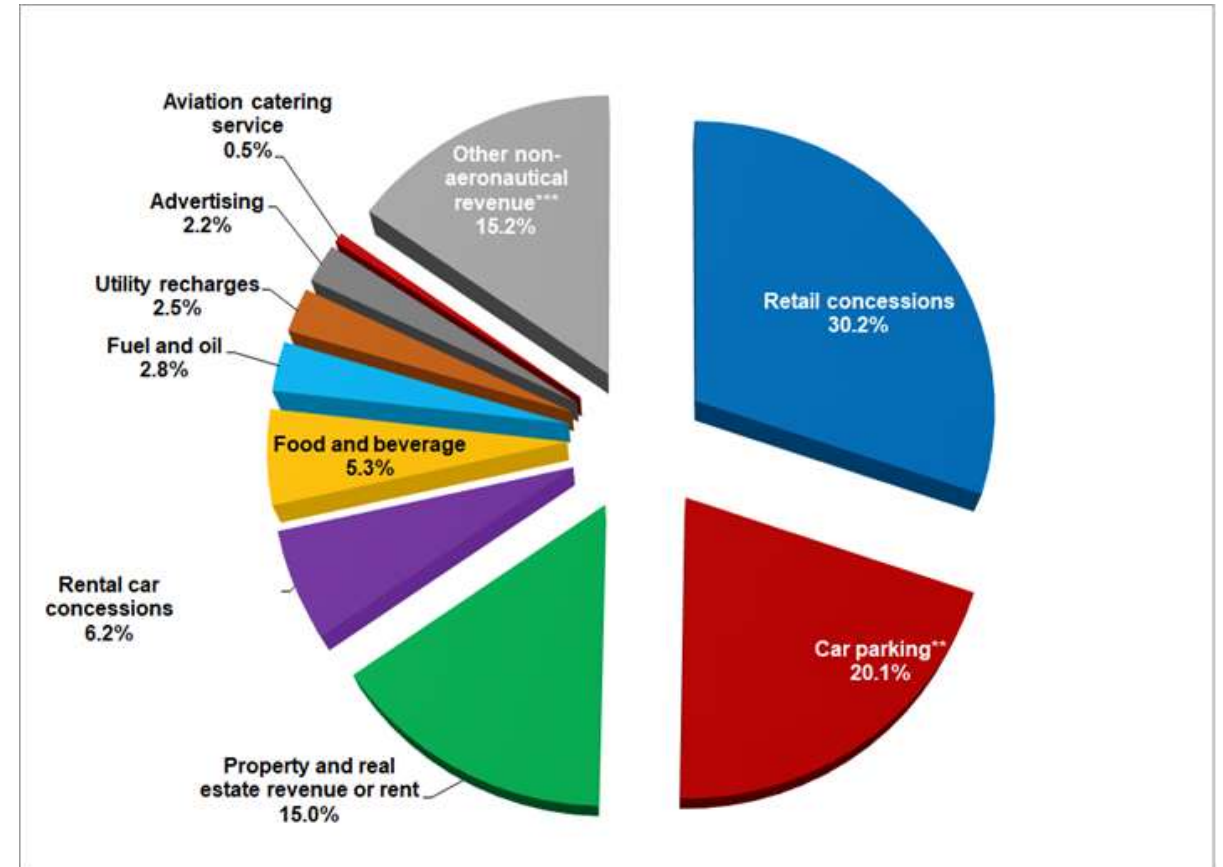


\*Refers to 2014 financial year

# Airports-Really Busy Places-Airport Revenues

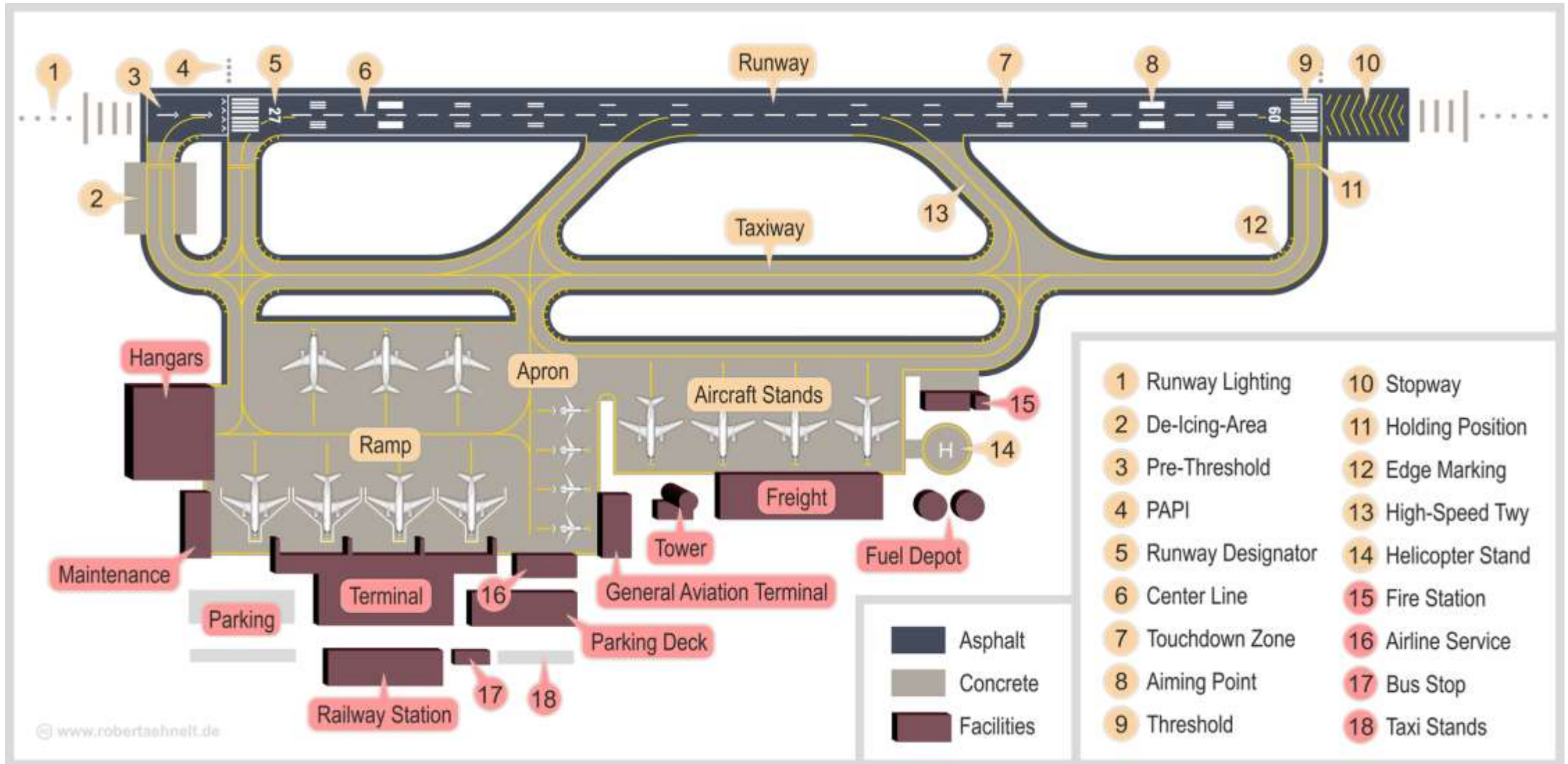
- **Aeronautical revenues**-generated from:
  - Airline terminal rents-gates
  - Landing fees
    - Charged per aircraft for landing at airport
    - Based on landing weight of aircraft
  - Passenger service fees-charges per passenger for facilities used on flights
    - Water , Food, wifi , etc
    - Paid by passengers airline tickets
  - Aircraft parking fees
    - Parked between landing and takeoff
    - JFK fee \$45 per hour and up based on aircraft weight
  - Hangar fees
  - Landing fees are charged per aircraft for landing an airplane in the airport property

- **Non aeronautical revenues**- generated from:





# Airports-Really Busy Places --Sample Infrastructure of a Typical Airport



# Airports-Really Busy Places – Some Airport Businesses and Jobs

- Airlines
- Helicopter Transportation
- Private Jet charters
- Airport Shuttle Services
- Flight Catering Services
- Airport Cleaning Services
- Ticketing and Reservation Services
- Luggage Delivery Services
- Aviation Fuel Supply
- Aircraft Sewage Deposal Company
- Coffee/Cafes
- Restaurants
- Bars
- Clothing Stores
- Airport Security Services- Police
- Airport Fire Department
- Air Ambulance Service
- Aircraft Cleaning/Washing Services
- Currency Exchanges
- Meteorological Services
- Airline Cargo Company
- Airport Management
- Airline Laundry Services
- Airport Cargo/Warehouse Management
- Airport Servicing and Maintenance
- Airport Lawn Care/Landscaping Services
- Snack Shops
- Book Stores
- Car Rental /taxis

# Airports-Really Busy Places--CVG



# International Airports

- **International airports** have customs and border control facilities enabling passengers to travel between countries
- International airports are usually larger than domestic and often feature longer runways and facilities to accommodate the heavier aircraft commonly used for international and intercontinental travel
- International airports usually host domestic flights
- By the second decade of the 21st century, there were over 1,200 international airports and almost two billion international passengers along with 50 million metric tons of cargo were passing through them annually.
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- Technical standards for safety and operating procedures at international airports are set by international agreements
- The **International Air Transport Association (IATA)**, formed in 1945, is the association of the world's airline companies
- The **International Civil Aviation Organization (ICAO)** is the **United Nations** organization overseeing civil aviation
- These two organizations served to create regulations for airports

# Airports-Really Busy Places-Airport Passenger Traffic

RANK 2018	RANK 2017	AIRPORT CITY / COUNTRY / CODE	PASSENGERS	
			(Enplaning and deplaning)	Percent change
1	1	ATLANTA GA, US (ATL)	107 394 029	3.3
2	2	BEIJING, CN (PEK)	100 983 290	5.4
3	3	DUBAI, AE (DXB)	89 149 387	1.0
4	5	LOS ANGELES CA, US (LAX)	87 534 384	3.5
5	4	TOKYO, JP (HND)	87 131 973	2.0
6	6	CHICAGO IL, US (ORD)	83 339 186	4.4
7	7	LONDON, GB (LHR)	80 126 320	2.7
8	8	HONG KONG, HK (HKG)	74 517 402	2.6
9	9	SHANGHAI, CN (PVG)	74 006 331	5.7
10	10	PARIS, FR (CDG)	72 229 723	4.0
11	11	AMSTERDAM, NL (AMS)	71 053 147	3.7
12	16	NEW DELHI, IN (DEL)	69 900 938	10.2
13	13	GUANGZHOU, CN (CAN)	69 769 497	6.0
14	14	FRANKFURT, DE (FRA)	69 510 269	7.8
15	12	DALLAS/FORT WORTH TX, US (DFW)	69 112 607	3.0
16	19	INCHEON, KR (ICN)	68 350 784	10.0
17	15	ISTANBUL, TR (IST)	68 192 683	6.4
18	17	JAKARTA, ID (CGK)	66 908 159	6.2
19	18	SINGAPORE, SG (SIN)	65 628 000	5.5
20	20	DENVER CO, US (DEN)	64 494 613	5.1
<b>TOP 20 FOR 2018</b>			<b>1 539 332 722</b>	<b>4.7</b>

# Next Session

Air Traffic Control

737Max

Covid-19