1 Air Transport as part of overall traffic

- Air transport: On one hand dismissed as commodity, on the other as as magnet for the population (high interest)
- Economist perspective: Air transport as part of econom. transport system
- Modern economy: Division of labour: Pre-requisite for this is a functioning air transport system
- Air transport is an **indicator of wealth and poverty**
- **Globalisation** builds strongly on air transport
- Strong growth projected (based on CAGR of 3.7% → 7.2 billion in 2035 / double of 2016)

Air transport vs. Aviation

- **Air traffic/transport**: All operations used to change location of people, freight and post by air and incorporates all services directly associated with the change of location (flight, catering, airport)
- **Aviation**: Air transport + in-kind services to produce air transport services (manufacturing of airplanes and traffic control systems)

Systemization of Air Transport:

- Functional specification: Civil/Military
- Transport Object: Passenger/Freight/Post
- Commercial: Public/not public
- Non-commercial (not-public): Factory flights, company (internal), private, state
- Length of leg: Short (2000km), Mid (5000km), Long
- Legal: Inland(domestic), Cross-border (international)
- Aircraft Type (Engine): Turbo-prop, Jet, Piston engine
- Regularity: Regular (scheduled), On demand (chartered)
- Business model: Network / charter / low cost / business jet

Specialities reg. Supply and Demand In contrast to other modes of transport, air transport has additional, special characteristics:

- Governmental framework conditions (regulations, state carriers, cabotage ban (no provision of transport services within a country by a foreign transport company))
- Special Infrastructure/State Controlled (Airports, air traffic control, SLOT)
- Intermodal Transport (dependency, limited ability to network)
- High fixed costs / perishable inventory (up to 80% fixed costs, production and use of services are combined, external production factor)
- Derived demand by GDP, and income as driver for demand
- Deregulation has increased supply (LCC)

Performance Metrics for Air Transport

- $PKM = PAX \cdot KM$ (passenger km = pax times km)
- $TKM = Tonne \cdot KM$ (transport/tonne km)
- Supply: $ASK = Available\ Seats \cdot KM$ (available seat km)
- Demand: $RPK = Seats\ sold\ (passengers) \cdot KM$ (revenue passenger km)
- $PKM = 1.852 \cdot PM$ (Miles - KM)
- $SLF = RPK/ASK$ (seat load factor in percentage), analogous for CLF (cargo load factor)

Air transport data - Global (IATA) 2017 - see slide 15

Air transport and COVID

- Demand shocks normally do not have long-lasting impacts (previously shocks of RPK minus 5-20%, but recovery after 6-18 months)
- RPK is depending on regions (high RPK in Asia Pacific, Europe, lower in Africa)
- Different markets recover at different paces (depending on vaccine availability, large markets, GDP and leisure markets)
- High uncertainty for prediction: 2036-2037 - uncertainties include: COVID development, Business travels, Global economy, Global security, Climate attitude

Air transport in Europe

- Overall increase in SLF, PKM
- Seasonality: Summer season 50% more flights
- EU traffic mainly stays in EU
- Largest traffic is LDN Heathrow (77m / year) in terms of PAX, Paris in terms of post/freight
- Most of non-EU traffic goes to non-EU Europe (36.4%), North America (19.8%) or Near East (13.3%)
- Strongest Airport pairs: Paris-Tolouse, Madrid-Barcelona, largest growth: Palma de Mallorca
- Nearly all domestic flights, as carriers work in a hub model
- PKM modal split within Europe: Air has 9-10% share, passenger cars 70%, Buses and Coaches 8%, Railways 7%.
- Share of business model within Air transport: 50% traditional scheduled, 32% LCC, 7 % business aviation, 3% Charter (diminishing due to LCC)

Air transport in Switzerland

- Traffic volume in comparison to GDP: Even though share of modes is low, air transport is 17x of Swiss GDP
- Lines and charters: stable at 450'000 movements (starts and landings) per year
- Increase of PAX by 5% over time due to high SLF and larger aircrafts
- Freight and post stable
- 34% of movements in CH are transfers (percentage of ingoing=outgoing transfer)
- Nr of Aircrafts were stable over the years (commercial), private however decreasing (80% of aircrafts in CH for sports purposes)
- In CH: 5.6% of GDP, 33.5 bn CHF value and 190'000 employees

Emissions

- Number of flights probably grow by 42% from 2017 until 2040
- Aviation around 3.6% of EU28 greenhouse emmissions, 13.4% of transport

- Environmental Efficiancy will increase, average fuel burn per passenger by then expected to be -12% and noise reduction by -24%
- CO_2 Reduction by 21% and NOX by 16%
- How are these addressed: Technology and Design, Biofuels and Synthetic Fuels, Air Traffic Management, Market based measures

Conversions

- Nautical Mile: 1 NM = 1.852 KM
- Statute Mile: 1 SM = 1.602 km
- Feet: M x 3.281 = FT
- Knot: 1 KT = 1 NM/H = 1.852 KM/H

	A320-200	A321-200	A340-300	B777-300	B747-400	A380
Zero Fuel Weight (T)	61,0	71,0	181,0	237,8	251	369
Max Take-Off Weight (T)	73,5	83,0	275,0	350,0	397	577
Max LDG Weight (T)	64,5	75,0	192,0	251	295	391
Max Fuel (T)	18,8	18,6	120	145	216	256
Range (NM)	3500	3500	8500	7900	7300	8200
Passengers	180	220	230	350	400	853

2 Aircraft Operations

Abbreviations

- AFIS: Aerodrome Flight Information Service
- AFM: Aircraft Flight Manual
- ALT: Altimeter
- AI: Attitude indicator
- ASI: Air Speed Indicator
- FIC: Flight Information Center
- GA or MISAP: Go Around or Missed Approach
- IAS: Indicated Air Speed
- KIAS: Knots indicated Air speed
- ROC: Rate of Climb
- RTF: Radiotelephony
- V STALL: Stall Speed

Flight Sequence of ZRH-LHR with an A320

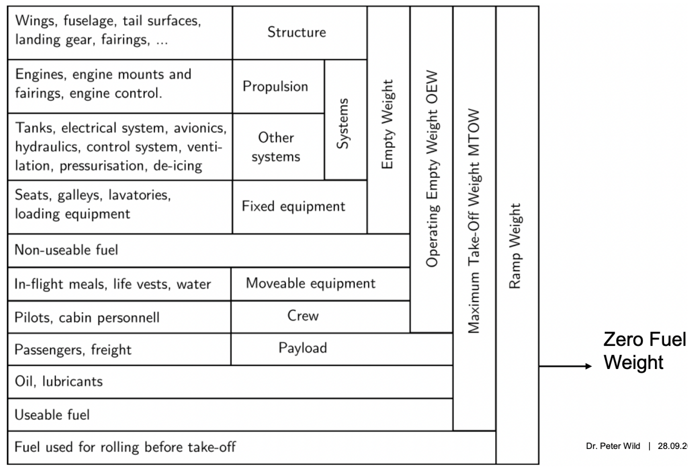
1. Prep at home
2. Checkin/ Pre-flight Planning
3. At the Gate
4. Pushback
5. Taxi
6. Take-Off
7. Climb
8. Cruise
9. Descend
10. Approach
11. Landing
12. Turnaround

1 - Preparation at Home

- Duty Time (65-90 min before Start of Duty until 30min after official End of Duty)
- Block Time (Rolling until Parking, in Duty Time)
- Flight Time (Take-Off until Landing, within Block, hence also Duty Time)
- Rest Period in Home Base: Matches previous Duty Time or 12hours (the greater one)
- Rest Period abroad: Previous Duty Time or 10 hours (the greater one)
- Block Times: 100 hours in 28 days or 900h per calendar year
- Duty Times: 13 hours per day (depending on check in times and delays), 60 hours per week (7 days) or 2000h per calendar year
- **Chart** Studies (airports, routes, public addresses (PA), duty times, specifically Passengers (PAX)/freight, weather WX, political situations)
- **Reserve/Standby**: Short haul 1h, Long-haul 1.5h
- **Crew**: Seating Position: CMD Commander and COPI Co-Pilot (1,2), 1 Senior Cabin Member (Maitre de Cabine) & 3 Cabin Members (on A320)
- Commander Rank: Senior Captain, Captain (4 stripes), Co-Pilot: Senior First Officer, First Officer (F/O) or Second Officer (3 Stripes, 2 Stripes)

2 - Check-In (T-65') Crew meets, collects documents, planning

- Airport: Departure Aerodrome (AD) and Destination AD
- Intermediate Alternates:
  - Short haul: Reachable within 60 min at one-engine operative (OEI) cruise speed
  - Long haul (3 and 4 engines): 120 min
  - ETOPS: Extended Twin Operations (A330): 180min
- Flight preparation: Weather: Weather assessment documents
  - General Weather assessment (SWC: Significant Weather Chart)
  - Satelite Images
  - Wind & Temperature Charts
  - Weather Forecast (TAF: Terminal Aerodrome Forecast) - long range forecast (9/18/24 or 30 hours)
  - Current Weather (METAR: Meteorological Aerodrome Report)
  - Airports must fulfil certain general minima for sight and/or cloud cover
  - Report Details Slide 14
- Flight preparation: NOTAM (Notice to Airmen): Info for airfields (constructions), airspaces, hazards (radioactive materials)
- Flight preparation: Operation Flight Plan (OFP)
  - Performance
  - Mass & Balance
  - Fuel Calculation
  - Route
  - ATC (Air Traffic Control) Flight Plan
- Cabin Briefing: Meet crew and inform them about flight, flight time, PAX, weather (turbulence), stopover
- Weights and Fuel (ZFW = A/C + Crew + Freight/PAX):



- For different Aircrafts, there is a maximum landing weight (Max LDG/MLDG), which is larger than the zero fuel weight. Weigths above the MLDG will require a checks on the aircraft after landing if they are exceeded. (See slide 21 for details)
- (T-40) Bus to Aircraft: Security checks, ID check for Non-Schengen Areas, Own bus

3 - At the Gate/Stand

- Aircraft: Power through GPU (GNU Power Unit) or APU (Auxiliary). Cooling (air) through Airport or APU.

- CMD: Walk around, aircraft acceptance (Aircraft Log/MEL), fuelling
- COPI: Cockpit Preparation, FMS (Flight Management System) loading (route & wind automatic)
- Cabin: Safety equipment check (fire extinguisher, axe, gloves, medical kits, cabin search, PBE (protective breathing equipment))
- Catering: Load food, drinks, newspapers for booked PAX
- Maintenance: Solve technical problems reported by maintenance / last crew (topping up oil, tyre pressure)
- Water/Waste: Empty toilets/refill, fill up water as required
- Loading Crew: Load aircraft with ULD (uniform load devices with luggage etc.)
- Overview: See slide 26 (stakeholders)
- T-20 (Cabin): Boarding begins: Special PAX first, Unaccompanied Minors (UM), Wheelchairs, Deportees, Medical (Blind, Deaf, Stretcher, Oxygen), Families, Musical Instruments, and anything connected with seating restrictions
- Finish Checklists: Cockpit Preparation. Take-off briefings
  - Departure Briefing (ATC Clearance) (SID= Standard Instrument Departure) departure route
  - Emergency Briefing: Procedure if aircraft experiences and engine failure or any other emergency (fire, both engines damaged)
- T-3 (Cabin): Boarding completed (headcount agrees). Coordinator (GND Handling Agent) confirms completion/PAX numbers and brings loading sheet (mass & balance) as well as NOTOC (Notification to Captain)
- NOTOC: Dangerous Good (what kind of), Volume/Weight, Where loaded (ULD NR.), UN Classification, Emergency Response Drill (info Fire Brigade etc.)
- (Ground): Complete Loading completed, Pushback tractor gets into position
- T-0 (Cabin): Close doors and arm them (including slides for evacuation)
- (Cockpit): Official ATC Clearance obtained for Departure Route & Pushback. Passengers are greeted over Public Address (PA)
- Engines are started during the Push with the help of the APU

5 - Taxiing to Runway

- The ATC determines the take-off sequence based on traffic and route
- Different checks are made during taxiing
- The cabin crew prepares the cabin (trolley, stowaway items) and shows safety on board film
- **Influence on Departure and Landing Sequence by categories of Aircraft (WTC: Wake turbulence category)**:
  - J/SUPER (A380)
  - H/HEAVY (136'000 kg or 3'000'000 LBS) or more
  - M/MEDIUM (less than H and more than L)
  - L/LIGHT (7000 kg 15500 LBS) or less
- Seperation and LDG: The WTC category defines a separation minimum (in Nautical Miles) from a leading to a following aircraft. Optimally, smaller planes go ahead
- Takeoff T/O Minimum (IFR, instrument flight rules): An instrumentally derived horizontal distance a pilot should see down the runway from an approach end, based either on the sighting of high intensity runway lights or on the visual contrasts of objects, whichever yields the greater visual range.
- Wind limits and contaminated runways: Crosswinds, tailwinds (normally 10KTS) assumed, and based on runway contamination, different thrust profiles have to be chosen

6 - Take-Off

- Performance Calculations TORA and ASDA, 2nd Segment (to 400 ft, 2.4% Gradient), Obstacle Clearance
- V1 (if smaller, take-off is rejected), Acceleration to VR (take-off rotation starts), V2 (flight continues with this max speed, climb)
- Take-off run acceleration (TORA): Acceleration to V1, then one engine fails with acceleration to VR and rotating
- Accelerate Stop Distance Acceleration (ASDA): Acceleration to V1, then reject and stop on runway
- 2nd Segment: Regulations from Authorities: Gradient 2.4% with one engine operative (normal OPS 13-27%) and usually for all engine climbs 3.3-10%
- Obstacle clearance

7 - Climb

- FL (flight level) 100 (depending on pressure, but normally 10'000 ft), altitude at standard air pressure: Max 250 KN
- Over FL 100: Speed determined by airline/manufacturer, for optimum efficiency: Normally 280-320 KTS
- Max FL390 (around 37'000 ft): low weight / valid for most airliners
- FL 390: 27 min / 1900 kg fuel burn / 180 NM speed

8 - Cruise

- Flight Measurement System (FMS) suggest MAX FL, and based on weight and wind + temperature optimum FL
- MACH around 0.78 (depends on outside temperature, but assume normally 300 m/s or 1080 km/h for speed and sound)
- Step Climbs: As the aircraft burns fuel, it becomes lighter and climbs to optimum cruise level. In practice, a step climb is carried out
- **Terrain/Obstacle Clearance**: Maps are published for minimum flight altitude (MGA, grid altitude), minor sector altitude MSA or min Terrain clearance altitude MTCA.
- They all guarantee following margins (even though differently calculated)
  - Obstacles up to 6000 ft: 1000 ft Margin
  - Obstacles above 6000 ft: 2000 ft Margin
- Tasks while cruising:
  - Flying pilot (FP): Flying, navigation, passenger announcements. Pilot monitoring (PM): Radio, Calculations, systems monitoring. Preparation of turnaround (30-40 min on ground): weather, flight planning, fuel, organisation of trouble-free sequence on ground
  - Cabin: starts with seatbelts sign off (FL 100) until seatbelts sign on (15 min befor Landing)

9 - Descent

- Top of Descent (TOD):Flight Monitoring System (FMS) calculates ideal descent taking constraints into consideration. Speed and attitude readings from approach are determined
- Calculation: Normally a 3 degree descent or 5.2%, distance * 3 = nominal height

- Performance: 17 min / 170 kg Fuel / 110 NM

10 - Approach

- Types of Approaches: Precision Approach, or Non-Precision Approach. Main difference: Non-Precision approach only guides flight crew on lateral axis. Precision approach also on vertical

- Precision Approach: An ILS (instrument landing system) is consists of a localizer (lateral) and a glideslope (vertical). The glideslope leads the aircraft on a 3° angle to the runway. Red/white station and larger beacons

- Non-Precision Approach:
  - VOR (VHF omnidirectional range): Allows naviagition on a specific course on or away from the station (FR=from and TO=to, multiple stations 1-6, given in degrees, readings agree with map). VOR station is circular
  - NDB (Non-directional beacon): NDB only shows the route to/from the station. NDB station is a large antenna above ground
  - RNAV/GPS (Area navigation/ global positioning system): Aircraft-based platform which can self determine its position wih the help of VOR, ILS, NDB, GPS and IRS (inertial reference system). Independent from ground (satelite based) and support direct routes instead of routes from station to station

- Approach type? Depending on:
  - Weather: Non-precision approaches need better weather conditions. due to imprecisions. Basically 500ft ceiling (cloud cover), 1500m visibility (ILS: only needs 220ft and 500m)
  - The on/board aircraft installations
  - Qualification of Crew members (for Cat. 2 or 3 approaches)
  - Needs of the crew (training)
  - Preference of the airfield/ATC (Noise, efficiency)

- Fog - Low visibility approaches:
  - Cloud base 200ft/500m visibility: Cat 1 approach via ILS. If visibility is below 400m RVR, then low visibility approach. Lower sequences, greater spacing in the air and on the ground are consequence
  - Category 2: 100ft/300m. Requirements: Qualified crew, minimum 1 auto-pilot (AP), 2 Pilots, Procedure Autoland
  - Category 3A: 50ft/200m. Requirements:Additionally to Cat 2, autothrust
  - Category 3B: No/75m. Requirements: Additional to Cat 3A, 2 AP, auto rollout and also often auto brake

11 - Landing

- Begins 50ft on the centerline and should be landed within 300-600m in touchdown zone

- Braking: Carbon brakes, Reverse Thrust, Ground Spoilers

- The landing distance is defined as the effective distance from 50ft above ground until still stand. A safety margin is built in. Measuring the landing distance, this LD=60% Length of required landing distance needed. Margin is total Runway (TR - LD/0.6 = Margin)

12 - Standing at place or at gate + Turnaround

- Rolling to standing place via signs or marshalls

- GPU is attached or APU switched on when engines are shut down

- Turnaround time is 30-40 min. This includes
  - Passengers leave
  - Aircraft is cleaned up
  - Catering restocked
  - Planning completed and A/C refueled
  - Checks/safety checks completed
  - Boarding starts again

3 Aircraft Aerodynamics

- Lift: Aerodyn. Force perpendicular to the flight vector
- Drag: Aeordyn. Force in opposite direction to flight vector
- Standard condition: $H = 2000m$ and $\rho = 1\ kg/m^3$

Fuel consumption

$$Fuel\ burn\ per\ distance \approx \frac{SFC}{M_\infty}\frac{Weight}{Lift/Drag}$$

M_∞ affected by aerodynamics and Engine, Lift and Drag by Aerodynamics, SFC by engine

Equilibrum of forces: Drag=Thrust (minimse thrust), Lift = Weight (mandatory). Design goal Lift $\gg$ Drag

Flight Performance: How far: c_L/c_D, How long: c_L^3/c_D^2

Forces

$$F_D = c_D\frac{1}{2}\rho_\infty V_\infty^2 A\ \ /\ \ F_L = c_L\frac{1}{2}\rho_\infty V_\infty^2 A = mg = L$$

The fuel consumption depends on the drag "Area": $c_D A$

Eq. of motion

$$T cos\alpha - D - mg sin\varphi = 0$$
$$L + T sin\alpha - mg cos\varphi = 0$$
$$\Theta = Attitude = \alpha + \varphi = AoA + flight/climb\ angle$$

Why does a wing generate lift: The wing diverts a mass of air downwards. For this the wing acts with a force to the fluid. In return the air generates a force of the same magnitude to the wing (actio = reactio).

Induced Drag (Drag due to Lift)

$$D_i = \frac{2}{\rho V^2 \pi}\left(\frac{L}{b}\right)^2\ ,\ \ F^* = \pi/4b^2(Prandtl)$$
$$c_{D_i} = \frac{1}{\pi}c_L^2\frac{F}{b^2} = \frac{c_L^2}{\pi\Lambda}$$
$$b = Wing\ Span, F = Wing\ Area, \Lambda = Aspect\ Ratio$$

- Induced drag (D_i) depends on ratio of lift and wing span
- The coefficent of induced drag (c_{D_i}) depends on the aspect ratio
- A slim wing with high aspect ratio produces less induced drag than a compact wing with small aspect ratio
- Induced Drag stems from the principle of linear momentum. No friction is included. The induced drag is an additional contribution to total drag
- In general however, for non elliptical lift distribution, an Oswald-Factor e must be considered $c_{D_{i,true}} = c_{D_i}/e$

Tip Vortices

- Consider Oswald factor e
- Heavy Aircraft $\rightarrow$ Strong tip vortex $\rightarrow$ High Separation Distance / Time

Drag Total Drag = Induced Drag + Parasite Drag

- Parasite Drag is depending on the Reynolds, Mach number and some velocity regimes
- Influence of Reynolds number: Laminar, turbulent flow and separation. Separation mainly due to pressure drag, turbulent and laminar flow due to friction drag (small contribution)
- Target of small drag: No separation, turbulent downstream and large range laminar flow
- Incluence of Mach Number: At airspeed M $\geq$ 0.7, the flow is no longer incompressible. Additional drag occurs
- Lift and drag depend on the angle of attack. The polar diagram describes the dependence of the lift and drag coefficients on the angle of attack α
- Following components can lead to drag: skin friction drag, induced drag, profile drag, form drag, compressibility drag, interference drag, base drag, trim drag

Flight Performance and characteristics

- Atmosphere: Aerodynamic Forces depend on the air density. The engine power (thrust) depends on the ambient pressure and temperature
- Steady thrust: $tan\varphi = \frac{Tcos\alpha - D}{Tsin\alpha + L}$
- Without thrust: $tan\varphi = \frac{-D}{L} = \frac{-c_D}{c_L} = \frac{height}{distance}$ flight path angle points downwards
- φ is a measure for the aerodynamic quality of an airplane (how far it can travel from a given altitude)

Drag at steady horizontal flight

$$L = mg = c_L\frac{\rho}{2}V^2F$$
$$V = \sqrt{\frac{2mg}{\rho F c_L}}$$
$$c_L = \frac{2mg}{\rho V^2 F}$$
$$D = D_{parasite} + D_{ind} = c_{D,para}\cdot\frac{\rho}{2}V^2F + \frac{\rho}{2}V^2F\frac{c_L^2}{\pi\Lambda e}$$
$$= \frac{\rho}{2}V^2F(c_{D,para} + c_{D,ind}) = K_1V^2 + K_2\frac{1}{V^2}$$

The function $D(V)$ intersects with the function of Thrust $T(V)$ twice due to its shape. There are two optimal points with velocities V_1 and V_2, where there is no excess thrust or drag ($T = D$). However the stall speed is determined as follows with the maximal Lift coefficient from the polar diagram:

$$V_{stall} = \sqrt{\frac{2mg}{\rho F c_{L,max}}}\quad (c_{L,max} = c_{a,max}\ from\ diagram)$$

- The maximum speed (ideally V_2 is determined from the maximum Thrust ($V_max, horiz$))
- The minimum speed is the stall speed $V_{stall} > V_1$
- The speed range is between minimum and maximum speed

Stability control

- Steady flight condition $\rightarrow$ Disturbance $\rightarrow$ Answer of airplane $\rightarrow$ Flight path
- Example: Horizontal flight, then Pilot command: elevator deflection or gust comes, then pitching moment, then determine if stable/unstable/indifferent
- $alpha$, $\Delta\alpha > 0$, $-\Delta c_m$, $\frac{dc_M}{d\alpha} > 0$ (positive criterion)
- Lilienthal: Positive long. stability, Wright: Negative long. stability
- Dassault Falcon: stable, Neuron (delta wing): instable, Raffale: indifferent/neutral

Development trends

Good airplane

- High lift to drag ratio (low drag)
- High ratio of payload to weight (low empty weight)

- High engine efficiency (high ratio of engine diameter to shaft power for propeller) + high compressor, combustor and turbine efficiency

Highest efficiency drivers

- Engine: -15% (high combustion efficiency, geared fan)
- Energy: -5 % (no bleed air, more electric aircraft)
- Aerodynamics: -10 % (Wing tip, engine integration, empennage config, Detail improvement)
- Structure: -5% (Detail improvment, composites, new alloys, new joining technologies)
- Air traffic management
- New configurations revolutions vs. tube-wing evolution (curent)
- Electric/hybrid aircraft - new design freedom

4 Manufacturing and Maintenance

Abbreviations:

- A/C: Aircraft
- AMM: Aircraft Maintanance Manuals (Detailed instructions)
- AMP: Aircraft Maintenance Program
- CAMO: Continuing Airworthiness Management Organisation
- CRS: Certificate of Release to Service
- DIS: Discard
- DOA: Design Organisation Approval
- EASA: European Aviation Safety Agency
- ETOPS: Extended Range Twin Operations
- FAA: Federal Aviation Agency
- FC: Flight Cycles
- FH: Flight Hours
- FNC: Functional Check
- IFE: In-flight entertainment
- MEL: Minimum Equipment List
- MOE: Maintenance Organisation Equipment
- MSN: Manufacturer Serial Number
- MX PFC: Maintenance Pre Flight Check
- OPS: Operational Check
- PFC: Pre Flight Check
- POA: Production Organistion Approval
- RST: Restore (Overhaul)
- SPC: Special Check
- STC: Supplemental Type-Certificate
- TC: Type Certificate
- XWB: Extra Wide Body

Manufacturing - Initial Airworthiness

A350 XWB Program Summary - see slides 7-9

Tasks in Approval of the A350 XWB

- MSN1: Initial Handling, Systems & Powerplant Tangentensteigung
- MSN2: Cabin Certification, early long-flight tests, in-flight entertainment (IFE), cabin hot & cold testing, visit the McKinley Climatic Lab in Florida, USA
- MSN3: High altitude (Bolivia) and cold weather (in Canada) testing, performance and measurement, hot and cold weather campaigns, systems and powerplant testing
- MSN4: External Noise, and lightning tests, avionics development/certification, training for pilot and maintenance
- MSN5: Cabin operability training, route-proving, ETOPS (extended twin operations) certification

Comparing A350 to A340 Final Assembly: A 350 has at first the fuselage completed, then the wings are attached. For the A340, the center fuselage with the wings are first assembled.

Important information:

- A350 XWB uses mostly Carbon Fiber Reinforced Polymer (53% weight)
- An Iron Bird is a zero-test rig, which is used to test hydraulic, electrical and flight control systems. It has the same components as installed on MSN1. It is also used to test the interface between Cockpit and A/C systems
- The McKinley Climatic Lab is used to demonstrate the whole operational spectrum of the aircraft on ground
- The EASA is the primary certification authority for A350, whereas the FAA is the primary cert. auth. of Boeing A/C. The FAA or EASA validates the approvals of their respective counterparts (bilateral agreement US-EU)
- Multiple screens of same type are used in the cockpit - why? Dispatch reliability/exchange capability, less stock of screens required by operator
- The A350 has an ETOPS Approval of 370min (2500 NM)
- Common Type Rating: Is approved by EASA as a way for decreasing the time of training required by a pilot to change from an A330 to an A350. Cross Crew Qualification normally takes longer (slide 15 details)

Regulatory Basics for Certification in Europe - Airworthiness

- Initial Airworthiness (EASA Part 21 + 26 [for passenger A/C], 748/2021 + 2015/640):
  - Airworthiness and environmental certification of A/C and related products, parts and appliances
  - Certification of Design Organisations (DOA) (Section J)
  - Certification of Production Organisations (POA) (Section G)
- Certification Specifications (CS) for Products:
  - CS25: Large Aeroplanes (1100 pages), CS-22: Sailplanes, CS23: Normal, Utility and commuter aeroplanes, CS-27: Small rotorcraft (up to 3.175 tonnes and 9 PAX), CS-29 Large rotorcraft (>3.175 tonnes), CS-31 Balloons
  - CS-34: Aircraft Engine Emmissions and Fuel Venting
  - CS-36 Aircraft Noise
  - CS-E Engines (only engine)
  - CS-26: Additional Airworthiness specifications for operation (Part 26) - for crew and transport important!
  - (CS-LSA): Light Sport Aeroplanes, (CS-ETSO): European Technical Standard Order

Examples

- CS25.581: Lightning Protection → Non-metallic and non-metallic, as mostly today many CFRP wings etc. → Static Wicks (Lightning Rods) burn away, in metal planes farrady cage. As well metallic meshes underneath the wing surface
- CS25.803: Emergency Evacuation: More than 44 passengers, maximum seat capacity can be evacuated from aeroplane to ground within 90 seconds. Compliance shown by actual demonstration outlined in CS25 Appendix J.

Part-21 Production Organisations in CH (slide 25)

- 19 in CH, Pilatus, Bucher, Lantal, RUAG Int. (CH.21G.0002,0015,0012,0021)

Largest Aircraft Manufacturers

- Commercial: Airbus, Boeing, (Bombardier), Embraer
- Private Large A/C: Bombardier, Cessna, Dassault, Embraer, Gulfstream
- General Aviation: Textron Aviation (Cessna, Hawker, Beech), Diamond, Pilatus
- Numbers:

- Most produced A/C: Cessna C172 > 44'000
- Most produced Heli: Mil Mi-8 > 18'000
- Most produced commercial airliner: Douglac DC-03: 16'079
- Largest manufacturere by produced A/C: Cessna > 450'000 A/C since 1945

MMEL - Master Minimum Equipment List

- An A/C is certified with all equipment operative. However defects occur, and the operator wants to fly
- Conditional Deviations from Type Certificate (TC) are authorised → Dispatch Conditions
- The Dispatch Conditions are listed in the MMEL
- The MMEL is an approved deviation from the Type Certicficate
- MMEL assures an acceptable level of safety while an aircraft is operative with inoperative equipment

MEL - Minimum Equipment List

- The MEL is based on the MMEL
- Is developed by Operator, and is less restrictive than the MMEL
- Contains operations specific items based on A/C configuration, equipment installed and routes flown (additional requirements on cleaning etc.)
- The MEL must be approved by the authority of the operator

Layout of MEL and MMEL

1. System and Sequence Numbers (Item Reference and designation (ATA breakdown designation))
2. Rectification Interval (B,C,D may be extended one time)
   - A: No standard rect. Interval
   - B: 3 consecutive calendar days
   - C: 10 cons. cal. days
   - D: 120 cons. cal. days
3. Number installed
4. Number required for Dispatch (dispatch conditions can be different for different numbers)
5. Remarks or exceptions (marked through (o), (*) or (m))

Continuing Airworthiness - EASA Part-M, -CAMO, -145 etc.

- EU No 1321/2014 regulates the continuing of Airworthiness of A/C and aeronautical products, parts and appliances, rights and obligations for organisations seeking approval to carry out following activities:
  - Planning for Continuing Airworthiness of A/C is done in the Part-CAMO Organisation (Annex Vc), according to tasks as described in Part-M (Annex I)
  - Execution of maintenance is done in Part-145 (Annex II) or Part-CAO Organisation (Annex Vd)
- EASA Continuing Airworthiness also regulates Part-66 licenses for maintenance personell performing maintenance activities (Annex III)
- Rights and Obligations for Part-147 organisations seeking approval to conduct training and examination of Part-66
- Additional requirements for continuing airworthiness of leased-in country aircraft (CAT) (Part-T) Annex Va

Planning and Continuing Airworthiness

- Part-CAMO: Commercial or Complex A/C, there continuing airworthiness is ensured by a CAMO
- Example: Swiss, Helvetic, Pilatus, Rega, Air Zermatt, Jet Aviation Business Jets
- Tasks are described in Part-M
  - Creating and updating maintenance program
  - Preparing workorders for the required maintenance on the A/C for the respective Maintenance Organisation
  - Implementation of all relevant airworthiness directives (AD)
  - Ensure that maintenance is carried out by an approved organisation

Perfomance of Maintenance in a Part-145 organisation

- Example: SR Technics, Swiss, RUAG, Rega, Pilatus Jet Aviation, Bucher Leichtbau (Maintance organisation)
- Is required to provide a suitable facility
- Must hav the licensed Part 66 certified personell available
- Must have the approval for the type of aircraft and scope (line/light or base maintenance)
- Must have necessary equipment, tools and materials
- Must have a QC-System in place
- Must have a maintenance organisation exposition (MOE) - org-chart
- Performs maintenance in accordance with the workorder received from the owner or CAMO
- Must record all its work in maintenance records
- Certifies the work performed in the technical logbook on the **Certificate of Release (CRS)**, which is copied after completion of work (one in aircraft, one on ground, going to CAMO)

Licensed Personnel according to Part-66

- Example: Technician of Aircraft
- Must demonstrate basic knowledge
- Must attend different module-courses and pass exams (license categories)
- Training time approx. 2 years
- Must have attended relevant A/C type trainings
- Prove experience, as license must be renewed by componént authority every 5 years

Part-147 Training organisation

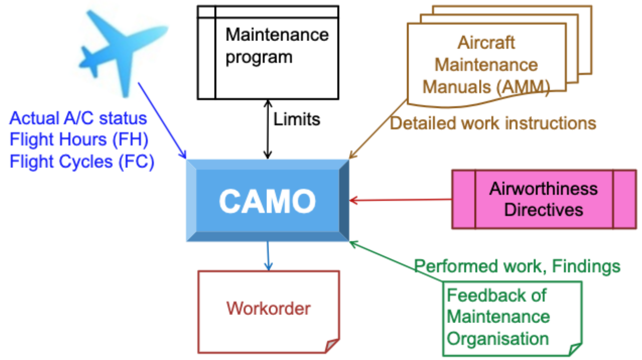
- Example: SR Technics, Pilatus, Aviotrace, QCM
- Must provide appropriate facilities
- Have apropriate staff
- Must provide teaching material including access to workshops for practical training
- Quality System
- Records of performed courses
- Must have a Maintenance Training Organisation Exposition

Aircraft Maintenance Program (AMP)

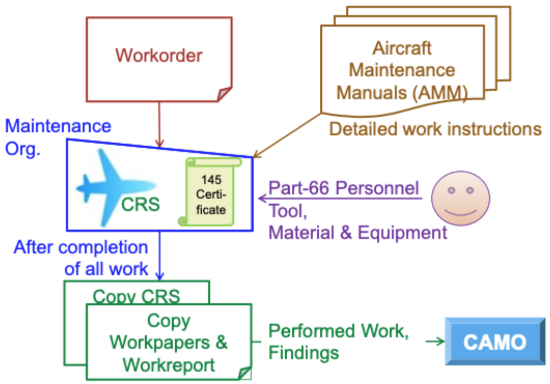
- All maintenance on an aircraft is based on its individual maintenance program
- It must be developed by the operator, bosed on the Maintenance Plannign Document (MPD)
- MPD is part of the certification process
- Operator/CAMO can add items or decrease mainteance intervals based on experience made during maintenance
- Increase of mainteance intervals is possible in cooperation with the TC holder

- Maintenace intervals (since ops start)
  - Line Maintenance:
    - MXPFC + PFC: Before each departure
    - W (Weekly): All 14 calendar days
    - A: Every 800 FH (approx 3 weeks)
  - Base Maintance
    - C: 1C,2C,4C,8C = 18/36/72/144 months
    - IV: 1IV = 6Y = 72 months
    - D: 1D = 12Y = 144 months

Planning of Aircraft Maintenance



Performance of Maintenance



SR Technics Ratings (partial only)

Class	Rating / Limitation	Base	Line
Aircraft	A1 Aeroplanes above 5700 kg		
	AIRBUS INDUSTRIE A300 series	NO	YES
	AIRBUS INDUSTRIE A310 series	NO	YES
	AIRBUS INDUSTRIE A318 series	YES	YES
	AIRBUS INDUSTRIE A319 series	YES	YES
	AIRBUS INDUSTRIE A320 series	YES	YES
	AIRBUS INDUSTRIE A321 series	YES	YES
	AIRBUS INDUSTRIE A330 series	NO	YES
	AIRBUS INDUSTRIE A340 series	NO	YES
	AIRBUS INDUSTRIE A350 series	NO	YES
	AIRBUS INDUSTRIE A380 series	NO	YES
	BOEING 737-300, -400, -500 series	YES	YES
	BOEING 737-600, -700, -800, -900 series	YES	YES
	BOEING 737-8/-9 series	NO	YES
	BOEING 747-100, -200, -300 series	NO	YES
	BOEING 747-400 series	NO	YES
	BOEING 747-8 series	NO	YES
	BOEING 757 series	NO	YES
	BOEING 767 series	NO	YES
	BOEING 777 series	NO	YES
	BOEING 787 series	NO	YES
	EMBRAER ERJ-170 series	NO	YES
	EMBRAER ERJ-190 series	NO	YES

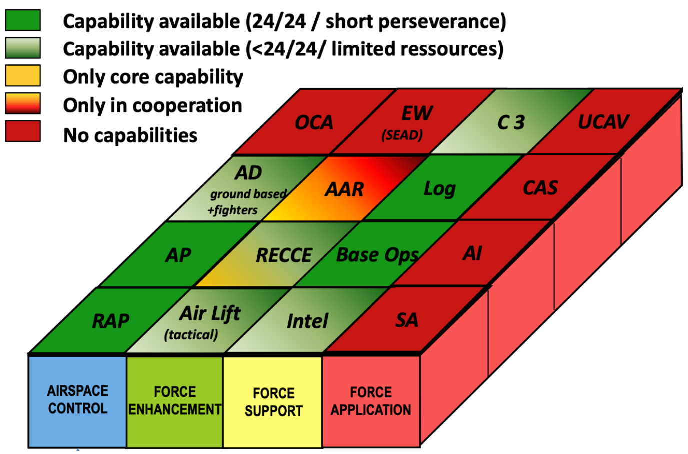
5 Military Aviation

Tasks and capabilities of the Swiss Air Force

- During times in peace: Surveillance of the airspace + air policing (AP)
- During times of peace, crisis and war: Gathering and distribution of intelligence, air transport (heli), and protection of the airspace (air policing, air defense)
- In the past: Enemy was known
- Today: Assumption about capabilities and devices of potential adversary

Task of the air force

Capabilities of the Swiss Air Force



Abbreviations

- RAP: Recognised Air Picture
- AP: Air Policing / Air Police
- AD: Air Defence
- OCA: Offensive Counter Air
- Air Lift: Air Transport
- RECCE: Aerial Reconnaissance
- AAR: Air-to-Air Refuelling
- EW: Electronic Warfare
- Intel: Intelligence
- Base Ops: Air Base Operations
- Log: Logistics
- C3: Command - Control - Communication
- SA: Strategic Attack
- AI: Air Interdiction
- CAS: Close Air Support
- UCAV: Unmanned Combat Aerial Vehicle

Air Police

- Identification: of foreign state craft (1/day)
- Detection: of airspace infringements (1/week)
- Help: In case of problems with navigation or radio communication (1/month). If a transponder is turned off, then the air traffic control (secondary radar) cannot detect airborne vehicle anymore. The military ATC can however detect Position, Altitude, Direction or Speed via a primary radar (+IFF) for RAP
- Enforcement: of airspace restrictions (1/year). Two airplanes, one behind and one next to cockpit

Rules when intercepted

- Intercepting Aircraft: Rocking of weeks = follow me (acknoledged by rocking wings)
- Intercepting Aircraft: Abrupt break away = you may proceed (acknoledged by rocking wings)
- Intercepting Aircraft: Circles aerodrome and lowers landing gear = land here (acknoledged by lowering landing gear)
- Intercepted Aircraft: Gear retraction and irregular switching of all available lights = cannot comply
- Intercepted Aircraft: Flashing of lights = in distress

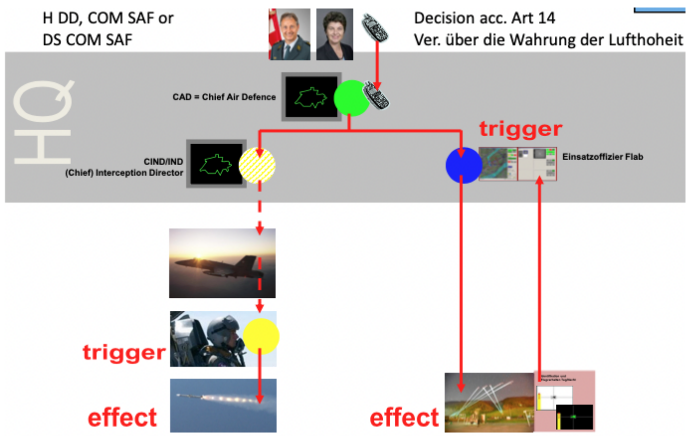
Enforcement of airspace restrictions:

- 30 F/A 18
- Radar, Datalink
- Mach 1.6
- 20mm M61A1 Gatling Gun (6000 rpm)
- Raytheon AIM-9X Sidewinder (Multipurpose Missile)
- Raytheon AIM-120B AMRAAM (Medium Range Air-to-Air Missile)
- Helmet Visor
- NVG (Night Vision Goggles)

Why WEF requires Constant Air Police:

- Air fields in Payerne, Emmen and Meiringen are each 10, 7.5 or 5 min away from Davos

Decision making



Airspace Control in Times of Peace

- In unrestricted airspace no weapons may be used against civil air traffic
- In restricted airspace the Head of the Defense Department may order the use of weapons in isolated cases. But only if air policing orders are disobeyed and no other means are available.
- The use of weapons is allowed for self defense and helping others in self defense.

- Against foreign state air traffic, namely military air traffic, weapons may be used if they enter Swiss airspace without permission or by deliberate deviation from permissions or restrictions and if air policing orders are disobeyed and no other means are available.
- International cooperation is not compatible with neutrality.

Planning Air Defense and Police

- 4 fighters (SOP) 144h/d
- 3-4 fighters for permanent protection
- Readiness 50-70%
- 20 fighters: 100/fighter per 14 days
- Today: 30 F/A 18 each: Can only be used 100h in 6 months
- Pilots: 32 pilots, each 12h/day
- Today: 3 Squaddrons, each 16=48 pilots

Airspace Control in Times of Peace, Crisis and War Permanent surveillance of the airspace

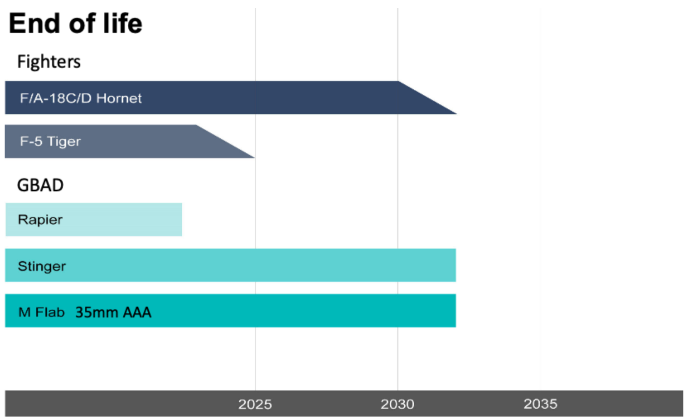
- In times of restricted air traffic with 4 fighters at all times in the air. Within 3 weeks, already we cannot preserve the AP/AD

Quick Reaction Alert (QRA) yesterday and today

- Core capacity: Formation and training of our militia component
- Readiness / adapted readiness: Notice at least 24h in advance
- Since 2021: Permanent Air Surveillance: 356d/24h

Definitions

- **Air Superiority**: That degree of dominance in the air battle of one force over another that permits the conduct of operations by the former and its related land, sea, and air forces at a given time and place without prohibitive interference by the opposing force.
- **Air Supremacy**: A position in war where one side holds complete control of air warfare and air power over opposing forces. It is defined by NATO and the United States Department of Defense as ”the degree of air superiority wherein the opposing air force is incapable of effective interference”.



Effects of Gaps in Capabilities for Switzerland

- Safety of civil air traffic at risk
- No protection of endangered civil infrastructure
- Limited air defense capabilities
- Overall limited defense capabilities
  – Useless investment in armored mobility due to air threats
  – Poor intelligence due to lack of aerial reconnaissance
  – Increased pressure on our forces due to lack of air to ground capabilities
  – Poor mobility in impassable terrain near a frontline due to lack of armed air transport

Air Lift Mission

- Transport of troops and material
- Emergency relief
- Fire fighting
- VIP Transport
- Dropping of Paratroopers

Current Air Transport Missions

- Transport of troops and materials
- For special forces: Infiltration and Exfiltration (low, night)
- CASEVAC (Casualty Evacuation)
- Peace support operations in Kosovo: readiness to bring international troops to uprisings / riots as fast as possible. (+ in Bosnia 2005-2009)
- Emergency relief, Fire fighting (Albania 99, Avalanches 99, Floods 00, Fires 03, Floods 05, Fires 07 Greece, Fires 10 Israel, drought 15, Fires 16, Fires 17 CH + Portugal + Montenegro + Italy, Floods 17, drought 18, Fire Fighting 18, Greece 21, ...)
- VIP Transport
- Dropping of paratroopers

Helicopters

	**25 AS 532:** SP (TH06) / SC: PU - Range ~ 700km - Endurance 2.5-3h (without aux-tank) - 15 pax oder 8 VIPs - Ca. 3 tons payload or sling load - CASEVAC: 2-6 casualities - 240 km/h cruising speed - Fire fighting / hoist - Self protection, armor (for crew and pax)
 	**20 EC-635:** E6 - Range ~ 550km - Endurance 2-2.5h - 4-6 pax - Ca. 550kg payload or sling load - CASEVAC: 1-2 casualities - 220 km/h cruising speed - Fire fighting / hoist incl. medevac (horizontal)

Conditions for Helicopter Operations

- Weather (feasibility, reachibility, IFR: Point in Space Approach)
- Distance to mission (slow)
- Landing site (45m Appr, 3m to obstacles, level for landing, demined)
- Fuel (Refueling needs time (30’ PU, 15’ E6, Hotrefuel PU (15’): fire brigade))
- Deployed Means (Helicopter, crew) (size, numbers)
- Air traffic coordination
- Overnight helicopter, crew (perseverance, comsec)
- Maintenance (shelter, logistics)
- Flight duty regulations, NVG: whole crew

- Changes of configurations: 30min (sling load) - 1h(Casevac) - 8h (FLIR) - requires time

Transport of Troops and Materials

- It is necessary to be able to evacuate dispersed or entrapped troops or casualties by means of air transport.
- This ability is very limited due to the lack of armed air transport
- $\rightarrow$ Poor mobility in impassable terrain near a frontline

Means of Aerial Reconnaissance

- Actual Means
  - 2 Super Puma with FLIR: search for missing persons and missing aircraft
  - Paratroopers: gathering of information behind enemy lines
- Soon:
  - Unarmed reconnaissance drone Hermes 900 HFE (Elbit Systems from Israel), inclusive: sensors, ground components, logistics, training, teaching-material, ..., for: gathering of information for civil and military commanders: ground troops, police, border control

Recconaissance (RECCE)

- Gap: Fighters with reconnaissance pod or built in abilities

6 Air Law

Licenses

- Light Aircraft Pilot License (LAPL): Single-engine, land aircraft with piston engine up to 2000kg departure weight, max. 3 passengers/non-commercial (fixed wing A/C, helis, gliders, balloons)

- Private Pilot License (PPL): Non-commercial (fixed wing A/C, helis, gliders, balloons)

- Commercial Pilot License (CPL): Commercial for certain type ratings (Single Pilot); or classes (for fixed-wing air-craft, helicopters and balloons)

- Airline Transport License (ATPL): Commercial/for MPA (multi pilot aeroplane) compulsory (for fixed-wing air-craft and helis)

Medical - Validity depends on age - Slide 9

Class Ratings For aircraft with single-pilot operation and weights below 5700kg, there are following class ratings

- SEP LAND - Single Engine Piston with Variants:
  - VP: Variable-Pitch-Propeller
  - RU: Retractable Undercarriage
  - T: Turbo Engine
  - P: Pressurized Cabin
  - TW: Tailwheel aircraft
  - SLPC: Single-Lever-Power-Control
  - EFIS: Glass cockpit, Electronic-Flight-Information-System

- SEP SEA - dito

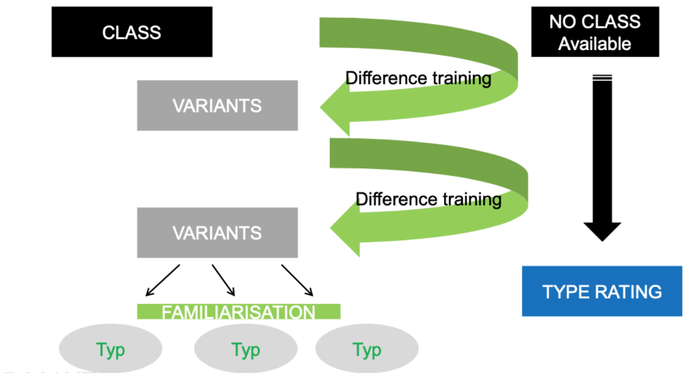
- SET - Single Engine Turbo Prop

- TMG - Touring Motor Glider

- MEP LAND - Multi Engine Piston
  - requires difference training for each type of aircraft flown

- MEP SEA - dito

Rating – Overview



Revalidation of Licenses

- Classes
  - Single-engine piston-engine aircraft generally valid for 2 years. 12 FH experience, 6 as Pilot in Command (PIC). 12 take-offs/landing and a 1 hour training flight with instructor
  - Multi-engine piston-engine A/C valid generally for 1 year

- Type Ratings
  - All aircraft with 2 pilots
  - All multi-engine aircraft with 1 pilot and turboprop or jet-engine
  - All single-engine A/C with 1 pilot and jet-engine

- Extension of Licenses (variety of extensions)
  - Aerobatics
  - Towing of gliders and banners
  - Night flight
  - Mountain flight authority for skiers and/or wheels
  - FI-Flight Instructur / CRI-Class Rating Instructor

- Radio Licenses: English Language Proficience (ELP) Check required in order to use the aeronautical radio service (lvl 4/6 - 4 years. lvl 6/6 no expiration)

VLL Par. 22 - Documents on Board/Air Worthiness Req.

- Registration Certificate (Eintragungszeugnis)

- Certificate of Airworthiness (Lufttüchigkeitszeugnis) or air permit with annex “scope of uitilization” (Zulassungsbereich des Luftfahrzeuges) in flight handbook

- (Valid airworthiness review certificate or the valid verification of the airworthiness checks)

- Noise Certificate (Lärmzeugnis) (if required)

- Proof of third party liability insurance on ground and if required for liability insurance agains passengers

- Concession for Aircraft Station (for radioelectric reception and transmission equipment)

- Aircraft Flight Manual

- Flight Book (clearance certificates as well)

- Checklist issued by manufacturer or check list created by the owner

Additional Requirements for VFR (Visual Flight Rules) Flight Plar

- Instrument Flight Rules (see Aircraft Operations): Weather, NOTAM, OFP

- VFR
  - DABS (Daily Airspace Bulletin Switzerland) is required
  - AIP (Aeronautical Information Publication) for VFR maps, Airport information and basic info
  - AIC (Aeronautical Information Circular): Publishes changes which affect aviation safety, e.g. new rules (included in NOTAM)

Air Traffic Control - Submission of Flight Plans

- Submission required for
  - IFR Flights
  - VFR-Night Flights (NVFR)
  - VFR-flights with landings in other countries
  - Zurich and Geneva Airport

- Optional for VFR-flights, however facilitates search and rescue operations

General Traffic Rules (ICAO Annex 2/VVR)

- Swiss traffic rules apply to all aircraft within Swiss territory, as well as abroad, unless other rules apply

- A commander must keep to the rules, whether at the controls or not and can only deviate from these in emergencies

- A commander (PiC) must be prepared for the flight, especially flying outside of the aerodrome vicinity and/or as IFR flight he must check the weather, must plan with an alternate aerodrome and have sufficient reserve fuel (Jet/turboprop 30 min /others 45 min)

- Anyone feeling sick, tired or under the influence, is not allowed to be an active member of the crew
- Maximum speed: Under FL 100, 250KTS (460km/h). VFR over FL200 are not allowed
- During flight, objects/liquids can only be dumped with the permission from BAZL/FOCA (except ballast in the form of water or sand/in emergencies/for rescue missions/tow ropes or under carriages at airfields/wind drift indicators for parachute jumpers, wind indicators for Landings or reporting bags for air races)

Class	Type of flight	Separation provided	Service provided	Speed limitation*	Radio communication requirement	Subject to an ATC clearance
A	IFR only	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
B	IFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
	VFR	All aircraft	Air traffic control service	Not applicable	Continuous two-way	Yes
C	IFR	IFR from IFR IFR from VFR	Air traffic control service	Not applicable	Continuous two-way	Yes
	VFR	VFR from IFR	1) Air traffic control service for separation from IFR; 2) VFR/VFR traffic information (and traffic avoidance advice on request)	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
D	IFR	IFR from IFR	Air traffic control service, traffic information about VFR flights (and traffic avoidance advice on request)	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
	VFR	Nil	IFR/VFR and VFR/VFR traffic information (and traffic avoidance advice on request)	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
E	IFR	IFR from IFR	Air traffic control service and, as far as practical, traffic information about VFR flights	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	Yes
	VFR	Nil	Traffic information as far as practical	250 kt IAS below 3 050 m (10 000 ft) AMSL	No	No
F	IFR	IFR from IFR as far as practical	Air traffic advisory service; flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	No
	VFR	Nil	Flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	No	No
G	IFR	Nil	Flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	Continuous two-way	No
	VFR	Nil	Flight information service	250 kt IAS below 3 050 m (10 000 ft) AMSL	No	No

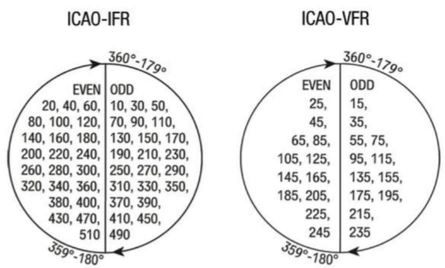
Airspaces - CH (Slide 30), UK (Slide 31), US (Slide 32)

Requirements for VFR

- Day: Beginning of the civil twillight and the end of the civil twillight (30 min before sunrise and 30 min after sunset), (6 degrees)
  - Visibility
    - Zone G (2000ft AGL): 1.5-5 km
    - Under FL100 (2'000ft < H < 10'000 ft): 5km
    - Above FL100: 8 km
  - Distances from Clouds
    - G: outside of Clouds
    - Above G: 300m above and below, 1.5 km in front
  - Night-VFR, Special VFR (within control zones and reduced weather conditions) and Controlled-VFR: Special Requirements
  - Airspace G: 600m/2000ft AGL: 1.5km allowed if aircraft speed allows a 180° turn with visibility, and helis may fly less than 1.5km if obstacles are recognised and other traffic is avoided

Semi-circle Rule

West= Even
East= Odd
VFR: +5 (+500ft)



Operation near Airfield

- Observe other traffic
- Integrate into the traffic flow
- Fly curves to the left (left-hand)
- Start and land against the wind

Minimum flight altitudes

- Uninhabited areas or forrest: height 150m, radius 150m
- Over heavily populated areas and over viewing areas of events: height 300m, radius 600m
- Over water: h 150m

Flight Hazards, Restrictions, Prohibited Areas

- Danger Areas (LS-D, limited in time and Scale): Should not be flown through during active periods (often army shooting practice). Options: Over- or underfly resp. circumnavigate it/ alternatively, request permission on ATC for crossing the area.
- Restricted Areas (LS-R): Must not be flown through during active phases (WEF or test flights)
- Prohibited Areas (LS-P): General flying ban (not in CH applied)

Altimeter Settings

- QNH: Elevation set at sea-level, shows above sea (MSL)
- QFE: Altimeter shows zero at airfield (pressure at airfield elevation)
- QNE: Standard pressure (1013 hPa) for flight level (FL) display
- VFR/IFR, In closely controlled zone or a control zones (IFR/VFR): Set to QNE if aircraft is above transition altitude (TA)
- VFR/IFR In closely controlled zone or a control zones (IFR/VFR): Set to QNH when below transition level (TL)
- VFR, Outside of controlled zone: Over 900m (3000ft): QNE (FL)
- VFR, Outside of controlled zone: Below 900m: QNH
- Gliders, Balloons: QNH

Collision Avoidance

An aircraft with right of way (Rechtsvortritt) maintains its course and speed (also converging traffic). When head-on, alter course to the right. When overtaking, alter course to the right **Collision Avoidance/Priorities from highest to lowest**

1. Aircraft in distress
2. Balloon
3. Glider under Tow
4. Glider
5. Air ship / zeppellin
6. Heli
7. Aeroplane and microlight

Collision Avoidance/Landing

- Landing Aircrafts take precedence
- Lower flying aircrafts take precedence
- Gliders take precedenced over powered aircrafts
- An aircraft in an emergency situation always takes precedence

Collision Avoidance/On Ground

- Starting aircraft takes precedence over rolling aircraft
- On ground, rolling aircraft must stop if they are on a collision course, or turn to the right
- On the ground, right of way applies

Emergency vs Urgency

- If an A/C is in an emergency situation, the commandor is no longer bound by the regulations and can deviate from these
- An emergency or an Urgency can be declared. For emergencies, immediate assistance from the ATC is needed
- Emergency:
  - SOS (morse)
  - 3 x MAYDAY
  - Red rockets (in short intervals)
  - Squawk 7700 (on Transponder)
- Urgency
  - 3 x PANPAN
  - Switch landing lights on- and off
  - Squawk 7600 for communication loss
  - Squack 7500 for hi-jacking

Violence on Board/Responsibility of the Commander

- Regarding Passengers:
  1. Passengers on board are under the control of the commander
  2. They are obliged to observe flight safety rules and maintain order and discipline on board
  3. After an unsuccessful warning, the commander is entitled to offload a passenger who does not follow instructions
- Beginning and Ending
  - The control of the commanding officer over the passengers begins with the closing of the A/C before the journey
  - It ends with the opening of the A/C after completion of the journey or journey segment, and after emergency landings or accident from the time when care of the passengers is taken over from others

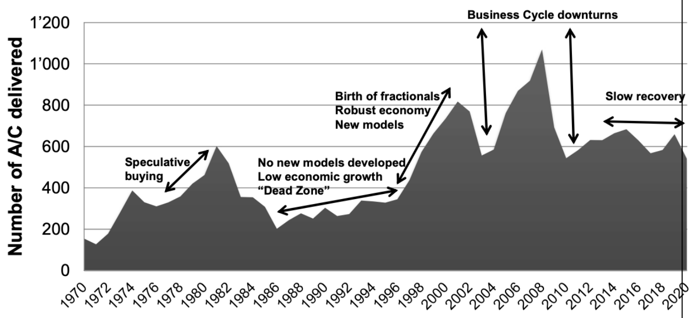
Standard Time UTC

- In aviation, everything runs in UTC (not time zones). Previously know as GMT (Greenwhich Mean Time)
- UTC is independent of summer or winter time
- CH: UTC+2

7 Business Aviation

Key Drivers

- Corporate Profits
- General Economic Growth
- Increases in Wealth
- Aircraft Product Innovation, e.g. increase in range, VLJs
- Alternatives to full ownership - membership programs, fractionals, on demand charters
- New Business Models



Slowdown in global growth, coupled with the ongoing COVID-19 drag and trade tensions, extended the low growth period.

Primary Motivators of Use

- Efficiency - EU average time savings 127min
- Productivity (153 min per trip/employee = 15% increase)
- Airline Schedule Inadequacy
- Security
- Privacy
- Control / Agility
- Luxury / Comfort / Reduced Hassle
- Cost Savings (for large groups, EU 15M hotel costs)

Customers

- End Users
  - Corporations
  - Wealthy Individuals
  - Governmental VIPs
  - Medical and Insurance Companies (120'000 departures annually EU)
- Intermediaries (Fly Commercially and have an AOC)
  - Charter Operations
  - Fractional Operations

Business Aviation Operating Models

- Commercial (Intermediaries) (600-1200 FH annually): Over 700 in EU. 80% in EU have fewer than 5 A/C
  - Aircraft flown for Business purposes by having an AOC
  - Air Charters (Air Taxis), Fractional Operators
- End User
  - Corporate (200-600 FH annually): Non-commercial operations with professional operations with prof. crews employed to fly the aircraft (corporate fleets)
  - Owner-operated (150-250 FH annualy): Aircraft flown for business purposes by the owner of the A/C

Average Annual Aircraft Spend - see slide 12

Direct Operating Costs = 10% of ownership costs

Business Aircraft Segmentation by Units

- Installed base is now dominated by large aircraft (shift from light to heavy). Longer distances, bigger cabins, prestige are causes for this
- Citations/Cessna and Bombardier account for 53% of the installed base

OEM Product line key drivers

- Size matters - flagship effect (Gulfstream = "Rolls-Royce")
- Leverage installed base
- Clear value proposition (PC-21 from Pilatus has features others do not have)
- Time to market
- Program complexity - risk factors
- Commercial Impact
- Aftermarket Services

New Aircraft Development

- New aircraft programs can either be derivative or clean-sheet designs
- Clean-design aircraft involves higher costs (designing, building and certifying)
- High cost of full program execution: Design, development, production, entry into service
- Ability to provide excellent after market services, e.g. strong MRO network

European Flight Patterns

- The network of airport pairs linked by business aviation has over 25'000 links, three times as many links as the scheduled network (top 30 city pairs only cover 5% of the links)
- 45% of business aviation flights are under 450km (most frequented city pairs are: Nice-Paris and Paris-Geneva)
- The most common range is 250-350km
- Airports served are mostly not the large ones due to conflicts with service airlines and available slots

COVID-19

- Even though COVID-19 had a large impact on aviation, business aviation particularly has recovered quite well. Record numbers in 2021.
- Reasons for Recovery
  - Accessibility/flexibility - serves destinations to which airlines have still not resumed operations or do not offer sufficient frequency
  - Safer - less exposure to the virus versus commercial flights

Dedicated Business Aviation Airports

- No conflict with commercial airlines

- No queues in the air or on ground
- Access to hangars
- Ramp access
- No security check (less rigid)
- Speedy immigration procedures
- Discretion
- Key BA Airports
  - Teterboro, NJ - largest Worldwide
  - Paris Le Bourget - larges in EU
  - London Fanborough
  - London Biggin Hill

Summary - Business Aviation Market

- Concentration
  - Fleet size $>$ 22'000 A/C
  - 81% of fleet in top 10 countries (US, MX, BR, CA, DE, VEN,CN,UK,AT,AUS,ARG)
  - 62% of fleet in the US
  - Top 20 airports Europe - 40% share by top 5 airports (4 in FR and CH)
- Fragmentation
  - $>$ 280 A/C in fleet, > 35 in production, 14 in development
  - Europe 700 operators, 80% $<$ 5 A/C per fleet
  - Europe top 30 city pairs cover only 5% of airport links
- Market drivers: Economy and Innovation
- Trand to larger aircraft - 62% unit share, 87% share value

Primary Businesses

- Airframe, Engine and Parts Manufacturers (21.6 B$)
- Completions & Refurbishements Providers (4.7B$)
- Charter & Fractional Operators (16.3$)
- Fleet Management (2.4 B$)
- Fixed Base Operators (FBOs) / Handling (13.7B$)
- Maintenance, Repair and Overhaul Providers (MROs) (13.2 B$)

Maintenance

- Key drivers: Growing fleet, aging aircraft (17.1 years avg. fleet age), uitilization
- Maintenance Center Types: OEM owned Service Center, Independent Service Center with OEM license, or without OEM license
- High entry barriers: Infrastructure, Capabilities, Licensed Mechanics
- Key Players: OEMs or OEM licensed service centers (Jet Aviation, Standard Aero, Duncan, West Star, ...)

Completions

- 503 (417 Narrowbody, 86 widebody) A/C in use worldwide (318 Boeing, 159 Airbus, 26 other)
- 7 to 12 VIP completion opportunities per year, incl. conversions (small and competitive market)
- Key Drivers: Green deliveries (empty aircraft, not painted), Airline Conversions
- High entry barriers: Infrastructure, Capabilities, Licensed Mechanics, Craftsmen, Good reputation, strong brand
- Key players: Jet Aviation, Lufthansa Technics, GDC Technics

Aircraft Accesibility

- Full ownership (with following alternatives)
- Branded Charter
- Fractional Ownership
- Jet Card Programs
- Air Taxis
- Memberships

Aircraft Management

- Full ownership
- Own flight department vs. third-party manager
- Low entry barriers
- Highly fragmented market
- Key players: Luxaviation, Jet Aviation, Solairus - each over > 200 A/C in fleet
- Benefits: Turnkey Solution - time saving and peace of mind, Economies of Scale, Charter Income, Finance, Tax benefits, Safety

Charter & Fractionals

- Charter
  - Key driver - economic activity
  - Pay as you go, upfront payment
  - Depending on where A/C located, repositioning costs can be high
  - Jet Card programmes start at 25 hours per year
  - Highly fragmented market (4500 business jets available, 1300 charter companies)
  - Demand for business jet travel in the charter market is returning after global pandemic
- Fractionals
  - Similar to timeshare on a property
  - Shares start at 1/16th of a private jet
  - Flate hourly rate for time in the air
  - No charge for positioning costs
  - Typically five year contract (option to terminate in three)
  - Netjet largest market player (70%)
  - Fractional Fleet down
  - Major Market consolidation (already tough to get into)

Fixed Based Operations (FBO) and Handling

- Key drivers: Departures (EMEA & Asia) and Fuel Gallons (USA, service included)
- Key Players: Signature/Landmark, Jet Aviation, Execujet, German Aviation Services
- Services: Handling, Fuel, De-Icing, GSE, Water and Toilet, Lounges, Catering, Ground Transport, Hangarage, Ramp Parking, A/C Cleaning, Line Maintenance

Operating Models for FBO and Handling

- Supervision: Own meet & greet, crew briefing service only, operational services mainly outsourced
- Ground Handling: Offices & lounge, A/C, crew and passanger handling, operational services insourced
- Full Service FBO: Comprehensive service portfolio, control over terminal and ramp, Additional revenues through fuel, hangarage, and providing services for customs, immigration and security check

Regional Differences - USA vs EMEA & Asia

- USA
  - Liberal market (dedicated bizav airports, level playing field for providers)
  - Two business modles (large chanis or single site providers)
  - Fuel, Hanger, GSE (integral part of FBO)
  - Ramp/Land Controlled by FBOs (no man in the van competition)
  - More land available (construction and facilitiy development easier)
- EMEA & Asia
  - Closed Markets (airports focus on airlines, different concessions for FBO, GH, GSE Fuel)
  - Many different busines models (everyone provides all services without concession - low entry barriers)
  - Fuel, Hanger, GSE (separate items)
  - Ramp/land controlled by airport (different competitors/models for FBO)
  - Space restrictions (lack of space, most available land dedicated to airline operations or freight)

Primary Businesses - Summary

- Challenging market conditions
- Several alternatives to full business A/C ownership exist that extend the benefits of private jet travel to many users - charter, fractionals, membership cards
- FBO/Handling: US focus on fuel vs. ROW (rest of world) a la carte services

General Market Challenges

Lack of common legal definition and standards of business aviation causes confusion and dilutes focus

- Emerging Markets
  - Overcome cultural and image hurdles
  - Unfavourable Tax Situation
  - Legal complexity
  - Contraints on part imports and exports on foreign registered aircraft
  - Approvals and licenses: lengthy and painful process
- Maturing Markets
  - Congestion at primary airports - increasing competition with airlines for slots
  - Increasing security measures degrade convenience
  - Regulatory environment (adds complexity and costs) - will drive restructuring activities
    - Certification
    - Operations
    - Tax and fees
    - Environmental Compliance
- Maintenance Challenges
  - Number of aircraft types increasing - 280+ in fleet
  - Maintenance Programs are changing (Aircrafts more reliable, longer intervals, fewer man hours per task)
  - OEMs taking greater share of aftermarket (PBTH (Pay by the hour) programs, Lower parts discounts, extended warranty)
- Operator Challenges
  - A small commercial business aviation operator has to comply with the same regulations and standards as an airline
  - Critical mass required to achieve sustainable profitability in an increased complex environment
- FBO hand Handling Challenges
  - Consolidation of small operators into large AOC companies leads to
    - Bundling volume to leverage buying power
    - Fleet operators signing up with network solution providers for regions and countries
  - Consolidation into larger FBO Chains
  - Single location providers looking for "network" partnerships i.e. Air Elite, Signature Select, etc

Future

- Younger Clientele: Users are becoming younger. Driven by their lifestyles, they expect choice, personalisation, price transparency and ease of access
  - Technology: Innovation makes experience faster, easier, more accesible and transparent
  - Moving away from Ownership: Renting models, similar to Airbnb, Uber
  - Sustainability: Environmental sustainable solutions

Sustainable Aviation, Technology: See Slides

Summary: Market Trends and Challenges

- Maintenance: 280+ A/C types to maintain, more reliable A/Cs, OEMs insourcing aftermarket services
- Operators: Small fleet, high costs
- FBO/Handling: Single Providers struggling
- COVID-19: Trend to smaller A/Cs impacts corporate profits negatively
- Main message: From fragmentation to consolidation to achieve critical mass
- Future: Business aviation be undergoing a paradigm shift, prompted by a combination of technological disruption and societal expectations

8 Air Traffic Control (ATC)

The main tasks of ATC

- Avoid collisions in the air
- Avoid collisions on the ground
- Ensure an orderly and expeditious flow of traffic
- Provide flight information services (weather data)
- Provide alerting services and support search and rescue crews

Standard Minimum Separation

- Horizontal distance: 5 Nautical Miles (9000 m) (for approaches: 3 NM)
- Vertical distance: 1000ft (300m)

Elements of Air Traffic Control

- Tower Control
- Approach & Departure Control
- Are Control
- Air Traffic Flow and Capacity Management
- Flight Information Services
- Military Air Traffic Control

Tower Control

- In control towers (TWR), air traffic controllers monitor traxiing manoeuvers, takeoffs and langings
- They oversee traffic in the immediate vicinity of the airport, i.e. the control zone (CTR) of approx. 20km around the airport
- The tower air traffic controllers also integrate into the often dense traffic of an airport the small A/Cs and helis flying according to visual flight rules (VFR)
- Working Positions:
  - ADC: Aerodrome Controller - issues landing and takeoff clearances and clearances in control zones
  - GND: Ground Manoeuvering - lead A/C on ground
  - CLD: Clearance Delivery - at international airports. A/C receive transponder codes for final clearances from CLD
  - AMS: Apron Management Service - gives clearance for engine start, pushback, gives permission and transfers responsibility to GND

Approach & Departure Control

- Approach (APP) air traffic controllers manage the arriving and departing A/C flying according to IFR within a specific section of the control zone and terminal control area (TMA) (region around airport 60km)
- Approach controllers manage the traffic climbing to upper airspace airways and descending traffic that leaves these airways toward the airport
- In case of dense traffic, aircraft waiting to land be directed into holding circuits (holdings)
- Working Positions:
  - DEP: Departure Controller
  - APW: Approach Controller East
  - APE: Approach Controller West
  - FIN: Final Controller
  - CAP: Coordinator for the Approach Sector

Area Control (Enroute Control)

- Area control or en-route services ensure the saftey and efficiency of traffic moevements through the airways
- In Switzerland, the controlled area includes parts of neighbouring France, Germany, Italy and Austria from 7'000 ft to 66'000 ft
- The airspace that skyguide controls at the the heart of Europe is the densest and most complex on the continent
- In order to safely and efficiently control and monitor the air traffic, the area is split into various control sectors with clearly defined lateral and horizontal boundaries

Enroute Controllers (RE, RP, RC)

- RE: Radar Executive (talks to A/C and controller to take responsibility)
- RP: Radar Planner (short-time future (15min) predictions for A/C route and solves potential conflicts)
- RC: Radar Coordinator (coordinates between different sectors (N,E,S,W)) - used for conflicts (extra pair of eyes)
- Tools and Procedures: Voice-control (RE), RP works on Systems with Radar Picture (Flight, callsign, type of equipment Wake Turbulence Category) - no more tel. required

Radar Labels

- Update every 5 seconds
- GXXX (ground speed)
- rls (equipment)
- 260 (Flight Level)
- V KOR32 (Coordinate to which flight level it should climb)

Flight Information Service

- VFR Flights
- Parachute Drops
- Special Flights
- Gliders and Balloons

Mixed Traffic in the Zurich TMA

- Arrivals (Green)
- Parachute / Special Callsigns (Orange)
- Below Airspace (V in yellow)
- Departures (Blue)

Tasks of Military Air Traffic Control

- When working in the ADDC, Air Traffic Controllers are "fighter controllers"
- They also manage all military aircraft in transit flights within CH. Like civil air traffic controllers, fighter controllres monitor the airspace on radar consoles
- The ADDC also helps the air police with the critical task of recognising aircraft with a questionable identity
- Specific deployment procedures are used in air defence training, and the protection of specified areas, e.g. WEF

Conventional Air Navigation Technology

- NDB for Transit
- VOR for 360°
- ILS with localiser (lateral direction) and tower for glide path

GPS

- Aircraft based augmentation Systems (ABAS)
- Spaced based augmentation systems (SBAS)

- Ground based augmentation systems (GBAS)
- RNP = Required Navigation Performance, RNP1 is for arrival and initial, intermediate and missed approach as well as departure navigation applications

New possibilities with Satellite Navigation

- Curved flight paths
- Less steep approach profiles
- Continuous Descent OPS
- Higher Navigation Precision

ATC today and tomorrow

- Virtual Center Concept
- Virtual and Central Services
- Remote Tower Systems
- Integration of Drones in Airspace Management

9 Airline Industry & Business Models

Airline Industry

- ...is a complex industry
- ...has been developed especially after deregulation
- ...is a cyclical industry
- ...'s traffic volume is strongly related to world GDP
- ...'s cost are 65-90% fixed costs
- ...shows decline of yield per seat-km (RPK)
- ...shows better productivity, worse margins of only 1-8%
- ...has developing networks: Point-to-Point (regulated market), Hub-and-Spoke (deregulated market), networks (alliances, global market)

Network Airline (Hub & Spoke) = Full Service Carriers (FSC), Network Carriers, Legacy Carriers or Flag Carriers, Traditional Airline, Mainline Carrier

- 2 types: Traditional/Lufthansa (Airline handles all aspects), 2. Aviation Busines Model Swiss (Airline handles mainly Flight Operations)
- **Advantages of H&S Model**:
  - Connecting many local regions which would otherwise not be served
  - Many connections
  - S-Curve Concept (much higher revenue with higher capacity or frequency)
  - Large and attractive network
  - Hub dominance (slots, gates)
  - Advantage in the reservations system (Comp. Res. System/CRS)
  - Economies of density (smaller routes can be covered by larger aircraft = lower costs)
  - Feeding Shorthaul-Longhaul (vs.)
- **Weaknesses**
  - Waves at the hub (Pax and therefore Crew/personell)
  - Seducement for "hub economies"/ sales at variable costs (Bait prices to the hub...)
  - Optimal connection leads to "waves" → higher personnel requirement & hub at the limit
  - Short transfer times → domino effect
  - H&S → additional operative costs (up to +45%)
  - High "Overhead" costs (one airline fits all...)
  - Flights from "origin to destination" via hub take longer
  - Long ground times for network (A/C utilisation low)
  - "Primary Airports" have higher charges
  - Overlapping structure (competition)
  - Demand for direct flights from PAX (time)
  - New airspaces allow more direct flights (chances)
  - Overloading and security checks at "Primary Airports"
  - Competitors have more efficient aircraft

Low Cost Carrier (Low Fare Airline, No Frill Airline). Main Motivation: First LCC Airline: Southwest - has never experienced financial loss. Net profit in the region of 18-24%

- Global Market Share: Stablilises at 35%
- Europe: From 17% in 2005 to 32% in 2013. Ryanair, Easyjet and Alitatlia
- Strategy:
- Advantages of LCCs:
  - Lower airport charges, faster turnaround times, less air traffic control-related delays
  - Better fleet utilisation
  - Lower complexity, higher capacity utilisation
  - Cheaper aircraft financing, lower maintenance and training cost, simpler swapping around of flight and maintenance staff
  - Lower distribution costs, lower complexity
  - Lower anciliarry costs, less complexity, additional revenues
  - Higher employee productivity (incentives and variable proportion of salary)
- Activity Systems (Michael Porter)
  - Activities complement one another in ways that create real economic value. One activity's cost is lowered because of the way others are performed
  - No catering on board means no need for cleaning and thus allows a turnaround time of under 30 minutes
- LCCs generate new customers (new demand, people who would otherwise not have traveled, otherwise by car or rail)

Charter Airlines

- Four basic types:
  - Vertical Integrated Organisation, tour operating travel agents, hotels etc. (TUIFly)
  - Independents (Condor)
  - Subsidiairies of network carriers (Edelweiss)
  - Scheduled Airlines (SWISS)
- Vertically Integrated: Parent company (tour operator) takes over 70-90% of the capacity
- As tickets are sold through mother company/tour operators and the destination is not regularly flown, a high SLF results
- Comparison to LCCs: 37% of all travel destinations are offered by LCCs. FLights under 2.5h are handled by LCCs (one-way, flexibility and frequency)
- Advantage of Charter: Lower unit costs
  - Larger A/C
  - Longer Sectors
  - High SLF
  - Higher Labour Productivity
  - Lower Insurance Costs
  - Lower A/C leasing costs
  - Lower Administration and Finance Costs

Sales strategies/yield management (Revenue Mgmt, Capacity Mgmt, Dynamic Pricing)

- Airlines maximise revenue through
  - Variable Prices
  - Seating Offer (Aircraft Size)
  - Booking Figures
- Turnover (revenue) is increased by 3-7% and profit by 50-100%
- Prices with LCCs and FSCs generally increase shortly before flight (given SLF is high)

- With Charter FLights, they withdraw them shortly before as quotas sold to travel agents and tour operators at an early stage

Regional Airline (Feeder): Definition

- Fewer than 100 seats and distances flying up to 800 km (turnover below 100M USD)
- Normally a subsidiary of an NWC (50%), and are dependent of these feeders/capacity providers
- 70% Hub to Non Hub routes
- Operate from smaller airports, with smaller aircraft (better financially)

Longhaul - Business Only

- Only business seating and corresponding service (48-56 seats)
- Larger overhead bins, PC-Laptop Connections, Fast Track Counter, VIP Service
- Popular for business customers (only like-minded people on board)
- Private Jet Feeling
- Only possible on selected routs
- Sufficient business passengers required
- However, do not last long: EOS, MaxJet, Silverjet, PrivatAir (all bankrupt or OPS suspended)

Trends

- Emerging Markets increasing (Asia, i.e. China and India) - 2/3 of population of emerging markets will take a trip in 2032
- Strategically different approaches between Boeing & Airbus
  - Boeing: Smaller and more A/C are needed as market becomes fragmented (=new routes and more direct flights)
  - Boeing services: Lower cabin pressure, more humidity, 50% larger windows, virtually larger cabins
  - Airbus: Markets have to consolidate, which require larger aircraft
  - Airbus services: Bars, casinos, sleeping areas, shower rooms (20% lower operational costs)
- Faster: Boom Supersonic
- Greener: Electric/Hybrid

Strategies for Success

- Clear strategy/positioning
- Activity System
- Adapted Networks/alliances
- S-Curve (Flying every day)
- Slots/Hubs dominance (gates)
- Eco of Densities (Seating/Aircraft Sizes)
- Ideal Capacity Efficiency
- Low Cannibalization
- Flat waves at the hub
- Freq. Flyer Program
- Larger Aircraft
- Longhaul
- Secondary Airport
- Short turnaround times = high A/C utilization
- Direct Flights
- Standardized Fleet
- Yield Management (Revenue)
- Direct Sales (Website)
- Few "Frills" or modular sales
- Performance-based salaries
- Consideration of emerging markets and/or trends

Value Chain Analysis

- Application: Competitive Advantage and Providing opportunities for additional competitive advantage for planning for expansion
- Value-chain analysis is an instrument for determining the optimal depth of value creation and is regularly applied in the run-up to strategic alliances, mergers or outsourcing endeavors
- Porter: Primary and Secondary Activities
  - Primary Activities: Are integrated in the actual performance process. They are accordingly arranged, ideal-typically, in Porter's model from entry-logistics to production, marketing and sales, output-logistics to service
  - Secondary Activities: Facilitate the actual production and are known as supporting activities to the primary activities. That means they can have cross-sectional functions.
- The value-chain analysis for a company must be able to consider the performance relationships between the upstream and downstream values of the competitors to be able to show all strategic options
- Variants
  - Integration = Provision of services by the company itself, make instead of outsourcing orders
    - Vertical Integration: Carry out successive value creating stages. Forward = take on activities which were taken care by customers, Backward = take on activities which were taken care by supplier
    - Horizontal Integration: Increase Activities on the same value creation level (innovation potential)
  - Outsourcing = Opposite of Integration. Activities are offloaded which do not offer a competitive advantage
  - Cooperation = Hybrid version of both. Activities are carried out by several parties and are only bounded by contractual obligations. Both parties' skills and value creation activities should complement each other.

Pros and Cons of Value Chain Analysis:

Advantages and disadvantages

Advantages	Disadvantages
Complete picture of the business system as a value-creation process Mapping of all activities which create customer benefit Extensive identification of competitive advantages using analysis of various parameters: Cost structure, Differentiation possibilities Key competencies Furtherance of understanding for business processes Due to its completeness, the value chain can also be used for other purposes, when an overview of the entire company is necessary.	Presentation of the value chain in heterogenous, widely diversified business is very complex High time and labor expenditure Allocation of costs to the value activities difficult because the usual allocation by cost type, cost centers and cost bearers is simply not assignable. Comparison data of competitors difficult to obtain

10 General Aviation

Definition and Scope - ICAO see slide 6

- Flight School
- Law enforcement
- Firefighting
- Sightseeing
- Package Delivery
- Air Ambulance
- News/traffic reporting
- Agriculture
- Wildlife Management
- Recreational Flying
- Disaster Relief
- Mountain Support

Modes of Transport

- Powered Flight
- Gliding
- Skydiving
- Helicopter
- Ballooning
- Not in GA: Scheduled line flight, Commercial Business Jet FLight, Charter Flight, Military Flight

Interest Groups/Associations

- Aero-Club Switzerland (AeCS): represents 24,000 members in the field of light aviation & aerial sports
- Aircraft Owner and Pilots Association: represent the interests of private pilots and aircraft owners (3500 members) in national and international aviation committees.
- Aero Suisse: (political organisation) safeguarding the interests of civil aviation and space travel in Switzerland and securing their basic existence. It has an influence on the design of the legal principles in the field of aerospace (150 companies)

General Aviation - Numbers

- Worldwide:
  - 1.1 Million pilots (2018) (2015/700K)
  - 340'000 A/C (370'000)
  - 35 Million FH (40)
  - Value Creation 40 Billion USD (comparison)
  - Comparison to CAT (Commercial Air Transport): 60'000 A/C / 400'000 Pilots
- CH:
  - 3 National Airports: 450k Movements per year
  - 11 Regional Airports: included above
  - 47 Airfields: 500k Movements
  - 24 Heliports
  - 500'000 PAX transported (1% of all PAX: Swiss Intl. 16 Million)
  - 270'000 Tonnes freight
- Value Creation
  - 500 Million CHF
  - Turnover: 1 Billion CHF

Divisions

- Powered Flight
- Gliding
- Skydiving/parachute jumping
- Helicopters
- Balloons
- Ecolight
- Experimental

Powered Flight

- Single Engine Piston (SEP): Examples - Cessna 172 Skyhawk, Piper PA-28-161-Warrior
- License Extensions
  - Towing of gliders
  - Aerobatics: Minimum flight altitudes of 500m above ground or 300m for glider pilots. Aerobatics over densely populated areas and airfields is prohibited. With special training you can go down to 100m for competitions.
- Mountain Flight/Glacier landings (MOU)
  - In Switzerland there are 40 designated glacier airfields at over 1100m above sea level. Glacier flights are challenging because of the reduced engine power required to operate in a harsh environment and the changing "runways".
- Seaplanes
  - Float plane flying is restricted in Switzerland, but there are exception permits for events such as the Fly-In in Hergiswil. Many Swiss pilots go to Como or Canada to get their licenses.
- Precision Flights (Powered Flights competition)
  - Theory: flight preparation: this is about exactly calculating a flight over five to eight legs, with a given wind, under time pressure (maximum 30 minutes).
  - Nav-flight: The prepared route (length 170 to 260 km) is now flown to the nearest second and meter.
  - Precision landings: 4 precision landings in different configurations (with and without power) complete the competition programme, whereby it is important to place the main landing gear as cleanly as possible on the zero line.

Gliding

- Aspects of Gliding
  - Comradship (working as a team)
  - Learn to fly at low cost (6-7000 CHF)
  - High Performance Sport (Alone in cockpit for few hours), make important decisions at high altitude with constant sun radiation
  - Learn precise flying: Gliding is about optimization in order to stay in the air as long as possible. Gliders can reach a glide ration of 80
- Operations (Sources of Energy)
  - Slope winds on the LUV side
  - Using thermals underneath the clouds (cumulus), heights up to 5000m can be reached (to the upper cloud limits is possible)
  - Wave flight: LEE waves occur in particular strong conditions on the windless side of the mountain (Lenticularis Cloud). 8000m can be reached this way (oxygen, pressure suits and thermal clothing needed)
- Cloud flights and competitions

- Specially established gliding zones with reduced cloud distance of 100m horizontal and 50m vertical
- in order to make full use of the thermals, there is a so-called cloud flight, analogous to flying with instruments. The competition is limited to aerobatics and large distance flights.

Skydiving / Parachute Jumping

- Procedure
  - Air drop machine (Pilatus Porter, Cessna 182 or 206)
  - Classical Jump from 3500-4000m above sea-level
  - Freefall at 200km/h (belly-first) and 360km/h head-first
  - 50 sec freefall
  - Release of parachute at 700-800m above ground, latest at 400 m (automatic emergency opening due to height and drop rate at 250m)
  - Round canopy or paraglider
  - Paraglider 60km/h forward speed and 5m/s drop rate
- Military Variations
  - HALO (High Altitude Low Opening): 8000m height and late opening (800m)
  - HAHO (High ALtitude High Opening): Long glide flight used ($> 40km$)
  - Can be tried also by civilians
- Competition
  - Target jumping: Landing on an electronic target as accurately as possible
  - Freestyle Jumping: Completing figures
  - Formation or relative jumping: Formation of colleagues form as many as pre-defined figures as possible

Helicopter

- Differences in OPS
  - Can stay still without moving forwards
  - Parag. 38 VVR: Helicopters can fly with a visibility of less than 1,5 km if they move with a flight speed that allows them to recognize other aircraft or obstacles in good time to avoid collisions. Below 1100m above sea level helicopters, for the most part, do not have to fly from an airfield (external landing provision)
  - Helis are only fully IFR-compatible in the higher weight classes (>3.5t)
  - No starting or landing runways are required (twice rotor diameter sufficient)
  - No pressurised cabin: Max altitude 6000m (exceptions up to 7000m)
- Range of Operations
  - Transport of materials
  - External Cargo Sling (ECS): ECS 1: ≤20m /ECS 2: >20m/ ECS 3: Logging ECS 4: Construction /HCS: Human Cargo Sling
  - Transport of people
  - Dropping off parachute jumpers
  - Measuring, photography/films, control flights
  - Avalanche triggering
  - Mountain hut supplies
  - Animal transport
  - Corporate Flights (inhouse company transports, goods, own personnel)
  - Rescue Flights
    * Primary Missions: Direct flights from scene of accident to medical centre
    * Secondary Missions: Relocation of patients from hospital to hospital
  - On behalf of authorities and civil organisations or scheduled flights (overseas, to oil platforms ATPL(H))
- Classical Types: Ecureuil AS 350 B3, Kamov KA 32 A12
- Critical voices:
  - A lot of media coverage compared to share of GA (5-10%)
  - Noise at low operating levels is a big topic of discussion
  - Heli-skiing a strong polariser, however offers cheap opportunities for training/learning flights

Balloons

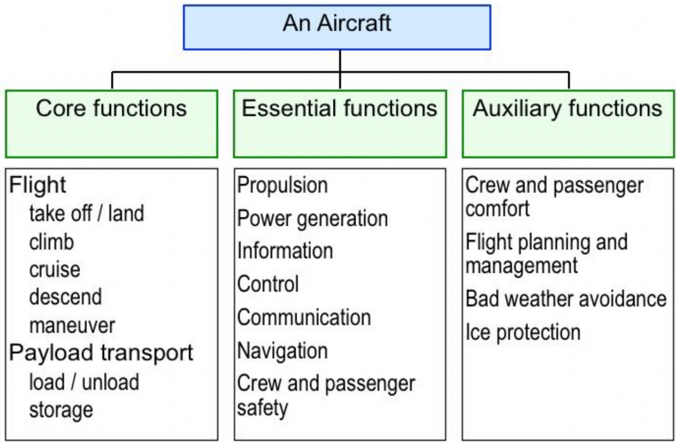
- Types of Balloons: Gas balloon (hydrogen), hot-air ballon (warm air)
  - Balloons travel, because they ride with the wind (therefore always windstill in basket)
  - Balloons do not like thermals, therefore flights are performed in the mornings and evenings (ideally winter)
  - 350 licenses currently issued for 380 balloons
  - Switzerland has the highest density of balloons in the world
  - Balloons cost up to 100k CHF, therefore mostly company sponsored (advertising) or are owned by clubs (gas balloons)
- Operations of Gas Balloons
  - Control by making use of winds
  - Climb rate max 9m/s (normally 3-4m/s)
  - Max. Capacity 12 people
  - Gas balloon
    * Ideally helium (safe, and high climb rate, but too expensive, therefore hydrogen)
    * Quiet (no burner)
    * Needs filling station (in CH only in Zurzach)
    * Is up to 100h in the air
    * Load-bearing capacity: $1kg/m^3$
    * One filling: 2000 CHF (more expensive)
    * Height Control: Release sand (climb), or gas (descend)
  - Hot Air Balloon
    * Up to 4 burners (only 1 in use): propane gas bottles (30-40 kg / 4 units)
    * Up to 15h in air
    * With 4 bottles normally 2-3 hours
    * For competitions: 5-6 hours
    * Load-bearing capacity: $250g/m^3$
    * Height control: with burner
    * Temperature in balloon: 80-100° C
  - Competitions
    * Navigation trips, in which waypoints or targets must be approached or overflown
    * Long-distance trips

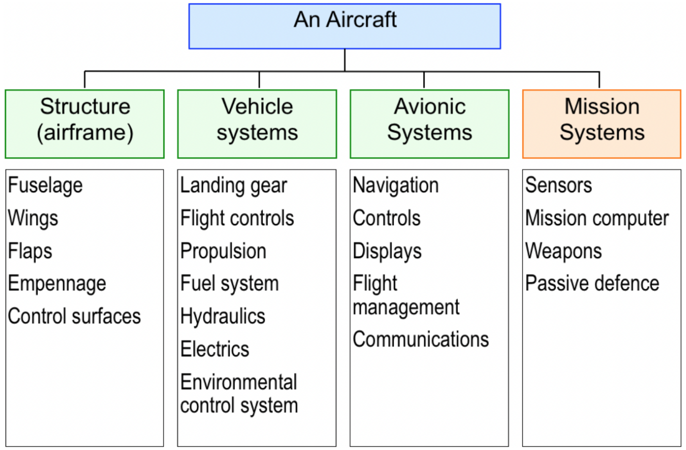
Ecolight: Since 4.7.2011, Light Sport Aircraft (LSA 600) have been allowed in Switzerland (up to 600kg); however, Ecolights/ Ultralights under 427.5 kg were banned. As of 1.10.2014, these have also been allowed (electr. UL without landing gear remain banned).

11 Aircraft Design & Systems

Definitions

- **System**: A combination of parts, components, facilities, procedures, personnel, skills, ... that are connected in an organized way to perform one or more functions
- **Function**: The lowest level of a specific action of a system, equipment, and flight crew performance on the airplane
- **Failure**: The inability of a system, subsystem or component to perform a function as intended (Functional Failure)
- **Failure Condition (FC)**: A condition with an effect on the aircraft and its occupants caused by one or more failures considering the relevant operational and environmental conditions





Example:

- **System**: Navigation and Spatial Orientation (Avionics System)
- **Function**: Display current altitude
- **Failures**: Loss of Altitude Indication. Misleading Altitude Information
- **Failure Conditions**: Loss of ALT - VMC - All Flight Phases or Misleading ALT Indication - IMC - Approach/Landing

Failure Condition Classification

- **Minor (D)**: No significant reduction in airplane safety, corrective actions well within crew capability, physical discomfort to passengers or cabin crew (Safety objectives not required)
- **Major (C)**: Significant reduction of safety margin, increase in crew workload, physical distress to crew or occupants, possibly including injury (May be required)
- **Hazardous (B)**: Large reduction of safety margin, physical distress or large increase in crew workload, serious or fatal injury to occupants (May be required)
- **Catastrophic (A)**: Multiple fatalities of the occupants, serious or fatal injury to flight crew members, loss of aircraft (Required)

Failure Condition Probability

- **Probable** failure conditions are those anticipated to occur one or more times during the entire operational life of each airplane
- **Remote** failure conditions are those unlikely to occur to each airplane during its total life but which may occur several times when considering the total operational life of a number of airplanes of this type
- **Extremely Remote** failure conditions are those not anticipated to occur to each airplane during its total life but which may occur a few times when considering the total operational life of all airplanes of this type
- **Extremely Improbable** failure conditions are those so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type

Acceptable Probabilites for commuter or transport A/C

- Probable corresponds to a probability lower than 10^{-3} but higher than 10^{-5}
- Remote corresponds to a probability lower than 10^{-5} but higher than 10^{-7}
- Extremely remote corresponds to a probability lower than 10^{-7} but higher than 10^{-9}
- Extremely Improbable corresponds to a probability lower than 10^{-9} (light general aviation: 10^{-6})

Design Concepts

- **Safe-Life**: systems or components will survive a specific design life with no failures
- **Fail-Safe**: a failure will cause no (or minimum) harm to other parts and systems or danger to personnel
- **Fault-Tolerant**: a system can continue operating in the event of the failure of one or more of its components

Examples of Design Concepts

- Safe-Life: the emergency oxygen system in an airliner. The chemical cartridges that generate oxygen have a prescribed life and must be replaced after a certain period. The manufacturer guarantees that the cartridges will not fail (meaning, in practice, that a failure is extremely improbable) during their life span.
- Fail-Safe: In air brakes on railway trains (Westinghouse system), the brakes are kept open by air pressure in the brake system. Should a brake line split, or a carriage become de-coupled, the air pressure will be lost and the brakes applied. The system is designed to avoid dangerous situations for people and material, and as such it can be defined Fail-Safe. Other example: Landing Gear of Pilatus PC-12
  - In any system or subsystem, the failure of any single element, component, or connection during any one flight (brake release through ground deceleration to stop) should be assumed, regardless of its probability. Such single failures should not prevent continued safe flight and landing, or significantly reduce the capability of the airplane or the ability of the crew to cope with the resulting failure conditions.
  - Subsequent failures during the same flight, whether detected or latent, and combinations thereof, should also be assumed, unless their joint probability with the first failure is shown to be extremely improbable.
- Fault-tolerant: Fly-by wire system (also Fail-safe)

Safety Processes

1. Hazard Identification (List of possible failures)
2. Risk Assessment (consequences)
3. Acceptable?
4. If NO, Risk Mitigation Method and do another Risk Assessment. If YES, done

Safety Processes - Example of Safety Requirements

- The average probability per flight hour of loss of all means of altitude information shall be less than 10^{-9}
- There shall be no single failure resulting in loss of all means of attitude information

Summary of basic principles (see script)

- Distinguish hazards from failures is essential to understand the difference between safety and reliability
- The criticality of failure conditions, not the criticality of faulty components, determines the level of analysis required
- A safety process at the END of development is useless
- The successful safety process is INTEGRAL to development
- In future, the safety process will GUIDE development

Failure Hazard Analysis (FHA)

A FHA is carried out at both aircraft and system levels; one flows down from the other. The FHA identifies functional failure conditions and determines their effects. The FHA identifies the failure conditions and their effects on aircraft and crew. These allow to define the safety objectives and a quantitative probability requirement for that particular condition.

Preliminary System Safety Analysis (PSSA)

The PSSA examines the failure conditions established by the FHA(s) and demonstrates how the system design will meet the specified requirements. Various techniques (such as FTA, Fault Tree Analysis) may be used to identify how the design counters the effects of various failures and may point towards design strategies which need to be incorporated in the system design to meet the safety requirements. Typical analyses may include the identification of system redundancy requirements, e.g. how many channels, what control strategies could be employed and the need for dissimilarity of control, for example dissimilar hardware or dissimilar software implementations, or both. The PSSA is therefore part of an iterative process which scrutinises the system design and assists the system designers in ascribing and meeting risk budgets across one or a number of systems.

System Safety Analysis (SSA)

The SSA is a systematic and comprehensive evaluation of the system design using similar tech- niques to those employed during the PSSA activities. However, whereas the PSSA identifies the requirements, the SSA is intended to verify the that the proposed design does in fact meet the spec- ified requirements as identified during the FHA and PSSA analyses conducted previously. The SSA occurs at the point in the design cycle where the system implementation is concluded or finalised, and prior to system certification.

Common Cause Analysis (CCA)

The CCA begins concurrently with the system FHA; it interacts with this activity and with sub- sequent PSSA and SSA analyses. The purpose of the CCA is, as the name suggests, to identify common cause or common mode failures in the proposed design and assist the designers to develop strategies which will make such failures impossible. Such common cause failures may include:

- Failure to correctly identify the requirement
- Failure to correctly specify the system
- Hardware design errors
- Component failures
- Software design and implementation errors
- Software tool deficiencies
- Maintenance errors
- Operational errors

The CCA is therefore intended to scrutinise a far wider range of issues than the system hardware or software process. Rather it is meant to embrace the whole process of developing, certifying, operating and maintaining the system throughout the life cycle.

Component Reliability In system safety analysis, a great deal of emphasis is placed upon the failure rate of a component or element within the system under review. This clearly calls into question how reliability values for different type of component are established. There are two main methods of determining component reliability:

- Analytical by component count (issues)
  - only as good as the data base of components and the factors used
  - predicted values are generally pessimistic thereby generating predicted failure rates worse than might be expected in real life
  - the technique has merit in comparing competing design options in a quantitative manner when using a common baseline for each design (good)
  - it is difficult to continue to update the data base; particularly with the growing levels of integration with Integrated Circuits (ICs)
  - increasing number of Commercial Off-The-Shelf (COTS) components also confuses the comparison
  - technique is particularly valuable when it can be compared with in-service experience and appropriate correction factors applied (good)
- Historical by means of accumulated in-service experience
  -

Maintenance Concepts

- Corrective maintenance: Refers to the repair or replacement of components, parts or subsys- tems which have failed or broken down
- Periodic maintenance: Refers to the scheduled overhaul or replacement of parts (Hard-Time) or to scheduled checks and inspections of parts to remove them from service before a failure can occur (On-Condition)
- Predictive maintenance: Refers to the monitoring of relevant operating parameters in a part or in a system to predict an incoming failure (Condition-Monitoring)

12 Airport Planning

Swiss Airport Landscape

- 31 Million ZRH
- 15.5 M GVA
- 10 Million BSL

Europe

- Europe Airport Landscape: Movements vs Passenger is different (shows there are differences in efficiency)
- Movement = 1 Takeoff or Landing
- Connectivity in Europe: Connecting destinations + frequency of flights to the same destination (density)

Worldwide

- Hub connectivity (Airport connectivity = sum of direct and indirect connectivity to the rest of the world through direct flights or indirect connections)
- Even though there are larger airports with more passengers around the world, European Airports are more connected
- Lenght of runways has a large impact. PC24 can land quite on very short runways

Examples

- Male: Passengers distributed by water planes or boats + Large A/C on runways
- Sao Paulo Congonhas: Sever traffic needs (Sao Paulo to Rio) + 2 RWY up to code C + private jets. Not compliant today
- Hongkong: Built on island (based on sketch). Only runway and terminal (Y-Footprint for efficiency)
- Amsterdam: Developed over 100 years (historically)
- Atlanta: Many runways, linear structures hence high capacity
- Istanbul: Y-Footprint, based off sketch

User- and stakeholder requirements

- Historically: Military + Government, today: Mixed ownership
- Passengers: Simplified Procedures
- Airlines: Customer Satisfaction
- Technology Vendors: Solution Providers
- Airports: Better resource use
- Border Agencies: Improved controls

Traffic Analysis - Main parameters

- Flight Schedule
- Number of air passengers (terminal capacity)
- Number of flight movements (runway, apron and airspace capacity)
- Cargo tonnage (size of cargo facilities)
- Traffic pattern (scheduled/charter/general aviation/military/IFR/VFR/training)
- Destinations (Schengen/non-Schengen, EU/International)
- Fleet mix (Design Aircraft, Airfield Layout, size and mix of aircraft stands)
- Number of parked Aircraft (Number of Aircraft Stands and Hangar Space)
- Airline Mix (Terminal Layout)
- Yearly traffic pattern, weekly traffic pattern, daily traffic pattern (peak hours, relevant intervals for facility sizing)

Numbers

- Ratio passengers vs. A/C movements: Correlated and proportional
- Ratio passengers/movement vs passengers/year: Correlated and proportional

Traffic Forecast

- Different sources, see slide 38

Design Parameters

- A/C movements per year or hour
- Passenger per year, hour and transfer ratio
- Cargo tonnage per year
- Design aircraft
  - Wingaspan Code F: 65-80 m (B777, and possible to fold wings to change from E on aprons to F on runway)
  - E: 52-65 m
  - D: 36-52m
  - C: 24-36m (A320)

Main airport logistics flows

- A/C guidance (On block to off block)
- A/C handling (deboarding to boarding)
- Bag handling (unloading + bag claim to loading + check in)
- Pax handling (boarding to deboarding))

Laws and Standards

- ICAO: Public international law (Annex 14 Aerodromes)
- EASA: Adapts ICAO into European context (FAA for US) - EASA CS-ADR-DSN
- Countries define national standards (often adapted from ICAO or EASA)
- IATA delivers guidance
- Switzerland: Federal laws, + spatial planning law (SAIP), Aviation Law, Environmental Law, Conservation Law

Site Analysis and Boundary Conditions

- Airspace (availability due to other airports etc.)
- Topography (consider mountains etc. as small approach angles 3°)
- Meteorology: Wind (against landing and takoff), visibility, Temperature
- Space Requirements (some dense)
- Geology, storms, water, fauna
- Location related to city (80% close to city center = 15km), also attracts settlement and industry
- Public Infrastructure (Airport equals midsize city, redundant power supply, water supply, waste disposal, fuel delivery)
- Noise (take-off=wide area due to more noise during liftoff)

Airport Elements

- Runway System
  1. Runway with turnpads (length typically 4km)
  2. Parallel taxiway (shorter sequences Takeoff and Landing)
  3. Rapid exits

4. Multiple entries
5. 2nd parallel taxiway
6. 2nd runway

- Obstacle limitation
- Apron and taxiway system (depend on)
  - Fleet mix
  - Number of A/C in peak hour
  - Number of A/C overnight
  - Rule of thumb: Stands ≈ 1.25 runway capacity/hour
  - 1 stand wingspan code E = $10'000\ m^2$ concrete (1 hectar)
  - Code C= $5'000\ m^2$
  - Requires enough space for different vehicles to deliver fuel, supplies etc.
- Terminal Footprints
  - Linear structures will yield shorter distances to walk
  - Terminal Sections: Multiple levels for separation of inbound and outbound PAX
- Baggage handling, performance measured by
  - Capacity/hour
  - Security Requirements
  - Customs Requirements
  - Transfer Share
  - Minimum Connecting Time
  - Self handling vs. multi airline ground handling
- Landside Access (parameters)
  - Taxi, public bus vs self-driven vehicles → curbside, parking
  - Road vs. rail
  - Segregated flows for people and goods
- Landside commercial utilization (airport city)
  - Well frequented sites are attractive for real estate development
  - Additional source of income for airport operators
- Cargo
- Aircraft Maintenance
  - Admin
  - Airport Maintenance
  - Workshops
  - Fire fighting & rescue
  - Fuel farm
  - Airline facilities
  - Meteo

Rules of thumb

- Simple runway: 10-20 movements per hour
- Runway with taxiway and rapid exits: 40-50 movements per hour
- Parallel runway system: 90-12 mvmts/hour, $10-15\ km^2$
- Number of stands ≈ 1.25 RWY capacity/hour
- 2.75 stands per 1 Million Pax / Year
- Wingspan Code E = 10'000 m^2 concrete
- 10'000 m^2 terminal space ≈ 1 Million PAX/year
- 50-150 PAX/Mvmt
- 1M PAX/Year ≈ 1000 staff
- Traffic Growth ≈ 2 x GDP growth (in country)

Economical Aspcects

- Aviation Revenue + Non-Aviation Revenue: Both are highly important to break even or make profit

13 Airport Operations

- Aircraft Operations
- Landside Operations (Terminal)
- Billing and Invoicing
- Information Management

13.0.1 Aircraft Operations

- Ground Handling
  - Passengers: Boarding/Deboarding + Transport
  - Baggage: Loading/Unloading + Transport
  - Cargo: Loading/Unloading + Transport
- Aircraft Services
  - Catering
  - Cleaning
  - Waster/Waste
  - Fuel
  - De-icing
  - Line Maintenance
- Apron Maintenance Service
  - Aircraft Guidance: Apron Control, Follow-me, Marshalling
  - Aircraft Stand Allocation
  - Aircraft Push-back
- Safety
  - Obstacle Management
  - Wildlife Management
  - Runway & Surface Inspection
  - Runway & Surface Maintenance
  - Snow Removal

Regulatory Framework for Airport Operations

- Concession Agreement
  - Authorises and commits a company to operate an airport
  - Regulates financing and charging
  - Issued by the federal or regional government
  - Varies widely in scope and detail
  - Several concessions possible for particular activities

National Authority

- ICAO SARPS to be implemented by national authority
- FOCA
  - Responsible for monitoring civil aviation in Switzerland and aviation development
  - Ensuring that civil aviation in Switzerland has a high safety standard and one that it is in keeping with sustainable development
  - Supervises aviation companies to which it issues an operating licence based on a technical, operational and financial evaluation

Accountable Airport Manager

- In CH: Organised through the Aviation Infrastructure Ordinance
- Commission Regulation (EU) 139/2014
- The aerodrome operator shall appoint an accountable manager, who has the authority for ensuring that all activities can be financed and carried out in accordance with the applicable requirements. The accountable manager shall be responsible for establishing and maintaining an effective management system.

Runway Capacity Allocation: Slot Coordination

- Mission:
  - Allocation of constrained or limited airport capacity to airlines and other A/C operators
  - Maximise the efficient use of airport infrastructure
  - Maximise the benefits to the greatest number of airport users
- Organisation:
  - Slot Coordination Switzerland
  - Independent Non-Profit Organisation
  - Regulation EEC95/93
  - Federal decree for seasonal airport slot planning and allocation

13.0.2 Landside Operations (Terminal)

- Terminal
  - Passengers: Checkin/Bag drop, Security Check, Passport Control (immigration/emigration), Transport, Boarding
  - Baggage: Bag drop, Transport, Security Check, Sorting, Delivery
- Others
  - Cargo: Truck loading/unloading, Storage, Packaging/Re-packaging, Security Check
  - Customs: All areas
  - Police: All areas
- Access
  - Car Parking
  - Drop-off / Pick-up
  - Bus Station
  - Railway Station
  - Taxi Stand
  - Truck Ramp

13.0.3 Billing and Invoicing - see Slide 37

13.0.4 Information Management

- Airport Operational Database
  - Core IT system for airport operations
  - Storage, processing and provision of flight and passenger related data
  - Basis for Billing
- Data Examples
  - Airline Schedules
  - Daily Flight Plans
  - Gate allocation
  - A-CDM Time-stamps
  - Nr. of Passengers, Transfer
  - Nr. of Baggage

13.0.5 Zurich Flughafen AG

- 280 Companies, 27'000 Jobs
- 31.5 Mio PAX per year, 86'000 per day
- Transfer passengers: 29.3%
- 275'000 Flights per year, 750 per day
- Peak day: 907 flights, 115'000 PAX
- 203 destinations, 77 airlines
- Federal Mandate: DETEC concession agreement 2001-2051
- Public Company: Shareholders: Public trading 61.7%, Canton of Zurich 33.3%, City of Zurich 5%, Not subsidised
- Flughafen ZRH AG (2019): 1.2 Billion turnover, 309.1 Million revenue, 1700 employees, 4.59 Million Balance sheet total
- Projects around the world, mostly in South America (Brazil, Colombia, Chile), some also in India

13.0.6 Challenges to Airport Operations

- Aircraft Turn-around
  - Turnaround Process
  - Collaborative Decision Making (A-CDM)
  - Departure Management
- Airport operations plan
- Adverse Conditions
- Hub Operation

Aircraft Turn-around

- Starts with On block step until Pushback of the vehicle
- Service Providers Included
  - Gound Handling Company
  - Airport Operator
  - Airline
  - ATC
  - Fuel Service
  - Catering
  - Cleaning
  - Waste Water
  - Freight Forwarder
  - Aircraft Maintenance
  - Police
- Indispensible services provided by third parties
- No or only general contractual relationship between airport operator and service provider, i.e.
  - Skyguide: Legal mandate issued by Swiss Confederation
  - Police: Sovereign state duty
  - Handling agents: Contracts with airlines
- **Performance-relevant processes are not under managerial control of airport operator**

Collaborative Decision Making

- Developed and supported by Eurocontrol
- Implementation required at all major airports in Europe
- Defines processes for airport operations: Rules and procedures, Input and output information requirements, Human-Machine-Interface (HMI) requirements
- A-CDM requires platform (to include ATC, Airline Operator, Network Manager, Airport Operator, Ground Handling)

Departure Management System

1. System calculates optimum take-off sequence, based on
   - ATC flight plan
   - ATC slot
   - RWY concept
   - Aircraft wake turbulence category
   - Aircraft speed class
   - Departure route
2. Result: Calculated Take-Off Time (CTOT) for each flight
3. Calculation of Target Start-up Approval Time (TSAT)
   - Consideration of taxi time from stand to RWY
   - Considering Target Off-Block Time (TOBT)

Time Stamps

- Target Off-Block Time (TOBT) (must be ready within +-5min of official TBOT to push back)
  - The time that the Aircraft Operator or Ground Handler estimates that an A/C is ready, all doors closed, boarding bridge removed, push back vehicle available and ready to start up / push back immediately upon reception of clearance from the Tower
- Target Start-Up Approval Time (TSAT) (created 30 min before TBOT)
  - Provided by ATC, taking into account TOBT, CTOT and/or the traffic situation that an aircraft can expect start-up/push-back approval
- Calculated Take-Off Time (CTOT)
  - A time calculated and issued by the appropriate Central Management unit, as a result of tactical slot allocation, at which the flight is expected to be airborne

Airport Operations Plan

- Timeline: 3 hours to 180 days with decreasing precision vs. A-CDM time-line approx 3h
- Predictability: Continuously updated plan of airport operations, and includes all relevant infos (pax, baggage, A/C, ATC)
- Common picture for all stakeholders: Information sharing
- Essential to increase efficiency of airport operations: Prerequisite for arrival steering

Arrival Steering - Target Time of Arrival (TTA)

- Today: Regulated by Eurocontrol only (no ATC etc.) to meet capacity limits. Overdemand is delayed at departure airport to avoid airborne holding
- TTA Concept: Airport, ATC and Airline define together optimal sequence of arriving traffic, and gets it reviewed by Eurocontrol. Eurocontrol delays flights of departures accordingly

Adverse Conditions

- Strong Winds
- Thunderstorms
- Snow
- Winter

- Fog

Strong Winds

- Impact on Flight Operations
  - Limited Availability of Runways
  - Crosswind / Tailwind Limit of Aircraft
  - Reduced Approach Capacity
- Impact on Ground Operations
  - Safeguarding of Equipment
  - Anchoring of Light Aircraft and Helicopters
  - Operational Limits for Aircraft Boarding Stairs and Bridges
  - Risk of Foreign Object Damage (FOD)
- Other
  - Impact on Large Geogrphical Area
  - Flight Cancellations and Deviations

Thunderstorms

- Impact on Flight Operations
  - Route Deviations
  - Runway Conditions (Heavy Rain or Hail)
- Impact on Ground Operations
  - Interruption of Ground Handling Activities
- Other
  - Strong Winds
  - Local Phenomenon
  - Damage to Aircraft Systems and Equipment

Snow

- Impact on Flight Operations
  - Closure of Runways for Snow Clearing
  - Runway Conditions
- Impact on Ground Operations
  - Surface Conditions
  - Closure of Apron & Taxiways for Snow Clearing
  - De-icing required
- Other
  - Resources: Equipment / Vehicles / Staff
  - Snow Deposit
  - Local Phenomenon

Winter

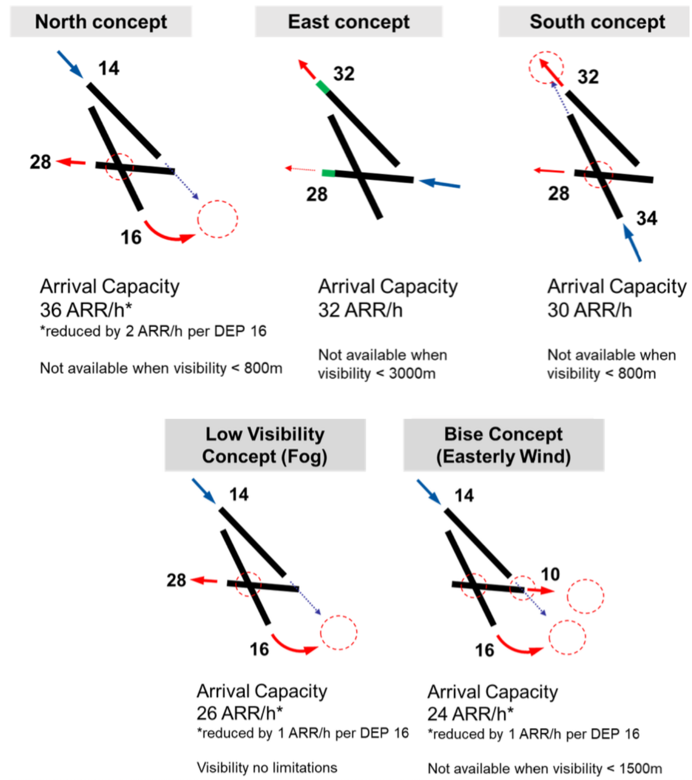
- Impact on Flight Operations
  - Closure of Runways for De-icing
  - Runway Conditions
- Impact on Ground Operations
  - Closure of Apron & Taxiways for De-icing
  - De-icing / Anti-icing required
  - Extension of Aircraft Ground Time
  - Aircraft Stand Availability
  - Surface Conditions
- Other
  - Resources: Equipment / Vehicles / Staff

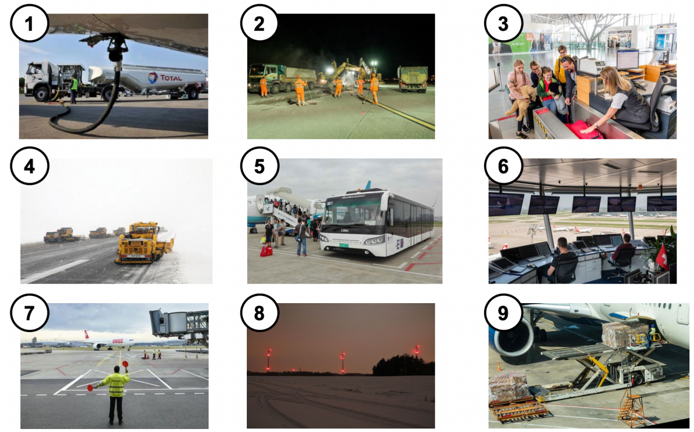
Fog

- Impact on Flight Operations
  - Limited Availability of Runways
  - ILS Cat II/III
  - Reduced Approach Capacity
- Impact on Ground Operations
  - Reduced Capacity on Apron / Taxiways
  - Runway Sensitive Area
  - Limited Availability of Road System
- Other
  - Local Phenomenon

Hub Operations - Challenges

- Connectivity
  - Minimum Connecting Time (MTC)
  - Passenger: Walking Distances, Waiting Times, Segregation
  - Baggage: Handling Times, Irregularities
  - Stand/Gates: Stand Allocation
- Pronounced Traffic Peaks
  - Arrival Capacity
  - Nr. of Aircraft Stands / Gates
  - Transfer Baggage Capacity
  - Transfer Security / Passport Control Capacity
  - Staff & Handling Equipment
  - Departure Capacity
- Off-peak In-efficiencies
  - Unused capacities
  - Staff & Equipment





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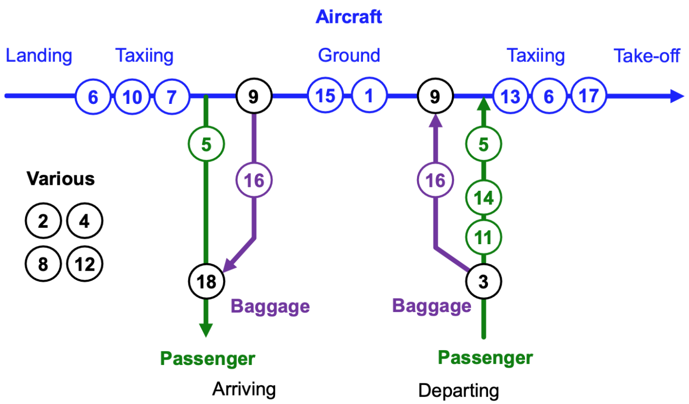
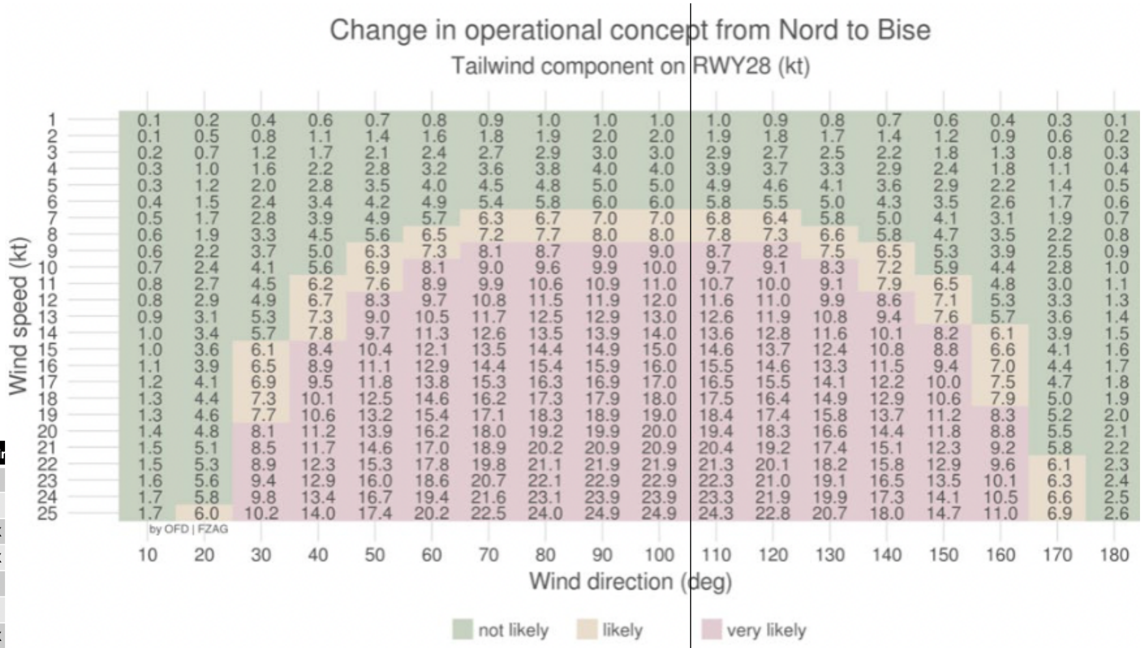
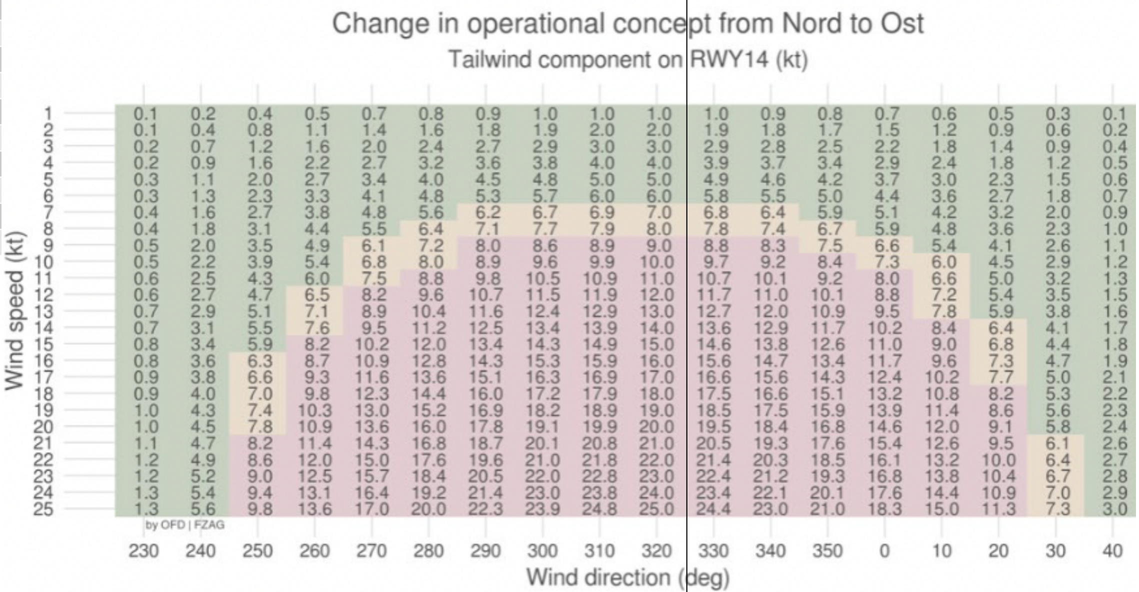
Nr.	Activity	Off-Airport	Runway(s)	Taxiways	Apron	Ramp	Stands	Termi
9	Aircraft Loading / Unloading						X	
10	Aircraft Guidance			X	X	X	X	
16	Baggage Handling & Transport					X	X	X
3	Check-in / Bag drop							X
13	Aircraft Push-back					X	X	
8	Obstacle & Wildlife Management	X	X					
14	Passport Control							X
4	Snow Removal		X	X	X	X	X	
15	Catering						X	
5	Bus Transport					X	X	X
12	Runway & Surface Checks		X	X	X	X	X	
1	Fuelling						X	
2	Airfield Maintenance		X	X	X	X	X	
7	Marshalling					X	X	
17	Aircraft De-icing				X		X	
6	Apron Control / Stand Allocation			X	X	X	X	
18	Baggage Delivery							X
11	Security Check							X







14 Air Freight & Aviation Security

Air Cargo

Pre-Covid Numbers (per day)

- 18.6 Billion USD in value Cargo
- 29 Million parcells (659 Million on singles day)
- 140'000 t Cargo, 898 Million Letters
- 200 race horses
- 1.1 Million Smart Phones
- 80'000 Flowers

Legal and Operational Issues - Part 1

- Warsaw Convention + The Hague Protocol + Montreal Protocol - in CHF since 1998
- Conditions/Contract printed on the back of every Airway Bill (AWB)
- Regulates liabilities of the airline, rights of the shipper
- Valid for all air transportation (regular and/or charter)
- Most common maximal liabilites for loss or damage 19 SDR per kg gross weight, i.e. approx. 25CHF/kg (Montreal)
- SR 748.411 regulates domestic air freight (between ZRH, GVA, BSL, BRN, LUG)
- Most countries have their own domestic transport regulations (on top of Warsaw Convention)
- IATA achieved standardization of transport conditions, tariffs, documentation + simpflification of transport invoicing
- Association IG Cargo: Lobbying, communication + PR, tackling air freight challenges by projects in industry, Exchange of information (cargo forums, presentations)

Transport Modes and Documentation

- Special Freigher Aviation: payload 250t
- Widebody Aircraft: For B747 payload up to 140t
- Narrowboday Aircraft: B737F up to 25t
- Inside: Roller beds for loading/unloading
- Passenger Aircraft: Cargo 50% fo worldwide transport. However limited in size and weight
- Passenger Aircraft: Loose belly load
- Capacities:
  - B777-300 (longhaul): 24t
  - A380-800 (longhaul): 22t
  - A340-300 (longhaul): 20t
  - A330-300 (long/medium): 18t
  - A320-214 (shorthaul): 3t
  - AVRO RJ100 (shorthaul): 0.5t
- Preighter (Passenger A/C as Freigher): Flexibility
- Transport Devices (Airfreight is loaded either loose, on pallets, in containers or in special containers (e.g., refrigerated) into the aircraft)
  - Containers
  - Pallets
- Airway Bill (currently printed, should become avail. on the internet) Functions
  - contract of carriage
  - acknowledgment of receipt
  - special handling instructions
  - freight bill
  - insurance certificate
  - customs clearance document
  - delivery confirmation

Infrastructure at Airports

- Storage and Handling in Air
  - Vault for valuables
  - Security screenign device
  - Animal Cage
  - Cool storage
  - Radioactive Material
  - Express-Channels
  - Loading areas
- Cargo Terminal
- Transport to/from A/C
- Loading and unloading of A/C

Goods typically transported by Air

- Valuables
- Sensitive Materials (Medicine, Laboratory/Research Equipment, Electronics)
- Urgent Shipments (Animals, Human Organs, Important Paperwork)
- Perishables (Fruits, Flowers, Meat, Food in General)

Air Cargo Market Structure

- Traditional Air Cargo: Combined logistic chains provided by independent airlines, truckers, forwarders and warehouse handlers (numerous service providers, coordinated by freight forwarders on behalf of shipper/seller or buyer/importer)
- Integrators: All transports and services provided by one single company

Economic Value - Part 2

- Stakholders
  - Supply Chain: Truckers, Ground Handlers, Security, Airport, Customs, Airline, Consignee, Shipper, Forwarder
  - Regulated by: International standards and norms (ICAO, ECAC, IATA), Security Regulations (ICAO, ECAC, IATA), National laws and regulations (FOCA), Customs and health regulations (EZW, BWL, BUVAL)

Value of global Air cargo

- Trade by value: 35% Air Cargo (6 Trillion per year)
- Trade by volume: 1% Air Cargo
- Cargo moved: 41% of passenger A/C with Cargo filled
- Air transport without cargo is not economically viable for combined airlines
- COVID: Pre COVID = 94% A/C used vs COVID = 59%, rest of Aircraft in service (Total 34250 A/C)

Key Figures Air Cargo Switzerland

- Export: Value Share Swiss exports = 80% and via swiss airports = 51%
- Import: Value Share via Swiss Airports = 35%
- Weight % = 1%
- Value per kg export = 1'413
- Air Cargo Jobs CH = 25'000
- Indirect Air Cargo Jobs = 163'000

- Air Cargo: 40% Metals, 32% Chemicals and div. Plastics, 21% Machinery and equip. electricals and watches, 6% manufactured and 1% others
- Main destinations: USA (35.1%), China (12.6%), Japan (5.9%), Singapore (4.6%), Hongkong (3.9%)...

Challenges

Challenges	Potential consequences
Stricter **security** measures	Increase of cost, transport delays, additional administration
Bottlenecks in **infrastructures**	Airports, roads and warehouses get increasingly congested
Steady growth of **sea freight**	Declining capacity utilization on aircraft and CH airports, pressure on margins, overcapacity
New competition by **railway** to/from China	Direct trains with ca. 20 days of transport, i.e. in the middle between air (5) and sea (40)
Shift of major traffic flows towards **Asia**	Little to no growth (industry and CH-airports) shrinking profitability and efficiency
Increased awareness for **environment** protection	New prohibitions and restrictions, higher costs, decreasing acceptance for air traffic
Opportunities	**Potential consequences**
New **overseas** markets	New free trade agreements with oversea countries result in raising demand (80% air cargo)
Changing buying behaviour through **online shopping**	Online shopping with direct delivery to door (e.g. Amazon-logistics-chain)
Technology developments	Digitization of logistics services and implementation of IOT (4.0.)
Political Awareness	The importance of independent entry ports in a landlocked country like Switzerland was shown clearly in 2020.

The ideal Swiss air cargo movement

- Switzerland does not need Mega Cargo Hubs with unlimited space, but needs to focus on it traditional strengths in innovation, quality, reliabiliy and precision. These are the main factors
  1. Adequate Infrastructure
  2. Sufficien air transport capacity
  3. Competitive cost structures
  4. Lean but clear regulations
  5. Effective security measures
  6. Electronic data exchange
  7. Opennness for new developments

Future

World air cargo traffic is still expected to growth annualy 4% over the next 20 years. E-commerce is expected to double every four years

- Green/Sustainable
- Being prepared
- Business travel
- Narrow-body long-haul
- Cargo vs Pax Airlines
- Open Borders
- Reform

Environmental Aspects - Part 3

- Responsibility of logistics and transport
  - Logistics & Transport has second largest share of CO_2 emissions (24%)
  - In 2050, the European Energy Agency (IEA) expects that global logistics will have the largest share with up to 40% (globalisation effect)
- Huge differences in CO_2 emmisions (Example Hamburg-Istanbul) - weight 500kg + no cooling
  - A321: 706 kg
  - Boeing 777F (freighter): 435 kg
  - Truck (40t): 503 kg
  - Container ship: 10 kg
  - Rail: 7kg
- Emission values of day to day products
  - CO_2 output significantly higher for Air transport compared to ship
- Calculations and Compensation
  - At Zurich Airport one ton air cargo produces an average of 11 kg CO_2
    * 95% by flight movements
    * 3% from truck transports
    * 2% from the airport (handling, heating, electricity, etc.)
- Conclusion and recommendation
  - with the choice of the right mode of transport the emission output can be reduced
  - Railway transport has the lowest and air cargo the highest output of CO_2 per kg, however, the impact of air cargo on the global emission effects is low due to the low volumes carried by air
  - Companies must set clear reduction goals and implement measures. They must establish clear policies when choosing their transports
    * Avoid
    * Optimise
    * Measure
    * Compensate
  - Awareness in the society must be raised that not only passenger trips are generating greenhouse gases but also transport and logistics services

Aviation Security

- Safety
  - Safety: Deals with preventive measures against the occurrence of events that have their origin in unintentional human and / or technical inadequacies. But also deals with comprehensive safety for the life and health of employees at their workplace (= occupational safety).
- Security
  - Addresses preventive measures against the occurrence of events that are committed by people with willful intent against companies or organizations, as well as the limitation or control of such incidents and the damage resulting from them.
- Most efficient security: Control the bad and leave the good

Threats

- Risk Analysis (targets of attacks are):
  - Passangers/employees
  - Airport Infrastructure
  - Airplanes
  - Hijacking
  - Sabotage
  - Other airplanes as weapons
- Why civil aviation is an attractive target
  1. Global reach, even if local
  2. Rapid transmission of information, increasing audience

3. Depriciate the embodiment of state power that airlines and airports symbolise
4. Powerful economic consequences beyond civil aviation
5. High lethal potential, and high probability of effecting people from multiple countries at once
6. Impede interconnectivity, disrupting global air transport
7. Instantly making powerful statements to world leaders

- Types of Security Checks
  - Security Checks of passengers and baggage
  - ... staff and goods
  - Security measures for aircraft
  - ... checks of air freight and air mail
- Security Equipment

Explosive Detection Dog	EDD
Explosive Detection System	EDS
Explosive Trace Detection	ETD
Metal Detection System	MDE
Visual Check	VC
Handsearch	HS
X-Ray Screening	X-Ray

- Objects to be found
  - Dangerous goods: Are not forbidden, but can be used to threaten or injure people or can cause fire and explosions
  - Prohibited items: are forbidden under the weapons act
- Number one weapon, the Unpredicitability of passengers and luggage
  - Selected at random, and choice is not made by staff
- Legal requirements
  - FOCA: Supervisory of CH through NASP
  - NASP: The NASP (National Aviation Security Program) defines the standards and their implementation. Framework instructions to the participating entities are defined in it.
- Future
  - Human Security Radar
  - Categorisation of Passengers
  - Drone Defence Systems
- Future Demands
  - Intelligence: Passenger differentiation based on risk and trust
  - Innovation: New control technology and processes
  - Service: Different understanding of work in the aviation security sector
- Current Weaknesses of today's security systems
  - Too tech-heavy
  - Overregulated
  - Pseudo Security
- Solutions
  - Raising employee awareness
  - Organisation with high reliability