The Aircraft Environmental Flight Envelope

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Introduction

How does climate change influence aircraft design and operation?

Aircraft are designed to operate within a given range of static temperatures and altitudes (pressures), called the aircraft environmental flight envelope. An aircraft is not allowed to operate in atmospheric conditions which are outside the certified flight envelope. Increasing or decreasing temperatures can then e.g. prevent airlines to reach certain airports occasionally, or even permanently.

HOW is this environmental flight envelope defined?

HOW does this envelope impact aircraft design?
Objectives of flight envelope

Aircraft flight envelope is used for several purposes:

- Input for our design
- Representative of operational conditions encountered by the aircraft
- Certified as a limitation of aircraft operation.
Definition of flight envelope

This envelope is directly linked to aircraft design as an input for:

**Structure**: thermal model, stress, loads, material choice

**Systems**: system qualifications, ground cooling, cabin pressurization, oxygen

**Overall Aircraft**: engine, aerodynamics, performance

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Focus on the main constraining parts of flight envelope
Definition of Environmental Envelope

**Maximum A/C Temperature at low altitude**

This limitation covers today the max temperature evolving in the following hottest airports and also the extreme thermo-mechanical conditions: Kuwait, Dubaï, Delhi, Bogota, Lhasa, Doacheng...
Definition of Environmental Envelope

Minimum A/C Temperature at low altitude

The minimum certified temperature for design is:
-54°C for structure thermal loads
-55°C for systems qualification
→ It covers today most of coldest airport (Bratsk in Russia, Fairbanks in Alaska, Churchil in Canada, Rovaniemi in Finland)
3 Definition of Environmental Envelope

Minimum A/C Temperature at high altitude

Ref: Extreme low temperatures in flight,

Initial limitation has been modified following customers feedback.
Experience on Long Range fleet over the North Pole of some Airline operations at -78°C as long as 3h.

→ The -80°C static temperature envelope, associated with TAT (Total Air Temperature) limitation, covers requirements of equipment specification, structure design and operations.
Main impact of these requirements on Aircraft Design

Cabin Pressurisation Load
System qualification Fuel temperature
Thermal Loads
Landing Gear Structure
Oxygen & performance
Load
No design constraint
air conditioning pack / avionic refresh / galley cooling / Thermal Load / Hydraulic Temp Engine & aircraft performance
Conclusion

The flight envelope corresponds to the extreme static environmental conditions the aircraft is allowed to encounter. Its shape depends on the aircraft type; i.e. aircraft cannot operate where they want. Already today, airports or flight altitudes may be inaccessible for some aircraft types or aircraft categories.

Aircraft manufacturers strive to give airlines operators the highest operational flexibility by designing the aircraft such that its flight envelope covers all routes and destinations they may need.

If the environmental conditions change, the aircraft design needs to adapt.

One of our questions:

What will be the changes of the extreme static environmental conditions
  – how will the minimum temperatures at cruise altitude (typically 35 000 ft – 43 000 ft) evolve?
  – how will the ground universal max/min temperatures evolve?
Thank you