Towards a Complete Co-Simulation Model Integration Including HMI Aspects

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Agenda

- Introduction to the Problem
- Holistic Co-Simulation
- The Complex Human Being
- Model Properties
- Model Abstraction & Refinement

- Example Implementation

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Towards a Complete Co-Simulation Model Integration Including HMI Aspects

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Abstract

Modern aircraft can be seen as heterogeneous systems, containing multiple embedded subsystems which are in today's simulations split into different domain-specific models based on different modelling methods and tools.
This paper addresses typical workflow-driven model integration problems with respect to model fidelity, accuracy in combination with the selected abstraction methods and the target system characteristics. A short overview of integration strategies with the help of co-simulation frameworks including an analysis of the inherent problems that emerge because of different domain-specific modelling methods is being given. It is shown that huge benefits can be reached with the help of a smart system break-up.
In detail, the discrepancy between the cyber-physical system simulations and human-machine interaction (HMI) models are being analysed. Therefore, a close look on typical shortcomings of behavioural models are being discussed, too.
To enable an effort-less human-in-the-loop integration into a cyber-physical system simulation, the usage of flight simulation software, offering real-time capability and a graphical user interface is suggested. This approach is applied to overcome today's complexity and shortcomings in human psychological models. An example implementation based on a commercial flight simulator software (X-Plane) together with a high-performance system simulation tool (Hopsan) via UDP communication is presented and analysed.

Keywords: flight simulator, model fidelity, co-simulation, mission simulation, workflow-driven integration, human-machine interaction, behavioural model, psychological model

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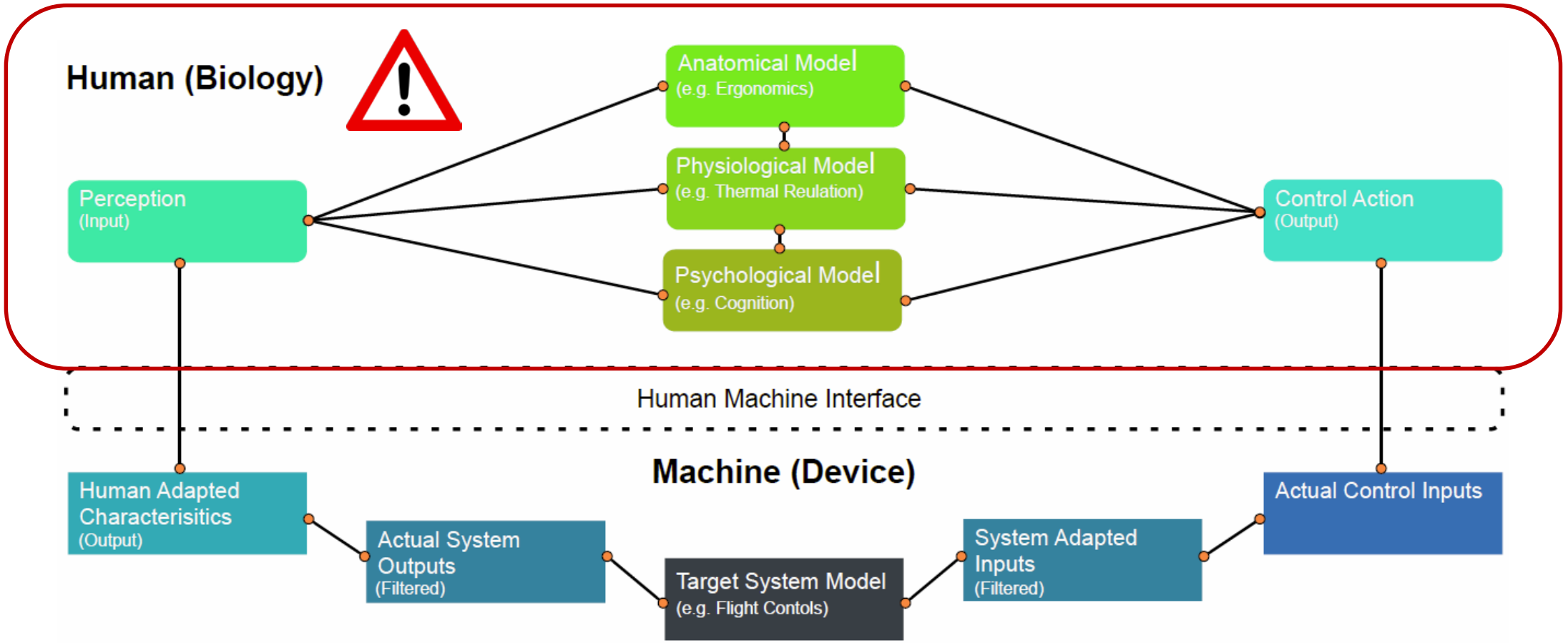
Introduction

- Boeing 737 MAX 8 aircraft involved in two fatal cashs → 389 deaths & significant revenue losses
- a final report is not submitted yet but first published investigation results point to the fact that the system (MCAS) overruled the operators (pilot) input commands

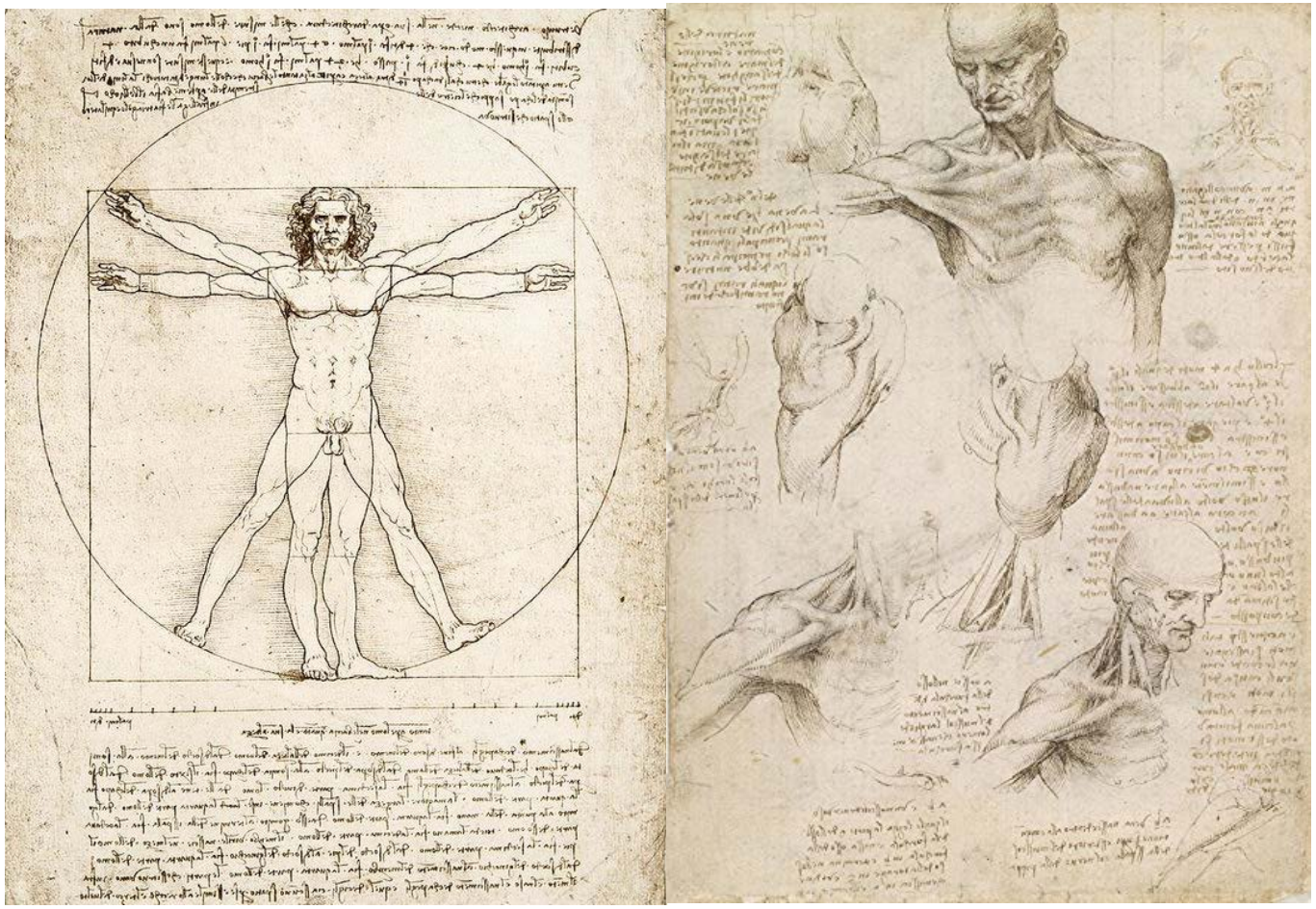
Holistic Co-Simulation Model



The Complex Human Being

- to date the human is often insufficient (only as stimulus-response system) or not at all in modern simulation models considered

- people's individual differences in, for example, age, sex, ability to take decisions, reaction time, social interactions and creativity require a much more appropriate representation of the human in simulation models



The Complex Human Being

How to integrate the human in simulations?

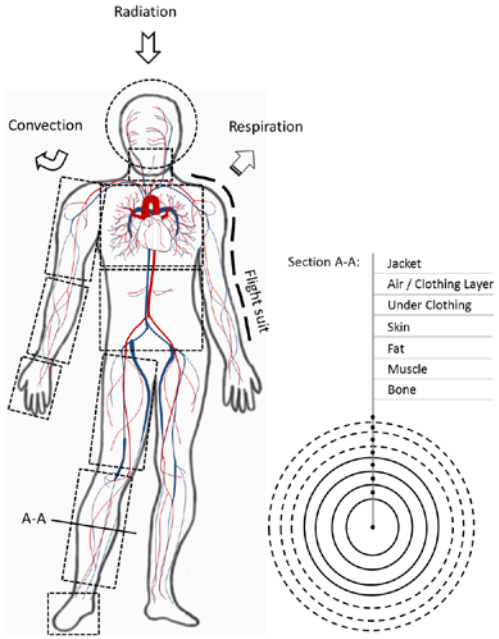
Modeling approach

+ experimental repeatability possible
+ optimization simulations possible
+ non real time simulation possible
- many human models are still at a basic research level

Human In The Loop (HITL) approach

+ actual human
- output get stochastic events
- simulation speed is limited to real-time only

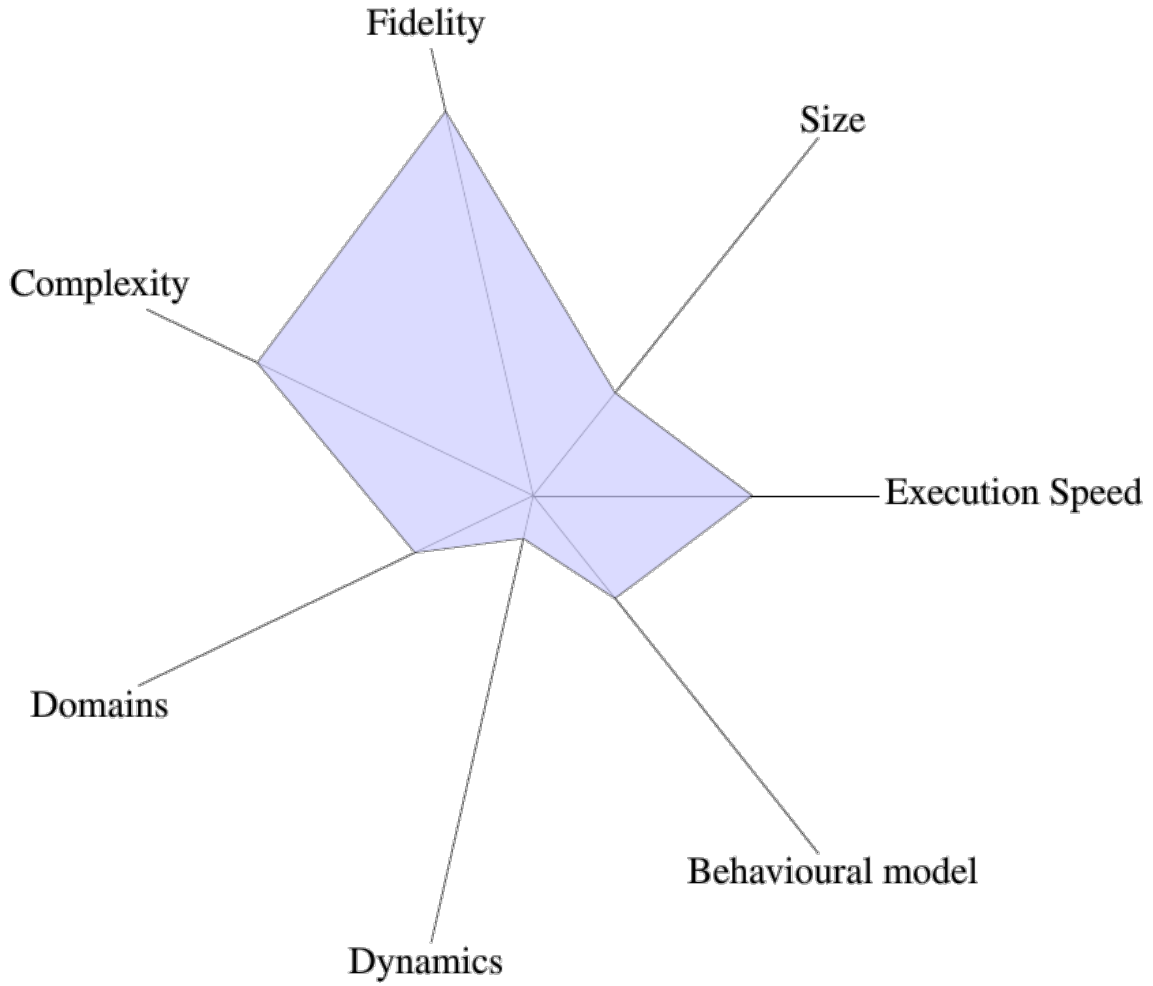
- high environment fidelity is necessary for both approaches since the humans' reaction on this inputs are deeply context specific



Credits to: ITA (SIVOR Flight Simulator Project)

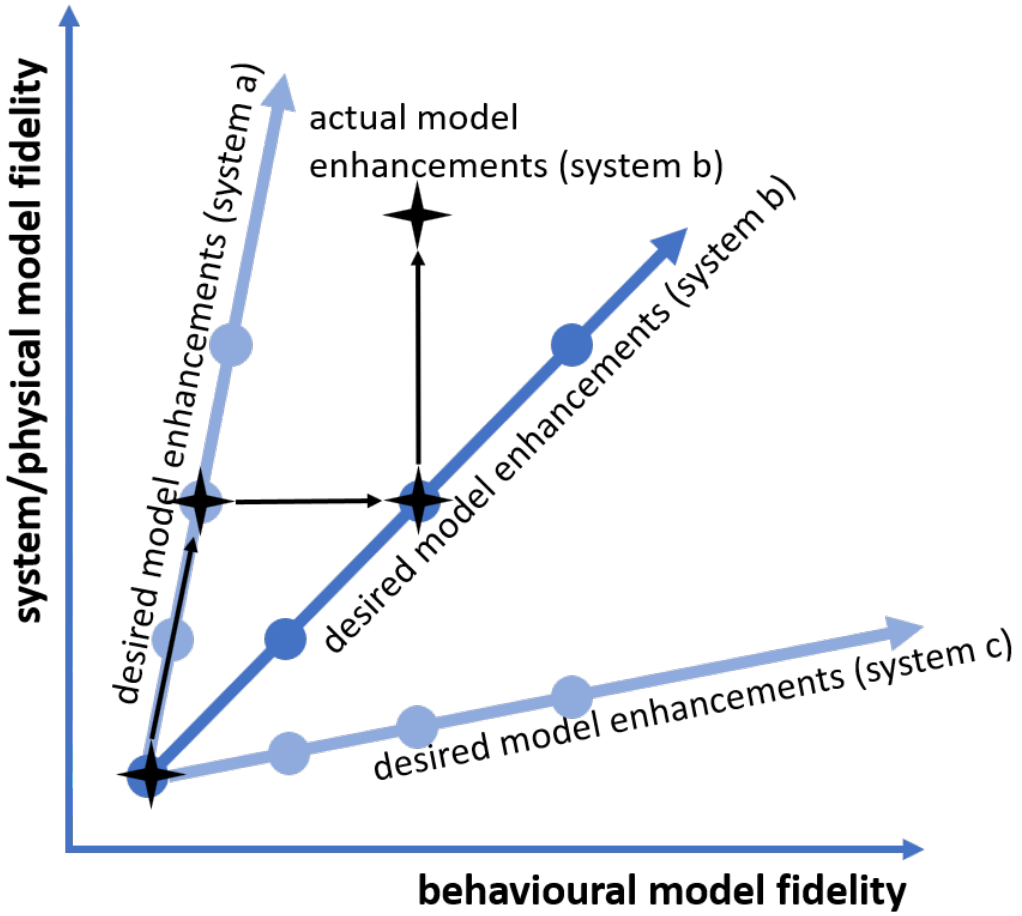
Model Properties

- a model is an abstract representation of a real system
- the question is: How abstract should the model be to simulate a real system?
- the system's properties can define a common ground prior abstraction methods selection and model implementation



Model Abstraction & Refinement

- concept of abstraction has to fit both the analysis needs and the systems characteristic
- any complex system model can be split-up into an structural and an behavioral part
- there is a unique combination of the model fidelity for each system
- model refinement occurs in discrete steps, often within a single domain only by either refining an existing model or replacing a modelling technique with another abstraction method



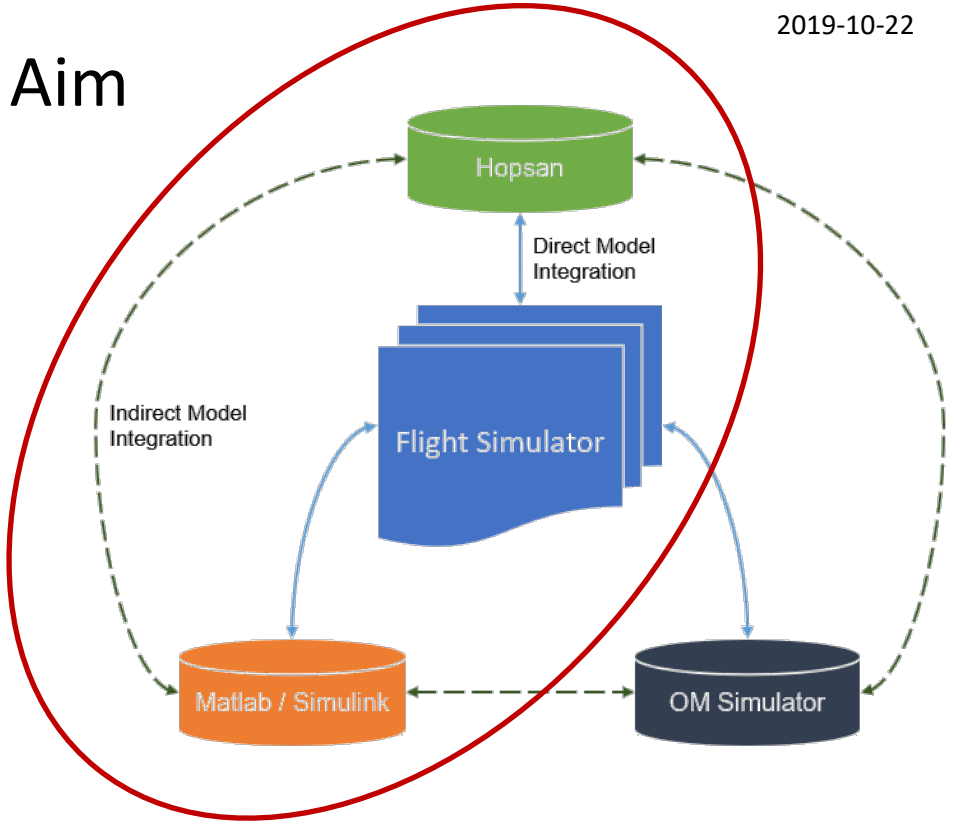
Example Implementation (Work in Progress)

Use case to test a in-house on-board/subsystem model together with a commercial flight simulator software

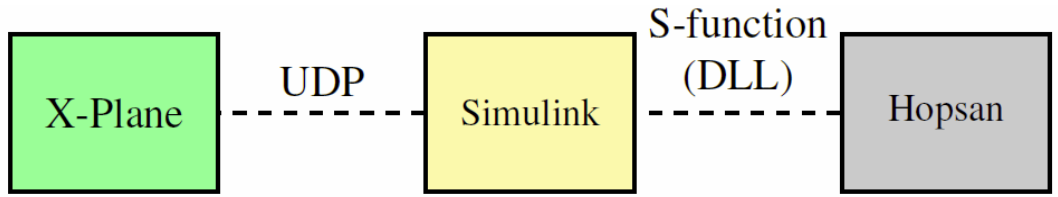
The Framework Setup (theory)

- the project aims to develop a platform for co-simulation of aircraft subsystems in a fight simulator environment integrating human being
- goal is to enable
  - flexibility
  - model replacements
  - human-in-the-loop and human-out-of-the-loop simulations

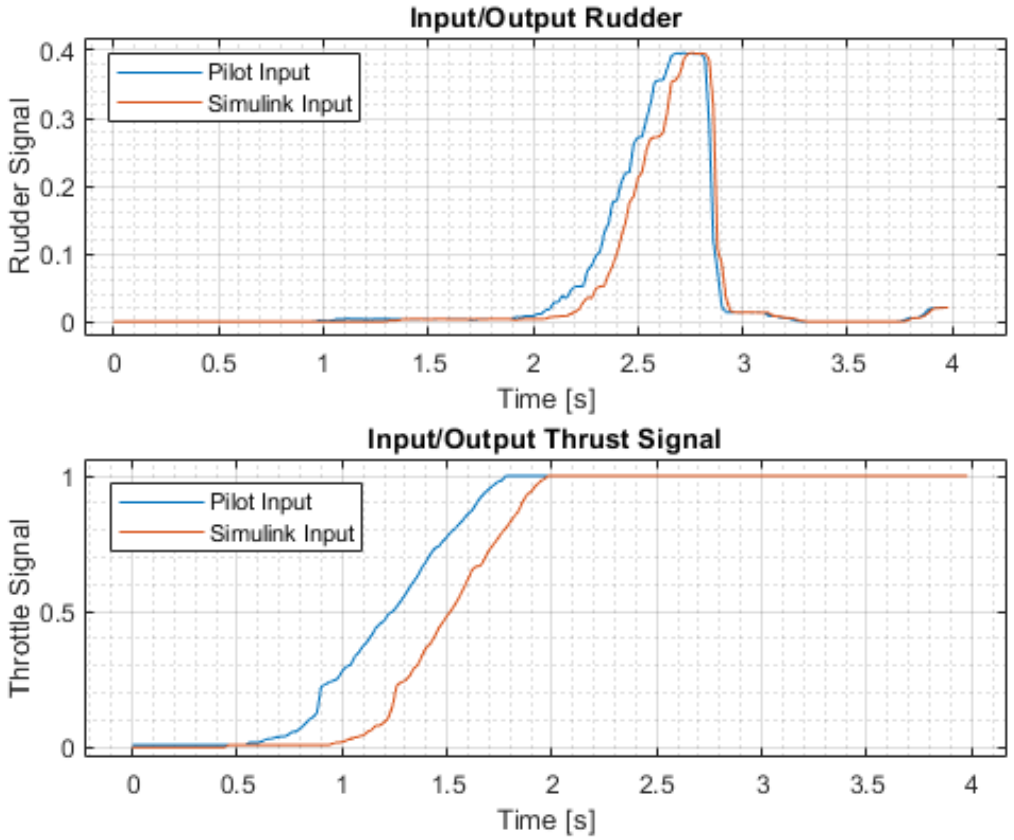
Aim



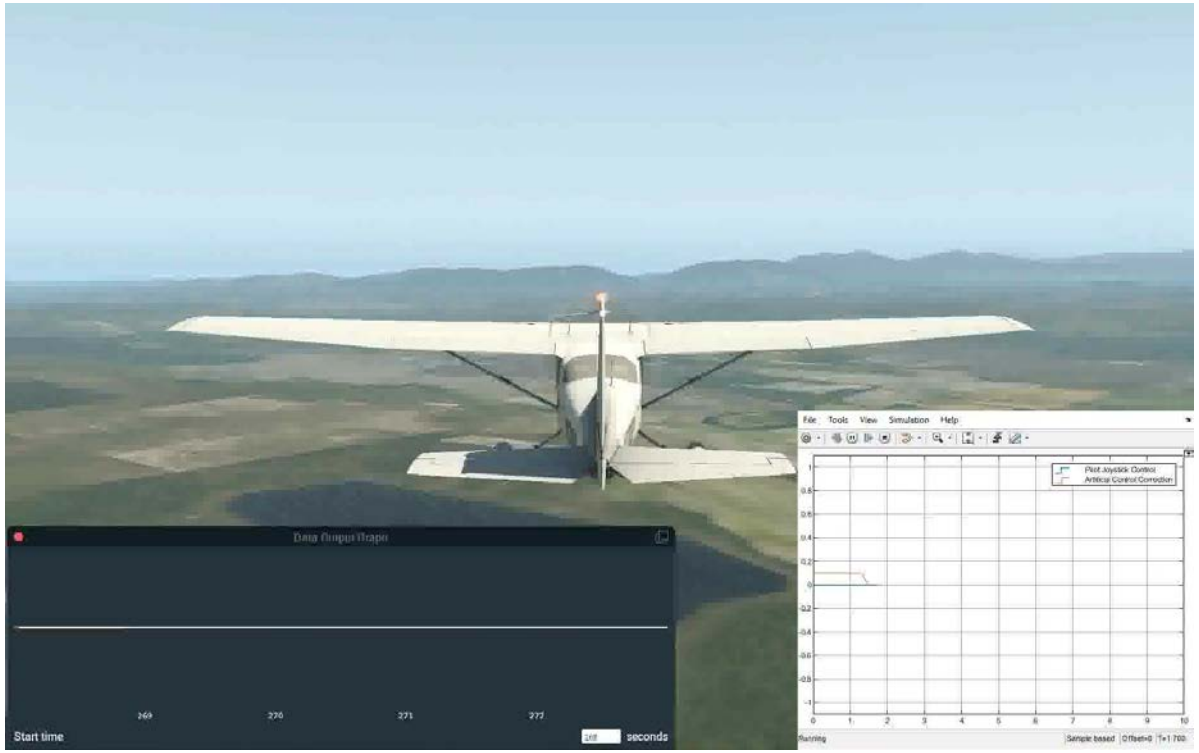
Realized (so far…)



First Results: Pilot-in-the-loop Simulations



Pilot and Simulink rudder and thrust control signal delay



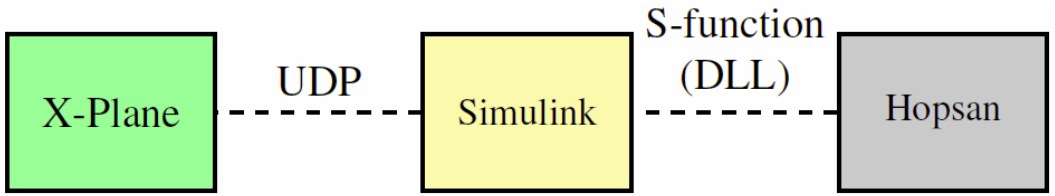
Aileron control signal from the pilot and the Simulink roll control model

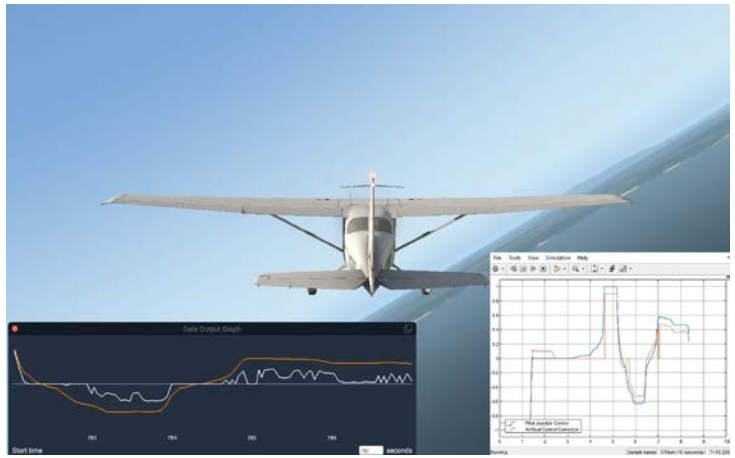
Conclusion

- cyber-physical (sub-/on-board) systems simulation is SOTA
- missing link: good, reliable human cognitive model
- HITL is the (cognitive model) *poor-mans* bridge
- commercial flight simulator software useful to support:
    - graphical user interface / environment rendering
    - supports soft real-time control
- HOPSAN models so fast that they do not hamper the flight simulator software

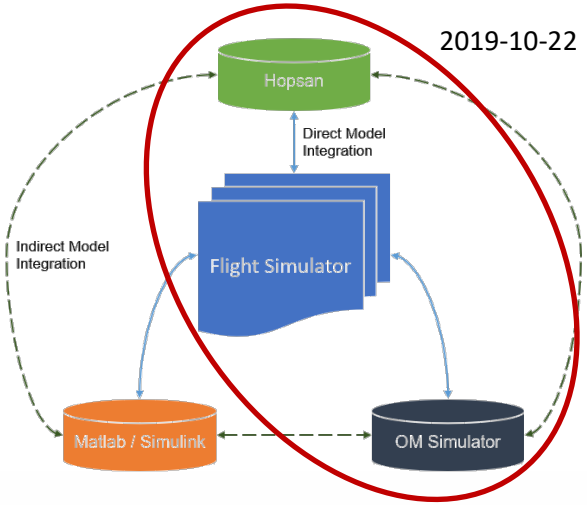
Way Forward …

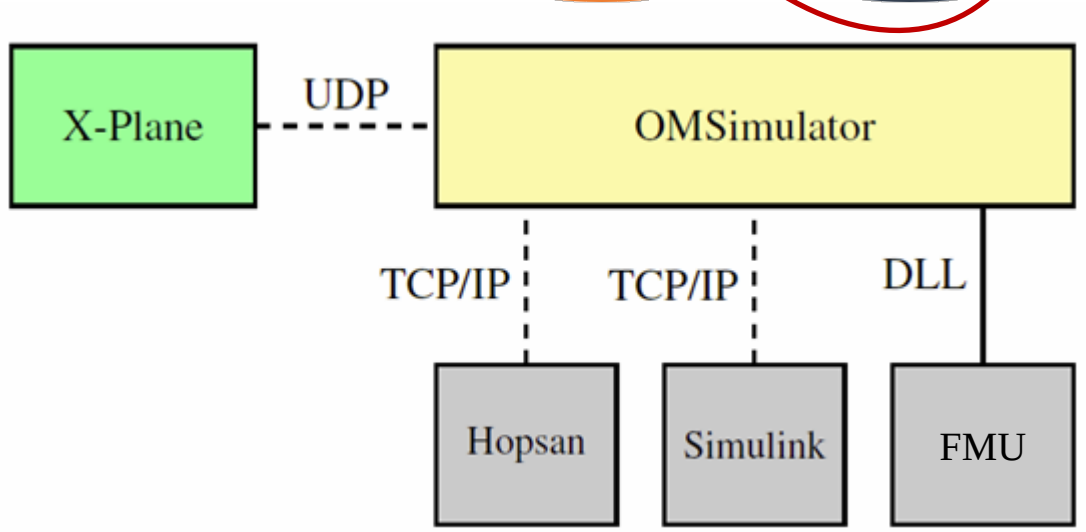
Realized (so far…)





Next Step





- planned implementation based on dedicated co-simulation tool for model execution and communication control

Thank you for attention!

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