

Prediction of Physiological and Psychological Crew Performance under Various Thermal Conditions

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Outline

- Background and Aim
- Method
- Results
- Conclusion & Future Work



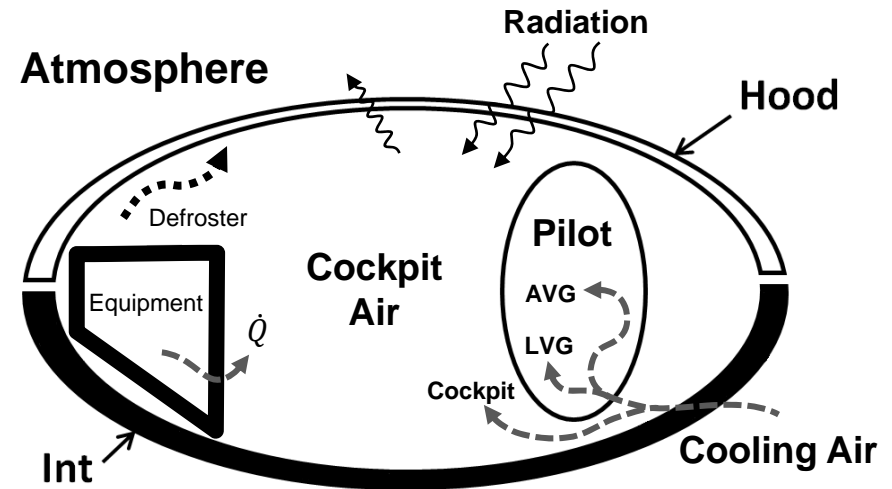
Background and Aim

- aircrafts are exposed to a wide range of thermal conditions
- if thermal comfort is not ensured the pilot can suffer from significant heat stress
- the project was initiated in order to increase the understanding for the thermal comfort in a cockpit for long endurance flights
- the aim of the present work is to develop a model for the thermal environment in the cockpit, and combine it with a thermoregulatory model of a human

Method

Combined cockpit-pilot model

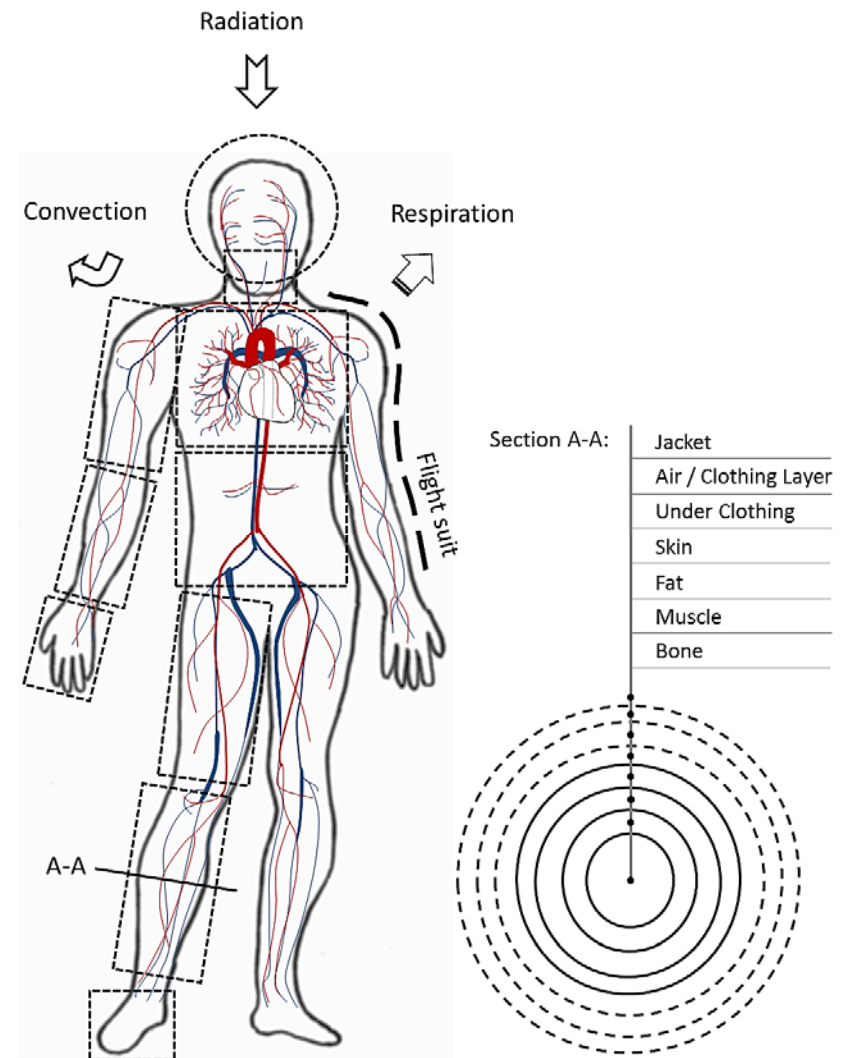
- the model combines the thermodynamics in a cockpit with a human thermoregulatory model representing the pilot
- the combined model consists of five sub-models, or parts presented in the figure
- the model combines lumped systems with finite difference modelling
- the thermal response of the pilot is computed by the thermo-regulatory model which receives its input values from the cockpit model



Method

Thermoregulatory model of the pilot

- the model is based on Westin's 16 segments thermoregulatory model¹
- the model consists of two systems:
 - I. **Passive:** the heat transport within the human body plus the heat exchange between the pilot and the cockpit
 - II. **Active:** control system which senses thermal changes in the body and responds with shivering, sweating, vasodilation, vasoconstriction, and respiration

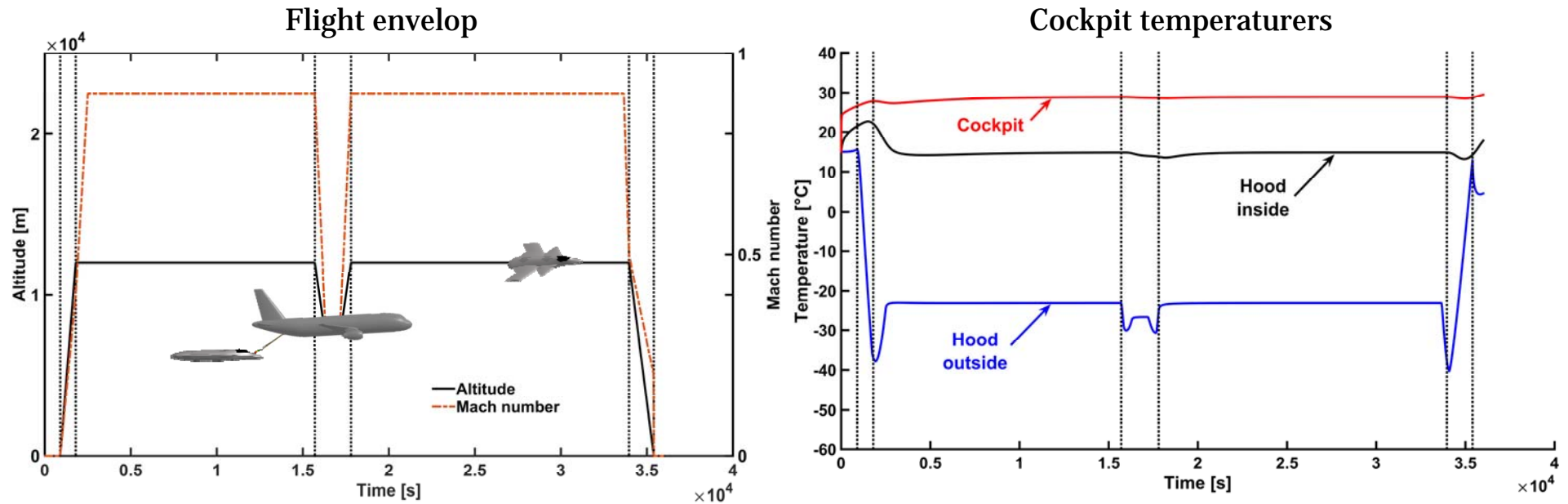


Results outline

- **Results:**
 - ✓ **simulation of a long endurance ferry flight including aerial refueling of a generic fighter aircraft, pilot-cockpit interaction study**

- **Work in Progress:**
 - ✓ **Validation**
 - ✓ **Pilot interview**
 - ✓ **Crew performance modeling**

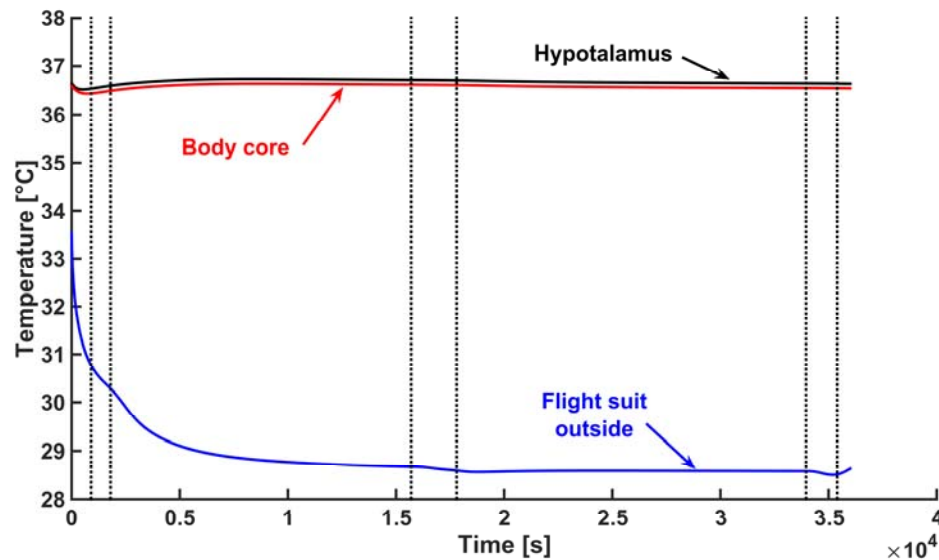
Results



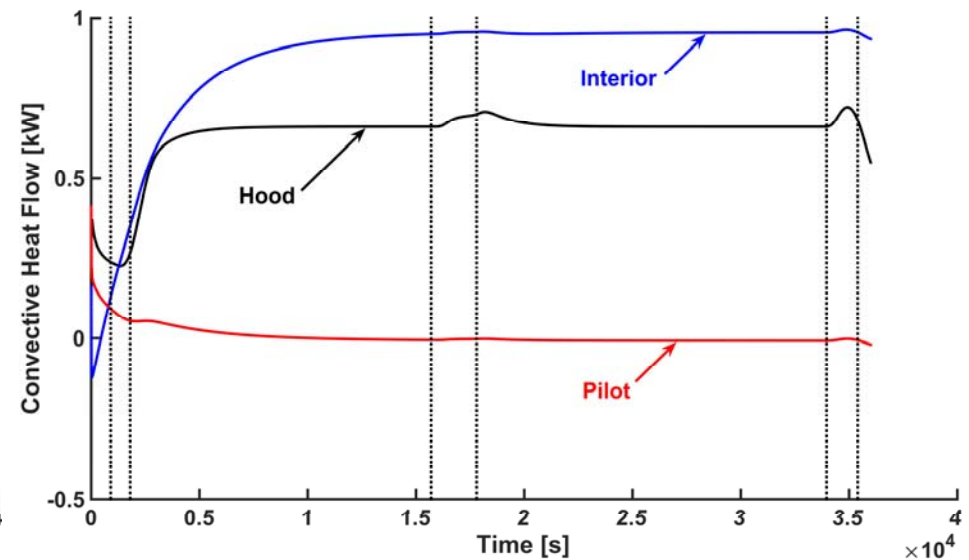
- decent for refueling only leads to minor reactions of the cockpit temperature
- environmental control system works properly

Results

Body temperatures



Convective heat flows

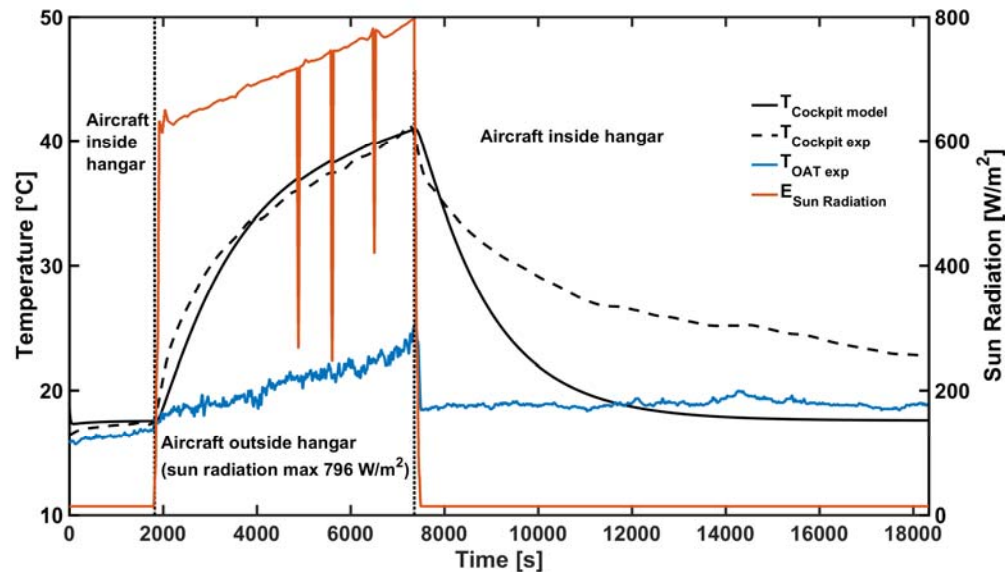


- both the cockpit and the pilot model are able to maintain a constant cockpit temperature over a long time
- the model is able to return to its original values after a temporary deviation.

Work in Progress

Validation

Cockpit temperature



Experimental setup



- the trend of the modeled cockpit temperature point in a first comparison with experimental data in a right direction
- further analysis and fine tuning of model input parameters are in progress

Work in Progress

Pilot Interviews

- the interviewed pilots are test pilots from SAAB and FMV
- the analysis of the survey results is still ongoing but show that the pilots statements support the need for simulation based cockpit thermal comfort studies and heat stress related crew performance modeling on ground and during flight

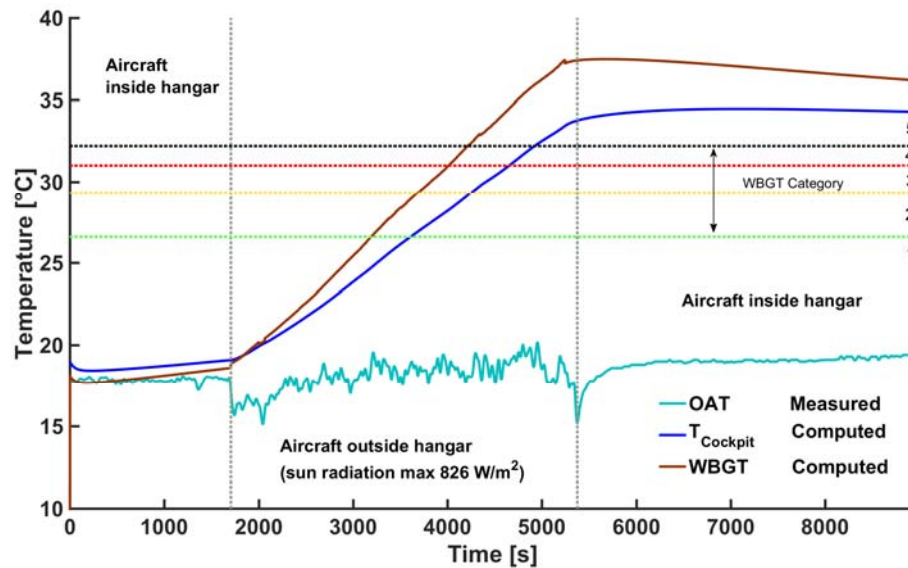


Picture credits to: Saab AB

Work in Progress

Performance Modeling

Crew performance estimation



Experimental setup



- heat related physiological and psychological crew performance limits can be estimated by modeling different heat stress indices like for example Wet Bulb Globe Temperature (WBGT)

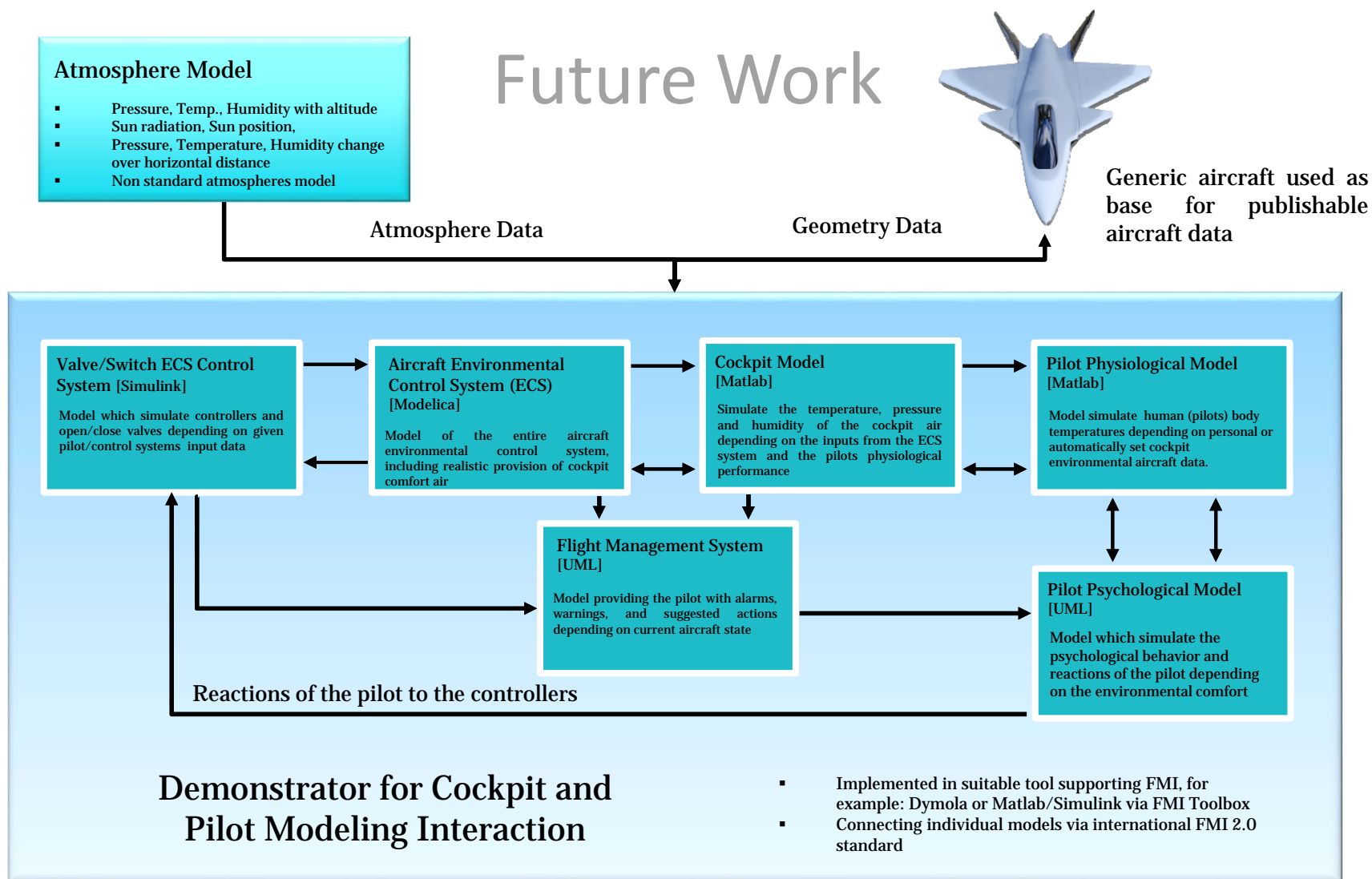
Conclusions

- **the cockpit model is suitable for pilot comfort related studies**
- **the cockpit-pilot model works properly for different flight cases**
- **long range flight missions can be simulated within a reasonable time**

Future Work

- further development and validation of the pilot model
- ECS model connection
- simulation of the pilots' cognitive capability depending on cockpit climate
- pilots' liquid and energy demand depending on temperatures and mission duration





Thank you for your attention!

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