Zusammenfassung Aviation Basics

↳ Humma Lai
AV24a

Woche 1: Einführung

1. Avicatik als Transportparte
2. Intermodalität, Interoperabilität
3. Fragilität
4. Internationalität 1: Karten, Sprachen, Masseneinheiten
5. Internationalität 2: Jahreszeiten, Zeitzonen
6. Zusammenhang, Ausblick

Lernziele:

- die Luftfahrt als eine Transportparte sowie die Schnittstellen und Abgrenzung zum Studiengang Mobility-Science
- werden sensibilisiert auf die Fragilität der Luftfahrt
- versch. Wege der Kartenprojektion & deren Vor-/Nachteile
- sensibilisiert auf die untersch. Masseinheiten & Referenzsysteme
- wissen wie Umrechnungen zwischen untersch. Zeitzonen korrekt ausgeführt werden

Gemeinsame Themen mit Mobility Science:

Übergeordnet: Safety/Security Manage., Dangerous Goods

Technich & Umwelt: Bauweise: Leichtbau, Navigation
Lärm- & Schadstoffemission

Operationelle Vorschriften: Lizenz, Betriebsbewilligung
Einsatzzeiten

Verwaltungsvorschriften: Zulassung, Aufsicht, Versicherungsfragen

Vergleiche in Bezug auf: Kosten, Zeiten, Umweltbilanz

Intermodalität: Verwendung mehrer Verkehrsmittel
Schnittstelle beim Übergang von einem Transportmittel auf das andere.

serielle Intermodalität: zusätzliches Verkehrsaufkommen, höhere PAX-Zahlen, Wettbewerbsvorteil

parallele Intermodalität: partielle Kapazitätsentlastung

Interoperabilität: Fähigkeit der Zusammenarbeit von Systemen, Techniken oder Organisation über Grenzen hinaus

Fazit: Transport-Subsysteme sollen als Ganzes betrachtet werden & nach möglichst gleichen Standards betrieben werden
Ziel: Interoperabilität in einem vernetzten Gesamt-transportsystem über Grenzen hinaus

Innere Gefahren: Human factors: menschliches Verhalten, Redundanz, Situational Awareness
Technik, Redundanz
Safety / Risk Management

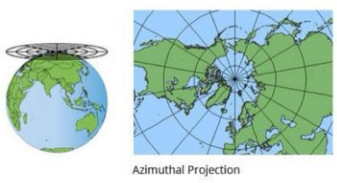
operationelle (innere Sicherheit): Safety

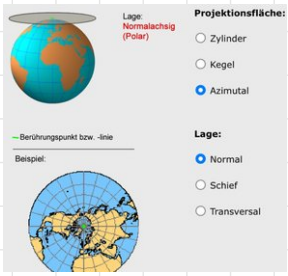
Äussere Bedrohung: Anschlag, Terrorismus (Wasser Piraten)

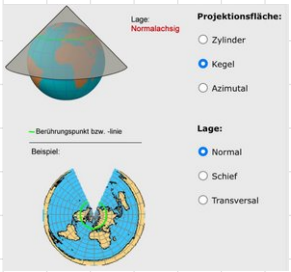
Sicherheit von Anschlägen: Security

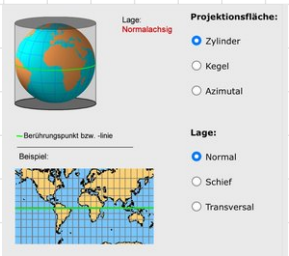
Kartenprojektion:

Klassifikation nach Abbildung:







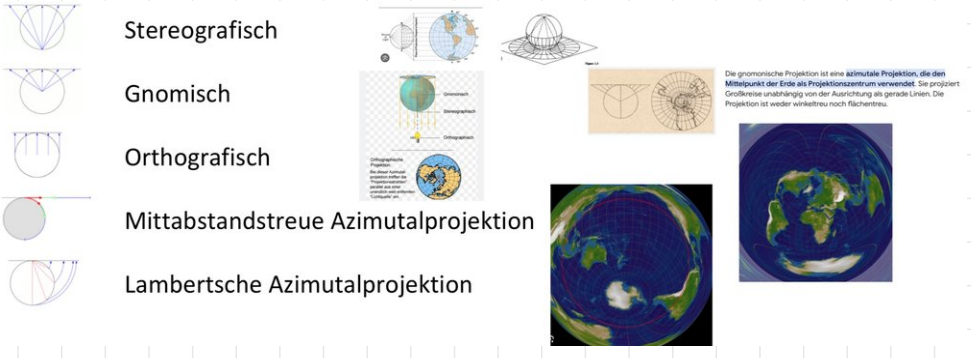


- Ebene: (plane / level)
  Kegel mit Öffnungswinkel: 180°
- Kegelmantel: cone coat
- Zylindermantel: cylinder coat
  Kegel mit Öffnungsgrad: 0°

Eigenschaften:

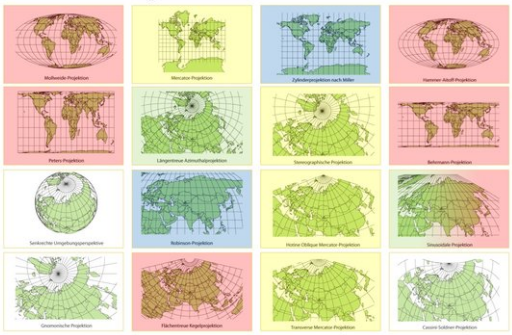
Winkeltreue: (true to angle)
Längentreue: (true to length)
Flächentreue: (true to area)
Mix / Kompromiss

Abbildungen:



Kartenprojektionen – Klassifikation nach **Eigenschaften**

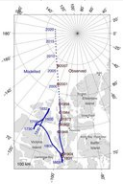
- Winkeltreu
- Längentreu
- Flächentreu
- Kompromiss



Einige Begriffe

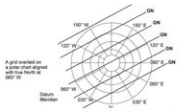
- Magnetic North vs. True North





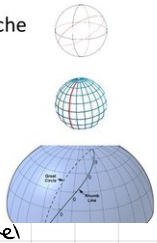
- Grid / Gitter

Polnavigation
Grid North anstelle True North
Orthodrome und Loxodrome identisch



Einige Begriffe

- Grosskreis (great circle) — Grösstmöglicher Kreis auf einer Kugeloberfläche
- Orthodrome — Auf Grosskreis; kürzeste Verbindung
- Meridian — Halber Längenkreis, von Pol zu Pol
- Loxodrome — Kursgleiche ("rhumb line")



↳ schneidet Längengerade immer im gleichen Winkel

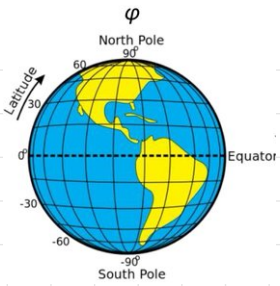


→ halber Längenkreis



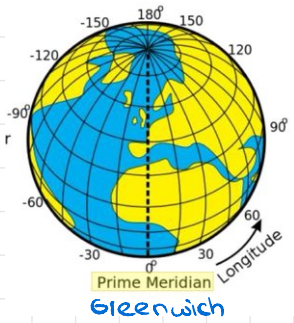
Animation einer Loxodrome | Loxodrome am Pol | Loxodrome am Äquator

Koordinaten:



Latitude: Breitengerade φ (phi) -90° bis 90°
0° → Äquator

Longtitude: Längengerade λ (lambda) -180° - 180°
0° → Greenwich



1 Grad: 60 Winkelminuten (')

1 Winkelminute: 60 Winkelsekunden (")

Umrechnung: Grad (°) ⇄ Minute (') ⇄ Sekunde (")
· 60 / : 60 · 60 / : 60

Beispiel: 25° 15' in ° : 60 ⇒ 25.25°

30.5° in (') · 60 ⇒ 30° 300'

Sprachen: Hauptsprache (ICAO): englisch

offizielle Sprachen: EN, FR, SP, AR, RU, CN

AR → arabisch

Masseinheiten in der **Luftfahrt**

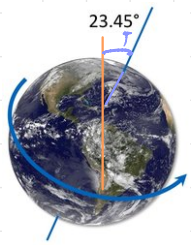
- *ft, m, km, NM, SM* (nautische Meile)
- *kts, MPH, km/h* (knots, miles/hour)
- *°C, °F*
- *kg, lbs* (pound)
- *l, USG, qt* (Volumenmass)
- *mbar, hPa, inHg* (Druck, Quecksilber)



Unterscheidung zwischen:
SI System (int.) = Metric System
Anglo-Amerik. Imperial System

at an vertical axis of:

Die Erde dreht sich um die Hochachse: 23.45°



UTC: Winterzeit in Greenwich (= GMT)

UTC Time = "Z" Time (Zulu)

LT: Local time = UTC ± Zeitverschiebung (Zeitzone)

DST: Daylight Saving Time – Sommerzeit

spring forward, fall back (von letzten Sonntag in März bis Oktober)

CET Central European Time

Winter: UTC + 1h (MEZ Mitteleuropäische Zeit)

Sommer: UTC + 2h (MESZ) (CEST engl.)

Einige Zeitzonen (Winter) (Sommer)

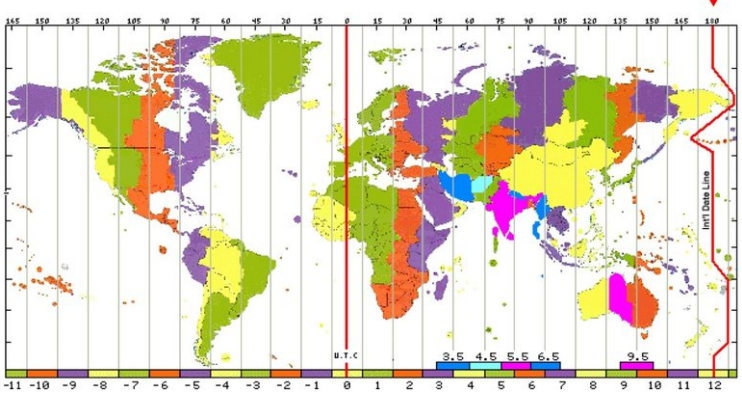
- **MEZ** (MESZ) Mitteleuropäische Zeit (inkl. CH) = UTC + 1h
- **GMT** (BST) Greenwich Mean Time = UTC

- **EST** (EDT) Eastern Standard Time = UTC - 5h
- **CST** (CDT) Central Standard Time = UTC - 6h
- **MST** (MDT) Mountain Standard Time = UTC - 7h
- **PST** (PDT) Pacific Standard Time = UTC - 8h
- **AKST** (AKDT) Alaska Standard Time = UTC - 9h

JST → Japan Standart Time = UTC + 9h (no DST)
ICT → Indochina Time = UTC + 7h (no DST)
GST → Gulf Standard Time = UTC + 4h (no DST)

IDL: International Date Line (180° Meridian Longitude) (UTC ± 12h)
Ist bei der IDL genau Mitternacht 00:00:00 so gilt auf der ganzen Erde gleiches Datum

IDL - International Date Line
(180°-Meridian)



UTC Berechnung
Bsp.
① Abflug umgekehrt von ± dazurechnen
② + Flugzeit
③ ± eigentlicher LT genau addieren

History of Aviation (Woche 2.1)



1 die Pionierzeit: (bis 1914)
2 der erste Weltkrieg und die Zwischenkriegszeit (1914- 1939)
3 der zweite Weltkrieg und die unmittelbare Nachkriegszeit (1939- 1950er
4 das Jet- Age (1950er - 1970er Jahre)
5 Liberalisierung und Massenluftverkehr (ab 1980)

1 die Pionierzeit (bis 1914)

frühe Versuche: Turmspringer, nach Art der Vögel zu fliegen mit Flügelprothesen,

Paradigmenwechsel 1650 nach Art wie Vögel zu fliegen galt gescheitert
- Luftfahrt leichter als Luft rückt in Vordergrund
  - ↳ Dichte des Flugobjekts kleiner als Luft
- 1783 erster bemannte Ballonflug Montgolfière (Heissluftballon)
  - ↳ wieso geflogen? keine Ahnung → dachten wegen Rauch deshalb viel Rauch
- Gasballon Charlière: (bemannt) (Gasballon) setzte sich vorerst gegen Heissl. durch
  - ↳ aufwendige Gasbeschaffung
  - ↳ geringe fehlende Steuerbarkeit

Verwendung Gasballone:
- ↳ Abenteuerflug für zahlende PAX
- ↳ Flugsport
- ↳ Fotografie / Kartografie / Wissenschaft
- ↳ Militär: Beobachtung (doch wegen fehlender Steuerbarkeit nicht so interessiert)

kein Luftverkehr !

→ airships

- La France 1883: erster Ballon mit Elektromotor
  - ↳ konnte wieder beim Startpunkt landen (10 km)
  - ↳ 1888: Antrieb mit Verbrennungsmotor
    1897: Aufstieg eines Aluminium luftschiffes (Starrluftschiff)
    - ↳ neue Verwendungen: kommerzielle Rundfahrten
      Luftverkehr (in D nicht CH)
      Militär: Fernaufklärung, Bomber
- Ende der 1930er Jahre: Verdrängung Luftschiffe durch Tragflächenflugzeuge

zentrale Voraussetzungen:
- ↳ Ablösung Tüftler, Bastler durch Wissenschaftler
- ↳ um 1800: George Cayley publizierte Grundlagen für dynamischen Flug
- ↳ um 1890: Otto Lilienthal publizierte wichtige Grundlagenwerke über Tragflächen ⇒ ab 1894 Serienherstellung von Normalsegelapparat
  - ↳ airfoils

- die Gebrüder Wright: Tragflächenflugzeuge fixed-wing aircraft
  - ↳ bauten auf Wissen von Lilienthal auf
  - ↳ 1900: erste Versuche mit Gleiter (Flugzeug ohne Motor)
  - ↳ 1903: erster bemannter Dauerflug mit Verbrennungsmotor "schweer als Luft"

Verwendung in Vorkriegszeit:
- ↳ Sportgerät (Spielzeug)
- ↳ Luftfotografie:
- ↳ Rundflüge
- ↳ kommerzielle Flugschauen (Eintritt verlangen, war eine Show)

aber kein Luftverkehr !

erste Tragflächenflugzeuge: unrentabel, unkomfortabel, unsicher, unzuverlässig, nur Sichtflug

2 der erste Weltkrieg und die Zwischenkriegszeit (1914 - 1939)

- Luftfahrt wurde zur Sache nationaler Bedeutung (wir können angegriffen werden)
- Piloten → Helden der Luft (nicht nur Selbstmord durch Sportgerät)
- Massenproduktion von Flugzeugen & Piloten

- nach dem Krieg
  - ↳ Helden der Luft versuchten nach dem Krieg von Luftfahrt zu leben
  - ↳ Flugzeug nicht mehr gebraucht → standen für Zivilluftfahrt zur Verfügung
  - ↳ Luftfahrt nicht rentabel

neues Interesse vom Staat an Luftfahrt führt international zu Unterstützungsmassnahmen
- ↳ direkte oder indirekte Subventionen
- ↳ Stärkung nationaler Fluggesellschaften
  - → durch geförderte oder erzwungene Fusionen
  - → Entstehung von Flag Carriers (Staaten zeigen wie modern sie sind)
- ↳ Beteiligung & Übernahme an Fluggesellschaften

- Beispiel Schweiz Gründung mehrer (unrentabler) Fluggesellschaften 1918:
  - → Aero Gesellschaft
  - → Ad Astra Aero
  - → Avion Tourisme

  } kein Linienverkehr, nur rentabel als Fotoflugzeuge & Taxiflugzeuge

- wegen mehrere Zusammenschlüssen & staatliche Subventionen:
  - ↳ 1922: erstmaliger Betrieb regelmässiger Luftverkehrslinie durch Ad Astro
  - ↳ Gründung weitere Fluggesellschaften und Ausbau Streckennetz

1931 ↘

- erzwungene Zusammenschluss Ad Astra Aero und der Balair zum neuen Flugcarrier Swissair (keine Subventionen, wenn kein Zusammenschluss)

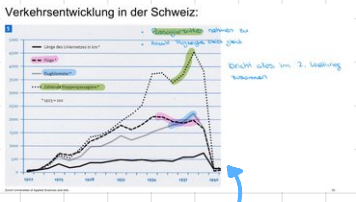
in Dübendorf ausländische Flugzeuge bezahlt zum Landen

80% Einnahmen durch Subventionen

- technische Innovationen & Hersteller
  - 1919: erstes Ganzmetall-Verkehrsflugzeuge Junker F-13
  - 1931: Lockheed Orion: erstes Verkehrsflugzeug mit einziehbarem Fahrwerk
  - 1933: Erstflug der Boeing 247 (exklusiv für United)
    - Platz für 10 PAX
    - Stromlinienförmiger Ganzmetallflieger mit freitragenden Flügeln, Einziehfahrwerk & pneumatischer Enteisung
    - Geburt des modernen Verkehrsflugzeugs
      (immer noch kein kommerzieller Erfolg)
  - Douglas 1934 DC-2, 1935 DC-3 ⇒ Konkurrenz mit Boeing
    - Kapazität: 21-35 PAX
    - → erstmal gewinnbringende PAX-Transport möglich
    - → erfolgreichstes Verkehrsflugzeug der Zwischenkriegszeit

- Entwicklung Flugplätze zu Verkehrsknoten
  - Bau Stationsgebäuden, Hartbelagspiste (1930)
  - Flugwetterdienst (angerufen um zu erkundigen, wie das Wetter ist)
  - Flugfunk (Erstmal in Flugzeugen mitnehmen dürfen Piloten)
  - Radionavigation (auf Karte am Boden geschaut, wo Flieger ist)
  - Luftverkehrsleitung (ATC)

PAX Zahlen stiegen stark an bis Ausbruch 2. Weltkrieg



3 der 2. Weltkrieg und die unmittelbare Nachkriegszeit (1939 - 1950er Jahre)

- Verkehrsentwicklung in der CH → Bundesrat bedingter Stillstand
  - wie in Europa
  - USA normal weiter

Starke Einschränkung Flugbetrieb auf "Kriegslinien" (Ausnahme Diplomaten)

- negative Auswirkungen des Krieges:
  - Zerstörung der Flugzeugflotten gewisser Gesellschaften (LOT)
  - Zerstörung der Luftinfrastruktur

- positive Auswirkungen
  - Massenproduktion → endgültige Industrialisierung des Flugzeugbaus
  - Massenausbildung von Piloten & Spezialisten
  - technische Fortschritte: grössere Reichweite & Traglasten
    grössere Geschw.

- Entwicklung von Interkontinentalflugzeugen
  - Douglas DC-4 & Lockheed Constellation

- Interkontinental Flughafen Zürich Kloten (Nachkriegsplanung)

- Nach dem Krieg

  ↳ 1944: Internationale Zivilluftfahrtkonferenz Chicago
  Chicago - Convention

  ↳ Gründung (P) ICAO
  ↳ Festlegung zahlreicher globaler Normen, Regeln

  ↳ europäischer Verkehrsnetz lag in Trümmern
  ↳ Luftfahrtinfrastruktur liess sich (im Vergleich zu Eisenbahn) schneller aufbauen
  ↳ Schweiz:
    ↳ Genf nach dem Krieg lange Hartbelagpiste
    ↳ Basel 1946 provisorischer Flughafen offen
    ↳ Kloten: erste Piste 1948

- Entstehung interkontinentaler Luftverkehr:
  ↳ 1945: erste DC-4 landet in Genf
  ↳ ab 1946: regulärer Linienverkehr zwischen New York - Genf

- Swissair gegen Interkontinentalflüge
  ↳ nur mit Subventionen DC-6 gekauft
  ↳ 1951 interkontinentale Flyglinie

Take-off Luftverkehr: Luftverkehr nimmt enorm zu

4 das Jet-Age (1950er & 1970er)

- Mai 1952: De Havilland DH-106 Comet erstes Düsenflugzeug im Linienflugbetrieb
  ↳ Probleme: Absturzserie 1953 und geringe PAX-Kapazität (40-50)

- Oktober 1955: Pan Am Bestellung von 20 Boeing 707 und 25 Douglas DC-8
  ↳ Auslösung Jet-Bestellungswettlauf
  ↳ Duopol Langstreckenflugzeug Boeing-Douglas

doppelte Anzahl PAX

- 1970: Wide Body Aircraft
  - Boeing 747 Jumbo-Jet
  - McDonnell Douglas DC-10
  - Lockheed L-1011 Tristar

- 1972: Markteintritt Airbus
  ↳ Nischenmarkt mit A300 mit 350 PAX

parallel

Marktlücke erwischt, so im Wettbewerb einsteigen können Wid-Body Aircraft

- 1971: Niederlage Überschallflugzeuge
  ↳ Abbruch amerikanisches Project: Supersonic Transportation
  ↳ Aufnahme Linienflugbetrieb Concorde

→ Probleme: Lärm, viel Treibstoffverbrauch, ÖL-Embargo

Probleme: PAX-Zahlen gestiegen, dennoch Flugzeug nicht immer voll ausgelastet + teure Anschaffung von Flugzeugen

- Jet-Krise 1: (1960) Überkapazität bzw. Überangebot von Düsenflugzeugen (jet aircraft) (von Steuerzahlen gerettet werden müssen)
- Jet-Krise 2:
  - Ölkrise 1973
  - Überkapazität wegen Wide-Body-Aircrafts
- Allgemeine Folgen der Nachkriegszeit
  - zunehmend rentabel
  - breitere soziale Schichten konnten fliegen
- Herausforderung Flugsicherung
  - Vervielfachung Luftverkehrsaufkommen
  - schnellere Flugzeuge
  - grössere Flughöhen
  - mangelhafte Koordination von Militär-/Zivilflugzeugen

Massnahmen:
↳ 1952: Kanalisierung Luftraum in EU zu Luftstrassen
Markierung Strassen mit Funkfeuer
Überwachung & Staffelung des Verkehrs

- Fluglärm

↳ Ablehnung Ausbau ZRH 1957 (überraschend)
Grund: Fluglärm

- 1960: Fluglärm internationale Thematik in Politik
- 1970: Höhepunkt Fluglärm

Grund: ↳ mehr Verkehr
↳ mehr Lärm wegen Düsen
↳ sozial Wandel

Folgen:
- Landeverbot für versch. Flugzeugtypen
- Nachtflug verbot
- Raumplanerische Massnahmen
- Einschränkung Ausbau Infrastruktur
- verstärkte technische Innovation für Vermeiden von Fluglärm

5 Liberalisierung & Massenluftverkehr

- 1997 Fusionierung McDonell-Douglas mit Boeing
- 1990er Duopol Airbus-Boeing
- Innovation: verstärkte Computisierung von Flugzeugen, Flugsicherungssystem. & Reservationssystemen am Boden eingeführt

- 1978: US Airline Deregulation Act löst Liberalisierungstendenzen aus
  - ↳ formell erst 1587
  - ↳ führt zu Umdenken (auch in Europa)
    - Wegkommen von Kartelldenken
    - weniger Luxus, weniger exklusiv sondern Rentabilität

Folgen: Globale Liberalisierungstendenzen

- tiefere Preise → noch breitere soziale Schichten können fliegen
- neue Unternehmenstypen: Billigfluggesellschaften, Regionalfluggesell.

- Erste europäische Billigfluggesellschaft:
  - ↳ no-frills-Flüge → Laker Airways (1977)

- 1978 Gründung Regionalfluggesellschaft Crossair AG
  - ↳ Verdrängungskampf von Airlines
    - ↳ trug beim Untergang der SwissAir bei (Swissair konnte sich nicht anpassen)

Organizations (Woche 2.2)

1 Allgemeines zu den Organisationen der Luftfahrt
2 Die International Civil Aviation Organization (ICAO)
3 Die International Air Traffic Association (IATA)
4 Die europäische Zivilluftfahrt Konferenz (ECAC)
5 Die Agentur der europäischen Union für Flugsicherheit (EASA)
6 Die Federal Aviation Administration (FAA) (USA)

1 Allgemeines zu den Organisationen der Luftfahrt

- 3 wichtigsten Formen:

Intergovermental (international governmental) organizations IGO

- «Zusammenschlüsse von Staaten, die durch völkerrechtliche Verträge gegründet worden und mit eigenen Organen und eigenen Zuständigkeitsbereichen ausgestattet sind.» (BPB)

- dienen der Koordination zwischen den Mitgliedsstaaten, haben keine Hoheitsrechte
- können selbst kein verbindliches Recht setzen Bsp. ICAO, ECAC
- nur wenige IGO sind supranationale Organ. und können verbindliches Recht setzen Bsp. EU (& damit auch EASA)

International non-governmental organizations INGO
- jede internationale Organisation, die nicht durch ein zwischenstaatliches Abkommen zustande kommt Bsp. IATA

National aviation authorities (NAA)
- BAZL, FAA

Entstehung:

- Luftfahrt transnational/global ausgeprägt daher auf internationale Regeln/Standards angewiesen
- Produktion & Zulassung von Flugzeugen braucht inter. Stan.

2 International Civil Aviation Organization (ICAO)

Die Vorgängerorg. CINA

- 1910 erste Luftkonferenz (Paris) erfolglos
  - Hauptstreit: Lufthoheit vs. Luftfreiheit
  - 1. Weltkrieg → Lufthoheit (Schutz vor Angriff)

- Pariser Konvention 1919 (nach 1. Weltkrieg) Festlegung Regeln:
  - staatliche Souveränität über ihren eigenen Luftraum
  - Lizenzierung Piloten, Flugwetterdienst ...
  - erste internationale Luftfahrtorg.: Commission Internationale de navigation Aérienne (CINA)
    - ↳ CINA aber primär eine europäische Luftfahrtorganisation
    - ↳ Schweiz schloss bilaterale Verträge ab

Gründung der ICAO:

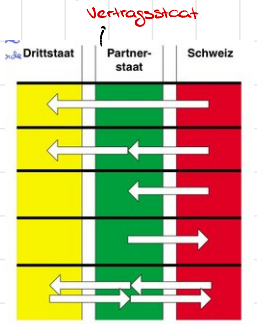
- USA und Verbündete planen Nachkriegsverordnung
  - ↳ grösste Fluggesellschaften, Flugzeugflotten, PAX-Potential technologischer Vorsprung → Wettbewerbsvorteil
  - ↳ wollen Reduktion von Regularien (int.)
    - ↳ möglichst freier Wettbewerb & freie Lufträume

initiieren 1944 internationale Chicago Konferenz

- internationale Zivilluftfahrt - Konferenz in Chicago 1944:
  - Ziel: Schaffung intern. Luftfahrtbehörde
  - Resultate: Transport / Transit - Vereinbarungen
  - Inhalte:
    - Gründung ICAO
    - Festlegung zahlreicher globalen Normen
    - technische Standards in Annexen festgelegt

    → Prinzip der Lufthoheit von CINA übernommen
  - Bedeutung der Chicago Convention:
    - keine nicht wirkliche inhaltliche Neuerungen
    - grosse Bedeutung → "universeller Charakter"
    - Grundstein für weltumfassende Luftfahrt
  - Inhalte Zusatzabkommen:
    Überflugrecht & Recht technischer Zwischenlandungen

"Freiheit der Luft": gewerbsmässiger Transport in einem anderen Vertragsstaat, von diesem zurück sowie zwischen einem Vertragsstaat und Drittstaat

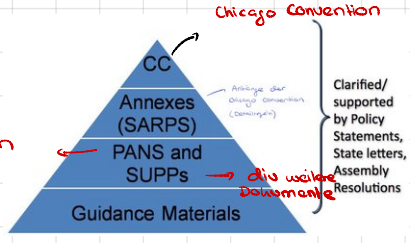


- ICAO heute
  - 160 seit 1947 Sonderorgan. der UNO
  - 193 (von 193 UNO-Mitgliedstaaten)
  - Montreal, Kanada
  - Ziele:
    - Verbesserung weltweite Safety & Security
    - Steigerung Kapazität & Effizienz
    - Förderung gesunden wirtsch. tragbaren Wachstum
    - Minimierung neg. Auswirkungen der Luftfahrt auf Umwelt (neu)
  - Mittel:
    - Richtlinien (Standards)
    - Empfehlungen (recommended practices)

    } Hauptrichtlinien

↳ Umsetzung rechtlich bleibt den Staat überlassen

- Hierarchie:



- Standards and Recommended Practices (SARP's) werden nicht in CC sondern Annexen festgehalten
  - Erfordernis die Standards regelmässig an den neuesten Entwicklungen anzupassen
  - Änderung von CC muss von Mitgliedstaaten ratifiziert werden (aufwendig) (Parlament)
  - Änderung Annexen viel schneller (2/3 Mehrheit) kann aber auch 2-3 Jahre dauern

- Wichtigste Organe
  - Assembly — je Mitgliedstaat 1 Stimme
  - Council — 36 Vertreter der Mitgliedstaaten

- Vertretung Schweiz
  - Assembly → fixer Sitz
  - Council & Air navigation commission
    ↳ seit 1980 Interessenvermittlung durch ABIS-Gruppe
      - Austria, Benelux, Ireland, Schweiz — neu Kroatien, Portugal
      - Kontinuierliche Vertretung im Rat und der Flugsicherungs-kommission der ICAO
      - 4-grösster Beitragszahler der ICAO

Umsetzung ICAO-Regeln:

- kann kein verbindliches Recht setzen
  ↳ Souveränität der Länder
  ↳ Länder müssen innerhalb 6 Tage Unterschiede melden

- Schweiz → Übersetzung teilweise abzusehen
  - teilweise Integration der ICAO-Standards in eigenem Recht
  - ab 1935 direkte Anwendung ohne eigene Rechtserlasse

International Air Traffic Association (IATA)

- INGO
  ↳ Mitglieder ≈ 330 Fluggesellschaften aus über 120 Staaten (80% des Luftverkehrs)

- ursprünglich: Kartell der Fluggesellschaften zur Absprache von Preisen & Dienstleistungen → Liberalisierung machte einen Stopp

- Ziele & Aufgaben:
  - Interessenvertretung (Lobby) von Airline gegenüber Regierung
  - Zusammenarbeit aller am Luftverkehr beteiligter Unternehmen durch Entwicklung dafür zweckdienlicher Mittel & Methoden (E-Tickets, Senkung Kosten)
  - Förderung eines sicheren, regelmässigen & wirtsch. Luftverkehrs

- Organe
  - Generalversammlung → jedes Mitglied hat 1 Stimme (unabhängig von Grösse)

- Clearing House:
  - zentrale Verrechnungsstelle
  - Voraussetzung Interline System
    - reisen mit 1 Ticket → mehrere Airlines
    - Abrechnung zwischen Reisebüros & Airline

Schweiz: grossteil der Airlie die die Schweiz anfliegen sind Teil von IATA
IATA-Standards sind von grosser Bedeutung in der CH

4 Europäische Zivilluftfahrt-Konferenz (ECAC)

- 160 unabhängige Regionalorganisation der ICAO

- Ziele:
  - kontinuierliche Entwicklung eines sicheren, effizienten und nachh. Luftverk.
  - ursprünglich Vorreiterrolle bei der Entwicklung einer europäischen Luftfahrtpolitik → heute EASA
  - Diskussionforum und Entwickeln neuer Ideen (Umwelt, Safety, Security)

5 Agentur der Europäischen Union für Flugsicherheit (EASA)

- 160 mit Eigenschaften NAA (Flugsicherheitsbehörde)

- Die EASA hat (de iure) selber keine Rechtsetzungskompetenz.
  Sie erarbeitet jedoch Regularien, die von der EU erlassen
  werden und daher für alle Mitgliedstaaten verbindlich sind. = EFTA-Mitglieder

- Allgemeine Ziele:
  - Einheitliches hohes Niveau der zivilen Flugsicherheit
  - Einheitliches hohes Niveau im Umweltschutz
  - Einheitliche Regulierungs- und Zertifizierungsverfahren zwischen Mitgliedstaaten
  - Vereinfachung des EU-Luftverkehrsbinnenmarktes und Schaffung gleicher Wettbewerbsbedingungen
  - Zusammenarbeit mit anderen internationalen Luftfahrtorganisationen und Regulierungsbehörden

- Aufgaben und Tätigkeitschwerpunkte:
  - Beratung EU-Kommission bei der Ausarbeitung der EU-Luftfahrtgesetzgebung, Umsetzung ICAO-Vorgaben in EU-Recht, Entwicklung eigener Richtlinien
  - Festlegung des rechtlichen Rahmens für Fluggesellschaften und Betriebe der Luftfahrtindustrie
  - Zulassung / Lizenzierung / Zertifizierung von luftfahrttechnischen Produkten (Flugzeuge, Triebwerke etc.), Luftfahrtunternehmen (Airlines & Hersteller), Flugplätzen, Flugpersonal etc.
  - Anleitung und Kontrolle der Mitgliedstaaten und der Industrie bei der Umsetzung der Vorschriften

- 5.6 Bedeutung für die Schweiz
  - CH nimmt aufgrund des bilateralen Luftverkehrsabkommens mit der EU von 2006 an der EASA teil
  - CH hat seither einen Sitz im Verwaltungsrat der EASA, jedoch mangels EU-Mitgliedschaft kein Stimmrecht
  - CH ist dennoch verpflichtet, bestehende und zukünftige Regelungen der EASA zu übernehmen (indirekt durch spezielles Übernahmeverfahren bzw.)
  - Wenn Verfahren abgeschlossen, haben EASA-Vorschriften in der Schweiz Rechtswirkung

- Ausblick:
  - Die EASA wird ihre Kompetenzen auch in Zukunft weiter ausdehnen und immer weitergehende Regularien erlassen
  - Durch Teilnahme der Schweiz an EASA wird es daher in der Schweiz auch weiterhin zu regelmässigen Änderungen der Vorgaben und Normen kommen

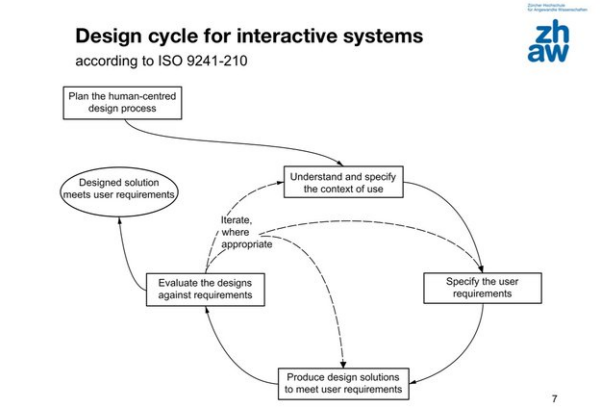
6 Federal Aviation Administration

- NAA
- Aufgaben:

- Hauptaufgabe: Festlegung und Überwachung des rechtlichen Rahmens zur Gewährleistung eines sicheren und effizienten Flugverkehrs (→ im Prinzip wie EASA in Europa)
- Dazu erlässt sie u.a. die Federal Aviation Regulations (FAR), d.h. Richtlinien, in denen die meisten Tätigkeiten in der Luftfahrt geregelt werden

- Die FAA nimmt mit ihren Entscheidungen unmittelbaren Einfluss auf die europäische – und damit auch die schweizerische – Luftfahrtindustrie. FAA-Zulassungen, -Normen, -Standards, -Beschlüsse, -Empfehlungen etc. wurden und werden oftmals auch international übernommen
- Umgekehrt hat auch die EASA Einfluss auf die US-Luftfahrtbranche
- EASA und FAA bemühen sich daher um gegenseitige Anerkennung von Verfahren und Regularien. Dennoch besteht nach wie vor ein hoher Harmonisierungs- und Abstimmungsbedarf

Human Factors Engineering + Unmanned Aviation (Woche 3.1)

- Unfall Air Intel Flug 148
  - vertical speed
  - flight path angle } gotten mixed up
  - 

  - human - machine systems is an iterative process
    users must be involved in the process right from the start

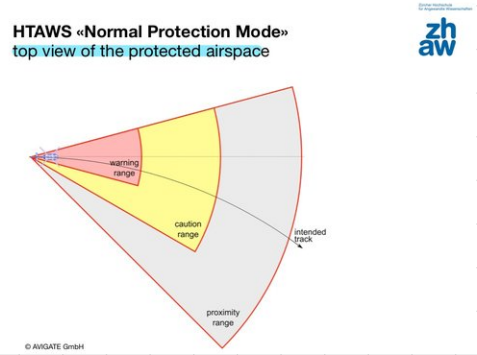
- the user doesn't know what he wants until he gets it
  then he knows what he doesn't want

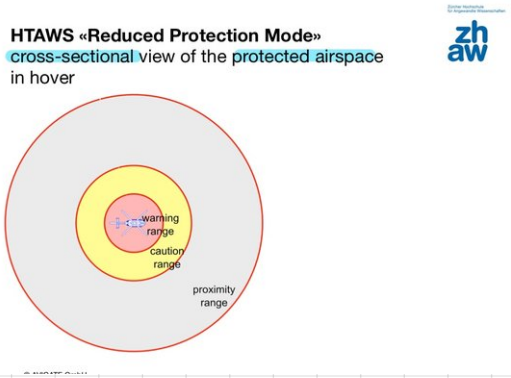
- a safety critical system or life - critical system is a system whose failure or malfunction may result in:
  - death or serious injury to people
  - loss or severe damage to equipment
  - enviromental harm

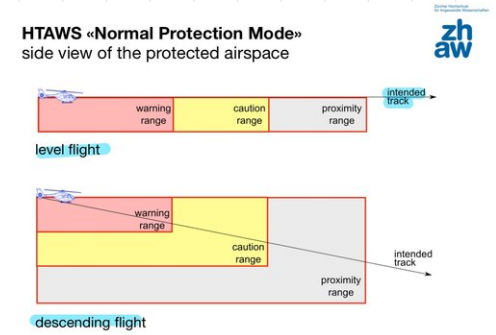
- Ergonomie: Anpassung Arbeitsbedingung an den Menschen
  - ergonomic product quality is described by the quality concept of usability
    quality concepts:
    - Usability describes the extent to which a product can be used effectively, effeciently and with a specific satisfaction (DIN ISO 9241-11)
      - effectiveness: describes the accuracy and completeness with which users can achieve a specific goal
        for example: navigation system that guides the user to a specific adress (street and house number) is more efficient than a navigation system that only guides the user to the street, where they can find the number of the house themselves
      - efficiency: refers to the cost-related effectiveness → the efficiency achieved in relation to the achieved accuracy and completeness with which the users achieves a specific goal
        for example: navigation system from which a user can select the address is more efficient than typing the whole address word by word

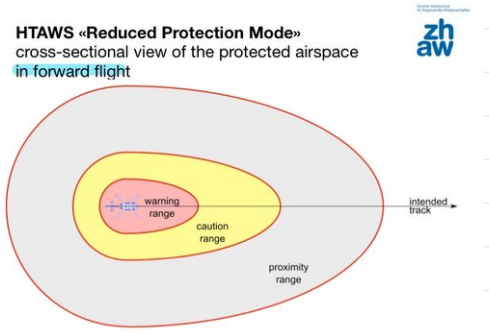
- **satisfaction**: is the extent to which the user's physical, cognitive and **emotional responses resulting** from the **use of a product** or service system are in accordance with the **user's needs** and **expectations**
  for example: user will be more satisfied with a navigation system that guides them with as few detours as possible
  delayed directions can lead to the user rejecting the navigation system

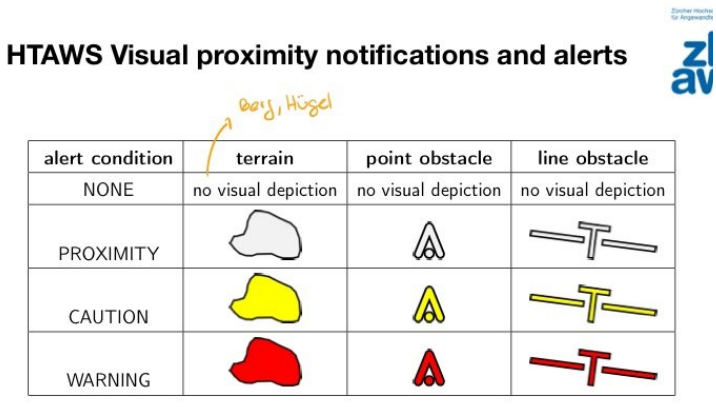
- HTAWS helicopter terrain awareness and warning system

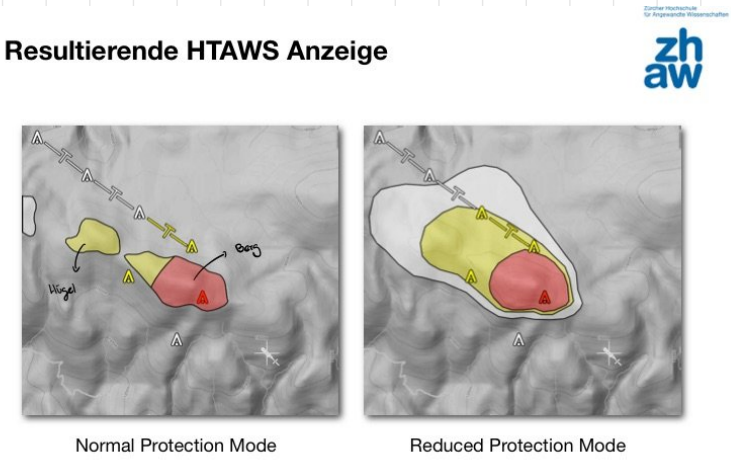




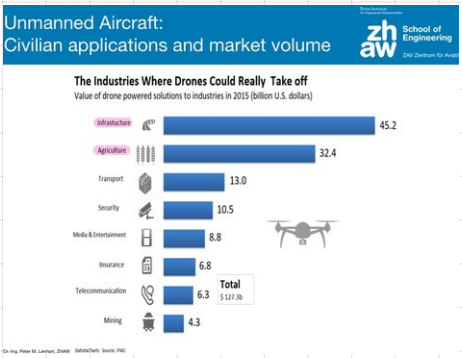








Unmanned Aviation:

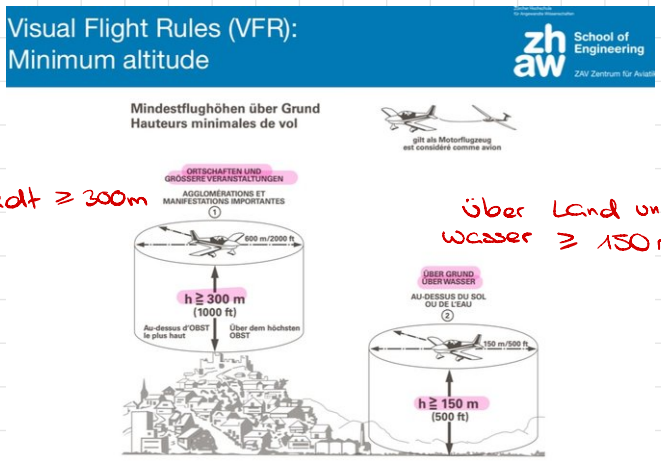
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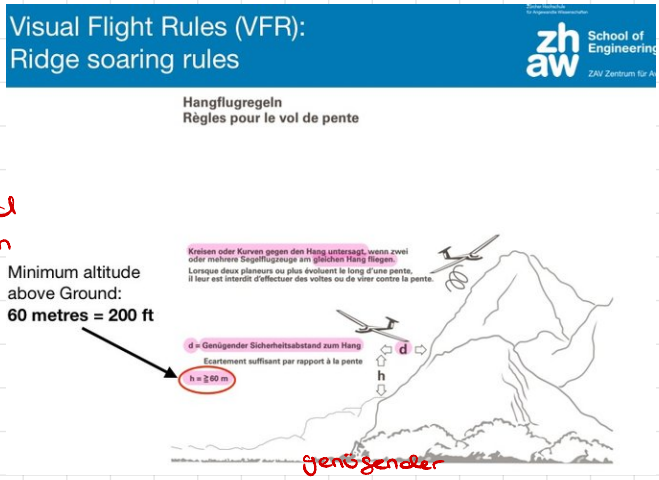
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- 

über Stadt ≥ 300m

über Land und Wasser ≥ 150 m



genügender
d = Sicherheitsabstand zum Hang
h ≥ 60m

„Ausser wenn dies für Start und Landung notwendig ist oder von der zuständigen Behörde genehmigt wurde, darf ein Flug nach Sichtflugregeln nicht durchgeführt werden:
1. über Städten, anderen dicht besiedelten Gebieten und Menschenansammlungen im Freien in einer Höhe von weniger als 300 m (1000 ft) über dem höchsten Hindernis innerhalb eines Umkreises von 600 m (2000 ft) um das Luftfahrzeug
2. in anderen als in **1** genannten Fällen in einer Höhe von weniger als 150 m (500 ft) über dem Boden oder Wasser oder 150 m (500 ft) über dem höchsten Hindernis innerhalb eines Umkreises von 150 m (500 ft) um das Luftfahrzeug."

„Überholen eines in ungefähr gleicher Höhe am Hang fliegenden Segelflugzeuges verboten.
Begegnung auf ungefähr gleicher Höhe:
Luftfahrzeug, welches den Hang zu seiner Linken hat, weicht nach rechts aus. Unter- oder überfliegen verboten."

Aircraft Systems 1: Basic of Aircraft Design
Aerodynamics, Aircraft Structures
Propulsion Systems (Woche 3.2)

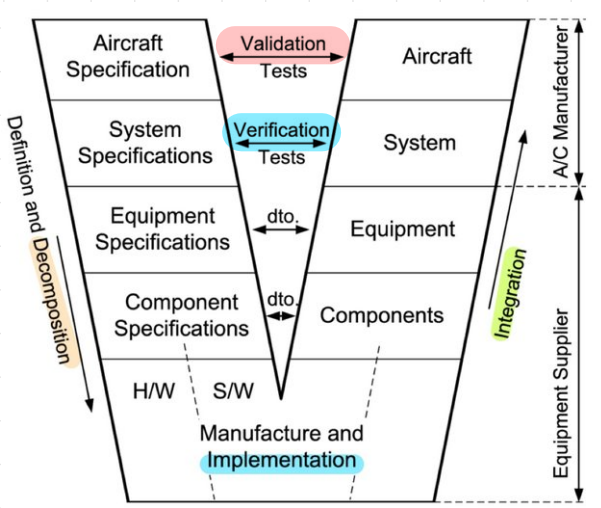
1. Why are we flying?
   - Types of missions
   - Benefits and Costs

2. What are the main functions of aircraft?
   - Transporting payload
   - Overcoming gravity
   - Overcoming drag

3. How can we do that?
   - Aircraft categories
   - Anatomy of the airplane

1. Why are we flying?
The aircraft design process:

The V model:
- understand the user needs
- derive aircraft requirements

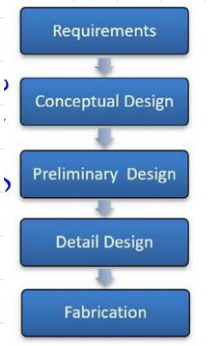


verify if requirements are met
validate if user requirements are met

verification: are you building it right?
validation: are you building the right thing?

Decompose - Implement - Integrate

- iterative process → going more and more into detail
- each phase will cost more and be longer than previous
- ensured that previous phases are done right



Types of missions:

Transporting payload
- people
- things
- to reach a certain position
- pilot training
- fun

Typical parameters to fly:

- mass and volume of the parameter
- speed and altitude
- infrastructure → runway length
- range / endurance

Regulations:

- climb rates
- safety requirements

Benefit and Costs

$$\text{efficiency} = \frac{\text{benefit / output}}{\text{cost / input}}$$

benefit:
- distance covered (A to B)
- time at position (sensor)

cost:
- financial cost: fuel, personnel
- time
- emissions
- risk

2. What are the main functions of aircraft?
Transporting payload:

2. Law of Newton:

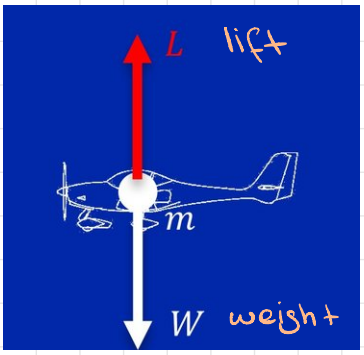
The change of motion ($\Delta\vec{a}$) of an object is proportional to the force ($\vec{F}$) impressed & is made in the direction of straight line in which the force is impressed

$$\vec{F} = m \cdot \vec{a}$$

weight force ⇒ $W = m \cdot g$

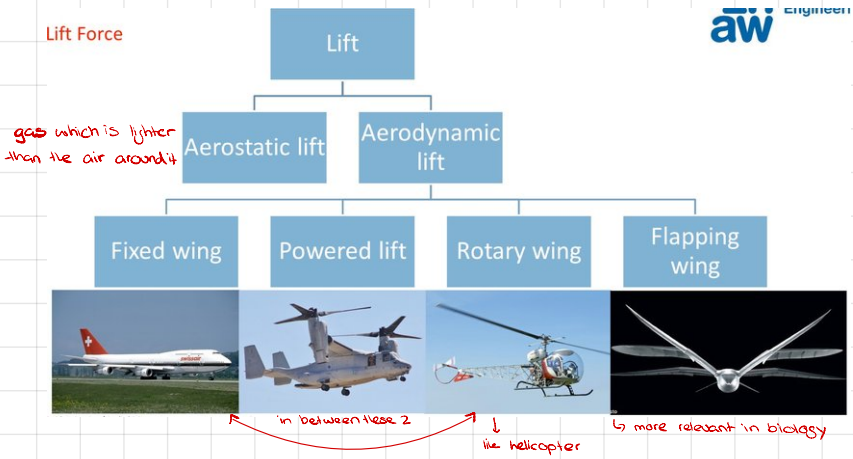
no force = no acceleration

Forces acting on the aircraft:
- weight
- lift



to overcome gravity we have to produce lift

Lift force:



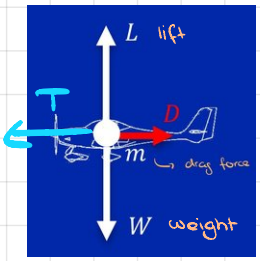
Overcoming drag:

converting potential energy into drag ⇒ propulsion
(Fortbewegung)

source of all drag: viscosity ⇒ high viscosity → high resistance
which means the easier the fluid moves - the lower the viscosity

Forces acting on the aircraft: weight, lift, drag
thrust

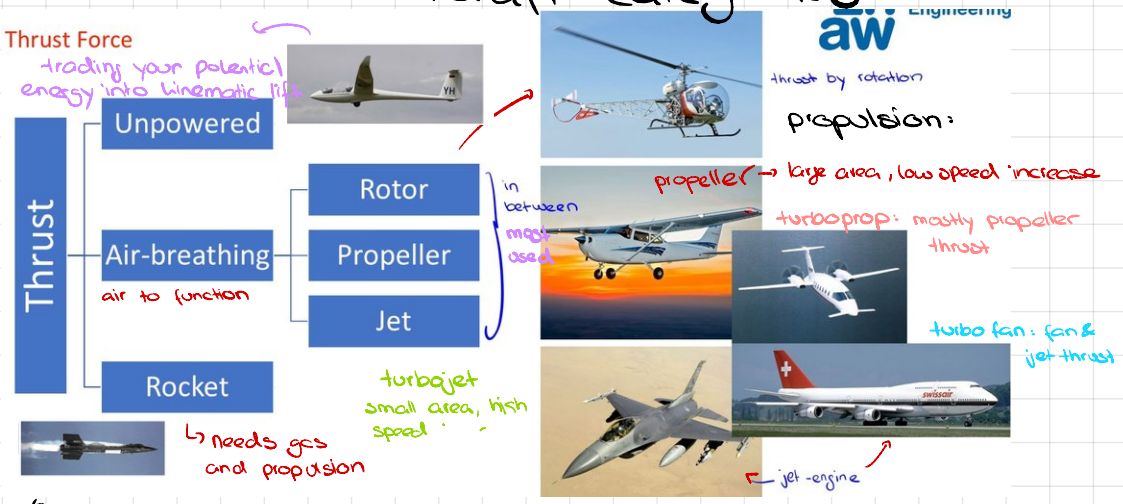
to overcome drag we have to produce thrust



$$\frac{\text{lift}}{\text{drag}} = \frac{L}{D} = c_{wert} \Rightarrow$$ measure for aerodynamic efficiency

3. How can we do that? Thrust force

aircraft categories



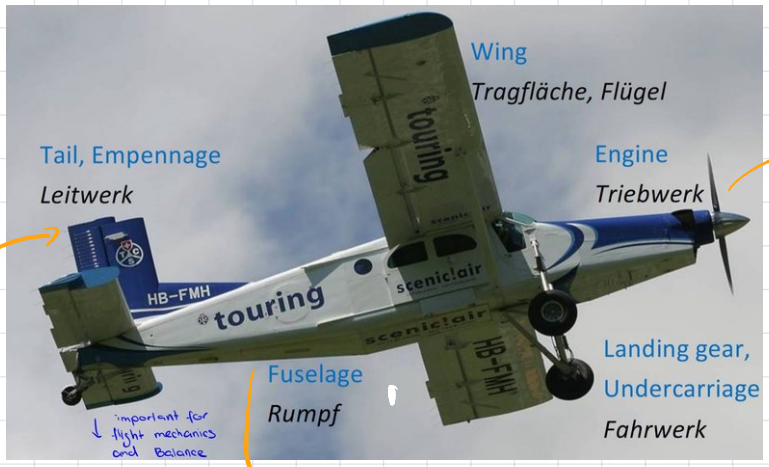
Thrust how to produce thrust

		Lift how to produce lift				
		Aerostatic lift	Aerodynamic lift			
			Fixed wing	Powered lift	Rotary wing	Flapping wing
Unpowered						
Air-breathing	Rotor					
	Propeller					
	Jet					
Rocket						

		Lift				
		Aerostatic lift	Aerodynamic lift			
			Fixed wing	Powered lift	Rotary wing	Flapping wing
Thrust	Unpowered	Balloon	Glider			
	Air-breathing: Rotor	Hybrid airship		Tilt-rotor	Helicopter	
	Air-breathing: Propeller	Airship		Tilt-wing	Gyroplane	
	Air-breathing: Jet		Airplane	Tail-sitter / Direct thrust		
	Rocket		glyder is not an airplane			

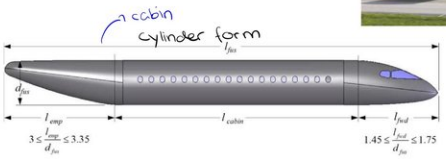
Anatomy of the airplane :

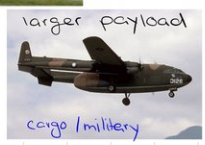
Overview :











Fuselage :

Primary function :

- provide space for payload

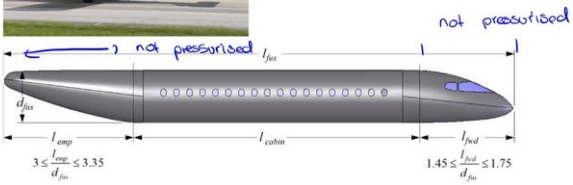
Secondary function:

- provide space for crew
- connect other parts of the airplane (landing gear, wing, empennage, engines)
- provide space for systems (avionic, hydraulics, electrics, pneumatics)
- provide space for fuel and other fluids

Shapes :

- Frustum
- pressure tube
- tadpole







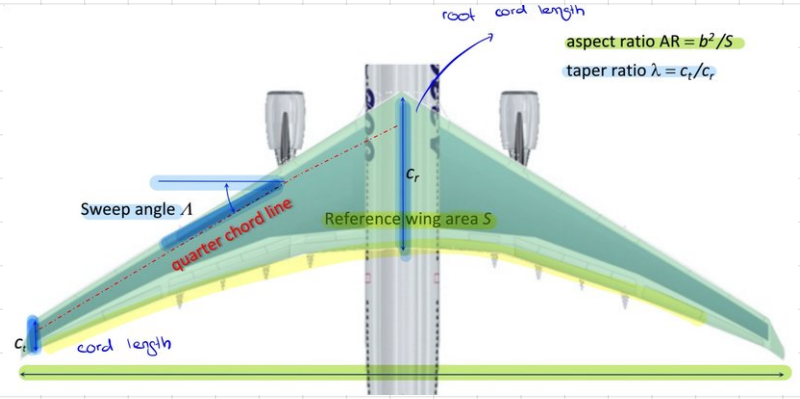
Wing:

Primary function: generate lift

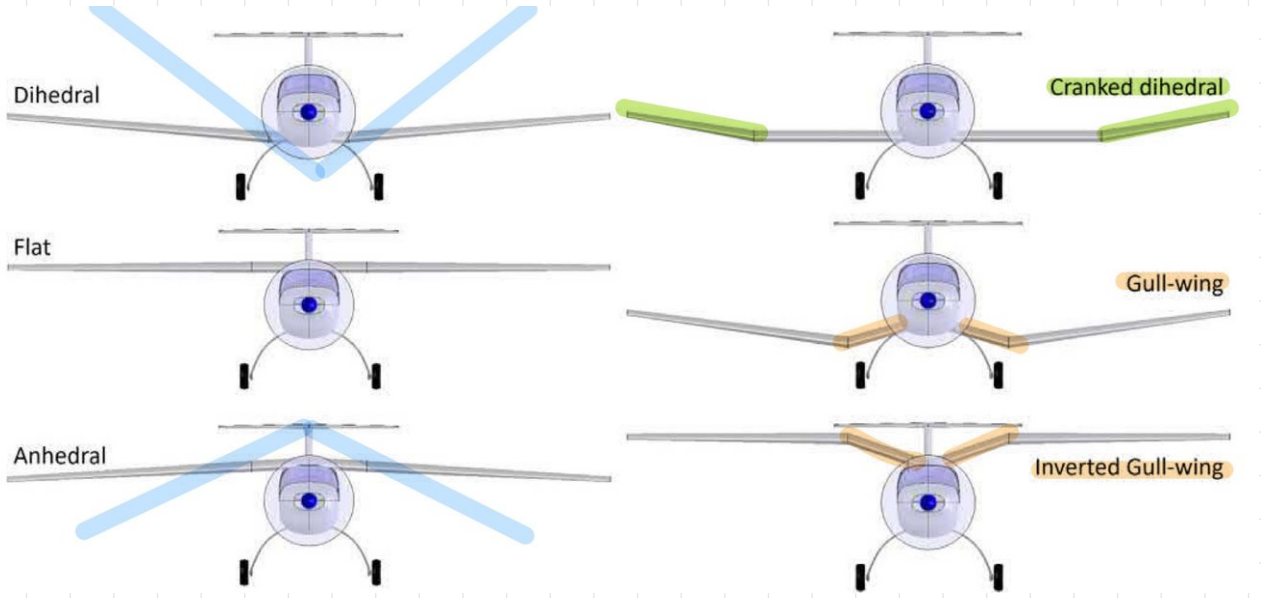
Secondary function:
- installation of landing gear
- installation of engines
- fuel storage
- roll control (ailerones, spoilers)

aspect ratio : $\frac{b^2}{S}$

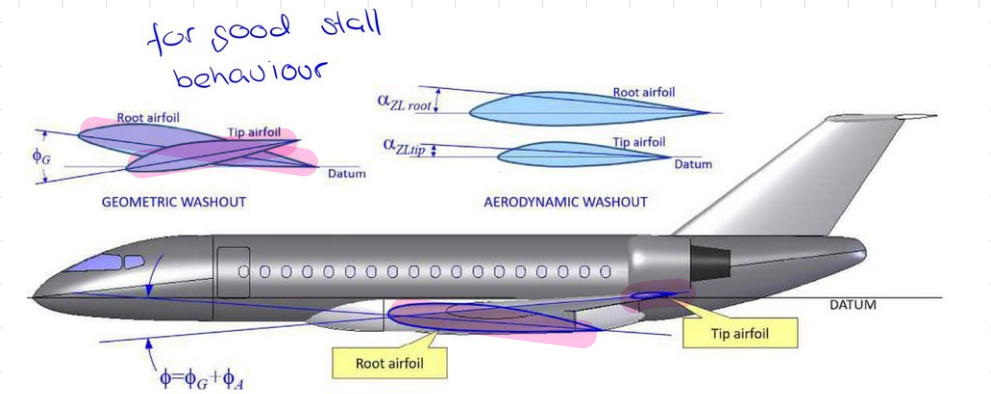
taper ratio $\frac{c_t}{c_r}$



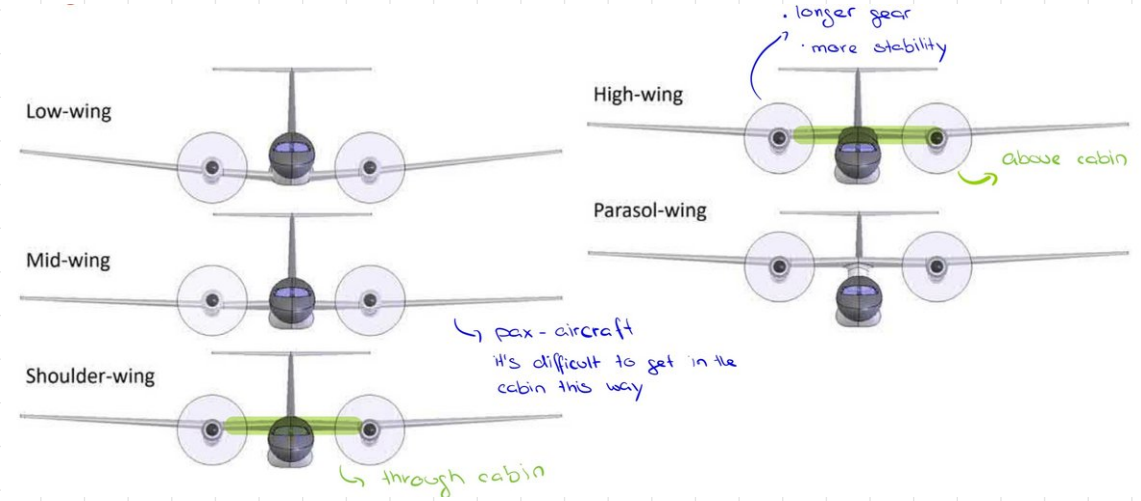
Wing shapes:



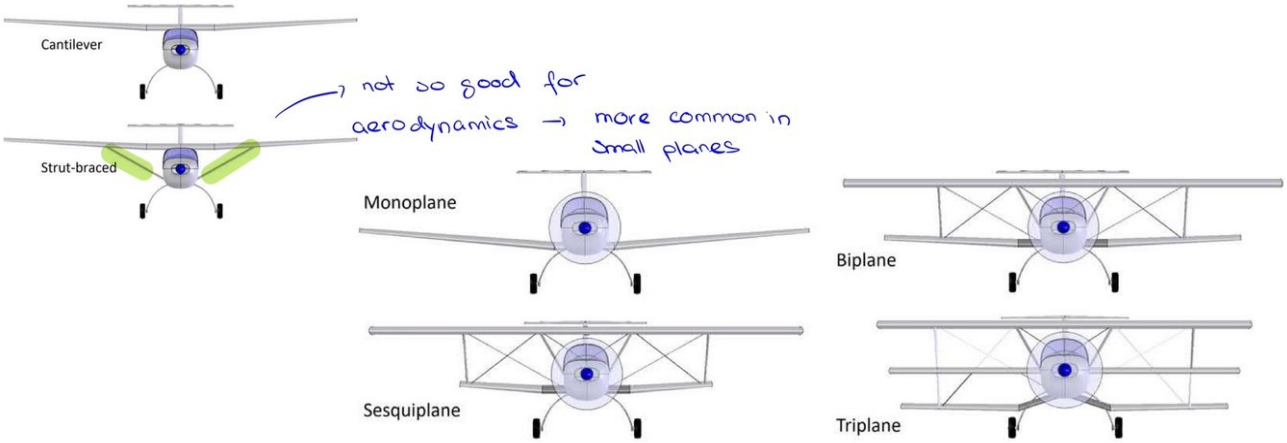
washout:



Position of the wing:



Types of wing:

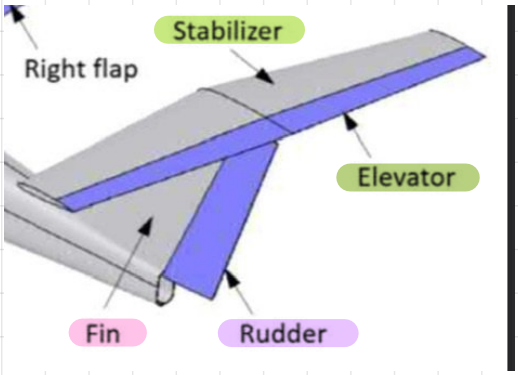


Empenage:

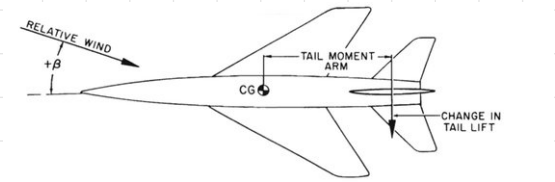
Primary function: provide stability and control

Vertical tail
- the fixed part is called fin or stabiliser
- the moveable part is called rudder

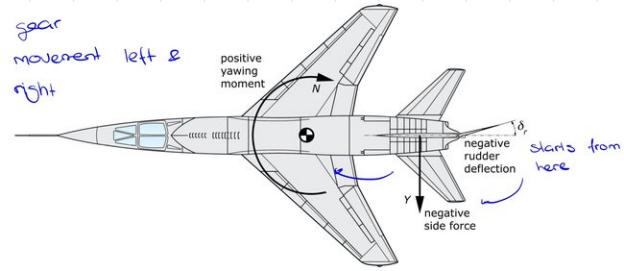
Horizontal tail:
- the fixed part is called stabiliser
- the moveable part is called elevator



- Provides stability



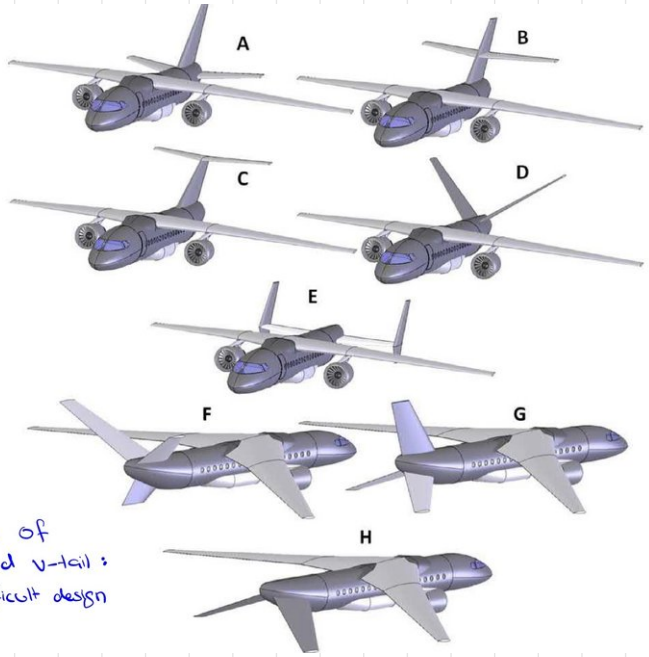
- Provides control



Shapes of empennages

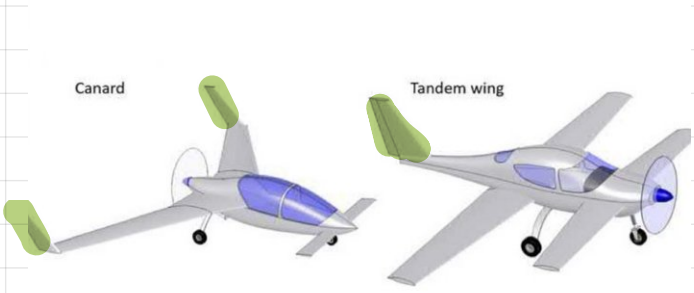
Empennage

- Conventional
- Cruciform
- T-tail
- V-tail
- H-tail
- Y-tail
- inverted Y-tail
- inverted V-tail



disadvantages of this this inverted v-tail: good clearance, difficult design tail at the back

Types of empennages:







Landing Gear:

Primary function:
- support the aircraft on ground, taxi, take-off and land
- Absorb the aircraft kinetic energy in the vertical direction at touchdown
- Stop the aircraft with the wheel brakes

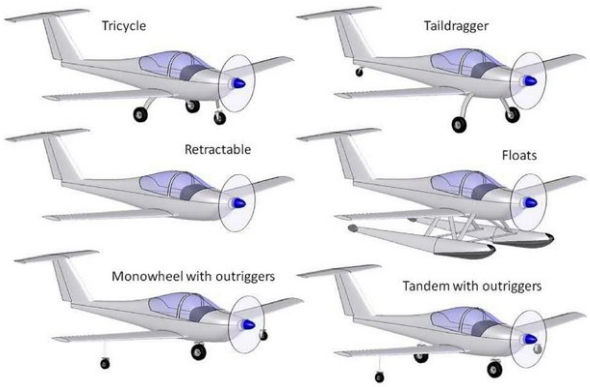
Usually divided into nose gear & main gear
↳ on most modern aircrafts main gear can retract after take-off to reduce aerodynamic drag





Types of landing gears:











Airplane design : Aircraft systems 2

Typical Designs According to Mission

aw Engineering

can't go to far (take-off/landing practice is good)



private pilot license
slam on the runway 1000 times - still flies
robust, good flight charac.
beginner aircraft



fixed gears, robust, easy to handle, side by side seats → good for teaching

military aircrafts



retractable gear, pilots behind each other, other type of engine
Preparing student for jet aircraft for much lower cost



fixed gear

all : propeller, 2-3 seats

one step further (not just take-off/landing)







commercial airplanes

↳ 2 engines (for safety reasons)



retractable gear
elaborate cruise system for high speed





only a few in the market
single engine jet



two engines



travel fast and longer distances



→ short range
→ high wing configuration (for landing purposes)





commercial for small routes





→ landing gear very good
very robust confisur.
beneficial for landing / take-off
very large engine in comparison to size



aside from general aviation aircraft for wilderness

conventional landing gear

4 float wings





a bit larger aircraft where you have short runways / rough surface



high wings
turbo jet engine similar to last slide but bigger aircrafts





all: something to carry thing / move around / vicibility from cockpit is very good / for operations in rough places
load gear / platforms







→ trying to replace by drones with camera
but you need helicopter for genuine lifting works













state of accident / to carry longer distance

retractable gear / 3 engines

to replace with this aircraft fixed wing aircraft for longer distances



interesting for aerodynamics

difference? in the middle designed for aerodynamic efficiency to glide as far as possible



aerobatic maneuvers for a perform.

transport aircraft

boeing project: somehow good aerodynamic struts

more aerodynamic efficiency



≠



opposite (who)

super-sonic again (concorde)

if want to fly fast, then you will loose a lot of fuel

Zurich University of Applied Sciences

Sources:

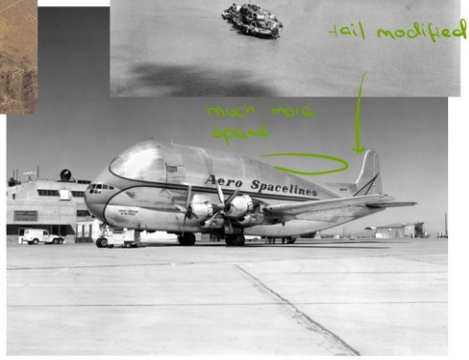
transporting a space shuttle



tail has additional vertical surface in order to carry a heavy aircraft → stability



tail modified



much more space

civilian planes

surveillance, coast guard

for that cameras on nose

having something on your nose is bad for stability

modification needed





Aircraft Systems 3 (Woche 4)

- Aircraft System Design
  ↳ the system "Aircraft"
  - aircraft system groups
  - ATA information standards
  - system integration
  - requirements

  ↳ safety system
  - practical safety objectives
  - design concepts

- Aircraft Systems
  - propulsion system
  - flight control system
  - emergency system
  - hydraulic system
  - pneumatic system
  - enviromental control system
  - ice protection system
  - electrical system
  - avionic system

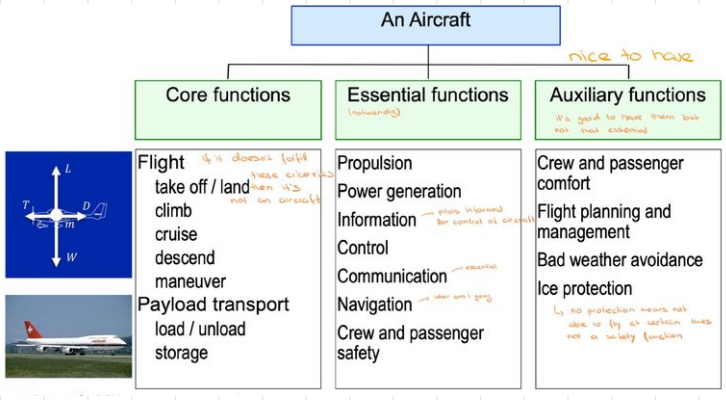
↳ The system "Aircraft"

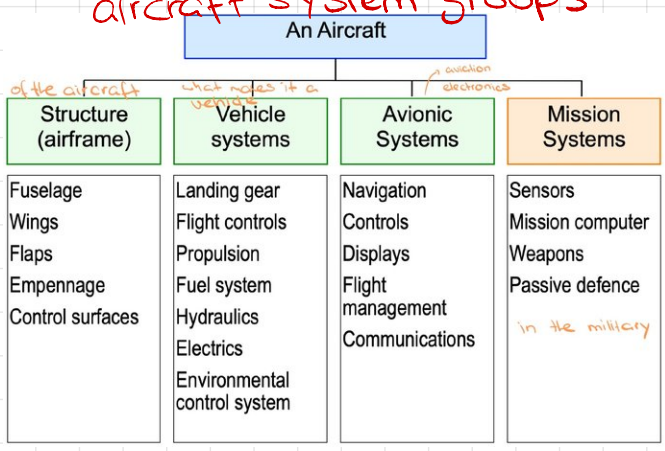
Definition of a System: Input → process function → Output

Feedback
output influences input

System Hierarchy:
systems have subsystem until you reach your components: transportation → air transport → aircraft

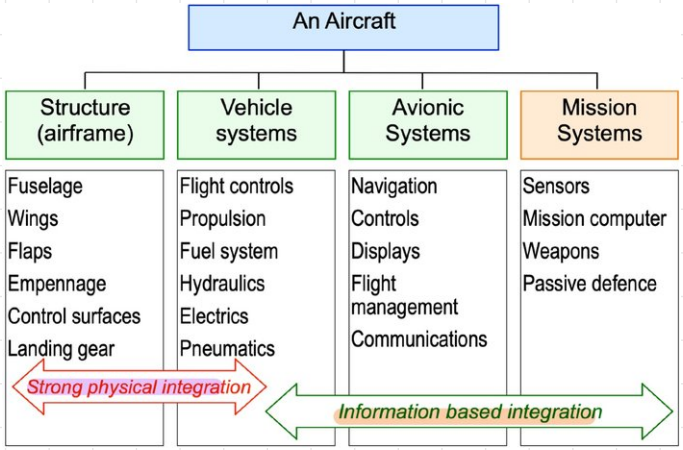
aircraft can be classified via functions | by structure
aircraft system groups

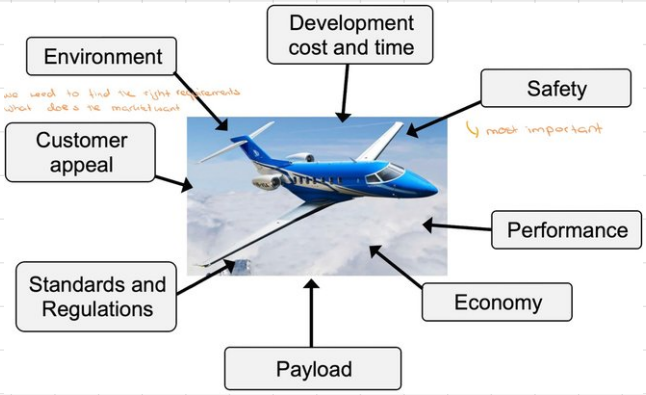




System integration: all is interconnected → complexity
total aircraft function because of interconnectivity

System integration:





↳ Safety Systems

Definition:

System ① → needs to be defined system
- Combination of parts, components, facilities, procedures, personnel, skills... that are connected in an organized way to perform one or more functions

Function ② identify the function of the system
- Lowest level of a specific action of a system, equipment, and flight crew performance on the airplane

f. example landing gear should be placed | other failures but if they're not influencing the core function than it's not a function failure not that bad

(Functional) failure
- Inability of a system, subsystem or component to perform a function as intended

Failure condition (FC)
- Condition with an effect on the aircraft and its occupants caused by one or more failures considering the relevant operational and environmental conditions

Single failure only of one component which are not independent from each other
- Failure of a single component, part, or element of a system, includes any set of failures, which cannot be shown to be independent from each other

there should be back-up system for it

- Navigation and Spatial Orientation (Avionics System)

function

- Display current altitude

could be 2

- Loss of Altitude Indication
- Misleading Altitude Indication

- Loss of ALT – e.g. in VMC – All Flight Phases
- Misleading ALT indication – e.g. in IMC – Approach/Landing
  ↳ critical

- Use of several, independent altimeters and static sources to prevent this

Severity of failure condition:

crashing the aircraft

Classification of Failure Conditions	No Safety Effect	<-----Minor----->	<-----Major----->	<--Hazardous-->	Catastrophic
Effect on Aeroplane	No effect on operational capabilities or safety	Slight reduction in functional capabilities or safety margins	Significant reduction in functional capabilities or safety margins	Large reduction in functional capabilities or safety margins	Normally with hull loss
Effect on Occupants excluding Flight Crew	Inconvenience	Physical discomfort	Physical distress, possibly including injuries	Serious or fatal injury to a small number of passengers or cabin crew	Multiple fatalities
Effect on Flight Crew	No effect on flight crew	Slight increase in workload	Physical discomfort or a significant increase in workload	Physical distress or excessive workload impairs ability to perform tasks	Fatalities or incapacitation

Design concepts:

- **safe - life**:

systems or components will survive a specific design life with no failures → A320 emergency oxygen system

- **fail - safe**: prioritizes safety by moving to a safe state

failure will cause no (or minimum) harm to other parts and systems or danger to personnel
→ PC-12 landing gear retraction system

- **fault - tolerant**: prioritizes continuity of operation despite faults

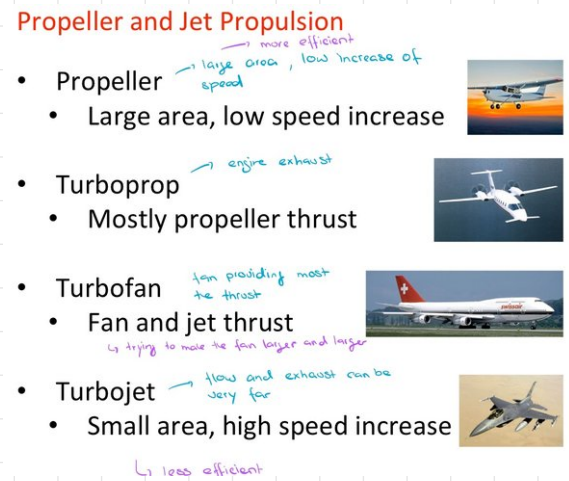
system can continue operating in the event of the failure of one or more of it's components
→ A320 hydraulic system even if one power fails other powers available

Aircraft Systems

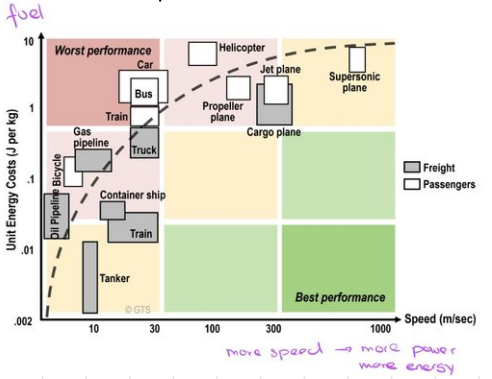
↳ Propulsion Systems

primary function: provide thrust (Schub)

requirements: high level of safety, reliability, overall efficiency, minimal drag, rapid response to engine change, low environmental impact



efficiency and environmental impact

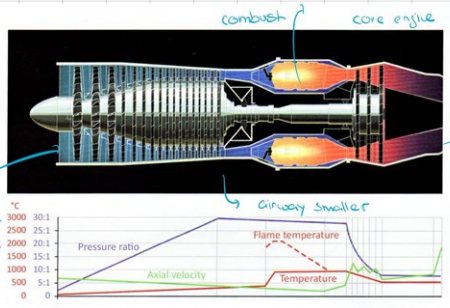


much more efficient than turbojet engine
today we have a bigger fan than the engine

thermal efficiency: from power in fuel flow to mechanical power → dependent on engine type

propulsion efficiency: from mechanical power to propulsive power → dependant on flow area

Turbojet:

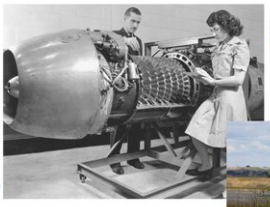


Turbojet

Examples

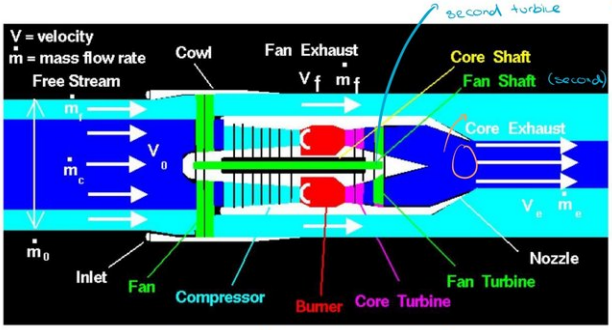
- Junkers JuMo 004 axial flow turbojet (1943): 2.8 kW/kg
- Pratt & Whitney F135 axial flow turbojet (2009): 38 kW/kg

a lot more power in comparison to size of engine






Turbofan:



second turbine

extracting energy or air from here ○ and giving it here →

much more efficient than turbojet engine

Examples

- Pratt & Whitney JT8D turbofan (1963)
- General Electric GE90 turbofan (1990): 52.9 MW at initial climb speed (200 kt), 6 kW/kg

fan is relatively small in comp. to engine




normally today we have a bigger fan in comparison to the engine




Turboprop

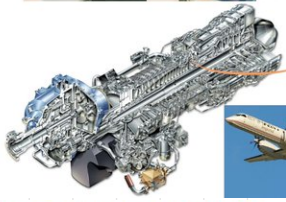
Turboprop

Examples

- Rolls-Royce RB.53 Dart turboprop engine (1946): 2.48 kW/kg
- Rolls Royce-Allison AE2100 turboprop engine (1990): 4 kW/kg

not that much of a difference



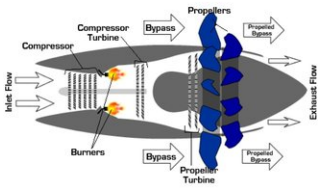




Propfan

Propfan / Unducted Fan (UDF)

Principle & Prototype



annoying

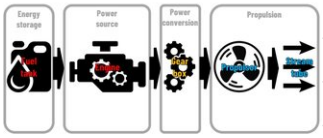


Propeller propulsion : • turbofan, propfan / unducted fan UDF
use rotating blades to generate thrust
↳ for larger GA
• piston engine
↳ for smaller GA
• electric propulsion (nowadays)



conventional piston energy:

used in smaller aircrafts
A conventional system, which could be replaced by EHPS, usually consists of a propeller driven by a piston engine
•Energy is stored inside fuel
•Engine converts fuel flow into mechanical power
•Propeller converts mechanical power into propulsive power



conversion of fuel into energy

Altitude effects
•The engine will provide less power when the air provided to it has lower density, i.e. at higher altitudes and higher temperatures (hot-and-high conditions).
•In order to provide enough air for the combustion process, turbochargers are usually needed at higher altitudes.
•Also air flow is needed for cooling

then we have less air → less temp → less power → lower

uses one or more pistons to convert energy released from fuel to mechanical energy

battery-electric propulsion system

Compared to a conventional propulsion system with a piston engine, a battery-electric propulsion system has the following advantages and disadvantages

Efficiency
•Very high efficiency of battery, power electronics and motor
•Around 90% efficiency from battery to propeller shaft, compared to around 30% for piston engines
•Propeller efficiency most important for overall efficiency of propulsion system
•Even better efficiencies of motor and power electronics relevant for cooling, not so much for propulsion efficiency (98 instead of 96% is not much of a difference, but 2% losses is half of 4%)

cooling has a connection to drag



Mass
•The overall system can be relatively light-weight for «zero range»
•Thanks to the high efficiency, only a third of the energy is required
•But batteries still have a much lower energy density compared to fuel and will be prohibitively heavy even at medium ranges
•Suitable for short range/endurance applications, such as certain UAV, UAM, aerobatics aircraft, self-launching sailplanes

Complexity
The system is less complex mechanically, there are only few moving parts. But espcially due to the battery it consists of many components and can be complex in terms of safety and system design.

electricity stored in batteries to power an electric motor → generates thrust
↳ no fuel → zero-emissions

distributed propulsion : multi-engine aircraft

Conventional: Multi-engine aircraft
•Due to increased safety, multi-engine aircraft are used for commercial aviation. In case of an engine failure, the remaining engine(s) have to be able to produce enough thrust for climb with a reduced climb rate with the failed engine producing additional drag.
•The system has to be sized accordingly, i.e. with 1 of 2 engines operating for twin-engine aircraft, or 3 of 4 engines. Due to increased maintenance effort and complexity, only few aircraft have more than two engines.
•Since the performance of twin-engine aircraft is poor after an engine failure and the probability of such an event is higher compared to a single engine aircraft, the historical accident rates are only somewhat lower.
•Nonetheless, multi-engine aircraft also offer better performance due to increased propeller area.

you can have one engine failure you still can fly with 2. one → additional drag



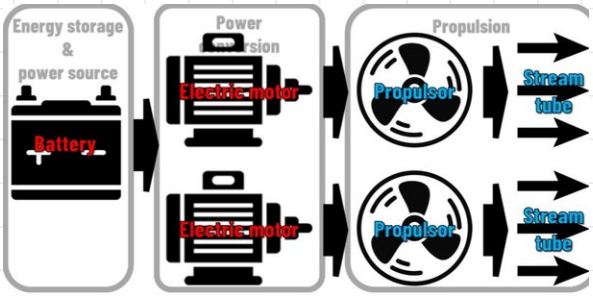
use of multiple smaller engines or electric propulsion distributed across the aircraft rather than relying on a few big large engines

distributed electric propulsion: DEP

Skaleneffekte — Wirkungsgrad — Leistungsdichte

electric motors are suited to scaling → efficiency and power density is less effected
propulsion systems with multiple motors are a new concept
multiple motors (and propulsors) used along the wing → distr. electric prop.





increased total area of propellers increases efficiency → less blockage of flow

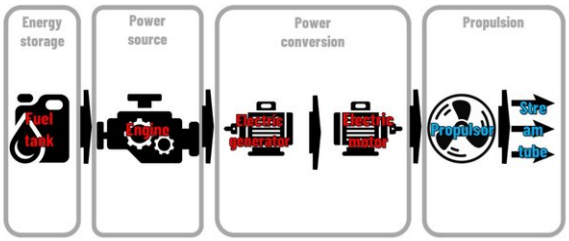
advanced propulsion system → multiple electric motor are strategically distributed across an aircraft

- in an aircraft with DEP in front of the wing results in: airflow over the wing has higher speed ⇒ higher lift at lower aircraft speeds
- DEP can be used for powered lift systems → like helicopters
- aircraft can be controlled (Steuerung) by placing assymetrical power settings on wingtips
  especially for powered lift -the fast reaction time of electric motor is neccessary for control.

for that reason: safety consideration must pay attention to failures near the wing tips esp. asymmetrical failure of multiple propulsors

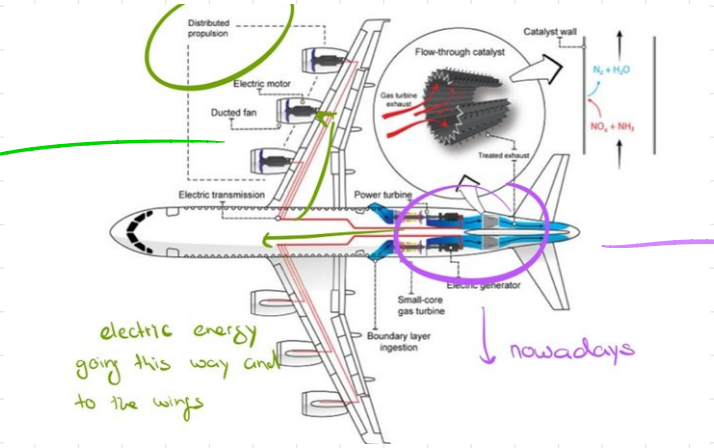
Engine generator & electric motor: ↗ combines fuel powered engine that drives generator to produce electricity, which powers an electric motor for propulsion

- Combination of conventional propulsion with electric propulsion
- Power is generated by a piston, turbofan, -prop, or -shaft engine
- Generator converts this into electric energy
- One or more electric motor(s) provide power for the propeller(s)



- using an electric generator adds mass to the propulsion sy. power requirements the same for a conventional system during transient flight phases (instationäre Phase). A battery is of advantage ⇒ side hybrid systems

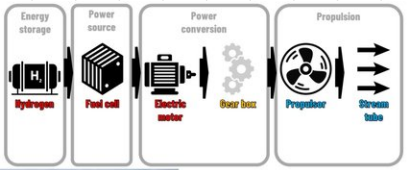
Advantage:
- use of distributed propulsion
- because of high specific power of electric motors allows further placement of propulsors from the engine
  (usually engine placement is limited due to structural inertia considerations)
  ↳ Trägheit

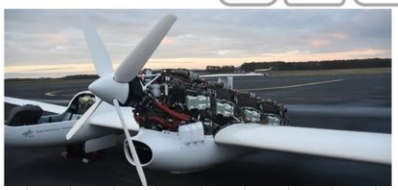


Fuel cell & electric motors :

uses hydrogen or another fuel to generate electricity through a chemical reaction in fuel cell
↳ electricity powers electric motor to provide propulsion

Hydrogen stored in liquid (LH2), gaseous (GH2), or other (e.g. methanol) form is supplied to the fuel cell, which generates electric power. The rest of the propulsion system is the same as for the battery-electric system.

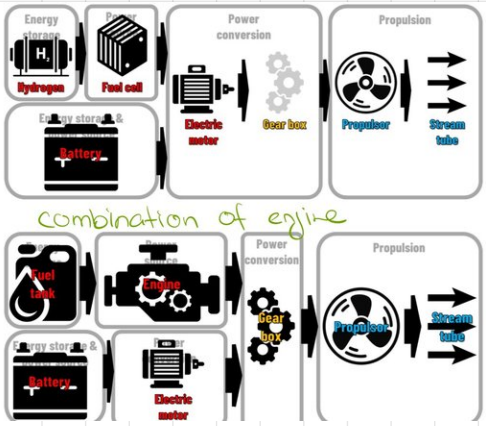




- fuel cells for mobiles are becoming lighter
- the efficiency can be high → max 70% , typical range 40% - 60%
- extreme high energy desity is stored in heavy & large energy tanks
  → leaks hydrogen over time
- hydrogen embrittels materials → has to be vented
- dynamic behaviour can be lacking for certain types, if not used as hybrid

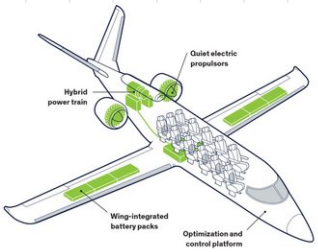
Hybrid propulsion systems : series, parallel & series parallel

- Series: Fuel cell (or other power source) powers electric motor. Battery can add (discharge) or subtract (charge) power to the balance, dependent on requirement
- Parallel: Engine and electric motor are mechanically connected
- Series-parallel: Engine, electric motor, and generator are mechanically connected



Hybrid systems combine several power sources:

- long term : engine, engine-generator, fuel cell
  for cruise flight
  fuel with energy density
- shor term : battery
  for take-off , climb , transient power requirements
  good dynamic behaviour of overall system



↳ long term power source can be smaller and optimized for power requirement during cruise flight

↳ Improvement dynamic behaviour of the system : by combining the long term power source (higher power requirement) and battery for take-off and climb

Optimisation of hybrid propulsion systems:

there is a lot scope to optimise speed via these parameters: climb rate, cruise altitude, cruise speed, desend rate

not a lot of scope for automotive vehicles

Other power sources like solar:

besides the long-term and short-term, conventional engine, dynamic power requirements is solar another power source

Leistungsausbeute

- relatively low power yield (per wing area) (25% under ideal conditions) but only aircrafts with very long wing loading and cruise speed can be powered this way
  ↳ Flächenbelastung Reisegeschw.
  angetrieben
  + aircraft has to fly above clouds → solar power only used for specific jobs





How to define efficiency in engineering?

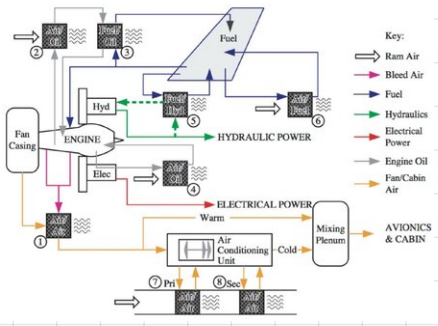
- aviation → we want to be ① lightweight ② reduce mass and therefore drag → power required

general: reduction of fuel consumption

Overall: Function of propulsion system

Primary function
- Provide thrust

Secondary functions
- Drive generators to provide electrical power
- Drive pumps to provide hydraulic power
- Turbine engines can provide bleed air to
  - power the ECS (environmental control system)
  - pressurise the cabin
  - prevent ice formation on aircraft surfaces



↳ Flight control system



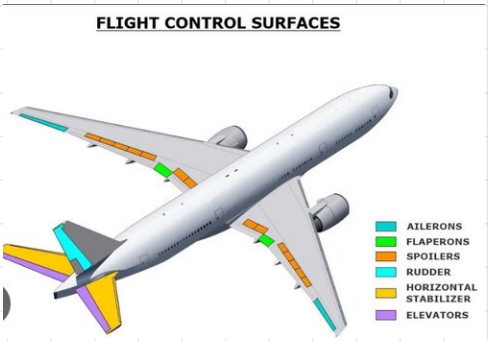
Definition of axis:

- control yoke: (joystick) controls the aircrafts roll by using the ailerons → change in flight path
- control yoke: can also change the pitch of the aircraft
- rudder petals: controls the aircrafts yaw

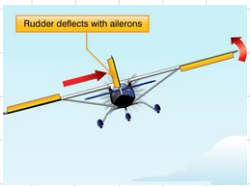
Actuator mechanical: mechanical or manually operated flight controls are the most basic way of controlling an aircraft They are used in smaller aircrafts where the aerodynamic forces are not excessive

- ailerons → roll
- elevator → pitch
- rudder → yaw

} primary control system — all connected through mechanical linkages → cables



Linear actuators: with follow up control



Actuation: Fly-by-wire

replaces the manual flight control system with an electronic interface. The movements of flight control systems are converted to electronic signals transmitted by wires.

Flight control computers determine how to move the actuator at each control surface to provide the expected response

↳ Emergency systems: no system is perfectly safe

- emergency system cover the most likely or critical failure scenarios of aircraft systems:
  - ↳ they should be seperated from primary systems to avoid failure
  - ↳ very reliable and should operate under overs conditions
  - ↳ should be easy to operate during stressful situations

Grouped into: warning systems, protection systems, escape systems

Warning systems: Function: fire detection, smoke detection

• Red	Critical condition	Warning	Immediate action required
• Amber	Abnormal condition	Caution	Immediate attention required
• Green	Normal condition		
• Other colors	Status or reminders		

Protection systems: Function: fire extinguishing system, emergency oxygen supply emergency equipment

Escape systems: Function: emergency exists, rescue parachutes, ejection seats

↳ Hydraulic systems:

Primary function: control moveable parts by transforming hydraulic energy into mechanical energy

Examples:
- Primary and secondary flight control actuation
- Landing gear extension and retraction
- Landing gear doors operation
- Wheel braking
- Nosewheel steering
- Door operation
- Loading ramp operation
- Passenger stair operation
- In-flight refuelling probe extension
- Canopy actuation

→ Übersicht

↳ Pneumatic systems: similar to hydraulics but with air (compressible)

Primary function: provide bleed air with high pressure and high temperature from turbine engine to other systems

Examples:
- Air conditioning and cabin pressurisation
- Cargo compartment heating
- Ice protection
- Turbine engine starting
- Windscreen de-mist and rain dispersal
- Pressurisation of hydraulic oil reservoirs, fuel tanks, water tanks
- Power generation by compressed air turbines
- Actuation

→ Übersicht

↳ Environmental control system

Primary function: provide safe and comfortable environment to crew and payload

Ideal parameters:
- Atmospheric pressure higher than 750 mb;
- Temperature between 18◦ and 23◦C;
- Relative humidity between 20 and 70%;
- CO_2 volume concentration below 0.5%;
- CO volume concentration below 0.005%;
- O_3 volume concentration below 0.25 parts per million

→ Übersicht

↳ Ice Protection System:

Primary function: De-ice or prevent anti-ice formation on safety critical parts of the aircraft

↳ Electric System: supply electrical power to other system

↳ Avionic System: many → any electronic device (including electrical part) for use in an aircraft → radio automatic flight control, navigation, fly-by-wire

aviation & electronics

Aircraft Systems 4 (Woche 5.1)

A	AD	Airworthiness Directives
	AEA	Association of European Airlines
	A4E	Airlines for Europe
	AFM	Aircraft Flight Manual
	ALI	Airworthiness Limitation Item
	AMC	Acceptable Means of Compliance
	AMOC	Alternative Means of Compliance
	AMP	Aircraft Maintenance Program
	AOC	Air Operators Certificate
	AOG	Aircraft on Ground
	ARC	Airworthiness Review Certificate
	ATA	Air Transport Association
B	BAZL	Bundesamt für Zivilluftfahrt
C	CA	Continuing Airworthiness
	CAA	Civil Aviation Authorities
	CAM	Continuing Airworthiness Management
	CAMO	Continuing Airworthiness Management Organisation
	CAME	Continuing Airworthiness Management Exposition
	CDL	Configuration Deviation List
	CMR	Certification Maintenance Requirement
	CofA	Certificate of Airworthiness
	CofR	Certificat of Registration
	CRS	Certificate of Release to Service
D	DD	Deferred Defect
	DOA	Design Organisation Approval (EASA Part-21 related)
E	DOT	Department of Transportation
	EASA	European Aviation Safety Agency
	EC	European Commission
	ECAC	European Civil Aviation Conference
	EMS	Event Measurement System
	ETOPS	Extended Range Operation with Two-Engine Airoplanes
F	FAA	Federal Aviation Administration
	FOCA	Federal Office for Civil Aviation
	IATA	International Airline Transport Association
I	ICAO	International Civil Aviation Organization
	IOSA	IATA Operational Safety Audit
L	LLP	Life Limited Part
	LTA	Lufttüchtigkeits Anweisung
M	MCC	Maintenance Control Center
	MEDA	Maintenance Error Decision Aid
	MEL	Minimum Equipment List
	MMEL	Master Minimum Equipment List
	MOE	Maintenance Organisation Exposition
	MP	Maintenance Program
	MPD	Maintenance Planning Document
	MRB	Maintenance Review Board
	MRBR	Maintenance Review Board Report
	MRO	Maintenance Repair & Overhaul Organisation
	MSG	Maintenance Steering Group
N	NAA	National Aviation Authorities
	NP	Nominated Person
	NPA	Notice of Proposed Amendment
	NPCA	Nominated Person for Continuing Airworthiness
	NPCT	Nominated Person for Crew Training
	NPFO	Nominated Person for Flight Operations
	NPGO	Nomiated Person for Ground Operations
	NOC	Network Operations Center *(former ELS => Einsatzleitstelle)*
O	OEM	Original Equipment Manufacturer
P	PFC	Pre-Flight Check
	PIC	Pilot in Command
	PIREP	Pilot Report
S	SAFA	Safety Assessment of Foreign Aircraft
	SASA	Safety Assessment of Swiss Aircraft
	SB	Service Bulletin
	SMS	Safety Management System
	SPI	Safety Performance Indicator
	STC	Supplement Type Certificate
	SUST	Schweizerische Unfalluntersuchungsstelle
T	TC	Type Certificate

- **Aircraft Dispatch** — *An Aircraft is ready for operation => it can be "dispatched"*
- **Airworthiness Directive** — *A directive from the authority (for instance EASA or FAA) to perform a specific task within a given timeframe*
- **AMC** — *Acceptable Means of Compliance (EASA) => guidance on how the law can be fulfilled*
- **AMOC** — *Alternative Means of Compliance (approval request towards local authorithy) => another way on how an airline considers to comply with law*
- **AOG** — *Aircraft on Ground => not able to fly due to technical problem*
- **CAME** — *Master Manual (Bible) for all EASA Part-M related contents. Basis Manual for CAMO (EASA Part-M Subpart G) approval certificate.*
- **CRS** — *Certificate to technically release the Aircraft/Engine or Component with the signature of an appropriately licenced mechanic*
- **ETOPS** — *Related to twin engine operated aircraft. Approval typically given for 180 minutes => Crew must always be able to land the aircraft within 180 minutes on an appropriate airport (affects the flight plan)*
- **OEM** — *Original Equipment Manufacturer / TC Holder (Airbus, Boeing, Cessna, etc.)*
- **DOA** — *EASA approved Design Organisations developing equipment, parts, material adequate to the OEMs covered e.g. with a STC (if major change)*
- **LLP** — *A part where the life is limited. After limit reached => part to be scrapped*
- **MEL / CDL** — *Minimum Equipment required to dispatch the aircraft. Located in each single aircraft*
- **MMEL** — *Master MEL published by TC holder (aircraft manufacturer). Airline is not allowed to operate according this manual*
- **MEDA** — *Investigation basic for human factor related occurrences*
- **MOE** — *Master Manual (Bible) for all EASA Part-145 related contents. Basis Manual for Part-145 approval certificate.*

optional

1. Main aircraft manufacturers
2. Airbus global market forecast 2023-2043
3. Boeing commercial market outlook 2023-2043
4. Aircraft maintenance: Roles and responsibility
5. Regulatory situations
6. Training organizations

Questions you should be able to answer:

1. Name some of the aircrafts manufacturers of the 20th cent.
2./3. What are the Airbus global market forecast and Boeing commercial market outlook?
4. Difference between EASA Part-M, Part-CAMO, Part 145
4. Is it allowed to transfer the overall responsibility for airworthiness
4. Is sub-contracting of contracted Part-145 tasks allowed?
5. Why do we have rules & regulations in civil aviation industry?
5. How are the continuing airworthiness requirement Annexes named in the EASA environment?
6. Name the different Part-66 License categories

1. Civil Aircraft Manufacturers: 1945 - 1960



Markt dominiert von amerikanischen Hersteller

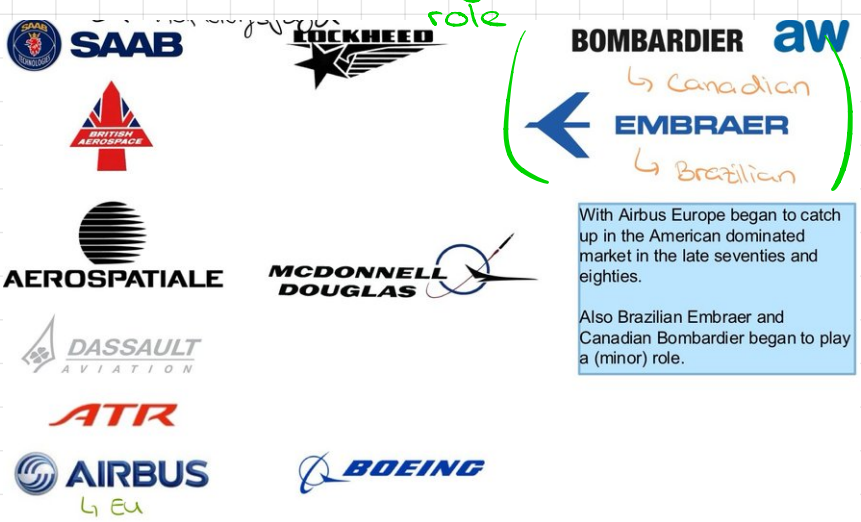
aviation boosted by 2nd world war

post war: enormous development and production industry

1960 - 1975 founding of Airbus 1970



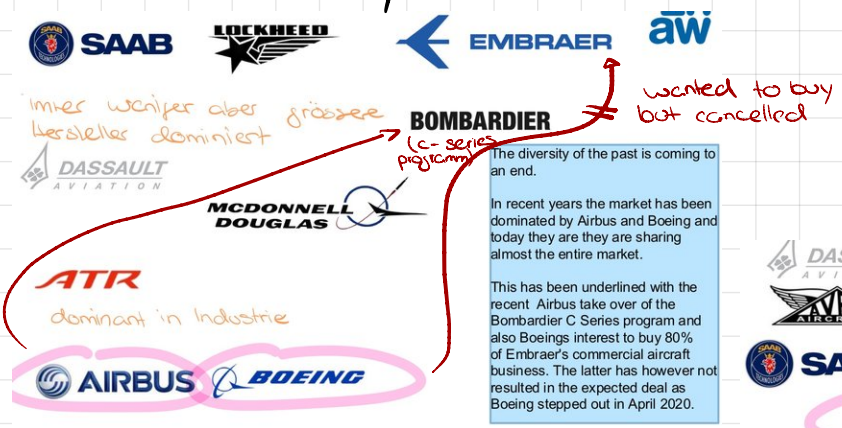
1975 - 1990 began to play a minor role



With Airbus Europe began to catch up in the American dominated market in the late seventies and eighties.

Also Brazilian Embraer and Canadian Bombardier began to play a (minor) role.

1990 - Today

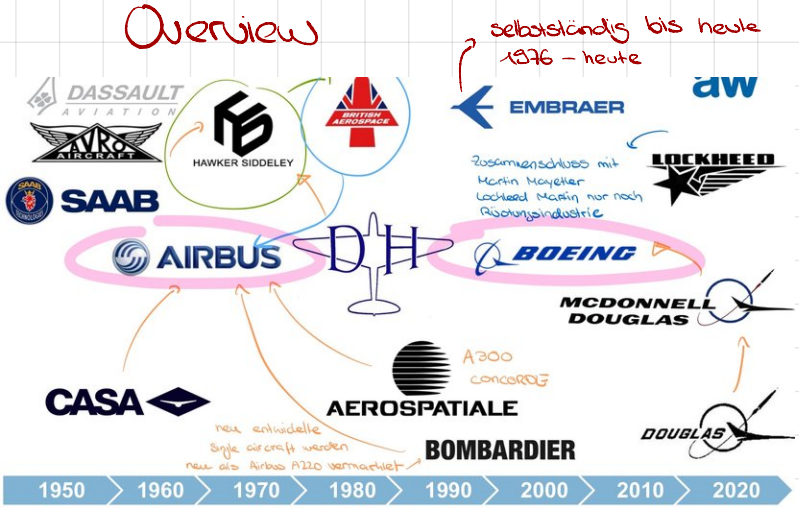


The diversity of the past is coming to an end.

In recent years the market has been dominated by Airbus and Boeing and today they are sharing almost the entire market.

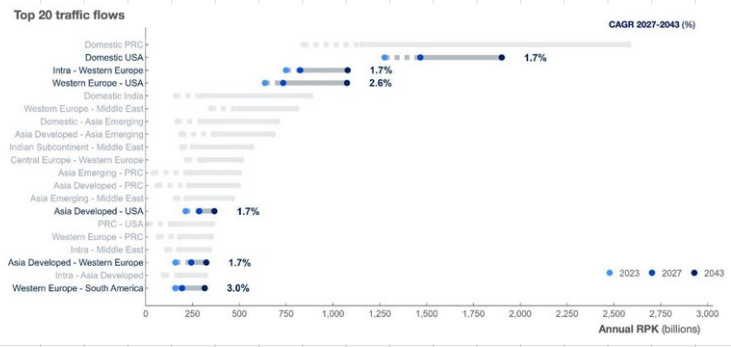
This has been underlined with the recent Airbus take over of the Bombardier C Series program and also Boeings interest to buy 80% of Embraer's commercial aircraft business. The latter has however not resulted in the expected deal as Boeing stepped out in April 2020.

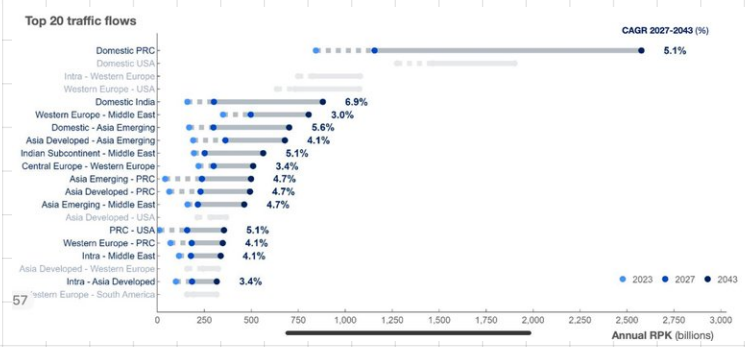
Overview



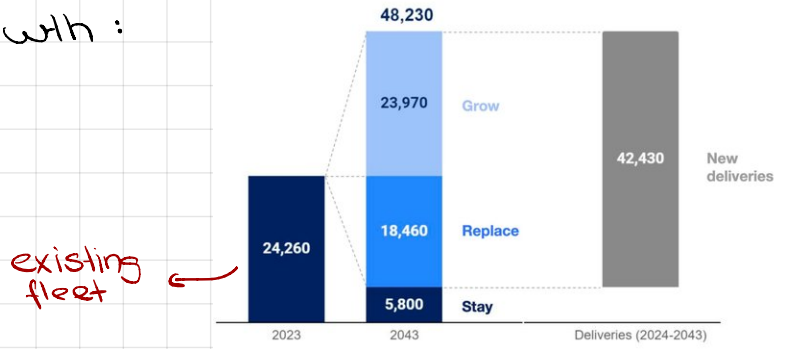
2. Airbus global market forecast 2023-2043

- industry is resilient and the numbers are as predicted growth positive
- there is modest traffic growth in mature flows (Straden) like: Domestic USA, Western Europe, WE — USA Asia Developed — USA, Asia Developed - WE Europe, WE - South America from 1.7% to 3%.
- stronger traffic growth in Asia, Middle East led by India and China (PRC) from 3.1 - 6.5%.



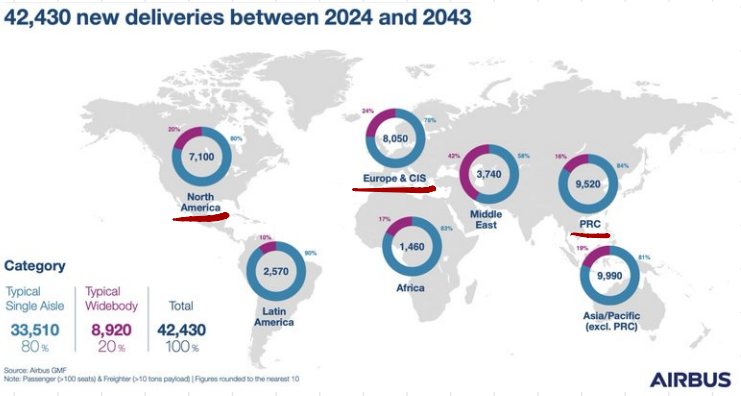


- expected growth:



existing fleet ←

42'430 new deliveries



PRC delivery number same as (or even more) than EU and N. America

- the most effective solution to decarbonise aviation is from SAU sustainable aviation fuels

TAKEAWAY:

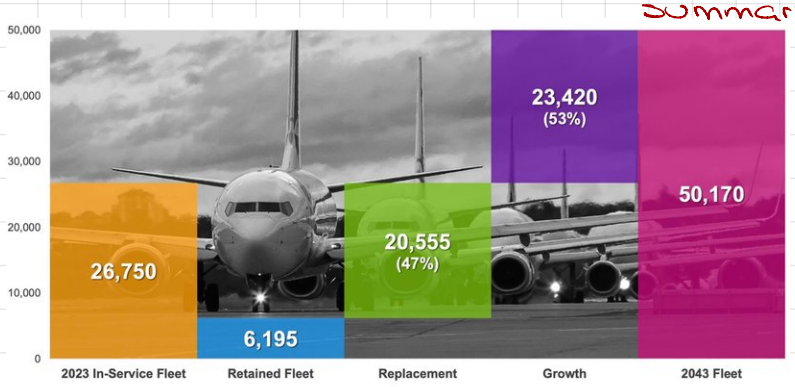


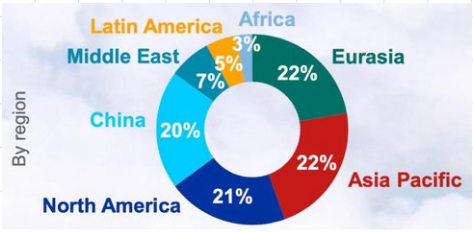
3. Boeing Commercial Market Outlook 2024 - 2043

- traffic prediction where it was projected (positive growth)
- expected growth

↳ 43'975 new planes

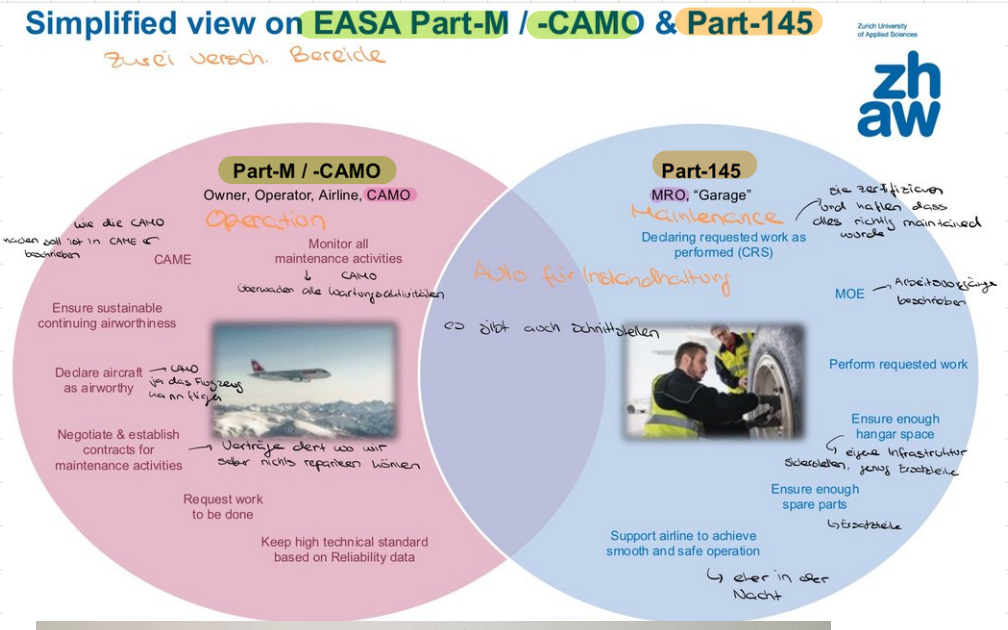
summary





→ China, North America, Asia Pacific Eurasia → biggest buyers

4. Aircraft maintenance: roles and responsibilities



Key Differences

Aspect	Part-M/CAMO	Part-145
Focus	Airworthiness management and oversight.	Physical maintenance and repair tasks.
Activities	Maintenance planning, documentation, and inspections.	Actual repair, inspections, and component servicing.
Organizations	Aircraft operators and management companies.	Maintenance and repair stations.
Personnel Requirements	Focus on management personnel.	Requires certified technicians (Part-66).
Scope	Ensuring aircraft remains airworthy.	Performing maintenance to ensure airworthiness.

Summary

- Part-M/CAMO deals with managing and planning airworthiness to ensure compliance with maintenance schedules and regulations.
- Part-145 focuses on the execution of maintenance tasks required to keep aircraft safe and operational.

CAMO: Continuing Airworthiness Management Organizations

↳ introduced in 2020 to replace and certain aspects of Part-M

CAMOs and CAOs perform a range of tasks, including developing maintenance programmes for aircraft, and organising and coordinating necessary modifications, repairs and maintenance work. Their other activities include carrying out technical inspections of aircraft (if they possess the appropriate authorisation) and managing technical records of aircraft. They may also provide private-sector services to aircraft holders.

1. Part M

- **Definition:**
  Part M is the regulatory framework under EASA that defines the requirements for managing the continuing airworthiness of aircraft. It outlines the responsibilities and standards for maintaining an aircraft's airworthiness.
- **Scope:**
  Part M applies to:
  - Aircraft owners and operators.
  - Organizations responsible for managing and performing maintenance.
- **Key Elements:**
  - Maintenance planning.
  - Record-keeping of airworthiness data.
  - Ensuring compliance with airworthiness directives and service bulletins.
  - Certification of maintenance tasks.
- **Purpose:**
  Provides the general rules for maintaining an aircraft in an airworthy condition.

2. CAMO (Continuing Airworthiness Management Organization)

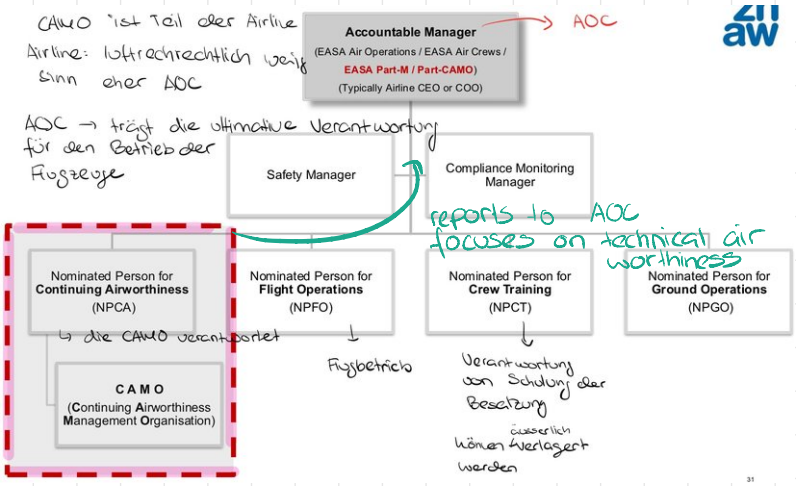
- **Definition:**
  CAMO is an organization approved under **Part M, Subpart G** that takes responsibility for managing the continuing airworthiness of aircraft. It is a formal entity tasked with ensuring compliance with Part M requirements on behalf of aircraft owners or operators.
- **Scope:**
  CAMOs perform the tasks outlined in Part M, such as:
  - Maintenance program development and oversight.
  - Airworthiness reviews (ARC issuance).
  - Monitoring compliance with maintenance schedules and regulatory requirements.
- **Key Elements:**
  - Can issue Airworthiness Review Certificates (ARC) if approved by the competent authority.
  - Provides a structured approach to managing continuing airworthiness responsibilities.
- **Purpose:**
  Ensures that aircraft owners and operators have a professional organization managing their airworthiness obligations.

Part M → rulebook

CAMO → team of organization approved to follow and apply that rulebook for ensuring continuing airworth.

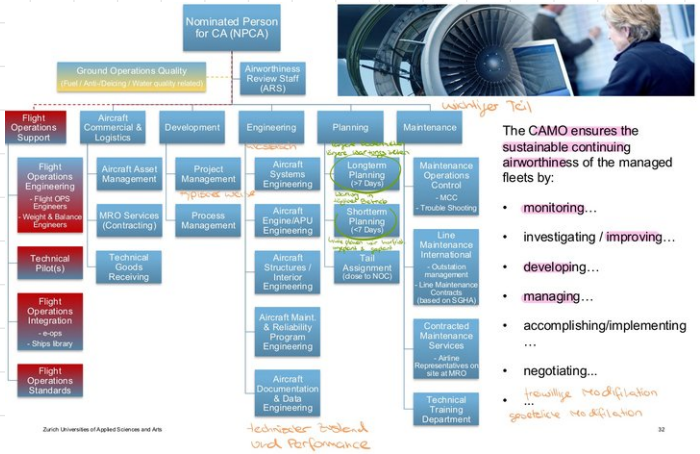
Aspect	CAMO	Part 145 → performs the actual maintenance
Primary Role	Manages airworthiness compliance.	Performs maintenance and repairs.
Responsibility	Administrative and oversight role.	Operational and technical maintenance.
Task Examples	Planning maintenance, issuing ARC.	Conducting repairs, inspections, overhauls.
Output	Maintenance programs, airworthiness reviews.	Certificate of Release to Service (CRS).
Approval Basis	Part M (Subpart G) or Part CAMO.	Part 145 approval.
Work Type	Indirect work (management and planning).	Direct work (physical maintenance).

AOC: luftrechtlich macht "Airline" kein Sinn



CAMO ist Teil von AOS → NPCA → CAMO

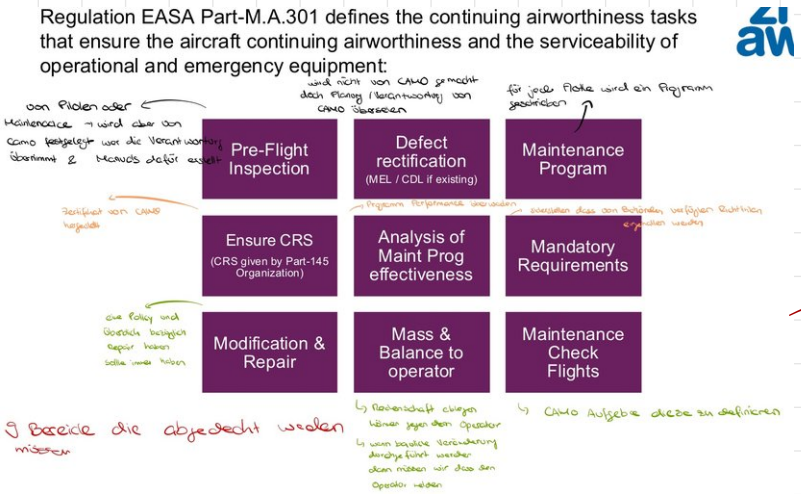
AOS carries the ultimate responsibility for air-worthiness and ensures flight (laut EASA)



CAMO setup (nur für Verständnis)

NPCA: mandatory position within a CAMO responsible for ensuring all tasks are performed in compliance with regulatory standards

↳ leads or supervises the CAMO-Team



• CAMO duties

→ für Übersicht

Responsibilities of an NPCA

Verantwortet die CAMO

- **Ensures sustainable continuing airworthiness of the fleet**
  - Maintenance has been performed according the approved maintenance program
  - All EASA & FOCA requirements have been fulfilled (incl. AD's, mandatory Mods, regulations, etc.)
  - Operation in accordance with the current MEL
  - Contracts are in place and fulfilled (Line- and Base Maint. incl. Engines & APU contracts)
  - Training completion is performed and monitored (incl. Pilots PFC training)

↳ Pre flight check ↳ nicht über CAMO durchgeführt doch Verantwortung liegt bei ihnen

- **Ensures co-operation with Authorities (interface to all EASA Part-M related issues)**

↳ Schnittstelle gegenüber Behörden(Aufsicht)

- **Involvement in setting the technical aircraft standard**
  - Involvement in decision making process about implementation or non-implementation of new Modifications
  - Reliability Targets (ATA Chapter rate, MEL rate, Dispatch Reliability Rate, etc.)

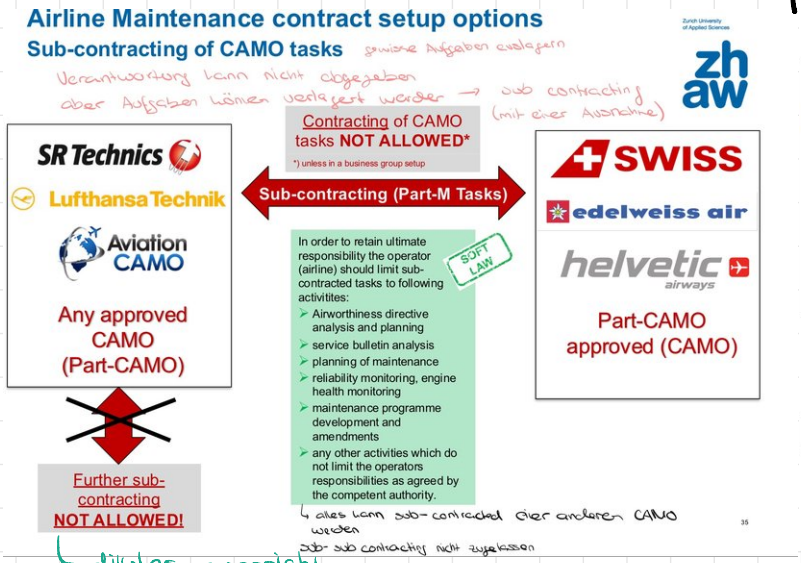
↳ Zuverlässigkeit eingestellt

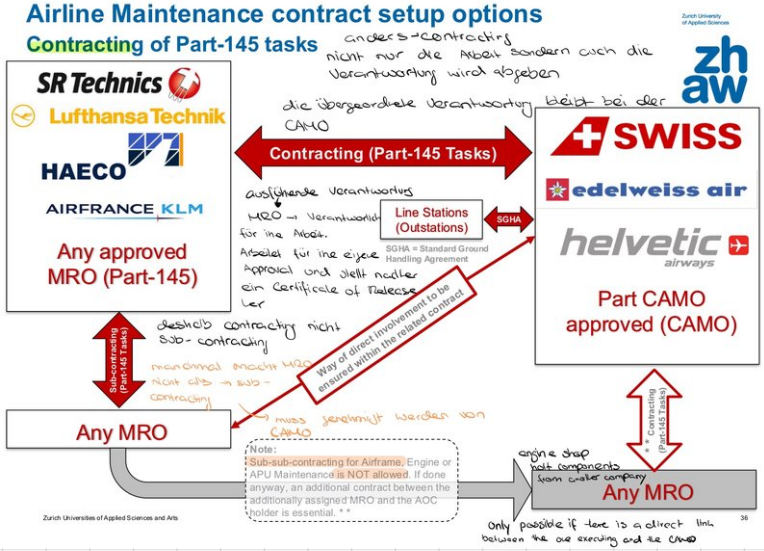
- **Communication co-ordination between Technical & Operational Division**

↳ teil von Operator Schnittstelle: Koordination technische und operationeller Betrieb

- ensures sustainable airworth. of the fleet
- ensures co-operation with Authorities
- involvement in setting the technical aircraft standard
- communication co-ordination between Technical & Operation. Division

Sub-contracting of CAMO tasks | Contracting of Part-145 tasks





Airline Maintenance contract setup options

Option 1 (Operator/Airline with no maint contract needed)

↳ Exot kommt kaum vor

Operator / Airline A

Part CAMO approved (CAMO)

- Enough CAMO staff to comply with Part-M
- Part-145 approved with all capabilities for aircraft, engine and APU maintenance
- Part-145 approved with all capabilities for component maintenance
- Part-66 approved
- Part-147 approved

Option 2 (Operator/Airline with some capabilities)

→ gibt es mehr

SR Technics
Lufthansa Technik
HAECO
AIRFRANCE KLM
Any approved MRO (Part-145)

Contracting of some Part-145 Tasks

1. Aircraft Base Maint. (C-Check, HMV)
2. Engine Overhaul
3. APU Overhaul
4. Component Maint.

eine eigene CAMO

Operator / Airline B

Part CAMO approved (CAMO)

- Enough CAMO staff to comply with Part-M
- Part-145 approved with Aircraft Line maint. capability
- Part-66 approved
- Part-147 approved

day to day maintenance könnert

Option 3 (Operator/Airline with no capabilities)

SR Technics
Lufthansa Technik
HAECO
AIRFRANCE KLM
Aviation CAMO
Any approved MRO (Part-145) & CAMO (Part-M)

Sub-contracting of Part-M Tasks

1. CAMO Tasks

Contracting of all Part-145 Tasks

1. Aircraft Line- & Base Maint.
2. Engine Overhaul
3. APU Overhaul
4. Component Maint.

kleine Flottengrösse dann wird als von aussen ausgeführt

Operator / Airline C

Part CAMO approved (CAMO)

independ on which contractual setup, the operator always bears the overall responsibility for the continuing air worthiness

- since April 2022 air carriers belonging to the same business group may contract a common CAMO (not subcontracting)

5. regulary situations

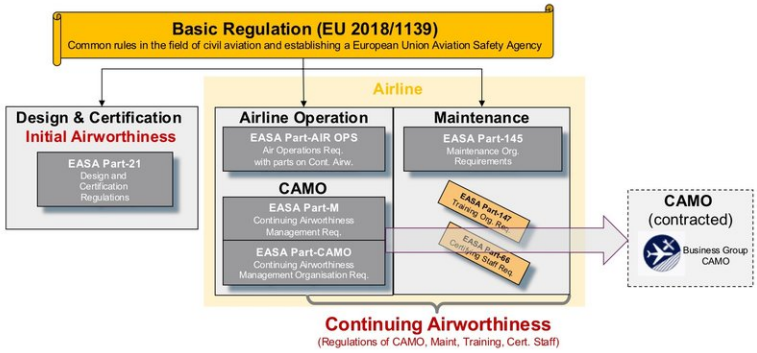
- transporting PAX and goods doesn't limit itself to the borders
- certain amount of danger and risk to aviation
  - ↳ lawmaking inevitable
  - ↳ rulemaking international

Rules to protect:
- people on the ground
- PAX and transported goods
- cockpit and cabin crew

} • safety ensure

- standardisation of activities within civil aviation industry worldwide
- ensure airworthy and reliable civil aircraft operation

EASA regulation architecture for airworthiness



ICAO Annexes and Documents
19 Luftfahrt

Base for the Annexes and Docs is the 1944 Convention of Chicago – referred to as Doc 7300.

Annexes:

A1: Personnel Licensing
A2: Rules of the Air
A3: Meteo Service for Int. Aviation
A4: Aeronautical Charts
A5: Units of Measurements (A/G)
A6: Operation of Aircraft
A7: Registration Marks
A8: Airworthiness of Aircraft
A9: Facilitation
A10:Aeronautical Telecomunication
A11:Air Traffic Services
A12:Search and Rescue
A13:Accident/Incident Investigation
A14:Aerodromes
A15:Aeronautical Info Services
A16:Environmental Protection
A17:Security
A18:Safe Transport of DG by Air
A19:Safety Management

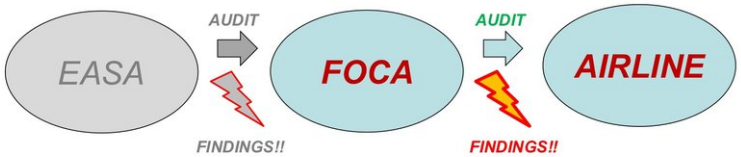
↳ nicht auswendig

- **Continuing Airworthiness Reg 1321/2014** (covering continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks)
  - ➔ ANNEX I: **PART-M** (Continuing Airworthiness Requirements)
  - ➔ ANNEX II: **PART-145** (Maintenance Organisation Approvals)
  - ➔ ANNEX III: **PART-66** (Certifying Staff)
  - ➔ ANNEX IV: **PART-147** (Training Organisation Requirements)
  - ➔ ANNEX Vc: **PART-CAMO** (Continuing Airworthiness Organisation Requirements)

↳ auswendig lernen

Force of Authorities

- *The local Authority gives the approvals on several manuals, processes, organisational setup, etc. Without this approvals, no aircraft certificates, no Part CAMO certificate, no Part-145 certificate, no AOC!*
- *The local Authority can revoke any of the above mentioned certificates at any time if based on respective circumstances. ➔ Consequences: Fleet on ground!*
- *A respective view out of an airline perspective should be existing in order to have success in a good co-operation with the authorities (transparency, honesty, open communication, etc.).*



NOBODY LIKES FINDINGS…
…BUT…
FINDINGS WILL HELP TO IMPROVE THE SYSTEM!

→ influence of authorities

↳ für Übersicht

EU Ramp Inspection program:

- Tool for the surveillance of operators which monitors technical and operational safety compliance through ramp inspections ("on-the-spot assessments") on their aircraft. The programme is categorized as follows:

SAFA	SACA	SANA
Safety Assessment of Foreign Aircraft	Safety Assessment of Community Aircraft	Safety Assessment of National Aircraft
• Aircraft from third countries • follows standards of ICAO	• Aircraft from member states • follows Article 4 of EASA Air Ops (EU 965/2012)	• Domestic registered aircraft • follows Article 4 of EASA Air Ops (EU 965/2012)



- Inspections carried out in accordance with standardized procedures. Results are entered in a centralized database (managed by EASA) and the competent authority is informed about the results.

50 Participating States

- Serious and repeated safety deficiencies can ultimately lead to a listing on the EU Air Safety List, which can result in severe restrictions or in the worst case scenario a ban on using European airspace.

6. Training organizations: Part-66 → licensing of maint. engineers

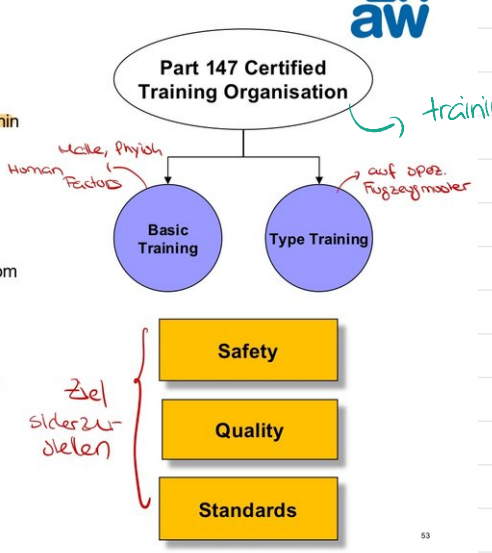
Maintenance Training

Maintenance of modern aircraft requires a certain set of skills and knowledge. In order to obtain a maintenance (EASA Part-66) licence certain training and experience requirements need to be fulfilled.

Requirements for training organisations are covered within EASA Part-147.

Basic Training for a Part-66 Licence is divided into seventeen different modules covering relevant topics from mathematics and physics to basic aircraft systems and maintenance practices.
Also, human factors is part of the basic training.

Type Training is a detailed system training on a specific aircraft type.



→ training of education for engineers

Ziel: Sicherheit

auswendig

Maintenance License Categories

LAW

66.A.3 Licence categories - Extract

Aircraft maintenance licences include the following categories and, where applicable, subcategories and system ratings:

(a) Category A, divided into the following subcategories:
- A1 Aeroplanes Turbine;
- A2 Aeroplanes Piston;
- A3 Helicopters Turbine;
- A4 Helicopters Piston.

(b) Category B1, divided into the following subcategories:
- B1.1 Aeroplanes Turbine
- B1.2 Aeroplanes Piston
- B1.3 Helicopters Turbine
- B1.4 Helicopters Piston

(c) Category B2
The B2 licence is applicable to all aircraft.
(...)
(g) Category C
The C licence is applicable to aeroplanes and helicopters.

EASA
European Aviation Safety Agency
EASA PART-66
Aircraft Maintenance Licence

LAW

66.A.15 Eligibility

An **applicant** for an aircraft **maintenance licence** shall be at least **18 years** of age.

145.A.35(l) Personal requirements

The **minimum age** for **certifying staff** and **support staff** is **21** years.

CAMO Training

Dependent on duties not only maintenance staff but also CAMO Staff must fulfil certain training requirements. These requirements will be subject to authority approval and must be described in the Continuing Airworthiness Management Exposition (CAME).

Training for CAMO Staff may include:

- Safety Management System Training
- Procedure Training → immer dann gemacht werden wenn sich etwas ändert
- EWIS Training → nur die, die darin arbeiten
- Fuel Tank Safety / CDCCL Training
- Aviation Legislation Training
- ...



Space (Woche 5.2)

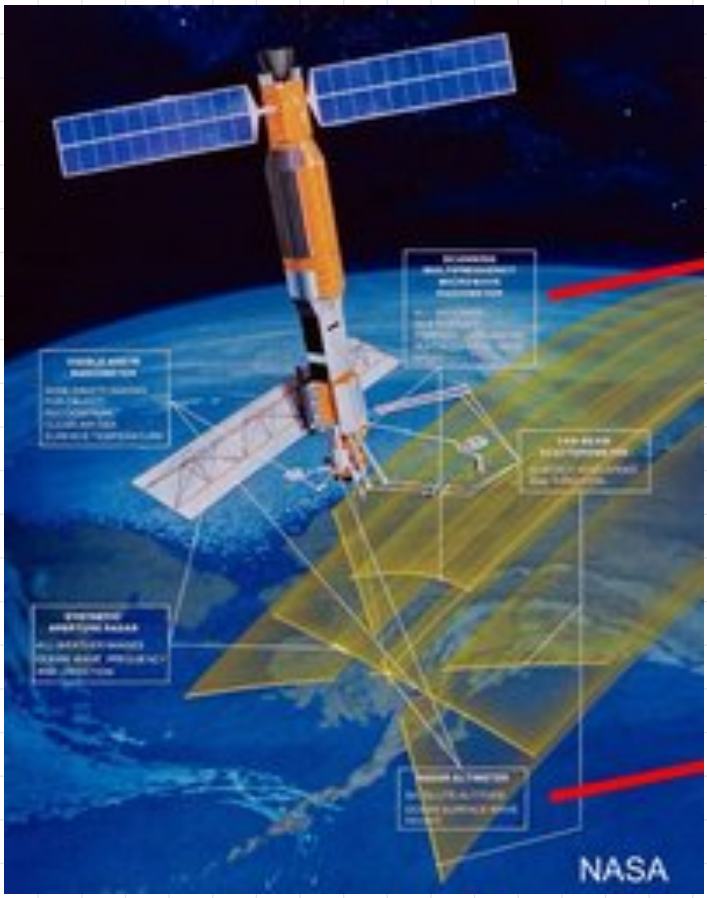
PAKSAT
geostationary satelite



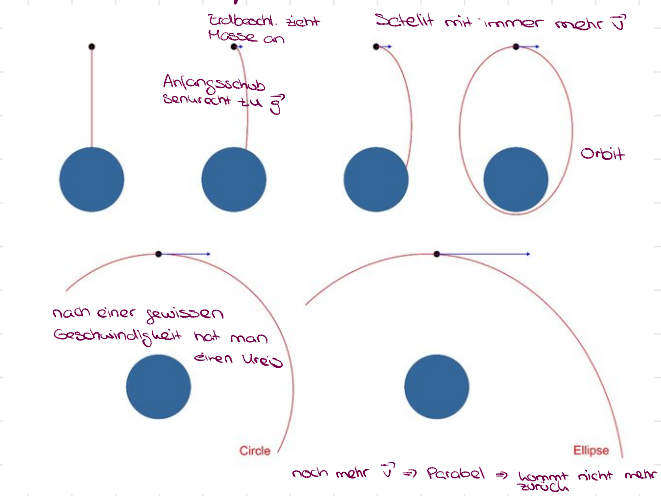
Lernziele:

- Grundlagen und Konzepte von Raumfahrtmissionen
- technische & operationelle Möglichkeiten & deren Grenzen/Machbar.
- Planung & Ziele einer Raumfahrtemission beurteilen
- Nutzen & Kosten einer Raumfahrtemission abschätzen

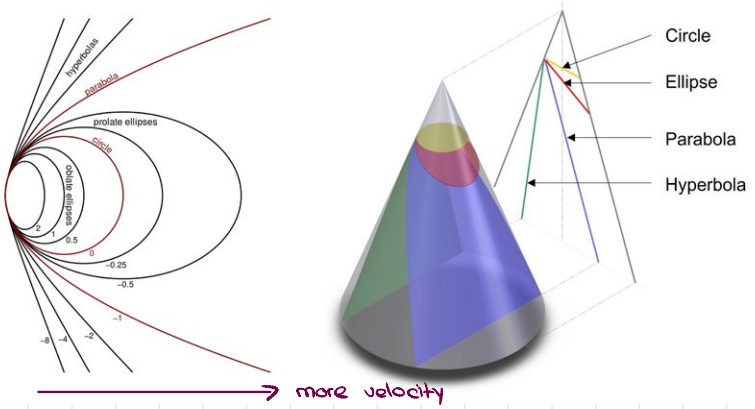
Space mainly limited to:
- earth bounded missions
  no interplanetary missions
- unmanned missions



Astrodynamics:



Orbit types: alle Arten von Bahnen



below this height the satelite looses it's geostationary position because it's orbital velocity increases
(orbital period becomes shorter than the Earth's rotation)

Satelites: (geostationary)

Height: ≈ 35'800 km
everything under this would crash because of the strong gravitational force

$\vec{v}$: ≈ 7 $\frac{km}{s}$

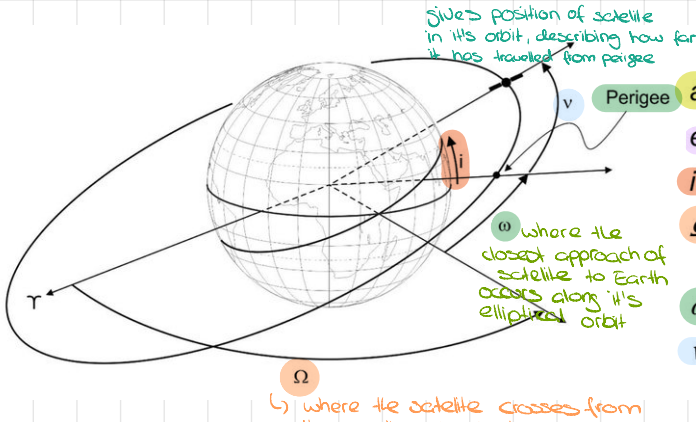
geostationary satelites
↳ revolves around the earth in 24 hours like the moon

GPS Satelite:

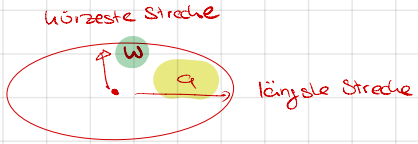
Height: 20'000 km
the lower the satelite ⇒ faster

Orbit elements:

über diese 6 Parameter kann die Satelitenbahn beschrieben werden



- a semimajor axis
- e eccentricity
- i inclination
- Ω longitude of ascending node
- ω argument of perigee
- ν true anomaly



$$e = \sqrt{\frac{a^2 - b^2}{a^2}}$$

wenn $e > 0 \Rightarrow$ Ellipse
wenn $e = 0 \Rightarrow$ Kreis
deviation from a perfect circle
wenn $e = 1 \Rightarrow$ Parabola
wenn $e > 1 \Rightarrow$ Hyperbola

für Übersicht

astronomische Bilder

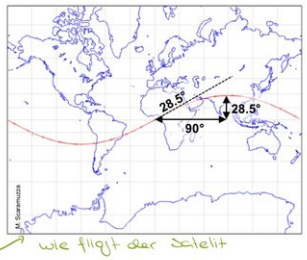
Ground Tracks

Hubble Space Telescope (HST)

große Halbachse
a = 6.923E6 m
e = 0
i = 28.5°
Ω = 0°
ω = 0°

Interval = 10'





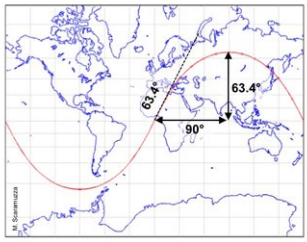
wie fliegt der Satelit

Soyuz

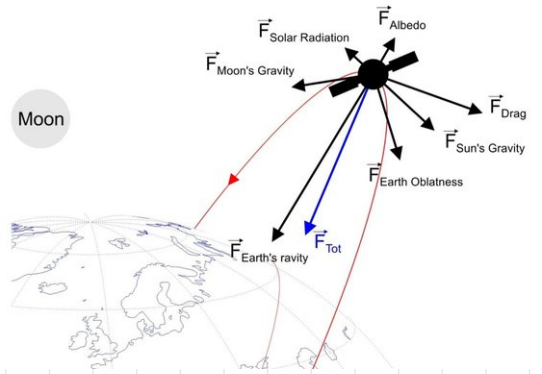
Molnyia Telekom. Satelit

a = 2.6554E7 m
e = 0.72 → wenn $e = 1$ dann fliegt Satelit weg
i = 63.4°
Ω = 0°
ω = 270°

Interval = 60'



Orbit Perturbations



Rocket propulsion:

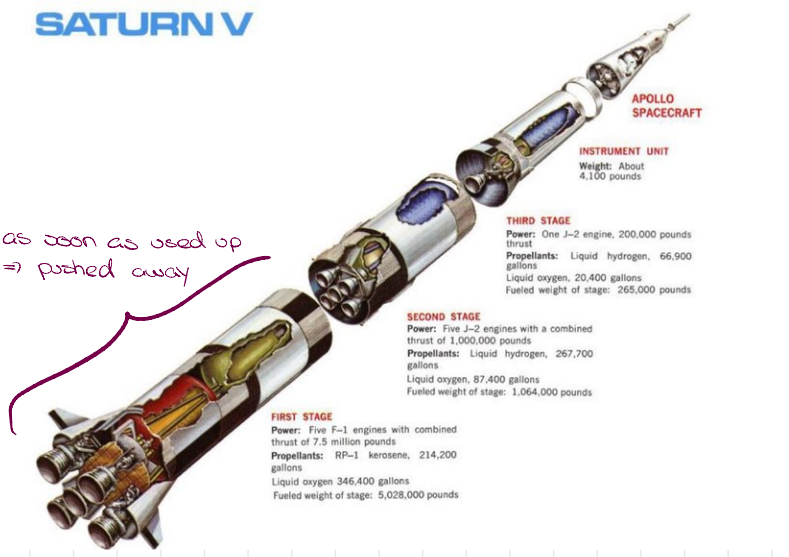
chemical propulsion: sehr viel Kraft → kleines Betriebssystem
Sauerstoff + Wasserstoff

electric propulsion: Auftrieb viel zu klein → dafür hält lange
↳ damit kein Satelit in Space

Launch vehicles:

↳ multi-level rocket to bring the rockets to space

↳ 1- level rocket are not sufficient to take the rocket to space
↳ uses much more energy → more fuel



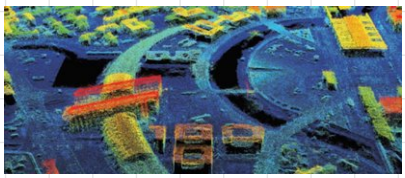
as soon as used up
⇒ pushed away

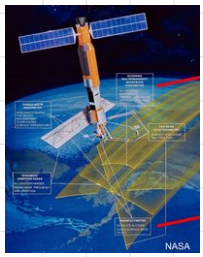
Satelite sensors: used to capture images and data from space ⇒ provides information about Earth's surface and atmosphere

Examples:

↳ Earth observation - SeaSat: monitors oceanographic phenomena and provides timely data

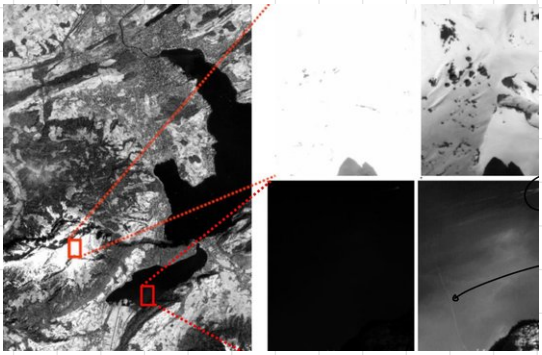
↳ all weather sea surface temperature
water in atmosphere
wind speed
ocean surface height





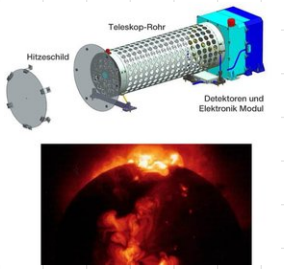
↳ TDX TomoSar: the absolute height is not measurable only the relative height is measurable / able to calculate with lasers which scan the height

↳ optical procedures:



↳ solar observations: Spectometre / Telescope for Imaging X-Rays (STIX)





Cosmic rays: charged particles with huge energy range coming to Earth from all directions

↳ ohne Schutz schnell tot

Telecommunication:

- application on satelites: satelite - satelite, satelite - ground
- low power high-data rate





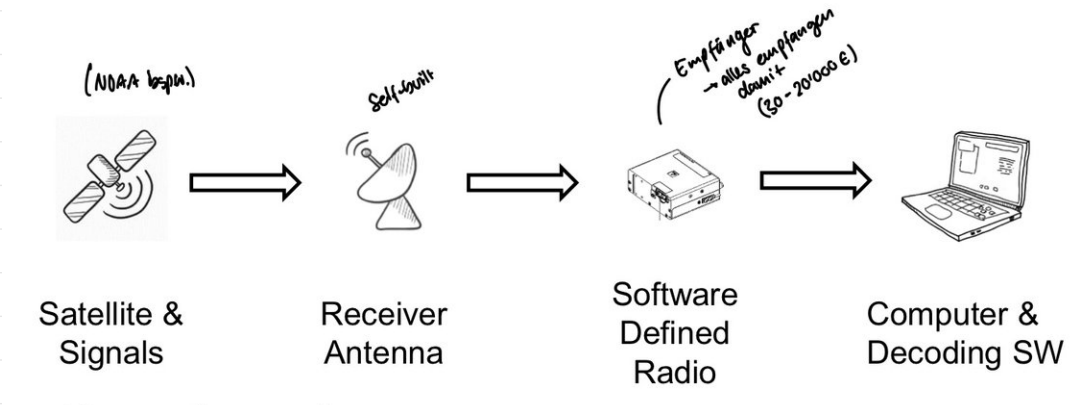


Reception of Satelite Signals:

Main objective: reception & recording of satelite signals with

- low cost HW/SW (Software Defined Radio)
- self built equipment (antenna, mounting)

- not necessarily weather images



- Reception only
- No transmissions to satellites
  → Law on Telecommunications

Atmospheric Physics & Applied Meteorology (Woche 6)

↳ The Earth's Atmosphere

- Examples of how meteorology affects everyday aviation life
- Outline the thermal stratification of the Earth's atmosphere and name the most important features of the different layers
- name key figures of the ISA and derive the difference to the real atmospheric conditions depending on the weather situation
- most important parameters of the approximite composition of Earth's atmos. and know the influence of air traffic on Earth's atmosphere

Kármán Line: boundry between aircraft and spacecraft "air" and "space" at 100km

Global average temperature without an atmosphere: -17°

Earth's atmosphere:

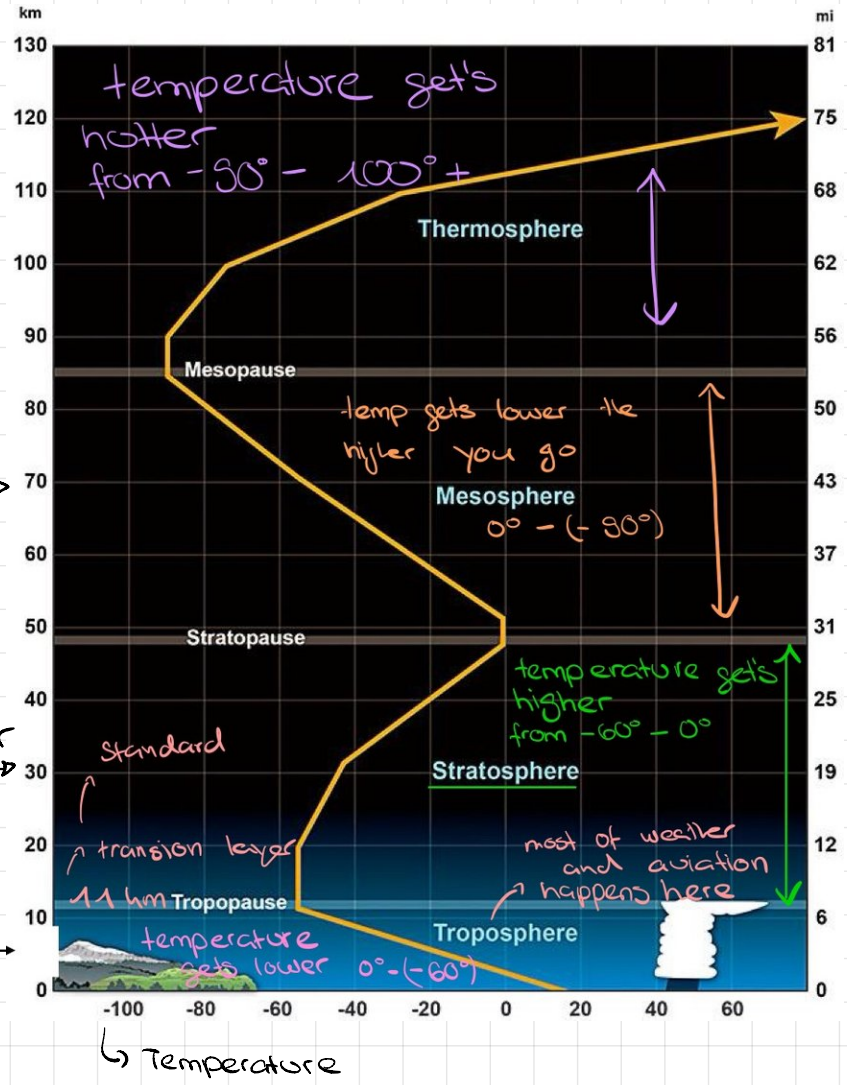
Temperature and Layers

Thermosphere
Temp. increases

Mesosphere
Temp. decreases

Stratosphere
Temp. increases

Troposphere
Temp. decreases



Atmospheric weight pushing on me : 624 kg

Atmospheric mass is not distrubuted equally :

Horizontal : variations in mass distrubution are small, but relevant when it comes to weather (low-pressure & high pressure systems)

Vertical : strong vertical gradient in the distrubution of mass and pressure

- 50% of mass is below 5.6 km (Troposphere)
- 90% of mass is below 16 km (early stratosphere)
- 99.9% of mass below 100 km (Kármán line Thermosphere)

With increasing altitude

- pressure and density decrease exponentially
- far less atmospheric mass pushing down on you

The international standard atmosphere ISA :

- is a static model of the atmosphere
- governed by set of equations
- it gives to every altitude the matching pressure, density & temperature
- tool in aviation as common reference system
- does not represent the real atmosphere
- no moisture in ISA (RH = 0%)

- ★ Pressure p at 0 meters : 1013.25 hPa
- ★ Temperature at 0 meters : 288.15 K , 15°C
- ★ Lapse rate : $-6.5 \frac{K}{km}$, $-6° \frac{C}{km}$ until the (troposphere), $-1.98 \frac{°C}{1000 feet}$
  how much temperature falls with altitude
- ★ Tropopause height : 11 km , (FL 360 / 225 hPa)
- ★ Humidity : 0% RH
  ↳ no water ↳ assumes dry air (effects of water vapour are not included
- ★ Density : $1.225 \frac{kg}{m^3}$

Transition layer and it's use

- atmospheric pressure decreases in a predictable manner with increasing altitude, following well-established physical laws (barometric formula)

barometric formula: tells you the pressure for any given altitude
when your flying an airplane how do you know your altitude? → depends on pressure
why the international standard → to show you the altitude

Before the transition altitude:
↳ altimeter is set to **local QNH**, reflecting altitude above sea level based on current local atmospheric pressure
→ true altitude

At transition altitude:
↳ pilots set altimeter to the standard pressure of 1013 hPa
→ Flight level (instead of true altitude)
→ indicated altitude becomes a pressure altitude regardless of local pressure conditions

Above the transition altitude:
↳ all aircraft operate on the same reference pressure, ensuring vertical separation even if local pressure causes pressure difference at lower altitudes
↳ pressure altitude

Significance:

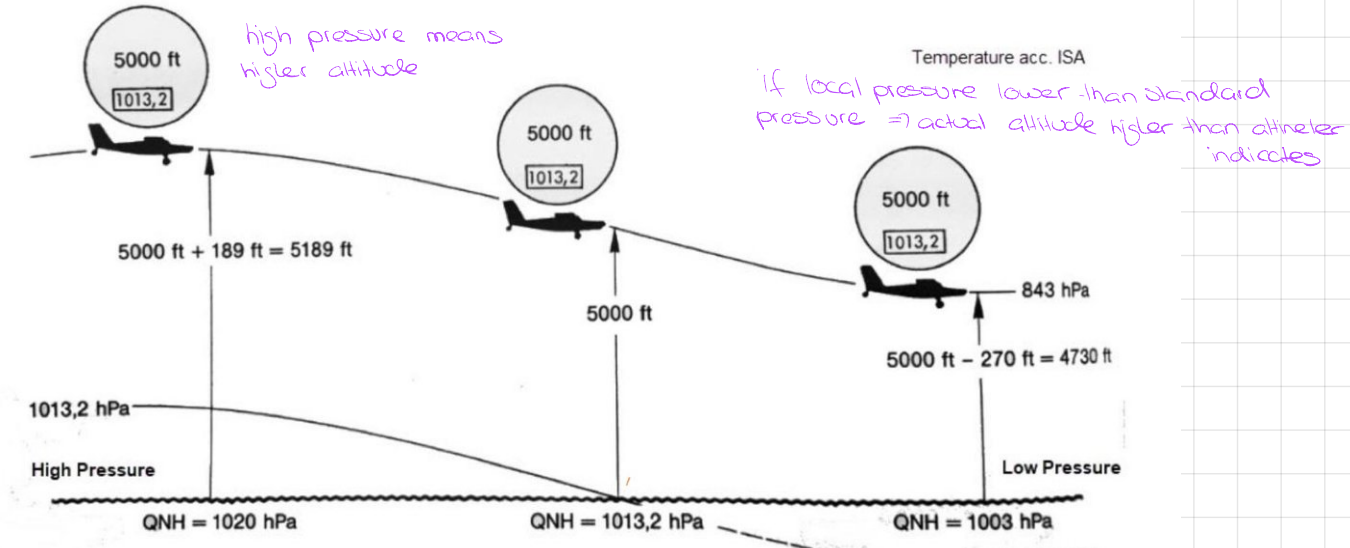
↳ aircraft switch to a standardized reference to ensure consistent separation at high altitudes, unaffected by regional pressure variations.

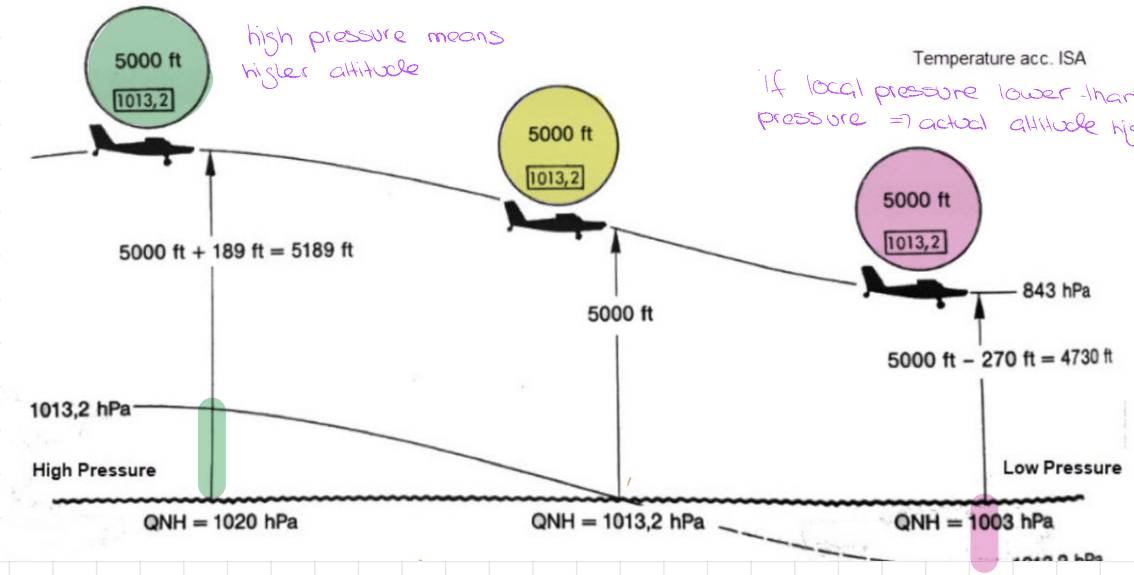
2. Standardized Reference for Global Operations

- **Standardization**: By using pressure instead of true altitude, aviation operations become standardized worldwide. This helps to:
  - Ensure that aircraft flying at the same **flight level** (FL) maintain consistent vertical separation, regardless of local pressure variations.
  - Simplify flight planning and ATC coordination across different regions with varying weather conditions.
- **Flight Levels (FL)**: At high altitudes, aircraft use **flight levels** based on **pressure altitude** (referenced to 1013.25 hPa), not their true altitude. This simplifies air traffic control in busy airspace since all aircraft flying at the same flight level are at the same pressure altitude, regardless of actual weather or local air pressure.

Summary of Reasons for Using Pressure in Aviation

Reason	Explanation
Predictable decrease with altitude	Pressure decreases in a known, predictable manner with altitude.
Global standardization	Flight levels (FLs) based on pressure provide consistency worldwide.
Ease of measurement	Pressure sensors (altimeters) are reliable and simple to use.
Uniform vertical separation	Pressure ensures that aircraft at the same flight level are safely separated.
Simple transition between altimeter settings	Clear transition from QNH (local pressure) to standard pressure at high altitudes.
Minimizes the effects of temperature	Pressure-based altitude is less sensitive to temperature changes compared to true altitude.





high pressure means higher altitude

Temperature acc. ISA

if local pressure lower than standard pressure ⇒ actual altitude higher than altimeter indicates

+ ISA umrechner anfügen

Fl lower than altitude

if temp. increases than true altitude is higher

Fl higher than altitude

if temperature drops the true altitude is lower

Explanation of the Image:

1. **Left (High Pressure Zone)**:
   - The actual atmospheric pressure at sea level is **1020 hPa**, higher than the standard 1013.2 hPa.
   - The aircraft's altimeter, set to 1013.2 hPa, displays an altitude of **5000 feet**.
   - However, due to the higher pressure, the aircraft is **actually higher** than the indicated altitude. The true altitude is 5000 ft + 189 ft = **5189 feet**.
2. **Center (Standard Pressure Zone)**:
   - Here, the local pressure is exactly **1013.2 hPa**.
   - The aircraft's indicated altitude of **5000 feet** matches its actual altitude, as there is no pressure difference to account for.
3. **Right (Low Pressure Zone)**:
   - The actual atmospheric pressure is **1003 hPa**, lower than the standard 1013.2 hPa.
   - The altimeter, still set to 1013.2 hPa, displays **5000 feet**, but the aircraft's true altitude is lower. Specifically, it is 5000 ft - 270 ft = **4730 feet**.

Limits

when we are close to the ground (airplanes) setting is not ISA but local pressure

aw ZAV Centre for Aviation

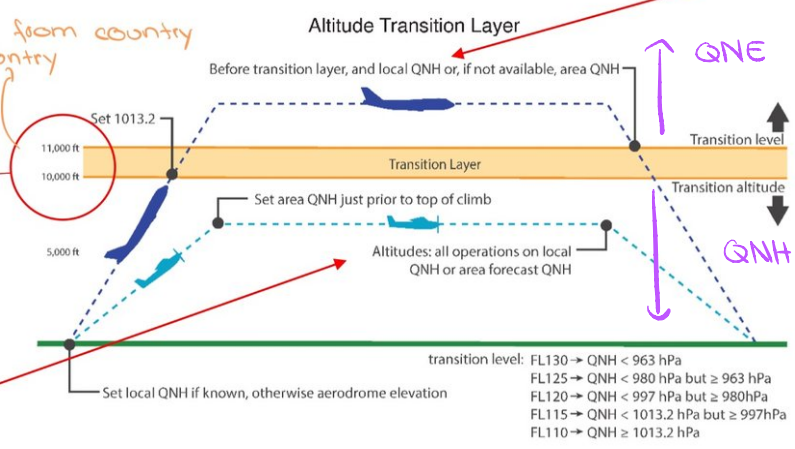
TRANSITION LAYER

PilotTrain VFRG The Unofficial Guide

Above the transition layer the altimeter is set to ISA conditions

Height of the transition layer can vary from country to country and (in most cases) depends on the atmospheric conditions

varies from country to country



QNE FL

QNH real altitude

Below transition layer the altimeter setting is at pressure that accounts for actual atmospheric conditions

Practice your knowledge on www.PilotTrain.com.au

Atmospheric condition:

Main components of dry air

- 78 % N_2 → just exists and gives density
- 21 % O_2 → important
- 1 % Ar Argon → noble gas doesn't interact with anything
- 0.04 % CO_2 → greenhouse gas ↑

Trace gases (long lived): more they are evenly distributed through the atmosphere

Ne	18 ppm	
He	5 ppm	
Kr	1 ppm	
Xe	0.09 ppm	
		usually stays the same
CH_4 ↑	1.5 ppm	(Methan)
CO	0.1 ppm	(K.Monox.)
H_2 ↑	0.5 ppm	
N_2O	0.25 ppm	(Lachgas)

↳ more time to mix in atmosphere

Trace gases (short lived, spatial variability): are lower distributed throughout the atmospheric layer

schlechter verteilt in der Atmosphäre

- O_3 (Ozon) bis zu 10 ppm in der Stratosphäre; 30 ppb in der sauberen Troposphäre; >100 ppb im "Sommersmog"
- NO_x 1 – 100 ppb (Stickoxide)
- NH_3 6 ppb (Ammoniak)
- SO_2 0.2 ppb (Schwefeldioxid)
- H_2S 0.2 ppb (Schwefelwasserstoff)

Most important trace gas is water with up to 4%. → water vapor is invisible

cloud → water which is visible

↳ feedback mechanism rather than a direct driver of climate change

temp rises → more water evaporates → intensifies the greenhouse effect → warming the planet

can contribute to extreme climate and weather uncertainty

feedback tech can amplify global warming

ppb: parts in billion

ppm: parts in million

dry air: mixture of all gases without water vapour

→ water?

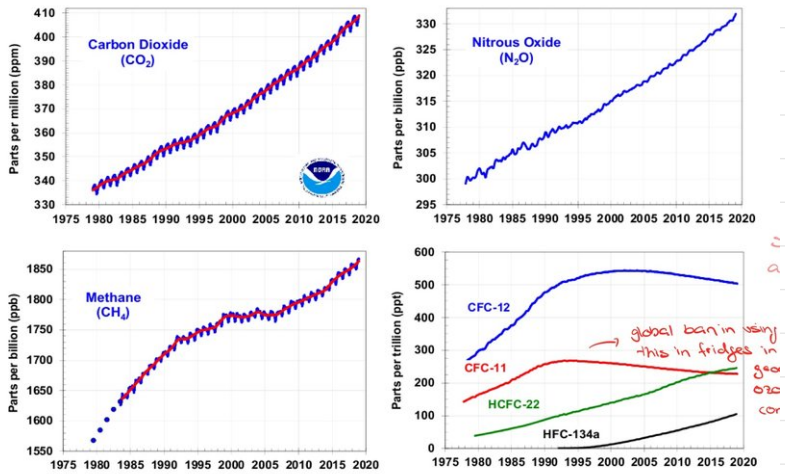
Changes in greenhouse gases: biggest effect on climate

- Carbon Dioxide CO_2
- Methane CH_4
- Nitrous Oxide N_2O

CFC-12, CFC-11

HCFC-22, HFC-134a

Climate active and change the temperature



↳ Weather forecasting & products

- know the main driving force of weather
- explain what a prognosis is
- name the most important features and tools of weather forecasting
- can explain reasons of uncertainty in weather forecasts
- name the most commonly used aviation weather products
- name typical weather hazards and know when they occure
- know the main impact of aviation on the environment
- name a few possible solutions towards a sustainable future of aviation

Weather: states of change/condition in the atmosphere in regards to heat, wind, cold rain, snow

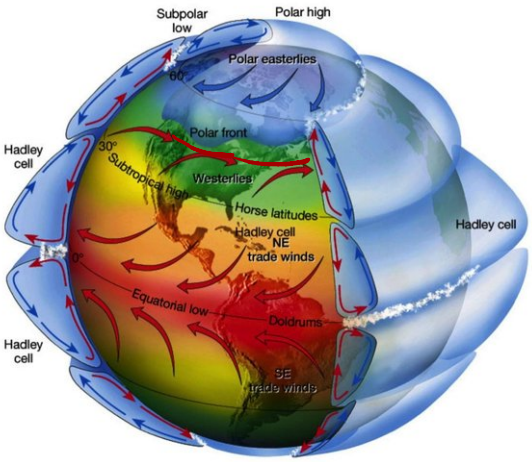
driving forces of weather: solar radiation → main source for atmospheric processes

→ spatial variation (räumliche Variation) in (incoming and outgoing) radiation leads to an unequal distribution (imbalance) of energy across the Earth's surface

↳ weather (as a solution): atmosphere's thermodynamic response in constantly wanting to restore the imbalance in energy distribution.

↳ The Earth is tilted at 23.5° → deviation axis
↳ leads to season ↳ difference intensity of solar radiation ↳ uneven clouds → trade winds
↳ uneven rotation leads to day & night

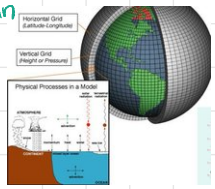
Meterology: **ICT** = Interkonvergenzzone: Da wo die Passatwinde zusammenstossen (=konvergent). Die Passatwinde entstehen durch die aus dem **Tiefdruckgebiet** am Equator enstehenden **Hochdruckgebieten** am 30. Breitengrad. Am Equator ensteht ein «Sog» der die Passatwinde an sich zieht. Die aufgewärmte Luft enzieht beim Wiedereinstrom zur Interkonvergenzzone Wasser aus dem Gebiet (darum Wüsten) und lässt dies im Hochdruckgebiet wieder abregnen (Darum Regenwald). Die Winde kommen aus dem Südosten, sowie Nordostem und werden durch die **Corolioskraft** in die entgegengesetze Richtung abgelenkt. Passatwinde sind beständige Winde. Für jede Höhe ist ein zugehöriger Atmosphärendruck kalkulierbar. Luft ist kompressibel, somit nimmt der Luftdruck mit der Höhe ab. Da der Luftdruck global sehr verschiedene Werte annimmt definiert die ICAO die ISA: **Druck** @ 0 m = 1013.25 hPa |



prognosis: statement of what is judged likely to happen in the future in connection with a particular situation

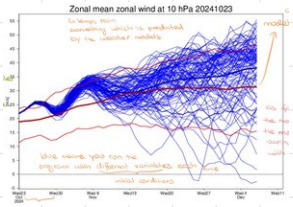
weather forecasts: predicts the weather for the next 5-14 days

Tools to weather forecasting: ① discretation → vereinfachung mathem. Formeln
② parametrisation: grid is covered with % of cloud instead of giving the amount of droplets



"Annäherung an Gittern"

Ensemble forecast: instead of running a single forecast, the computer is run a number of times from slightly different starting conditions
ensemble → complete set of forecasts

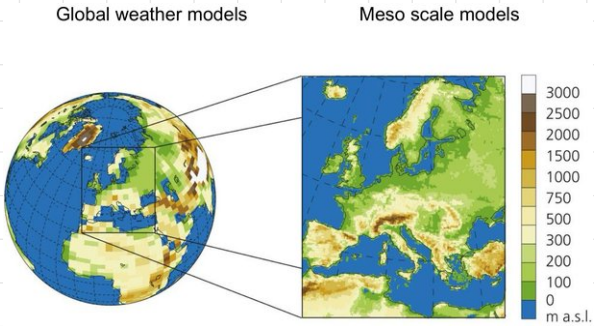


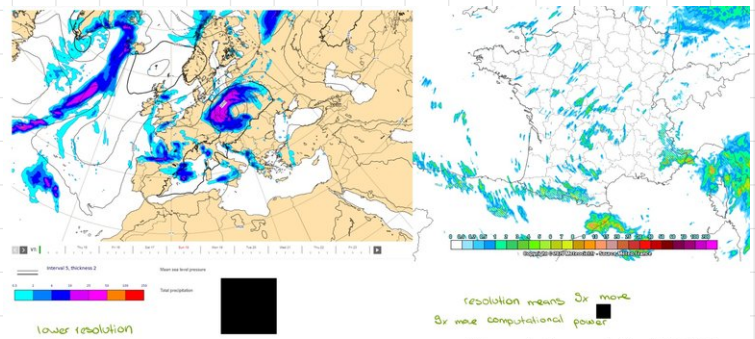
↳ as far as the model runs the more the variability gets over time

Model performance: models should represent atmosphere as good as possible
more detail needs more computational power → always a trade-off

- temporal resolution → how often we calculate physical model (every 10s)
- spatial resolution → räumliche Auflösung
- parametrization
- ensemble members → number of runs

scale & resolution:





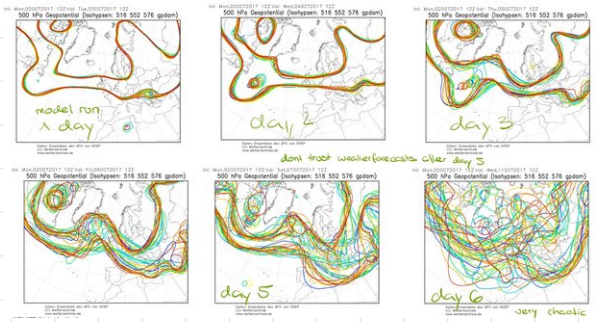
Globalwettermodell «IFS»
ECMWF (EU)
1 Pixel = ~9km (!) - global

Mesoskalenmodell «AROME»
(modular einsetzbar)
1 Pixel = ~1.3km

Probability & Ensemble forecast:

↳ die ensembles liegen mit der Zeit immer weiter auseinander. Ab Tag 5 sind die Spaghetti-Plots nicht zuverlässig genug für eine Prognose.

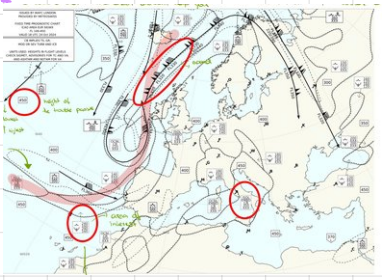
Spaghetti plots → visualization



model uncertainity also comes from a mix of deterministic & probalistic

↳ How much? ↳ How likely?

Aviation products:



SIGWX-Charts (SWC):

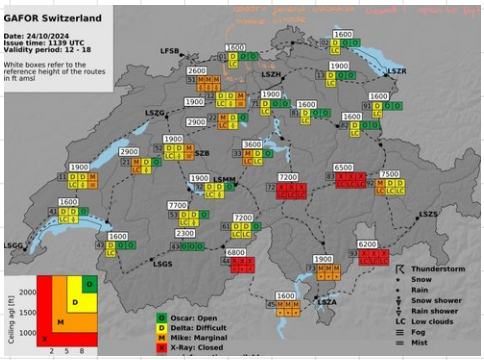
↳ shows weather activity at upper atmosphere

3: **What type of report can a pilot check to know how the weather at the airport will be in 4 hours:**
a) METAR
b) Satellite pictures
c) TAF
METAR = actual conditions, Satellite pictures do not provide forecasting information, SIGWX charts provide information about the upper atmosphere, thus TAF (Terminal Area Forecast)
d) SIGWX charts

↳ issued every 6 hours because of short validity (only 6 hours)
↳ shows: jet-stream, turbulence, icing, tropopause height, volcanic eruptions
↳ FL 100 – 600

GAFOR: General Aviation Forecast

↳ prognosis for all the frequently used airports



TAF: Terminal Area Forecast

↳ when you are flying somewhere else. predictions every 3-6 hours

METAR:

↳ when you are approaching. predicts the momentarily weather situation

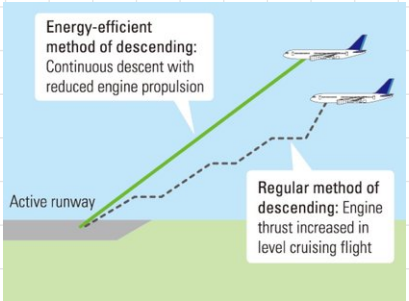
Weather hazards:

Turbulence: happens because of weather → upwinds, downwinds
Wake Turbulence: happens when aircrafts fly under/above each other
Clear air turbulence: no idea why it happens and no pic to describe it
Icing: frost contained wing → aerodynamics change with ice

Environment: toxicology

↳ depends on the exposure
↳ people affected by engine exhaust are people working in the aviation industry
↳ CO_2, H_2O, NO_x, Russ, SO_2, CO, unburned hydrocarbons

Sustainabe Aviation:

① 

② sustainable aviation fuels

③ Innovation & Engineering

Flight Operations (Woche 7 + 10.1)

Airspace: Classes and services, Swiss airspace concept	Flight Plans
General rules of the air, VFR/IFR	General Aviation

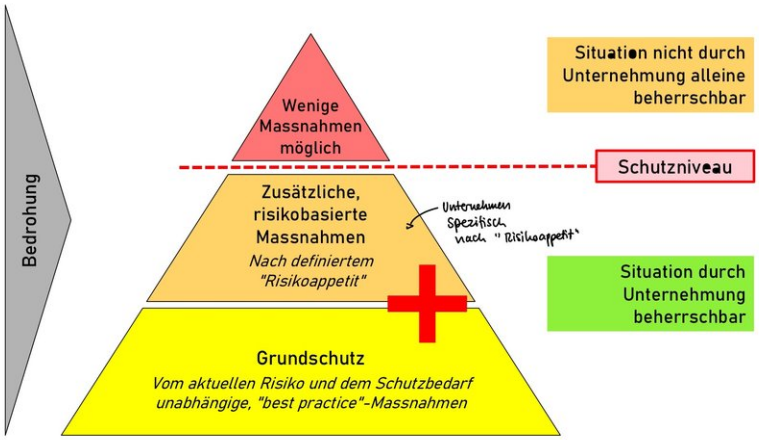
siehe Quizlet und vergleiche mit prüfungs-relevanten Folien

Operational Safety & Risk Management (Woche 8.1) 3/4

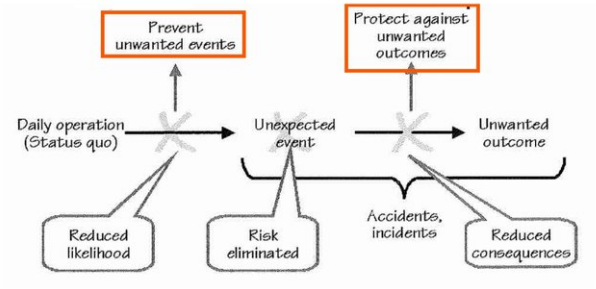
OPERATIONAL RISK MANAGEMENT

- Allgemeines Schutzkonzept
- Bow Tie
- Lines of defense
- Risk identification
- Risk mitigation

Allgemeines Schutzkonzept von Unternehmen



Risk Management?



Risk Identification – Risk Treatment – Risk Owner

Risk Identification

process of finding, recognizing and describing risks

involves the identification of risk sources, events, their causes and their potential consequences

Risk Treatment

process to modify risk

risk treatment strategy:

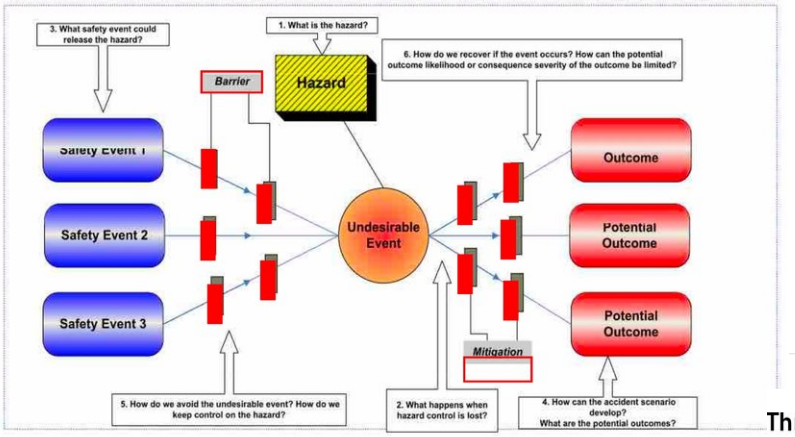
i) avoiding,
ii) taking,
iii) transferring, or
iv) mitigating risk by changing likelihood or impact

Source: ISO/IEC 27000

Risk Ownership

Person or entity with the accountability and authority to manage the risk

The so-called «Bow-Tie»



Three generic strategies for risk treatment (ICAO)

a) ***Avoidance.*** The operation or activity is cancelled because safety risks exceed the benefits of continuing the operation or activity. Examples of avoidance strategies include:

1) operations into an aerodrome surrounded by complex geography and without the necessary aids are cancelled;

2) operations in RVSM airspace by non-RVSM equipped aircraft are cancelled.

b) ***Reduction.*** The frequency of the operation or activity is reduced, or action is taken to reduce the magnitude of the consequences of the accepted risks. Examples of reduction strategies include:

1) operations into an aerodrome surrounded by complex geography and without the necessary aids are limited to daytime, visual conditions;

c) ***Segregation of exposure.*** Action is taken to isolate the effects of the consequences of the hazard or build in redundancy to protect against them. Examples of strategies based on segregation of exposure include:

1) operations into an aerodrome surrounded by complex geography and without the necessary aids are limited to aircraft with specific performance navigation capabilities;

2) non-RVSM equipped aircraft are not allowed to operate into RVSM airspace.

d) ***Risk taking.*** No further risk treatment, the risk is accepted as such.

Risk identification...

...and a word of caution on Risk Management

Einige Probleme der Risikoidentifikation

- Risiken können vergessen oder übersehen werden
- Risiken können je nach Kenntnissen und Wissen einseitig erkannt werden ("risk bias")
- Granularität der Risiken (zu viele oder zu wenige)



Konsequenzen

- Unvollständige "Risikolandschaft", relevante Risiken fehlen
- Unhandliche / nicht mehr handhabbare Menge von Risiken, zu komplexe Risikosysteme

→ Ein Risikomanagement-System ist nie vollständig – und genügt als alleiniger "Schutz" nicht

→ Verwendung von vorbereiteten, branchenspezifischen, systematischen Risikolandschaften (oder "funktionalen Modellen")

→ Permanenter Review der Risiken, und Anwendung "mit Augenmass" und XMV

Quality criteria for risk mitigation strategies

a) ***Effectiveness.*** Will it reduce or eliminate the safety risks of the consequences of the unsafe event or condition? To what extent do alternatives mitigate such safety risks? Effectiveness can be viewed as being somewhere along a continuum, as follows:

1) ***Engineering mitigations.*** This mitigation eliminates the safety risk of the consequences of the unsafe event or condition, for example, by providing interlocks to prevent thrust reverser activation in flight.

2) ***Control mitigations.*** This mitigation accepts the safety risk of the consequences of the unsafe event or condition but adjusts the system to mitigate such safety risk by reducing it to a manageable level, for example, by imposing more restrictive operating conditions. Both engineering and control mitigations are considered "hard" mitigations, since they do not rely on flawless human performance.

3) ***Personnel mitigations.*** This mitigation accepts that engineering and/or control mitigations are neither efficient nor effective, so personnel must be taught how to cope with the safety risk of the consequences of the hazard, for example, by adding warnings, revised checklists, SOPs and/or extra training. Personnel mitigations are considered "soft actions", since they rely on flawless human performance.

b) ***Cost/benefit.*** Do the perceived benefits of the mitigation outweigh the costs? Will the potential gains be proportional to the impact of the change required?

Quality criteria for risk mitigation measures

c) ***Practicality.*** Is the mitigation practical and appropriate in terms of available technology, financial feasibility, administrative feasibility, governing legislation and regulations, political will, etc.?

d) ***Challenge.*** Can the mitigation withstand critical scrutiny from all stakeholders (employees, managers, stockholders/State administrations, etc.)?

e) ***Acceptability to each stakeholder.*** How much buy-in (or resistance) from stakeholders can be expected? (Discussions with stakeholders during the safety risk assessment phase may indicate their preferred risk mitigation option.) → fiel z.B. gut für Airline wenn mehr aber schlecht für Umwelt

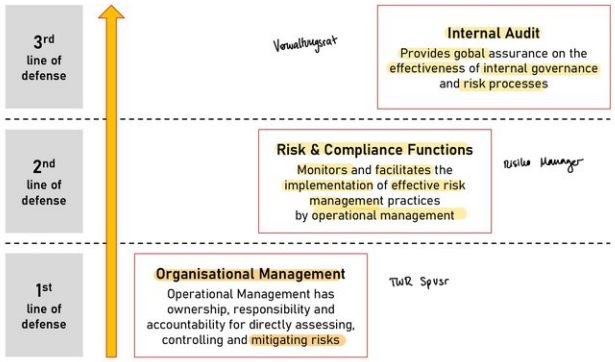
f) ***Enforceability.*** If new rules (SOPs, regulations, etc.) are implemented, are they enforceable?

g) ***Durability.*** Will the mitigation withstand the test of time? Will it be of temporary benefit or will it have long-term utility?

h) ***Residual safety risks.*** After the mitigation has been implemented, what will be the residual safety risks relative to the original hazard? What is the ability to mitigate any residual safety risks?

i) ***New problems.*** What new problems or new (perhaps worse) safety risks will be introduced by the proposed mitigation?

Risk management in the organisational structure „Three lines of defense"



OPERATIONAL SAFETY MANAGEMENT

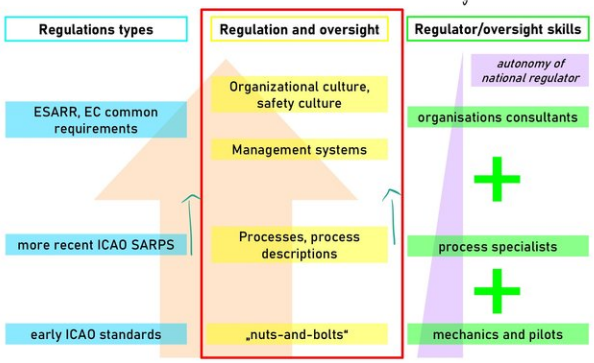
Nicht behandelt: Arbeitssicherheit

- Standards & Safety Regulation
- Safety (Risk) Management System
- Safety Risk Assessments
- Safety Investigations
- Safety Culture
- Human Factors
- Just Culture
- Organisationsformen

→ civil transport has evolved to ultra safe system

→ regulations, standards and oversight are key elements for the safety of commercial air transport

How regulation and oversight have evolved



The objective of all Safety **Management** activities is to

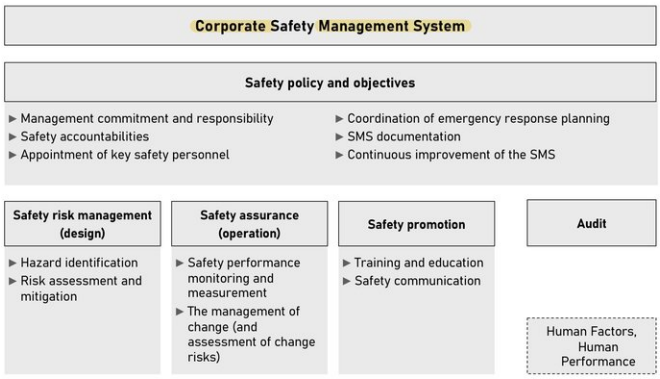
- identify and
- mitigate RISKS

in the entire (operational) system, before they lead to an accident.

Eight building blocks of Safety Management System

1. Senior management's **commitment** to the management of safety.
2. **Effective safety reporting.**
3. **Continuous monitoring** through systems to **collect, analyse, and share** safety-related data arising from normal operations.
4. **Investigation** of safety occurrences with the objective of identifying systemic safety deficiencies rather than assigning blame.
5. **Sharing** safety lessons learned and best practices through the active exchange of safety information.
6. **Integration** of safety training for operational personnel.
7. Effective **implementation** of Standard Operating Procedures (SOPs), including the use of checklists and briefings.
8. **Continuous improvement** of the overall level of safety.

ICAO Safety Management System Structure



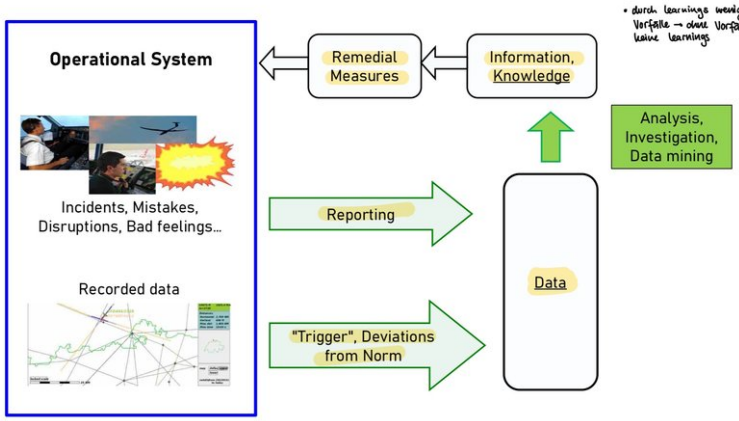
Occurrence reporting and investigations, "Safety Assurance"

"ATM Service Providers shall ensure that **occurrences** are formally and systematically investigated and that lessons are learned."

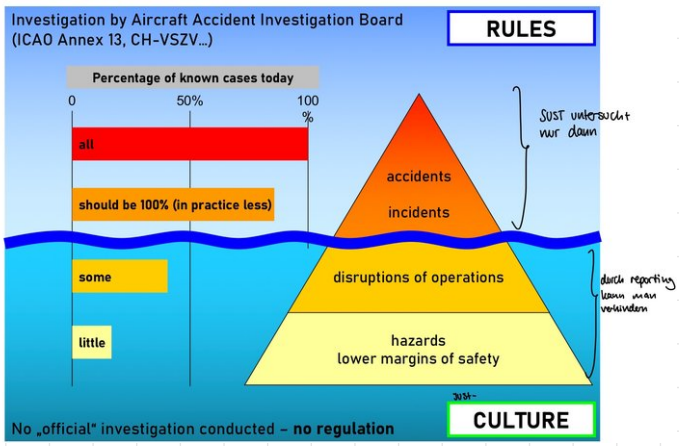


Learning from Incidents and Accidents

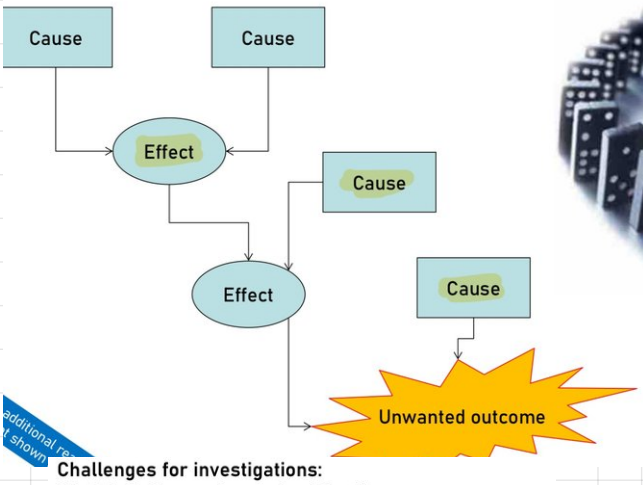
Problem: hängt von Vorfällen ab
→ System heilt sich selbst
• durch Learning weniger Vorfälle → aber Vorfälle keine Learnings



Accidents have deeper roots – which are often hard to see...

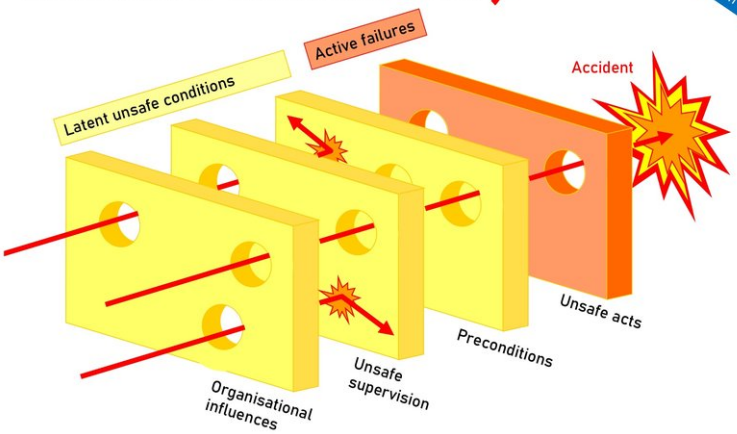


Linear Accident Model (sometimes called "Domino Model")

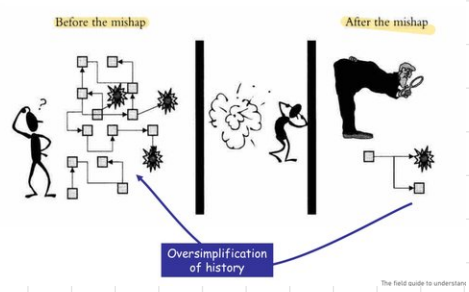




James Reason's "Swiss cheese model»

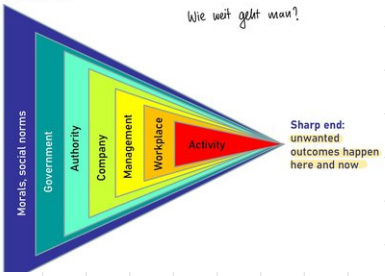


Challenges for investigations: Hindsight bias and oversimplification



Challenges for investigations: Sharp end – blunt end

Wie weit geht man?



"Human Error" – The role of the human in the system



- **Fallible humans create problems within otherwise safe systems.**
  Changing human behavior and automating systems reduces accidents happening.

OR

- **Failure and success have the same source: people's ability to adapt their performance.**
  Better understanding of daily workarounds reduces accidents happening.

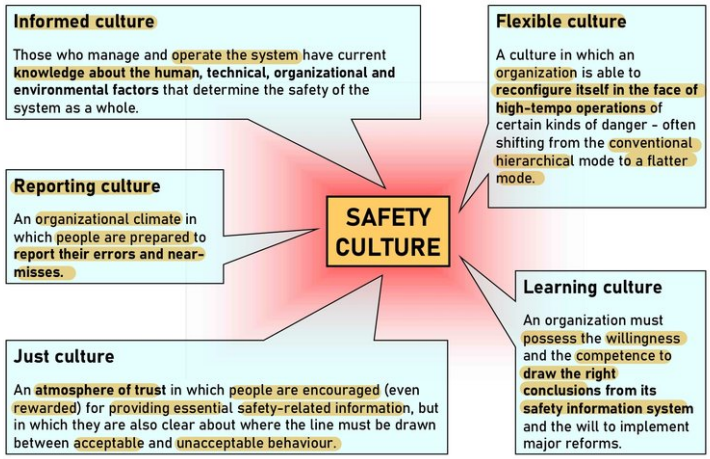
Definition of "Safety Culture"

« It is the way Safety is done around here … »

or, more formally :

"Safety culture is the product of individual and group **values**, attitudes, competencies and patterns of behavior that determine commitment to and the style and proficiency of, an organization's Safety health and Safety management."

Safety Culture: Building blocks (just one model of many)



Just Culture



good safety culture

1. Keep the discussion about risk alive, especially when everything looks safe.
2. Welcome bad news and strive to encourage fresh and new views.
3. Recognize yourself as personally involved in the creation of Safety.
4. Consider that the company supports decisions made at individual level.
5. Accept that the way you respond to business pressures may erode Safety.
6. Care about the rhythm of changes imposed to the system.
7. Prepare yourself to respond to unexpected situations.

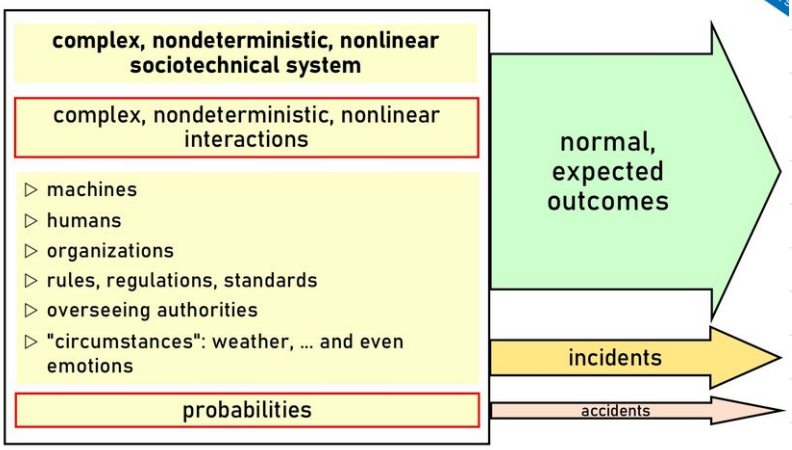
bad safety culture

1. Consider past success as a guarantee for future Safety.
2. Shoot Safety messengers.
3. Blame people in retrospect.
4. Make decisions if you feel you miss the expertise and the authority to do so.
5. Support goals that can only be achieved by jeopardizing Safety.
6. Believe that deviating from rules and procedures is the only way to cope with business pressures.
7. Encourage complexity and fragmentation of problem solving.

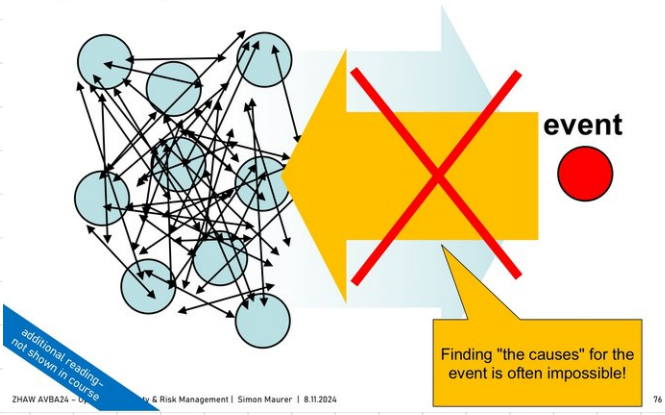
Verhalten von Organisationen im komplexen Umfeld

- Komplexität
- Wie sich sichere Unternehmen verhalten
- Verhalten von Organisationen in operationellen Krisen
- Organisationskultur

Characteristics of a complex system

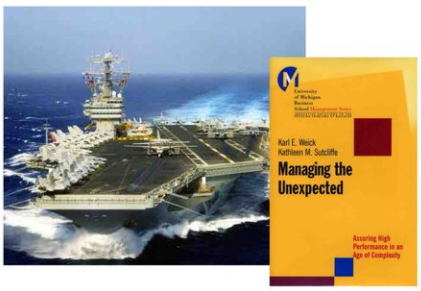


The combination of probabilistic factors and small deviations in the system may lead to an unwanted outcome



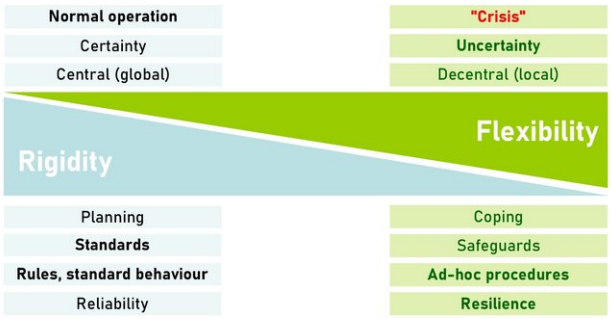
"High Reliability Organizations consider the emergence of abnormalities as an unavoidable property of complex systems"

- Sensitivity to the business front end
- Reluctance to (over-) simplify interpretations
- Systemic learning from events
- Commitment to resilience
- Deference to expertise



Particular capabilities:
- Switching between centralized and decentralized modes of operations
- Strong culture as centralization mechanism
- Deliberate management of the balance between stability and flexibility

An organisation in a complex high-risk environment must behave both rigidly and flexibly to deal with crisis situations.



Human Factors (Woche 8) 1/4

Aerodromes (Woche 9)

Security, Emergency Response 10.2

Safety : protection from unwanted incidents

Security : protection from intentional harm

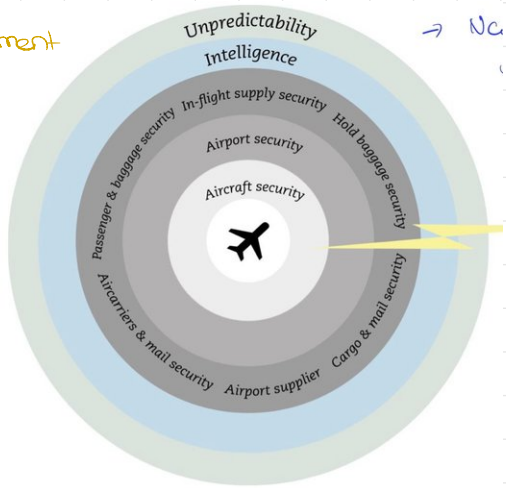
↳ unauthorised access, fake diversion / insider, stowaway protester, attach on aircraft, cyber attacks

threat : ① intent or desire to attack the target
② the capability to do so

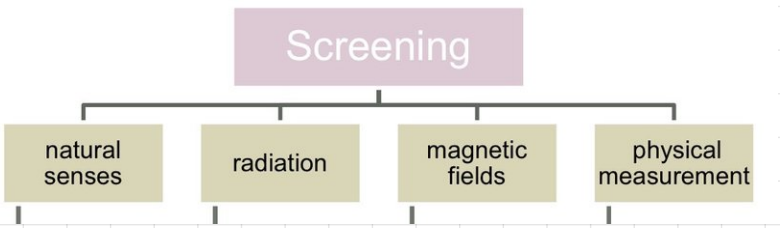
risk : threat x vulnerability → nur das können wir steuern

Security Programm: (SeMS) Security Management of Security

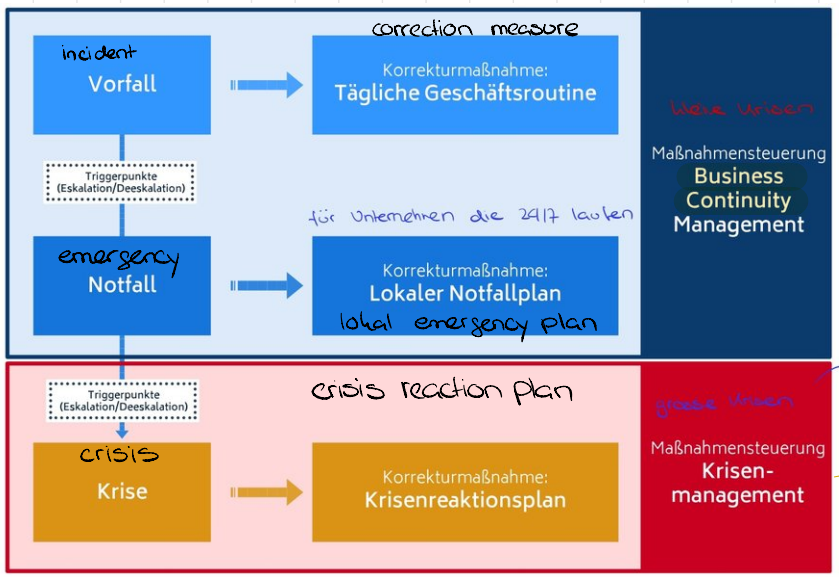
multi-layered approach for security:







methods



→ Business Continuity

→ vorbereitet sein denn in der Krise kann man nicht denken

https://www.dmw-assekuranz.de/risikomanagement/das-krisenmanagement/

Crisis Management

Crisis management: systematic handling of crisis situations

↳ includes the identification and analysis of crisis, development of strategies, as well as initiation and monitoring of countermeasures

Disciplines 3 C's

Krisenmanagement

Command
- Organisation
- Krisenstab
- Infrastruktur
- Prozesse
- Checklisten

Communication (grösste Hürde, denn der Multiplikator ist einfach viel grösser)
- Sender
- Inhalte
- Adressaten
- Kanäle
- Social Media

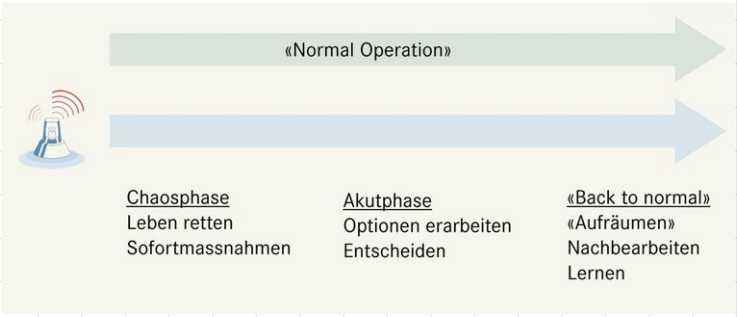
Care (verletzt) (die verletzten betreuen)
- Betreuung
- Direkt Betroffene
- Mitarbeitende
- Kunden
- Angehörige
- Logistik

zu Beachten während der Vorbereitung:
- common sense
- sound judgement
- adaptability



Phases:





Air Navigation Services 11

Quizlet da keine Folien

BAZL – Bundesamt für Zivilluftfahrt 12

- Struktur und Funktion des BAZL als Fach Amt im UVEK verstehen
- wichtigste Elemente der Luftfahrtentwicklung an einem Beispiel
- regulatorische Strukturen in Europa und Rechtssetzungsprozess
- Elemente der Sicherheitsaufsicht & Konzept erklären
- Konzept für Luftfahrtsektor Bereich Emissionen

BAZL: regulator, ensures high standard of safety and security, promotes civil aviation, supports sustainable development

→ promote Switzerland as an attractive location
↳ collaborates with international aviation organizations to make sure Switz's national interests are considered

BAZL ≠ MAA military aviation authority

Political structure (national): Parlament → oversight (Aufsicht), responsible → UVEK (Bundesrat)
Specialised authority (Fachbehörde) BAZL

- **Klare Rollenteilung im System Luftfahrt:**
  - Regulator/Aufsichtsbehörde
  - Provider
  - Operator & Organisationen

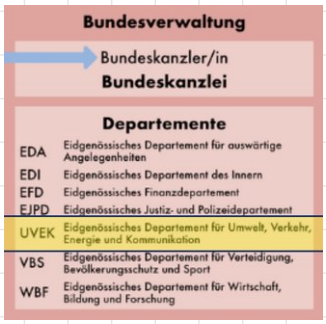
aber keine Polizei — aber gewisse Aufgaben im Bereich Verwaltungs

- ***Regulator:*** «Rechtsetzende» und "Rechtsdurchsetzende" Instanz, zuständig für internationale Kontakte und Vereinbarungen, fungiert auch als Polizeibehörde
- ***Provider*** *(Dienstleister):* erbringt hoheitliche Leistungen im Auftrag des Regulators (z. B. Skyguide)

Mehrheitsschweiz — nicht gewinnoptimierte Unternehmen — gehört dem Bund

- ***Operator/Organisationen:*** private Unternehmen, welche auf dem Markt Luftverkehrs-Dienstleistungen anbieten

ca. 400 Unternehmen in der Schweiz



VFAL: Verordnung über die **Finanzhilfe** für **Ausbildungen** im Bereich **Luftfahrt** (Art.103 LFG)

- **Berufspilot / -in**
- **Fluglehrer / -in**
- **Flugzeugtechniker / -in**

UVEK → BAZL ist Unterkategorie

BAZL ist divided into categories: aeronautical development and security + safety
→ are separated into 2 (getrennt in der Schweiz)

Vorgaben National

Parlament (NR/SR): Vorstösse, Entscheide und

LUPO: Luftfahrtpolitischer Bericht (letztmals verabschiedet vom BR 2016) ca. alle 10 Jahre ↳ alle 10 Jahre wird er revidiert

Inhalt → Leitsätze: fördern ↓

- Anbindung der Schweiz an den Luftverkehr
- Infrastruktur (SIL)
- Sicherheit
- Organisation der Flugsicherung
- Ausbildung und Forschung
- Neue Technologien und…

Sicherheitsempfehlungen der SUST
(CH Sicherheits-Untersuchungsstelle)

Political structure: ICAO Annexes 1-19 → SARPs
(international) EASA

aviation development: sustainability strategy in all infrastructure
→ look at the needs of the futur gen while consumption of resources

sustainability relies on: ecology, economic, social impact
↳ instruments
- SIL: aviation infrastructure plan
- enabling innovation
- control through charges (Gebühren)
- development of regulations national & international

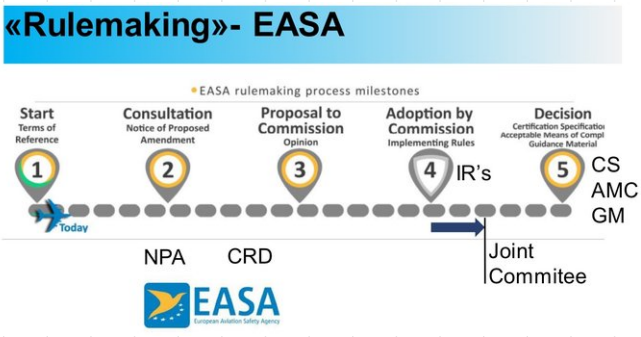
Die Schweiz kennt Sachpläne für die Bereiche (Zuständigkeit beim Bund):
SIL

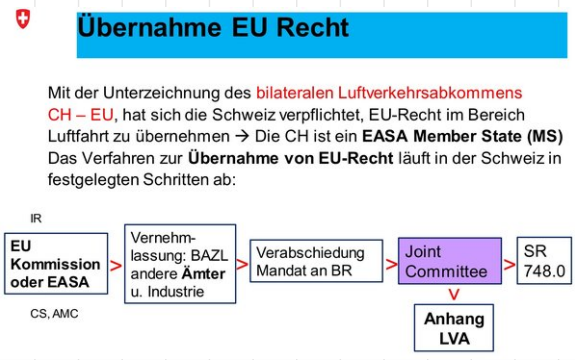
- Fruchtfolgeflächen
- Übertragungsleitungen
- Militär und Waffenplätze
- Alptransit
- Verkehr → **Luftfahrt**

SIL:
- planning and coordination instrument of the Bund for civil aviation
- puts binding goals and requirements for the infrastructure
- coordination between construction and operation of aerodromes and neighbouring areas

2 Parts: cocept part & object part
- general goals and requirements for the ENTIRE infrastructure of civil aviation
- concretisises these requirements from the concept part for individual aerodromes (Flugplätze)

motion: proposal from the legislative to introduce new law





State Safety Programm SSP: goal to receive an acceptable level of safety

ICAO Annex 19 ⇒ Safety Management

Die SSP Quadranten der Schweiz

improve aviation safety

defines safety goals, policies
allocates resources

SAFETY POLICY & OBJECTIVES 1

- LUPO
- FOCA Safety Policy
- Regulatory framework
- Resources

SAFETY RISK MANAGEMENT 2

FOCA to:

- Identify potential risks across CH aviation system
- Implement MS (CM&SMS) with stakeholders (Certification)
- Establish effective reporting system (EU 376/2014)
- Accident investigation capability

→ identifies and mitigates potential aviation risks

fosters safety culture by sharing safety information

SAFETY PROMOTION 4

- Safety Information
  - Communication (internet)
  - Dissemination (reporting)
- Internal & external addressees

SAFETY ASSURANCE 3

FOCA Safety Oversight:

- Monitoring of Compliance & SMS via Audit & Inspection
- Risk & Performance based oversight concept

→ monitors compliance through audits and inspections

The **Efficiency-Thoroughness Trade-Off (ETTO)** is a concept describing the balance between efficiency and thoroughness in operational processes, particularly in safety-critical industries like aviation.

Explanation

- **Efficiency**: Focuses on completing tasks with minimal resources, effort, or time. It prioritizes productivity and cost-effectiveness.
- **Thoroughness**: Emphasizes careful and detailed execution of tasks to ensure safety, accuracy, and compliance with standards.

Since resources (time, staff, attention) are limited, organizations often need to trade between these two priorities.

Oberstes Gebot: ETTO (Efficiency-Thoroughness-Trade-off)

- Dafür braucht es nicht primär polizeiliche Überwachung, sondern überzeugende Anleitung und Ausbildung sowie ein **gut abgestimmtes Zertifizierungs-, Inspektions- und Audit-System (Aufsichtsplanung).**
- Leider geht es auch in einem grundsätzlich **nicht-punitiven**, von «**just culture**» geprägten, System nicht ganz ohne **Sanktionierungen**, nämlich dann, wenn **vorsätzlich** oder **grob fahrlässig** die Vorschriften missachtet werden.

Zertifizierung/Zulassung (Certification/Approval)

Systematisches Überprüfen und erteilen von Zertifikaten für

- Operator
- Organisationen
- Luftfahrzeuge
- Luftfahrtpersonal

Aufsicht (Oversight)

Laufende Kontrolle von Personen und Organisationen bezüglich Einhaltung der Vorschriften (Compliance) und dem Funktionieren eines SMS in Form von

- Inspektionen
- Audits
- Daten

weitere Überwachungsformen

WLF: wirtschaftliche Leistungsfähigkeit

Ramp Inspections:

Climate change:

Secondary effects in the context of aviation and climate change refer to the indirect or non-CO2 impacts of aviation emissions on the climate. These effects are distinct from the direct warming caused by carbon dioxide (CO2) and are often more complex and variable. Here's a detailed explanation:

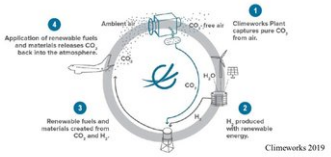
	CO_2-Emissions	Non greenhouse gas emissions (Non-CO_2)
Properties	CO_2 is a greenhouse gas Amount depends on the type of fuel and is proportional to the fuel consumption	Additional effects different from greenhouse gases Amount not proportional to CO_2, dependent on engine type and the environment Condensation trails: Formed mainly from water vapor of the ambient air
Impact	Always warming Low uncertainty Once emitted, impact for hundreds of years Constant emissions → warming still increases Impact independent from location, time of the day and weather	Warming and cooling Persistent contrails at night strongly warming, during day cooling High uncertainty Impact in Minutes, Hours, a Decade (NOx) Constant emissions → impact does not increase Impact depends on location, time of the day and weather

- no linear effect of CO_2 and secondary effects

Fossil-free-aviation:

Fossilfreies Fliegen

- Auf Grund seiner Energiedichte und weiterer Eigenschaften ist Kerosin der für die Luftfahrt am besten geeignete Treibstoff
- Kann Kerosin auch ohne die Verwendung fossiler Ausgangsstoffe (Erdöl) unter Verwendung erneuerbarer Energie hergestellt werden?
- Ja: Power-to-Liquid & Sun-to-Liquid
- Problem: Kosten, Skalierung
  → **Unterstützung durch Beimischpflicht**

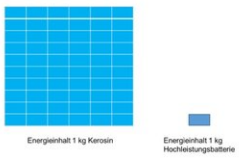


Fazit:
Fossilfreies Fliegen ist heute eine realistische Option für die Zukunft

Elektroflug

Entscheidend für einen möglichen grossflächigen Einsatz von elektr. Antrieben sind

- Volumen und Gewicht der für einen Flug zu transportierenden Energie



- Für die Ladung der Batterien benötigte Zeit
- Lebensdauer der Batterien (max. Anzahl Ladezyklen)
- Bereitstellung der Energie an den Flughäfen
- Die tatsächliche globale Reduktion der CO2-Emissionen und der Umweltbelastung insgesamt im Vergleich mit anderen Varianten

Key Features of CORSIA

1. **Objective**:
   - Achieve carbon-neutral growth in international aviation starting from 2020.
   - Offset the increase in CO2 emissions from international flights beyond 2020 levels.
2. **How It Works**:
   - Airlines calculate the CO2 emissions from their international flights.
   - If their emissions exceed 2020 levels, they must compensate for the excess by purchasing carbon offset credits.
3. **Carbon Offsets**:
   - These are certified reductions of CO2 emissions from projects in other sectors (e.g., renewable energy, reforestation).
   - The idea is to balance emissions by supporting activities that remove or reduce CO2 elsewhere.
4. **Phases of Implementation**:
   - **Pilot Phase (2021–2023)**: Participation is voluntary.
   - **First Phase (2024–2026)**: Participation remains voluntary.
   - **Second Phase (2027–2035)**: Man...ory for most countries, except for least developed

SUST - Sicherheitsuntersuchungen 13

Introduction to Safety Investigations in Swiss Civil aviation

Lernziele:

Sie sind in der Lage

- in einem geschilderten Szenario zu entscheiden, ob ein **Flugunfall** oder ein **schwerer Vorfall** vorliegt und in welcher Weise die Schweizerische Sicherheitsuntersuchungsstelle zuständig ist;
- zu erklären, welche **grundsätzlichen Massnahmen** die SUST je nach Ereignis einleitet;
- zu erläutern, wie die **Stellung der SUST** gegenüber anderen Organisationseinheiten des Bundes bzw. der Kantone ist;
- zu erklären, wer Flugunfälle und Vorfälle melden muss und wie die **Meldewege** geregelt sind.

- Based on ICAO Annex 13 (→ technische Norm), which governs aviation accident investigation principles

Goal: prevent future accidents and incidents, not to assign blame or liability

- What happened?
- Why did it happen?
- How can one improve?

Investigation authority should have: (EU 2010)
- independence in the investigation (→ without influence)
- unrestricted authority over its conduct
- independent of administrative authorities (→ Verwaltungsbehörde) and criminal proceedings (↳ Strafverfahren)

Common misunderstanding



Nichts vertuschen:

blame or liability. Nevertheless, the accident investigation authority should not refrain from reporting a cause merely because blame or liability might be inferred from the statement of that cause. An example of a formulation of the

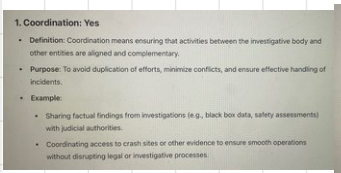
↳ die Schuldfrage geht der SUST nichts an, aber sie darf auch nicht zensiert werden

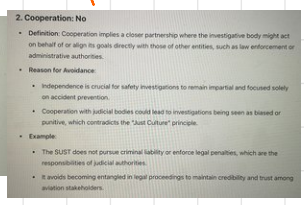
↳ wenn das Ganze strafrechtliche Folgen hat, dann muss das auch so ehrlich vorgelegt werden

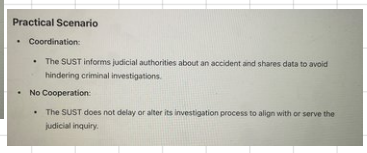
↳ Beweismittel verwaltet (sorgfältig)

↳ technisches Gerät zuschreiben

Cooperation with judical authorities
Coordination yes! Cooperation no!







Schutz sensibler Auskünfte

Art. 24 Verwendung von Auskünften in Strafverfahren

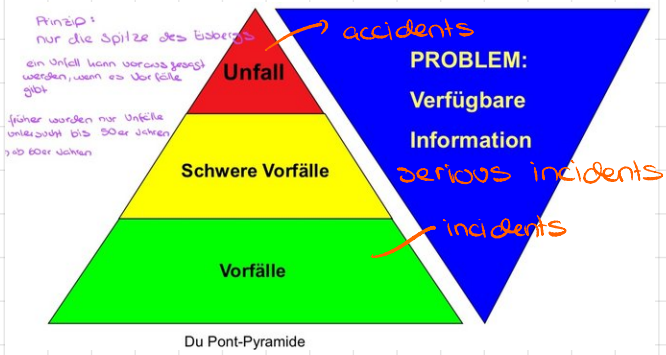
«Die von einer Person im Rahmen einer Sicherheitsuntersuchung erteilten Auskünfte dürfen in einem Strafverfahren nur mit deren Einverständnis verwendet werden.»

Offenheit und Ehrlichkeit gegenüber der Sicherheitsuntersuchungsstelle sollen keine negativen Auswirkungen für den Betroffenen haben.

↳ 2/3 geben ihre Aussagen dem Strafverfahren

SUST entschuldbare Argumente die Staatsanwalt schafft

makes safety regulations does not issue regulations → separation of power vis-a-vis the supervisory authority



Du Pont-Pyramide

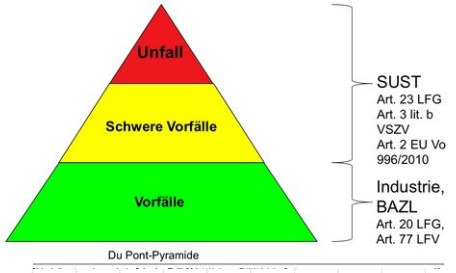
Vorfälle sollen „an der Basis" untersucht werden

↑ incidents

- Täglicher Betrieb möglichst umfassend überwachen
- Systematische Auswertung von Flug- oder Radardaten
- Offene Kommunikation von Fehlern – *reporting culture* → just culture
- Fehler dürfen nicht bestraft werden

Who to report?

Meldewege und Zuständigkeiten



Du Pont-Pyramide

accidents and serious incidents: aircrew → report to UVEK
aero-police

Meldepflicht Unfälle und schwere Vorfälle Art. 17 VSZV

Art. 17 Zivilluftfahrt: Meldungen an die Meldestelle[30]

[1] Zwischenfälle in der Zivilluftfahrt sind der Meldestelle unverzüglich durch folgende beteiligte Personen oder Stellen zu melden:

a. die Eigentümerinnen und Eigentümer der Luftfahrzeuge;
b. die Halterinnen und Halter der Luftfahrzeuge;
c. die Flugbetriebsunternehmen; Segelflugzeuge
d. das Luftfahrtpersonal;
e. die Organe der Flugsicherung;
f. die Flugplatzhalterinnen und -halter;
g. die Polizeidienststellen;
h. die Zollorgane;
i. das Bundesamt für Zivilluftfahrt. Drohnen → Modellflugzeuge

[2] Zwischenfälle von Ultraleichtluftfahrzeugen, nicht zertifizierten unbemannten Luftfahrzeugen, Hängegleitern, Fallschirmen, Drachen, Drachenfallschirmen und Fesselballonen sind nicht zu melden.[31] ehemalige Militärflugzeuge

alle Flugzeuge selbst gebaute Flugzeuge

Just culture:
«Fehler machen ist erlaubt, Fehler verschweigen nicht!»

What is investigated?
Zwischenfälle, sofern sie der Verhütung weiterer Zwischenfällen dienen können oder nach internationalem Abkommen Pflicht dazu besteht
↳ spätestens 2 Monates nach Ereignis

Ablauf einer Sicherheitsuntersuchung

- **Meldung** → 24/7 Stunden → Rega Notfallmeldestelle
- **Beurteilung des Ereignisses**
- **Untersuchungshandlungen**
- Entwurf Schlussbericht
- Qualitätskontrolle
- Betroffene Verkehrskreise können Stellung beziehen
- Bei begründetem Einwand: Korrektur oder Ergänzung
- Schlussbericht

im Ausland nur:

Zuständigkeit

- Schwere Vorfälle und Unfälle von zivilen Luftfahrzeugen
  - über schweizerischem Hoheitsgebiet
  - von schweizerischen Luftfahrzeugen
    - über der hohen See
    - wenn sich der zuständige Staat nicht darum kümmert
- Vertretung der Schweizer Interessen bei schwere Vorfällen und Unfällen von zivilen schweizerischen Luftfahrzeugen im Ausland → Pilatus

Zuständigkeit - Sonderfälle

- Unfälle oder schwere Vorfälle bei denen ein Militärluftfahrzeug involviert war.
- Unfälle und schwere Vorfälle von zivilen Luftfahrzeugen, die einer zoll- oder polizeidienstlichen Verwendung dienten, wenn für die Prävention nützlich.
- Andere Zwischenfälle, wenn zu vermuten ist, dass eine Untersuchung wichtige Erkenntnisse zur Verhütung von weiteren Zwischenfällen bringen kann.

Beurteilung der Ereignisse

- Massnahmen abgestuft nach
  - öffentlichem Interesse (nicht veröffentlichem Interesse)
    - Flugverkehr
    - Schulung, Transporte etc.
    - Drittgefährdung (spezialsach nicht in Annex 13 ganz selten ohne Flugzeuge kaputt zu machen ↳ bei Landung einen Stromleitung wegen)
  - Verletzungsgrad (sobald man schwerverletzte und Tote hat)
  - Wahrscheinlichkeit der Wiederholung (↳ gross ↳ sofort Untersuchung)

2. Arten von Meldungen

1. **Unfälle:** Ereignisse mit:
   - Todesfällen oder schweren Verletzungen.
   - Schweren Schäden am Luftfahrzeug.
2. **Schwere Vorfälle:**
   - Beinahe-Unfälle, die unter leicht anderen Umständen zu einem Unfall hätten führen können.
   - Beispiele: Gefährliche Annäherungen (AIRPROX), technische Ausfälle.
3. **Vorfälle:**
   - Ereignisse mit geringerer Gefährdung, aber potenzieller Bedeutung für die Prävention.
   - Beispiele: Nicht eingehaltene Sicherheitsprozeduren.

Ablauf einer Sicherheitsuntersuchung Untersuchungshandlungen

- Spurensicherung
- Aufzeichnungen auswerten
- Befragungen
- Autopsie
- Zwangsmassnahmen
- Technische Analysen
- Rekonstruktionen
- Simulationen
- Versuche
- …
- **Gehen, wohin die Erkenntnisse uns führen…**

Forschung & Entwicklung Woche 14

siehe Quizlet