Zukünftige Anforderungen an Flugzeugklimasysteme

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Do passengers get enough oxygen?

[illegible] examine [illegible] at that [illegible] 8,000-foot mountain – not as much [illegible] carried to vital [illegible]

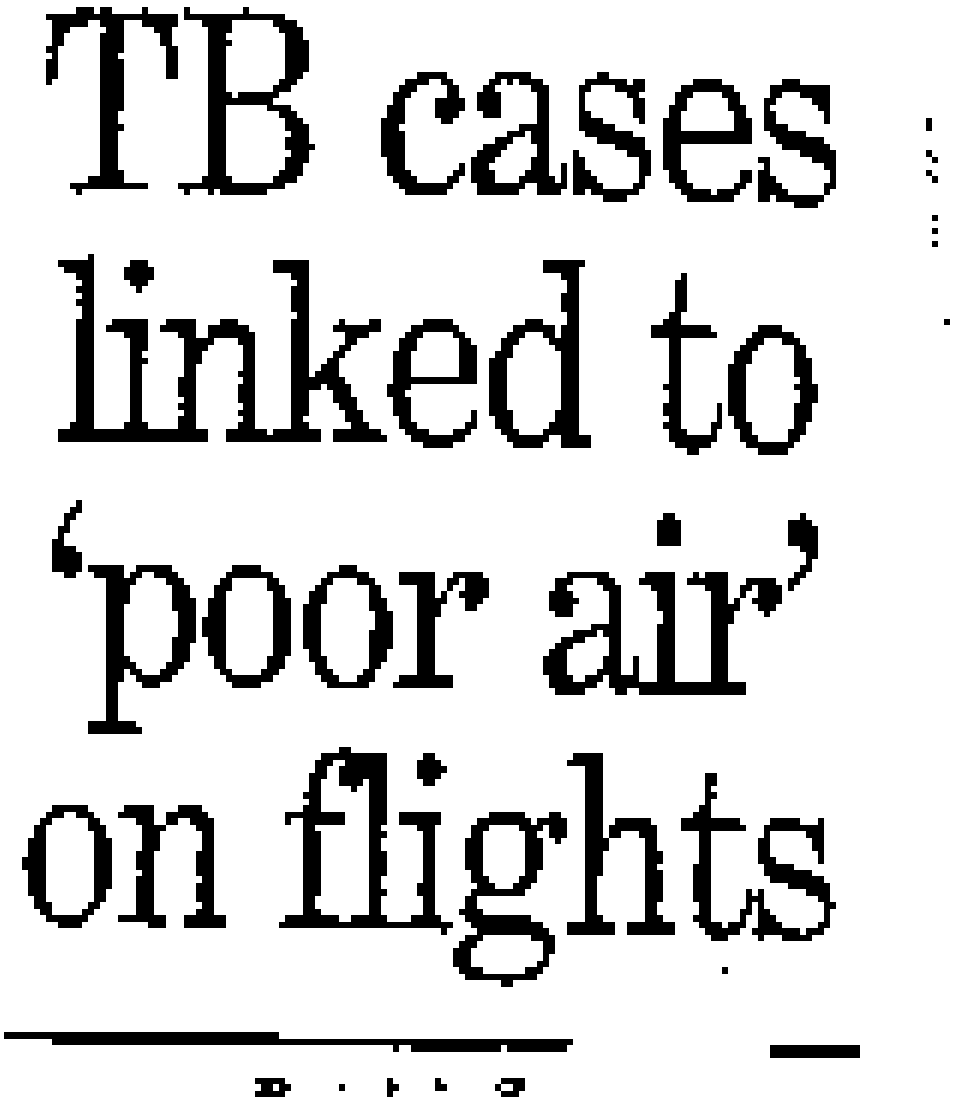
Luftfahrt

Vom Fuß ins Gesicht

Die Bordluft in Flugzeugen ist ungesund: Sauerstoffnot und Krankheitserreger bedrohen die Passagiere.

A lady lawyer in San Francisco charges the systems of air recycling in the aircraft cabin with conveying viruses to the passengers.

" The airliners are the new *plague-spreaders*: they do sow cold and 'flu "



Is 8000 feet appropriate?

British pilots overcome by fumes

Flight Attendants Question Health Risk Of Recirculated Air in Newer Cabins

Poor Cabin Air Quality Seen as Threat to Health and Safety

Here we are……

…… what to do?

The role of Aircraft Manufacturers

AIRBUS' objective is to fulfill…….

….. the airworthiness requirements

….. the needs and wishes of our customers

….. fulfill the airworthiness requirements

- Safety as #1 concern
- Not compromise occupant health
- Certify our aircraft types for operation around the world (several airworthiness authorities)

….. fulfill the needs and wishes of our customers

Who are our customers?

- Airlines

  ….. from low cost carriers to premium class operators

- The passengers

  ….. from backpackers to the ‘diva’

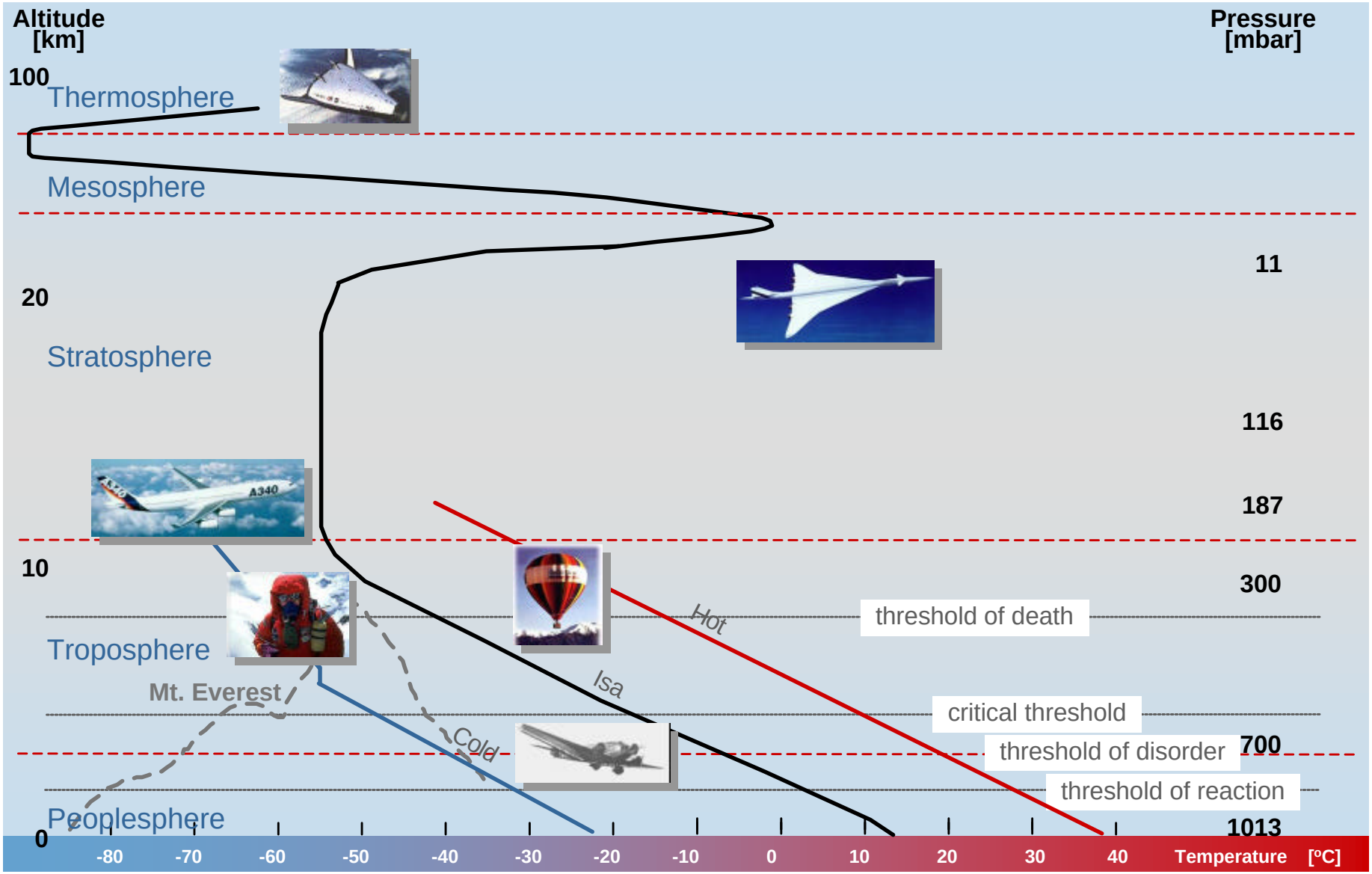
- The crew

  ….. from maintenance staff to cockpit and cabin crew

Passenger and Crew Comfort

Ensure passenger and crew comfort under extreme outside conditions.

The Atmosphere



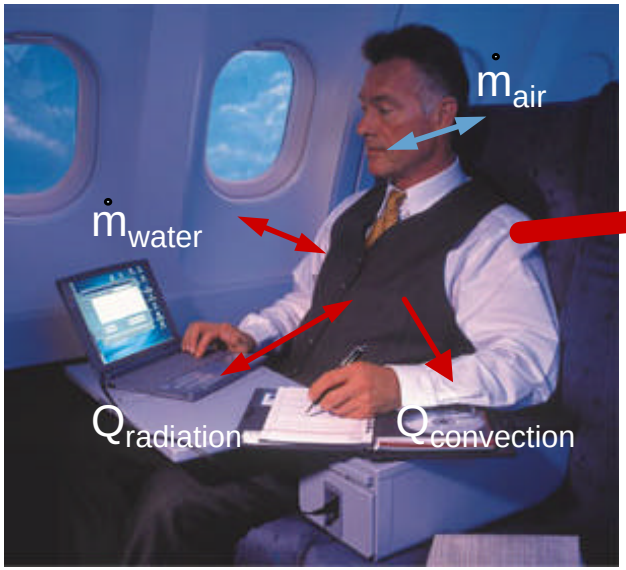
Air Systems Primary Functions

- Contribute to safety, health & comfort of passengers and crew by
  - providing appropriate thermal conditions
  - providing good air quality
  - providing suitable cabin pressure
  - providing counter-measures in case of smoke in cabin
- Ensure specified thermal conditions to transport freight in Cargo Compartment
- Cool food and beverages
- Cool electronics in specified compartments
- Provide de- or anti-icing capabilities for specified areas
- Provide pressurization capabilities for other systems (e.g. water, hydraulics)
- Provide pneumatic power distribution for engine start capability

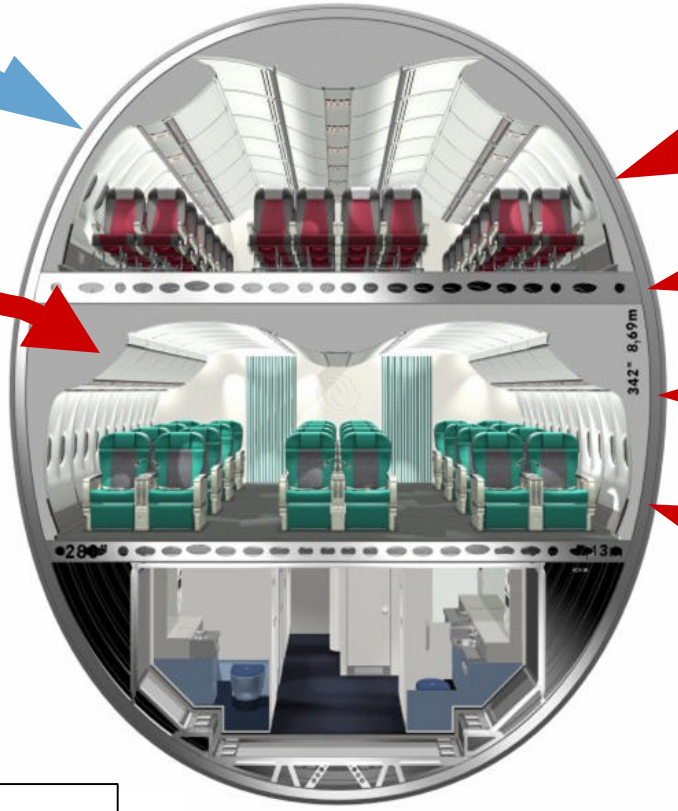
The Air Systems have to ensure multiple primary functions

Air condition dimensioning

demand of
outside air



heat balance of a human being

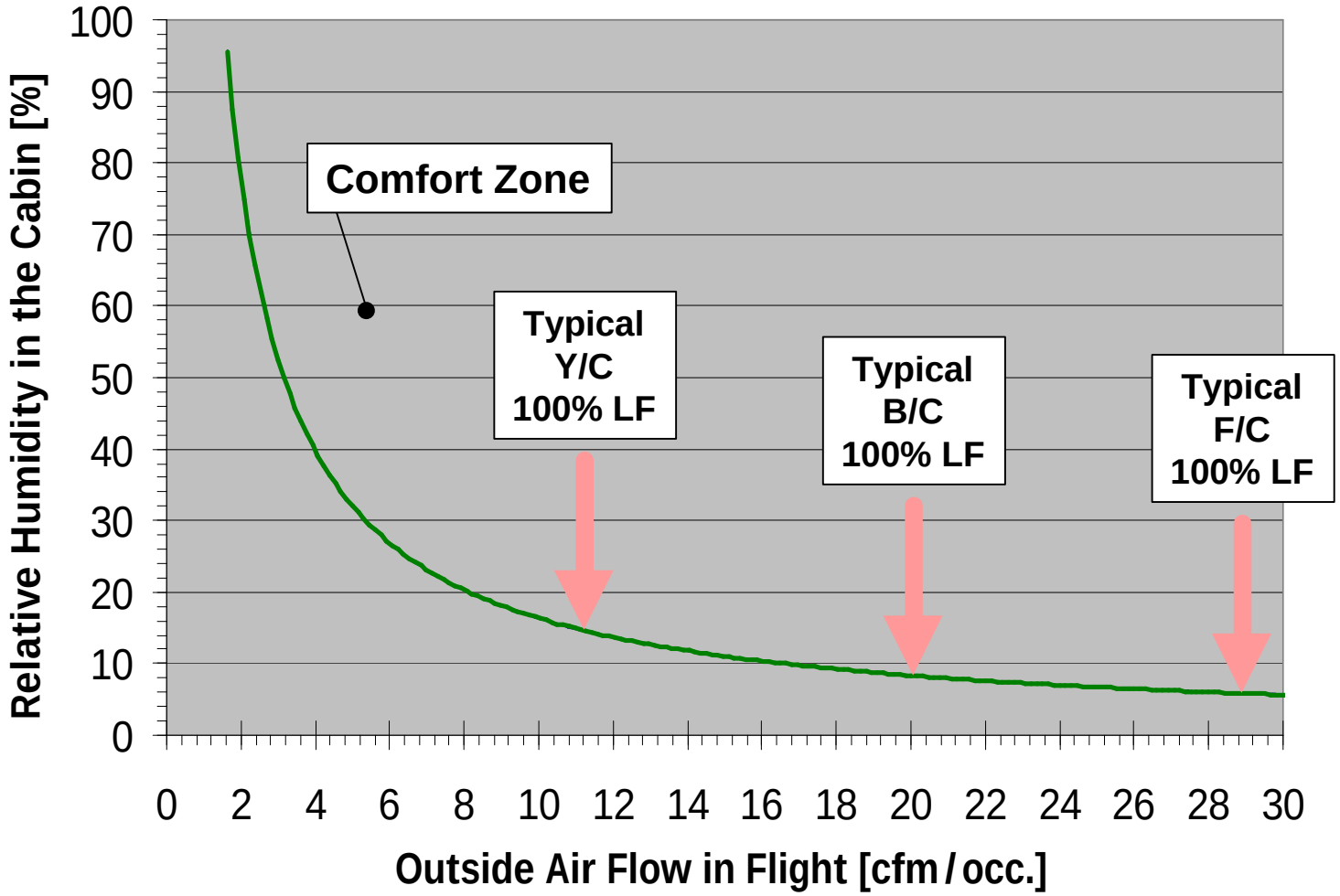


$$\dot{m}_{cab}\, C_P \frac{dT_{cabin}}{dt} = \sum \frac{dQ}{dt}$$

heat balance + **demand of outside air**

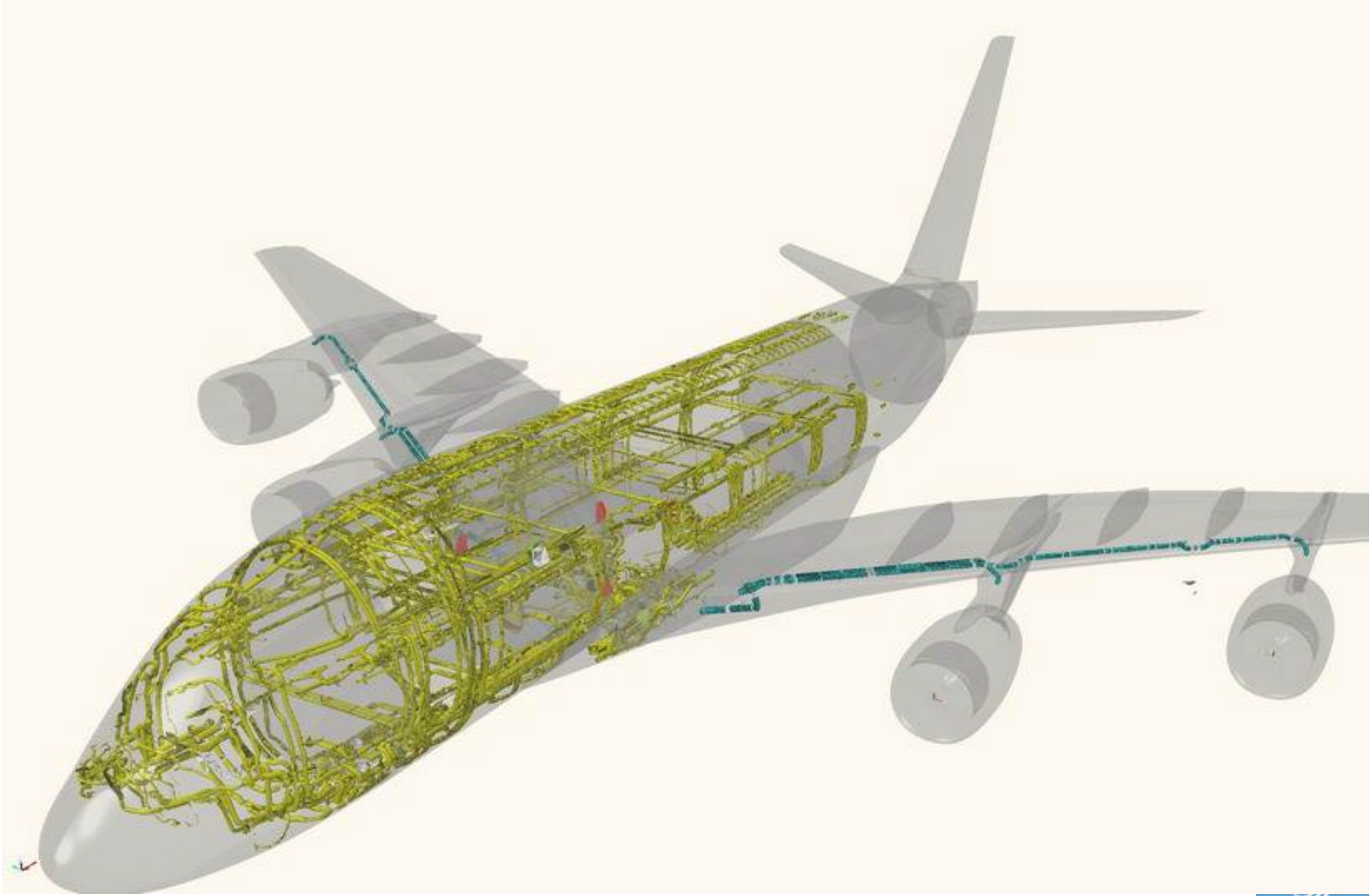
=> ***demand on climatic efficiency***

Why is cabin air so dry during flight?



**Outside air virtually without humidity,
occupants only source available**

DMU A380 Air-Conditioning & Bleed Air System



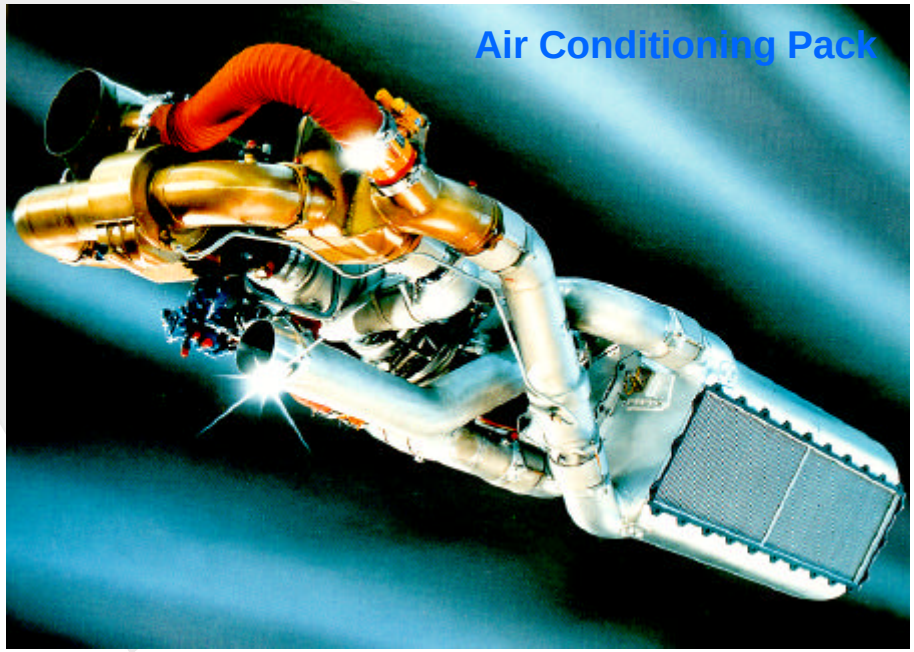
Air Generation System

Main Tasks:

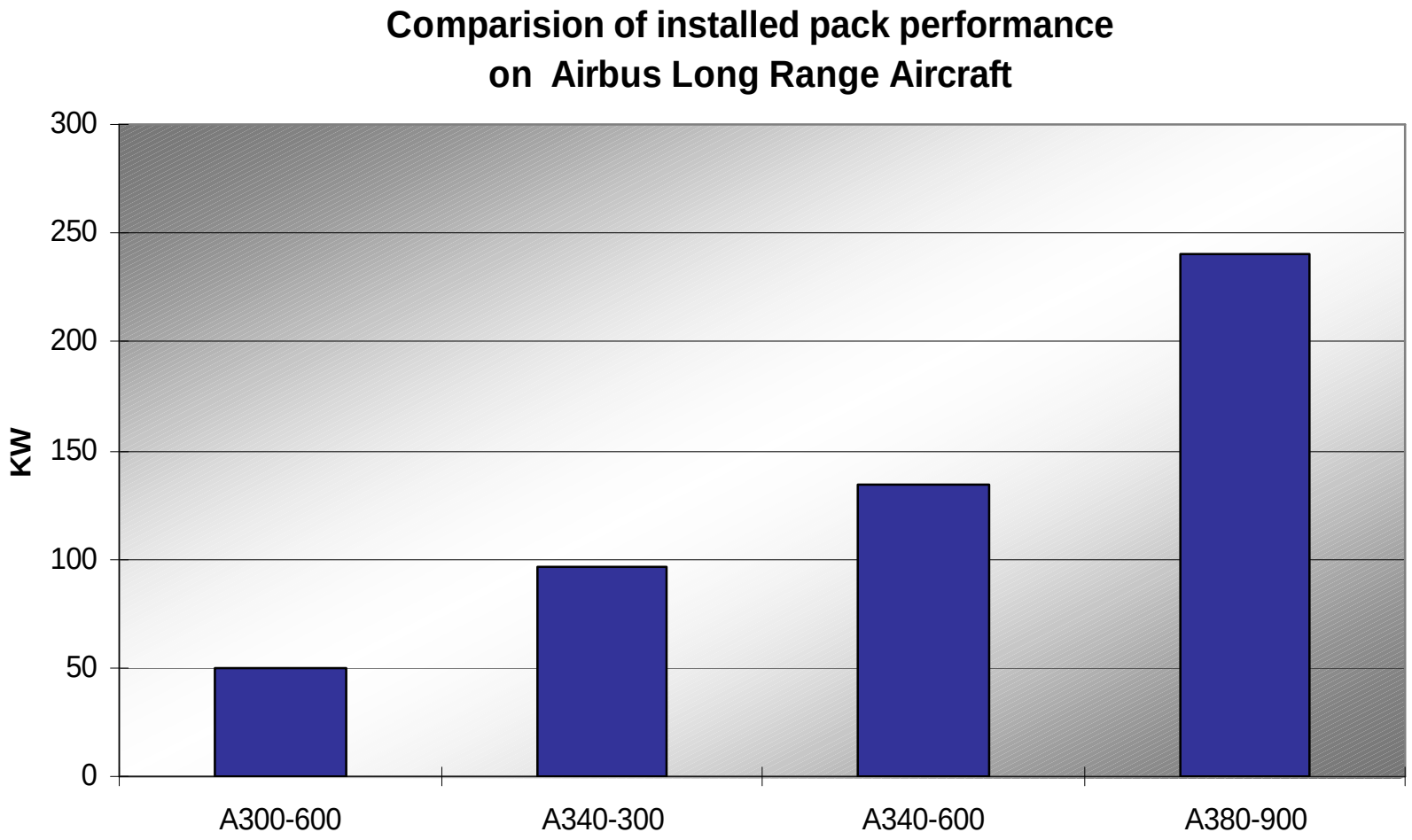
- Provide air to pressurize cabin
- Provide fresh air for passengers
- Cool down bleed air to required temperature
- Decrease humidity of bleed air

Characteristic of A340 Pack:

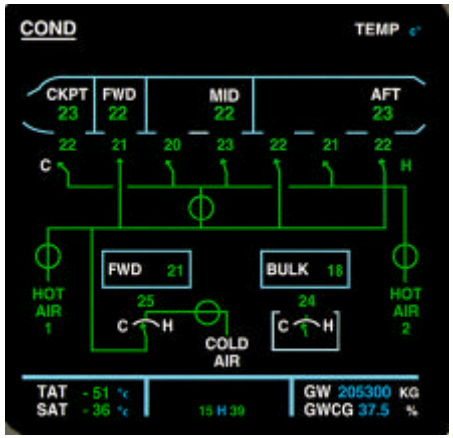
Installation:	in front of main LDG bay
Weight:	ca. 180 kg
Max. airflow:	1,65 kg per sec
Airflow temperature:	-50°C to + 50°C

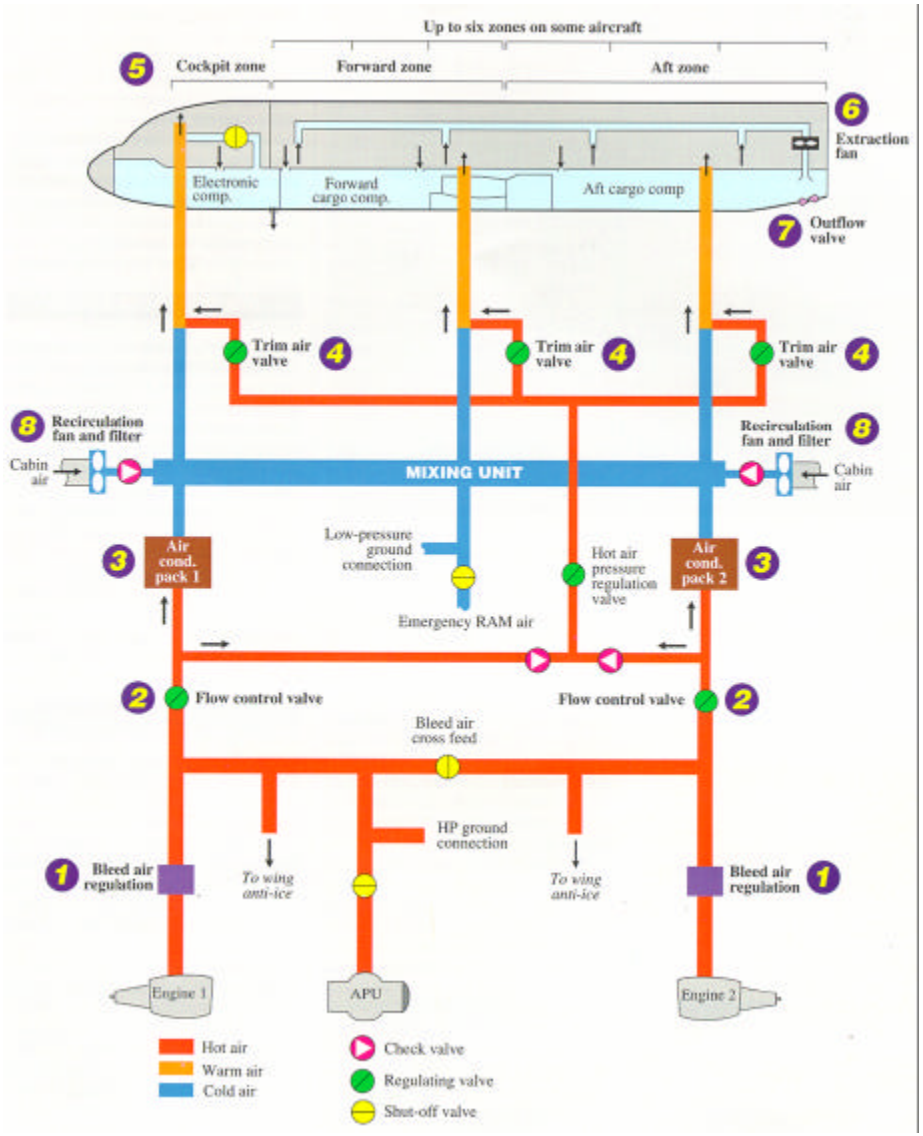


Pack Performance



Zone Temperature Control

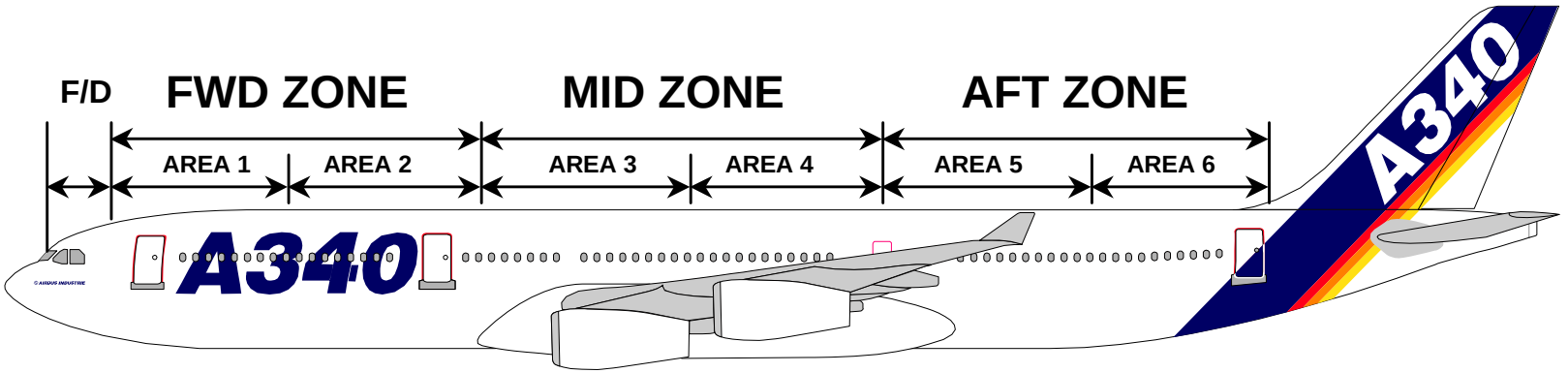




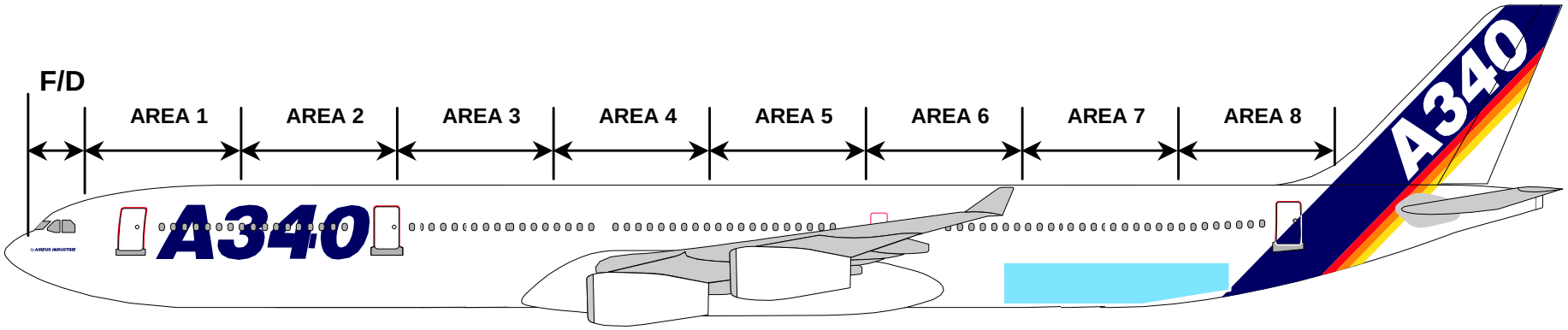
Main Tasks of Zone Temp Control

- Determination of demanded air temperatures in the various zones (5)
- Computation of required pack (3) outlet temperature
- Control of trim air system (4) according to the requirement of each zone
- Monitoring of system functioning and communication with pack controllers and entire aircraft systems
- Prevention of cabin pressurization, if doors are not locked closed

Temperature Control



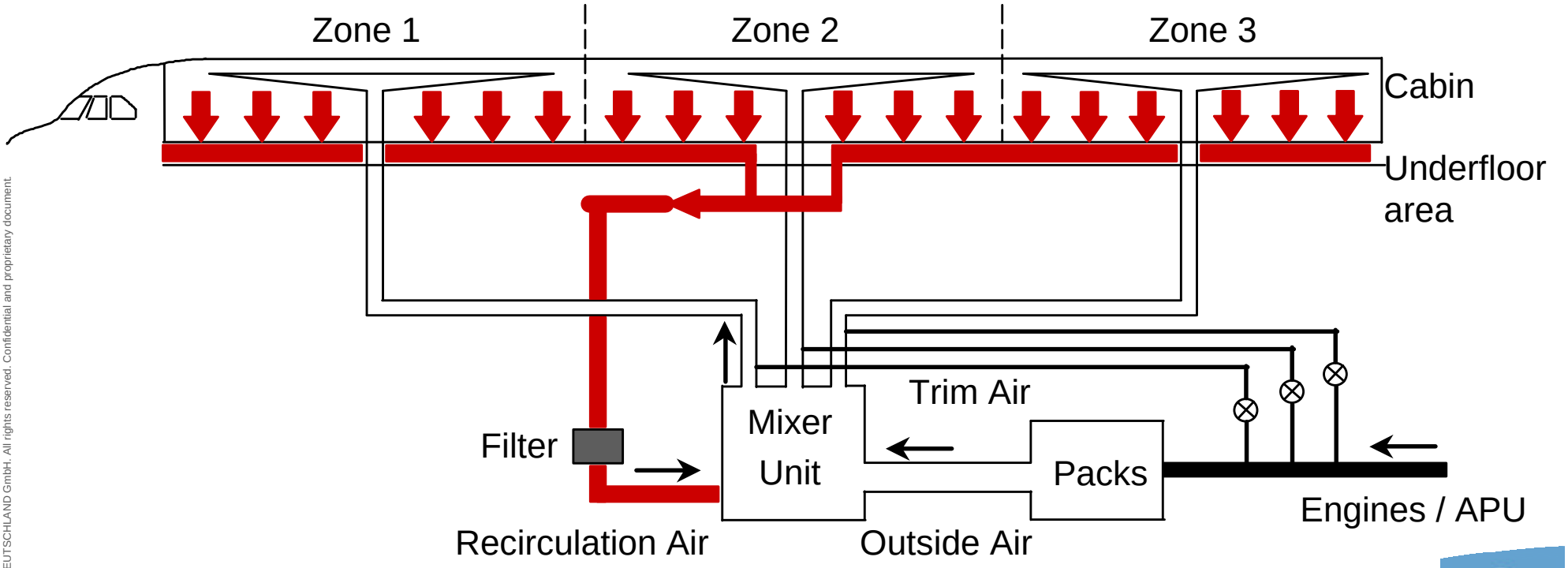
A340-300



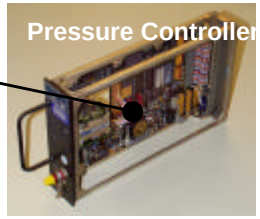
A340-600

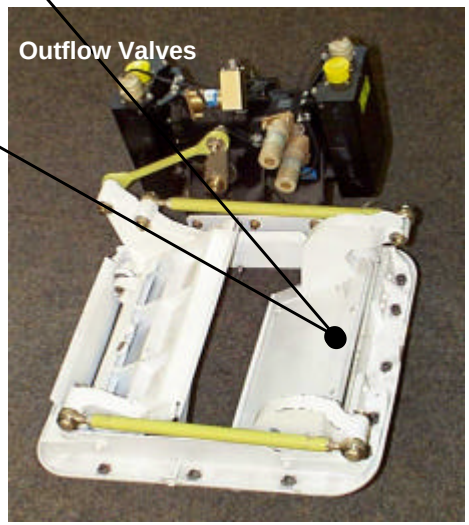
Dimensioning of air distribution

- multi-area concept: allows more accurate temperature control
- 2D air distribution through continuous longitudinal distribution for the supply- and outlet air
- preferably noiseless, which means limit of air speeds:
  outflow velocity < 2m/s
- small air speeds close to pax (< 0.25 m/s)



Cabin Pressure Control



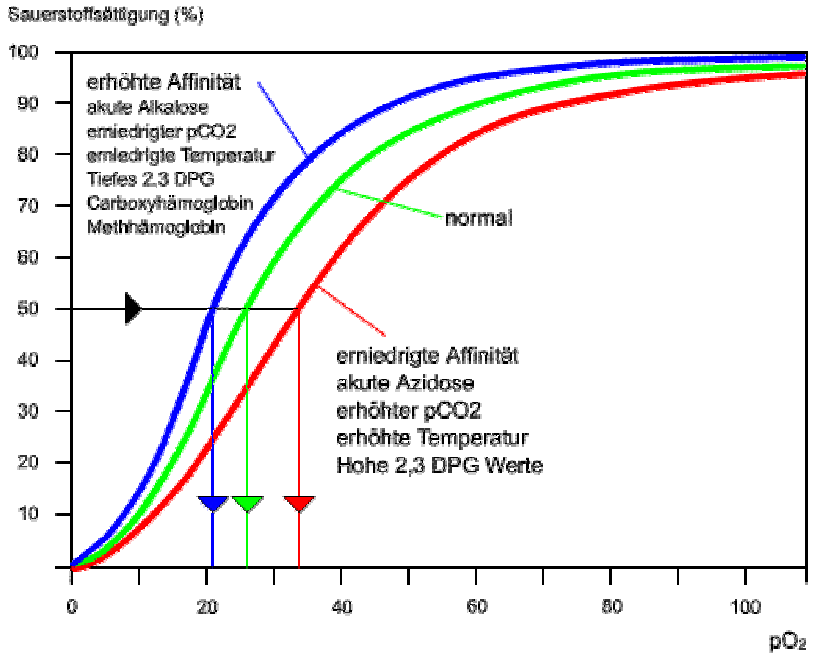


Main Tasks CPCS:

- Fully automatic cabin pressure control in all flight and ground conditions
- Control cabin pressure according to the needs of passengers breathing
- Limit cabin pressure, to prevent structural overstress
- Monitor system behaviour, to detect and react on component failures
- Ensure additional safety redundancy in terms of overpressurization and negative differential pressure
- Comunicate to entire aircraft systems

Pressurization

- Pressurization of the cabin by supply of external air
- Control through adjustment of the air outlet valve
- Cabin pressure altitude (pressure equivalent):
  - rules: max. 8000ft
  - Airbus: 7300ft – 8000ft
- Compromise between weight (increased requirements on structure because of pressure difference) and Oxygen-partial pressure for human health and comfort



Why reducing cabin pressure during flight?

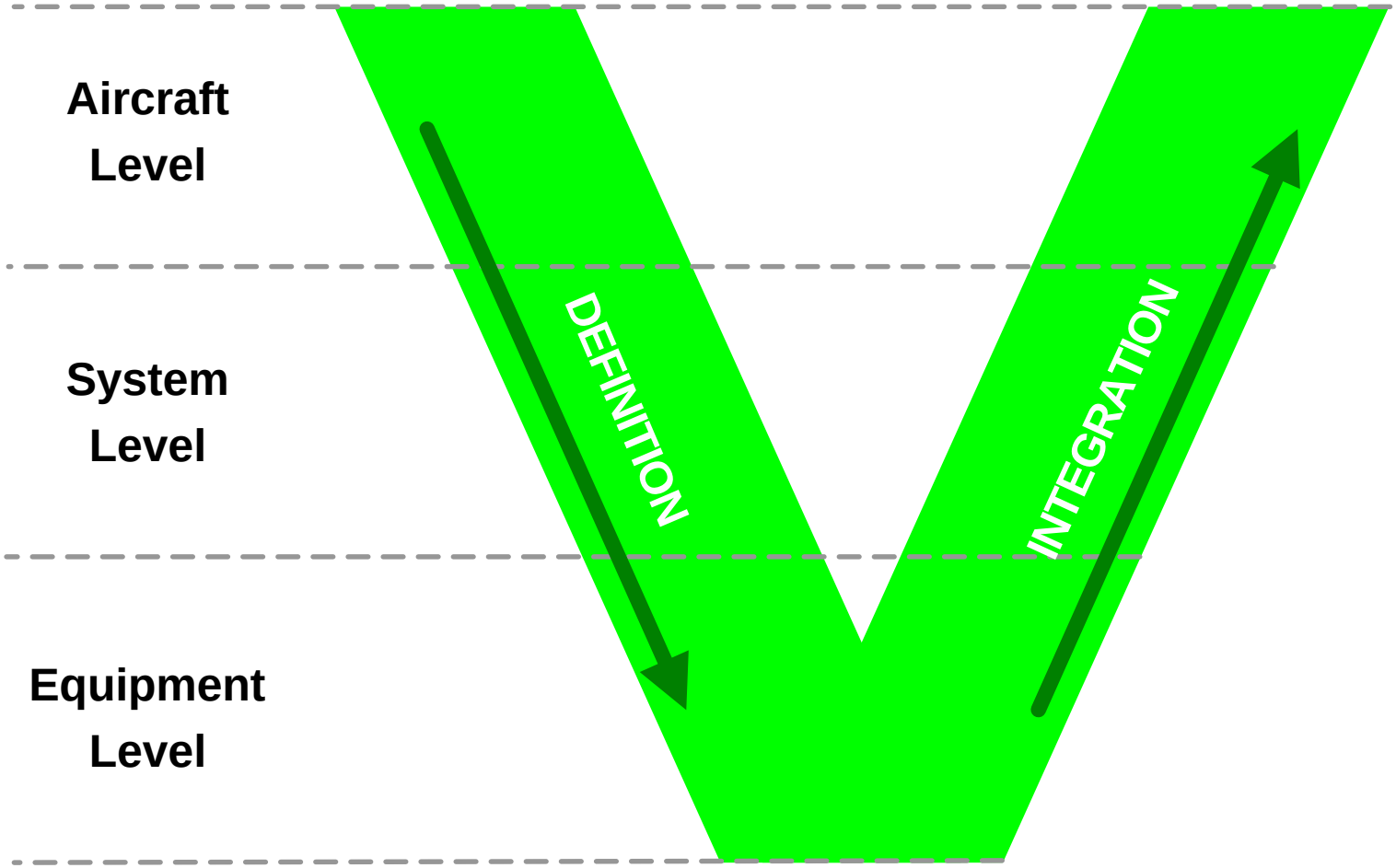
Load on the door due to pressure difference

Ground pressure in the cabin/
41,000 ft flight altitude

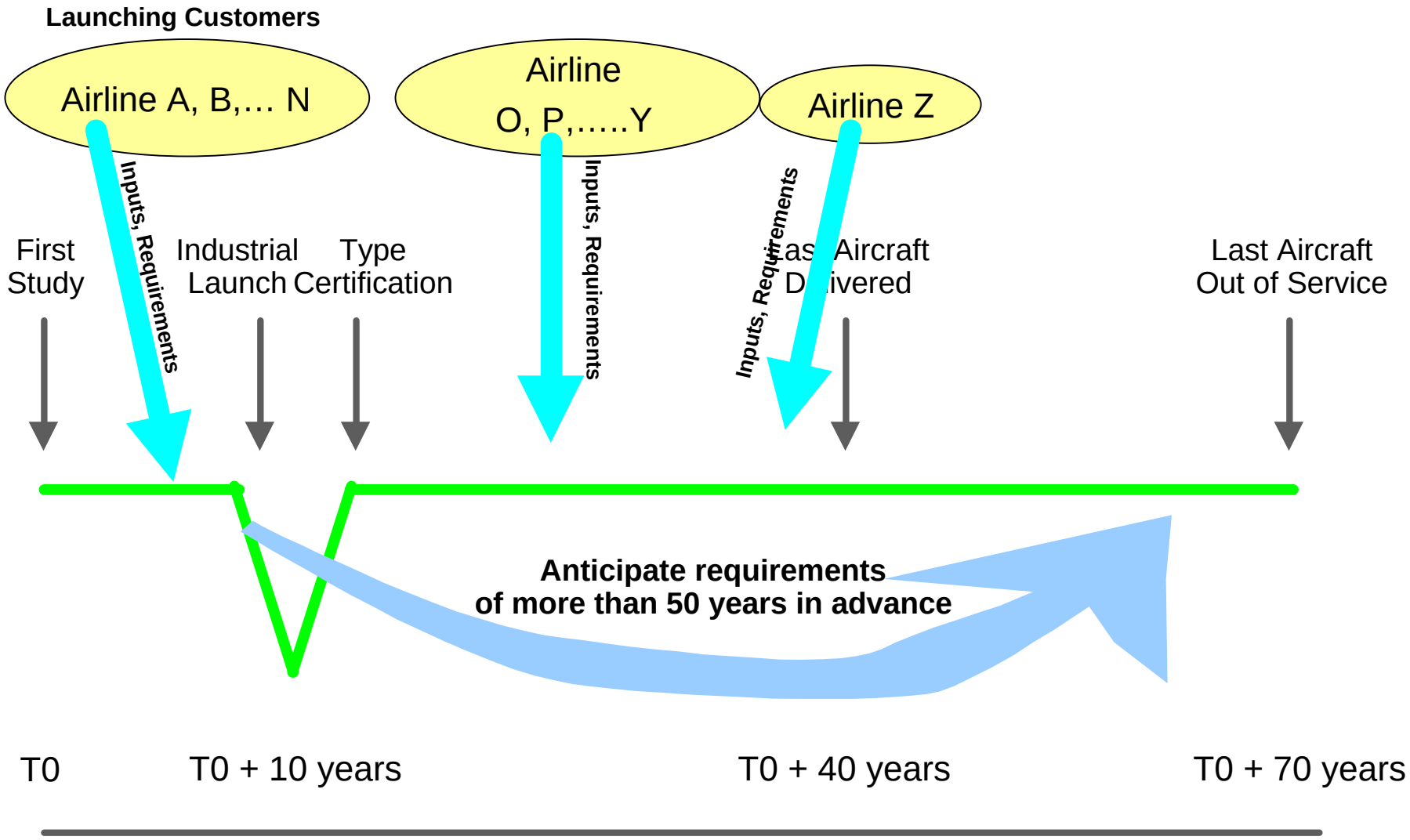
8,000 in the cabin/
41,000 ft flight altitude

Insulation

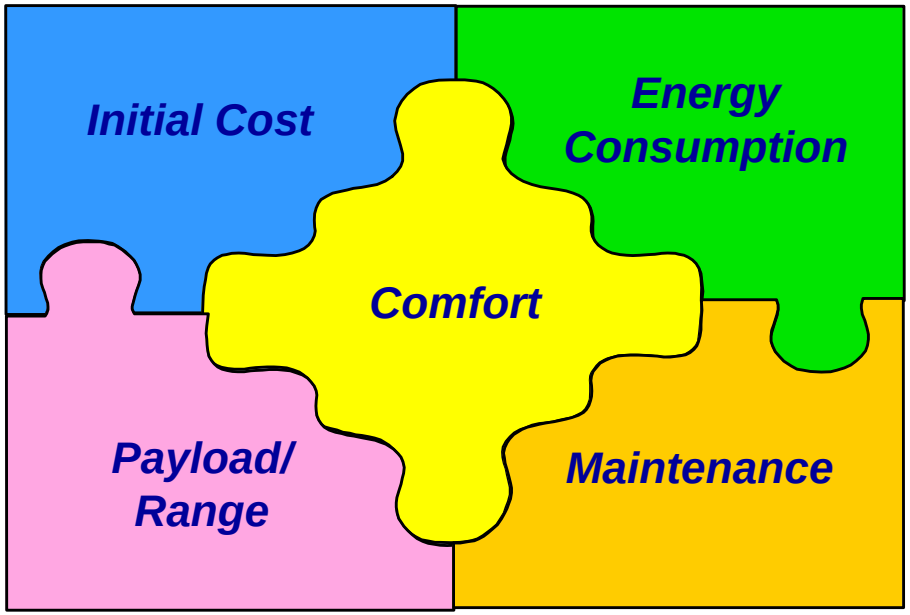
The aircraft development process



Typical aircraft lifetime



Aircraft design as balance between aspects



A good balance between the factors creates a superior aircraft design

The GREEN GIANT for our planet

2.9 L / PAX / 100 km

What are the consequences of a GREEN GIANT?

- Minimum weight
  - Optimum material selection
  - Best structural stress analysis
  - Prevent unreasonable margins
- Minimum energy consumption
  - Optimized thermodynamic processes
  - Optimized energy flows throughout the aircraft
  - Optimized control-laws (e.g. balance between outside air flow and recirculation air flow)
  - Prevent unreasonable margins

The GREEN GIANT philosophy creates the tendency for on-point design

Market tendencies

- A300, A310, and A320 family initial development considered traditional 1, 2, or 3 class layout
- A330/ A340 introduced extended flexibility concept for galley and lavatory locations
- Beginning with late 90’th, special compartments like enhanced crew rest areas entered service
- A340-500/-600 developed for high level of customization
- Tendency to VIP cabin configuration within special first class of premium operators
- Another tendency seen towards low-cost carriers

Differences in requirements and wishes between airline customers increases

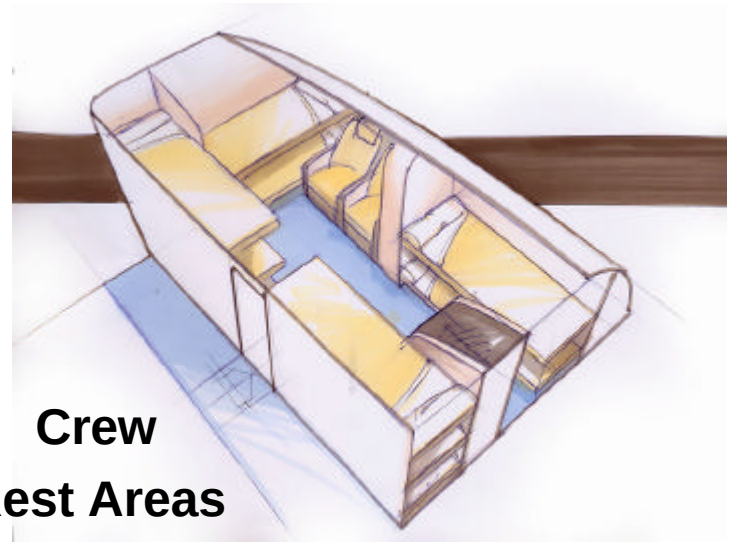
Example: Economy Class vs. Special First Class

Economy Class Configuration

Special First Class Configuration

Cabin air flow pattern needs to consider different cabin configurations

Examples for special wishes



Crew Rest Areas

Bar

Bed

Salon

What does that mean for the system design?

- Ensure flexibility of the ventilation system to cope with different cabin configurations
- Consider special compartment ventilation & extraction for basic air conditioning system design
- Consider special functions for basic air conditioning system design

…….but

- Don’t compromise the design for those customers, which don’t have special requirements
- Don’t compromise the business case for low-cost carriers
- And: remember the GREEN GIANT philosophy

The secret of superior aircraft design

- The GREEN GIANT philosophy creates the tendency to on-point design
- Customer requirements and wishes show tendency to differentiate more than in the past
- As many as possible customer requirements and wishes needs to be met to gain a competitive advantage

Optimum balance between aircraft performance and sufficient functional flexibility is the winning argument

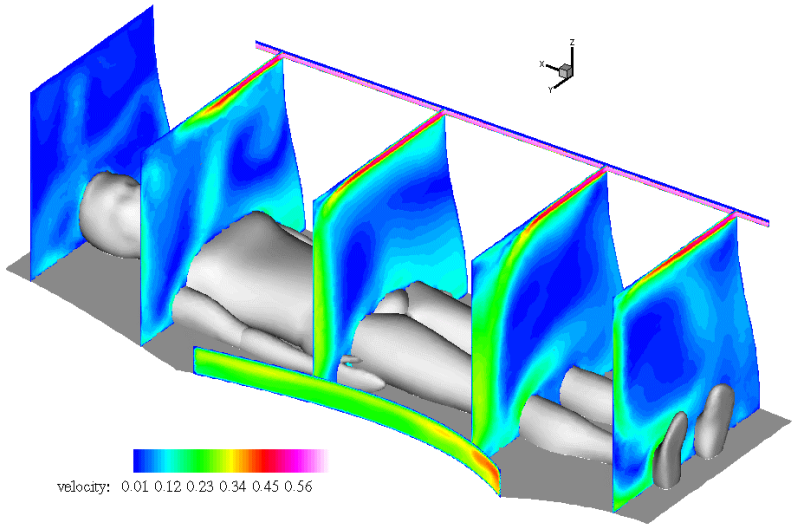
How to ensure proper Thermal Comfort?

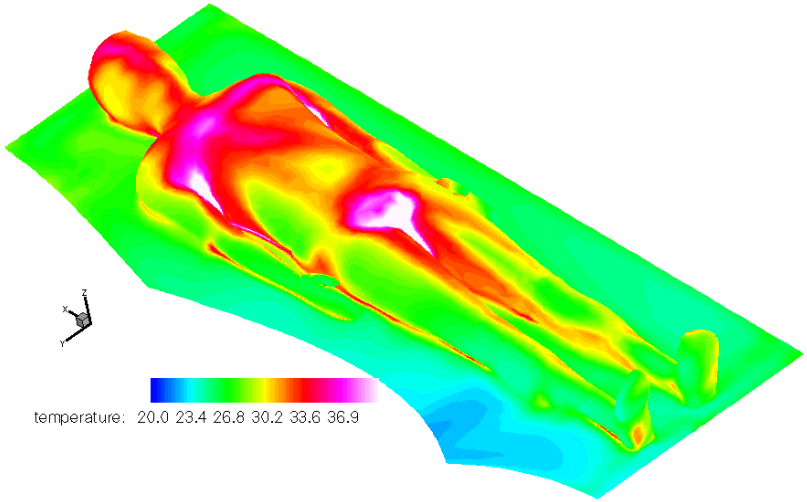
- Thermal comfort seen as the main driver for cabin environment perception
- Thermal comfort is achieved by a reasonable balance of temperature, air velocity and humidity
- Proper flow patterns must be achieved even in case of different cabin configurations
- Air draughts have to be prevented as well as low flow areas which are perceived as sticky
- Adequate thermal comfort must be ensured for seated sedentary passengers as well as for working or resting crew members

Example: Thermal comfort prediction (I)

Computational Fluid Dynamics (CFD)
to predict Thermal Comfort

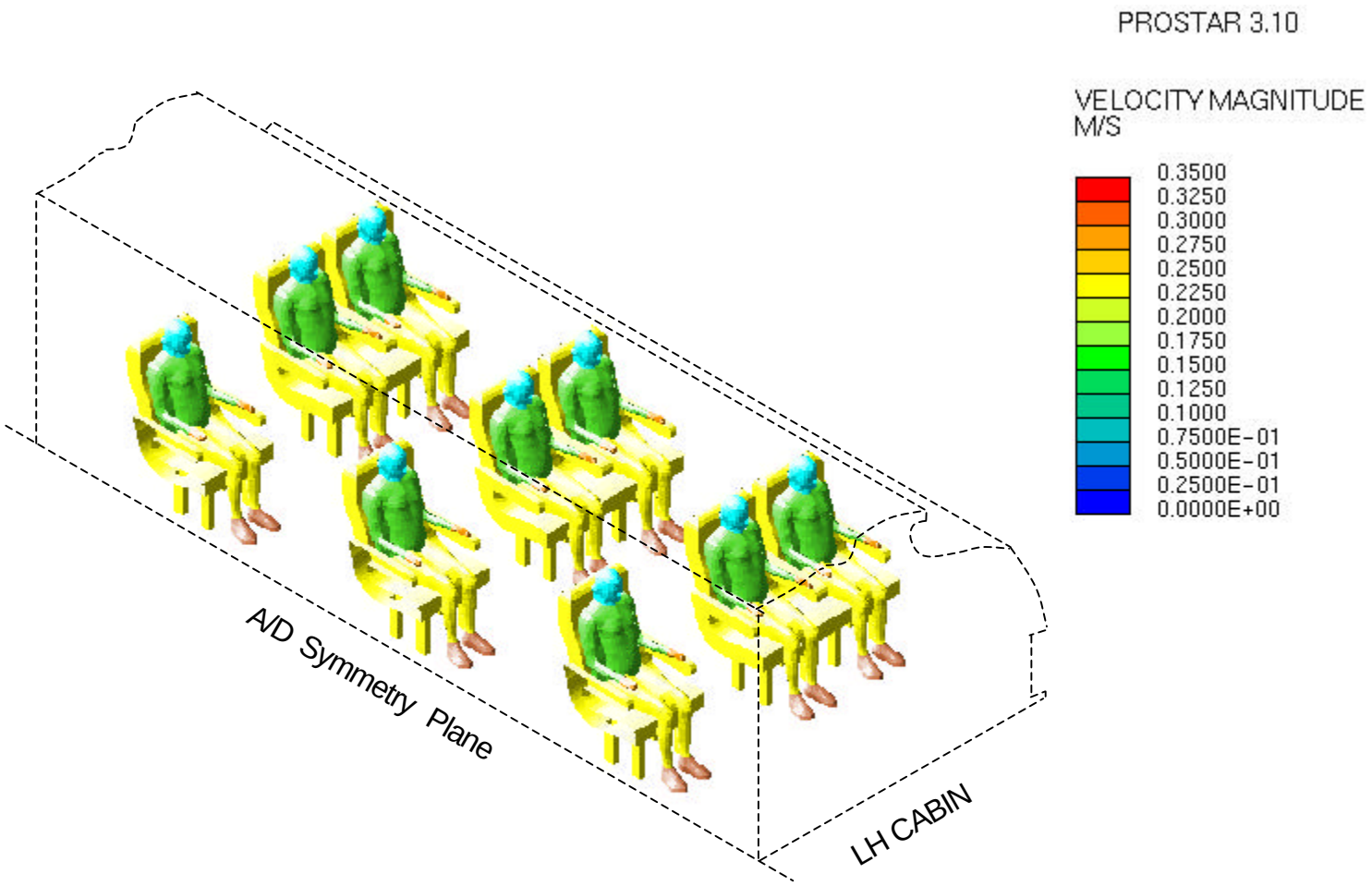
Example: Thermal comfort prediction (II)





Consideration of human physiology
For Thermal Comfort prediction

Example: Thermal comfort prediction (III)



CFD post-processing tool to ease Thermal Comfort assessment

Example: HEPA filtration

- The A300-600 and the A310 aircraft types got recirculation filters with higher efficiency compared to most of the building application from early on

- The A320 family and the A330/ A340 aircraft got HEPA filters from the beginning

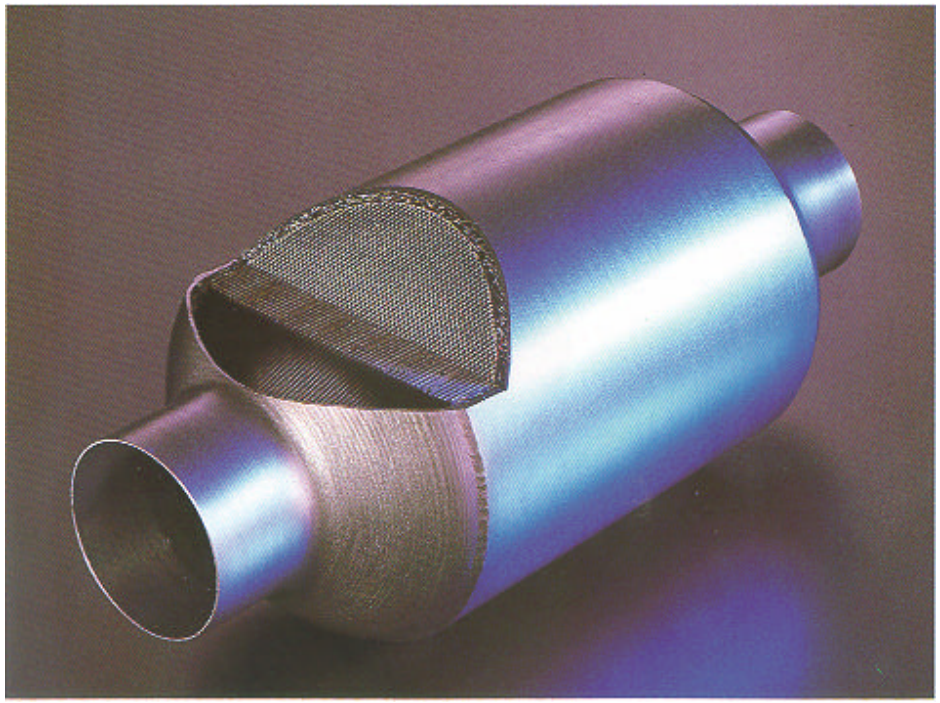
- Although we believe, that the A300-600 and A310 filters are fully sufficient for health protection, we offer optional HEPA filters for those aircraft on customer request

Customers can realize an

all-HEPA filter fleet if they select to do so

Example: Ozone converters

- Ozone converters are required by Airworthiness Authorities for certain routes
- A300/ A340 have got ozone converters as standard equipment
- All other Airbus aircraft can be equipped optionally with ozone converters



Source: Engelhard

Customers can realize an all-ozone converter fleet if they select to do so

What are we doing?

- We are committed to provide a safe, healthy and comfortable cabin environment
- We perform in-service air quality campaigns
- We continuously invest in a sophisticated toolset to predict thermal comfort
- We initiate, push, and participate to research
- We actively participate in standardization boards (AECMA-STAN/ Europe, ASHRAE/ US)
- We provide the public, the airline customers, and the scientific committees with information (UK House of Lords Inquiry, US National Academy of Science)
- We continuously upgrade our aircraft models with newest technology equipment

And certainly we try to do all this a bit better

than other airframe manufacturers

to contribute to a competitive advantage

of our Airbus aircraft

Thank You