FUTure PRopulsion and INTegration
towards a hybrid-electric 50-seat regional aircraft

Preliminary Hybrid-Electric Aircraft Design with Advancements on the Open-Source Tool SUAVE

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Jonas MANGOLD, Dominik EISENHUT, Felix BRENNER, Nicolas MOEBS and Andreas STROHMAYER

FutPrInt50

University of Stuttgart
Germany

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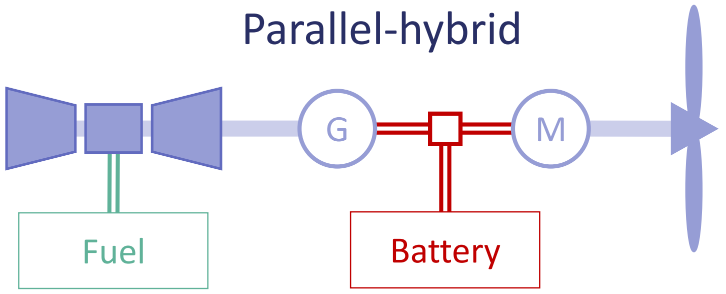
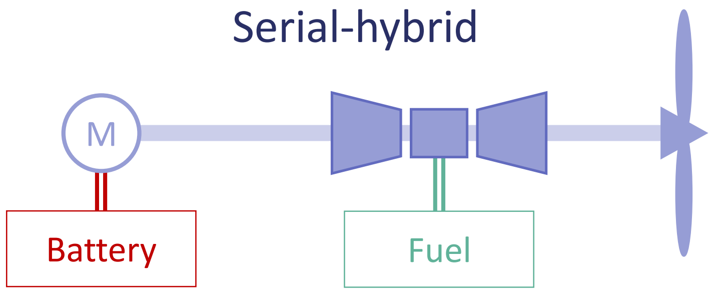
Introduction into Hybrid-Electric Aircraft Sizing: Challenges and Issues

- Conventional sizing with Breguet equation no longer possible
- Multiple possible propulsion architectures
- Component models are usually black boxes with efficiencies
- Assessment of hybrid-electric aircraft





→ **Models with multidisciplinary dependencies**
→ **Designing for feasible and competitive aircraft**

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Open-Source Tool SUAVE: Advantages

SUAVE is a preliminary aircraft design environment

- Common handbook methods already implemented
- Process split in vehicle definition and (mission) analysis

Advantages especially for HE aircraft

- Propulsion architecture is independent of mission solver (does not use Breguet)
- Numerical iteration
- Component models easily interchangeable

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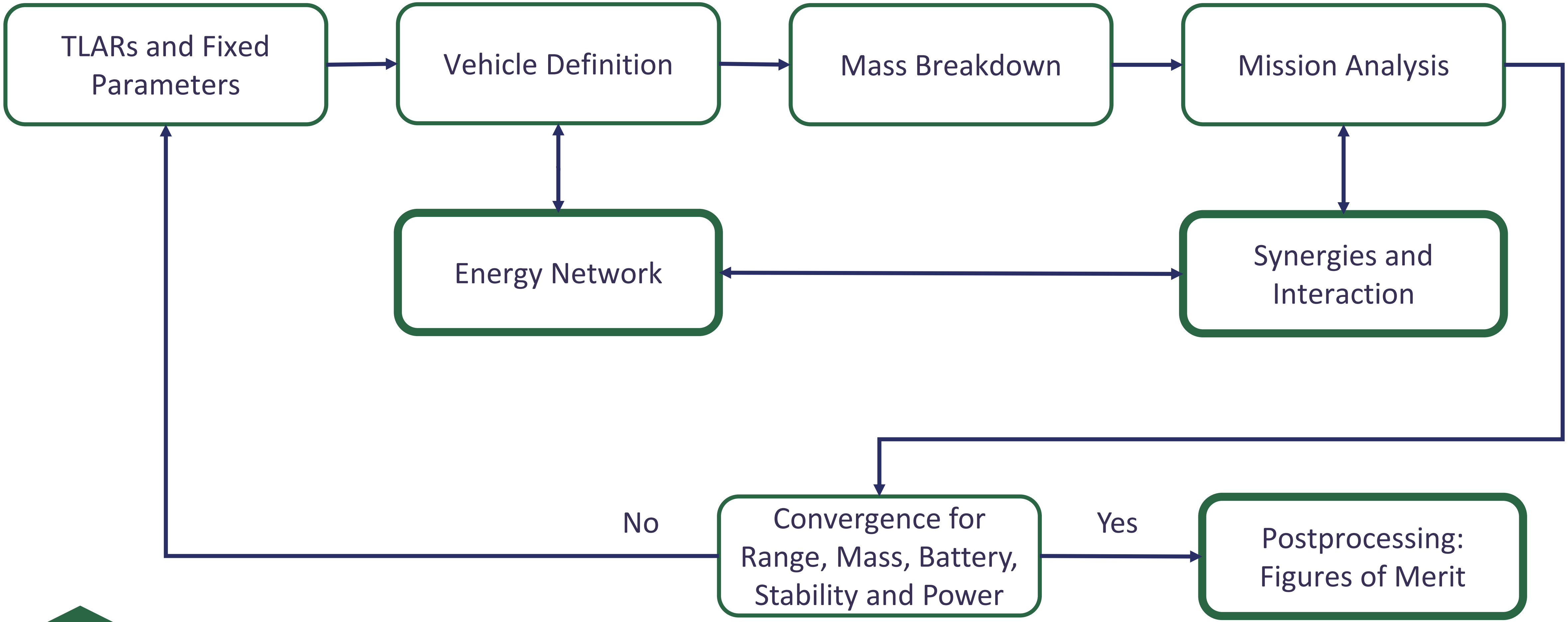
Sizing Loop for Hybrid-Electric Aircraft



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Energy Network – Integration of the Hybrid-Electric Components

For all components that require energy

→ **Goal:** Thrust and mass flow rate

Components included

- Turboshaft, Gearbox and Propeller
- Battery, Cable, Converter/Inverter, ESC, Electric Motor
- Thermal Management System

Mission Solver: Interaction of additional components

- Iterative solving of models
- Including interaction for aerodynamics
  - Δc_D, ΔP through TMS
  - Δc_L and Δc_D for Propeller Wing Interaction

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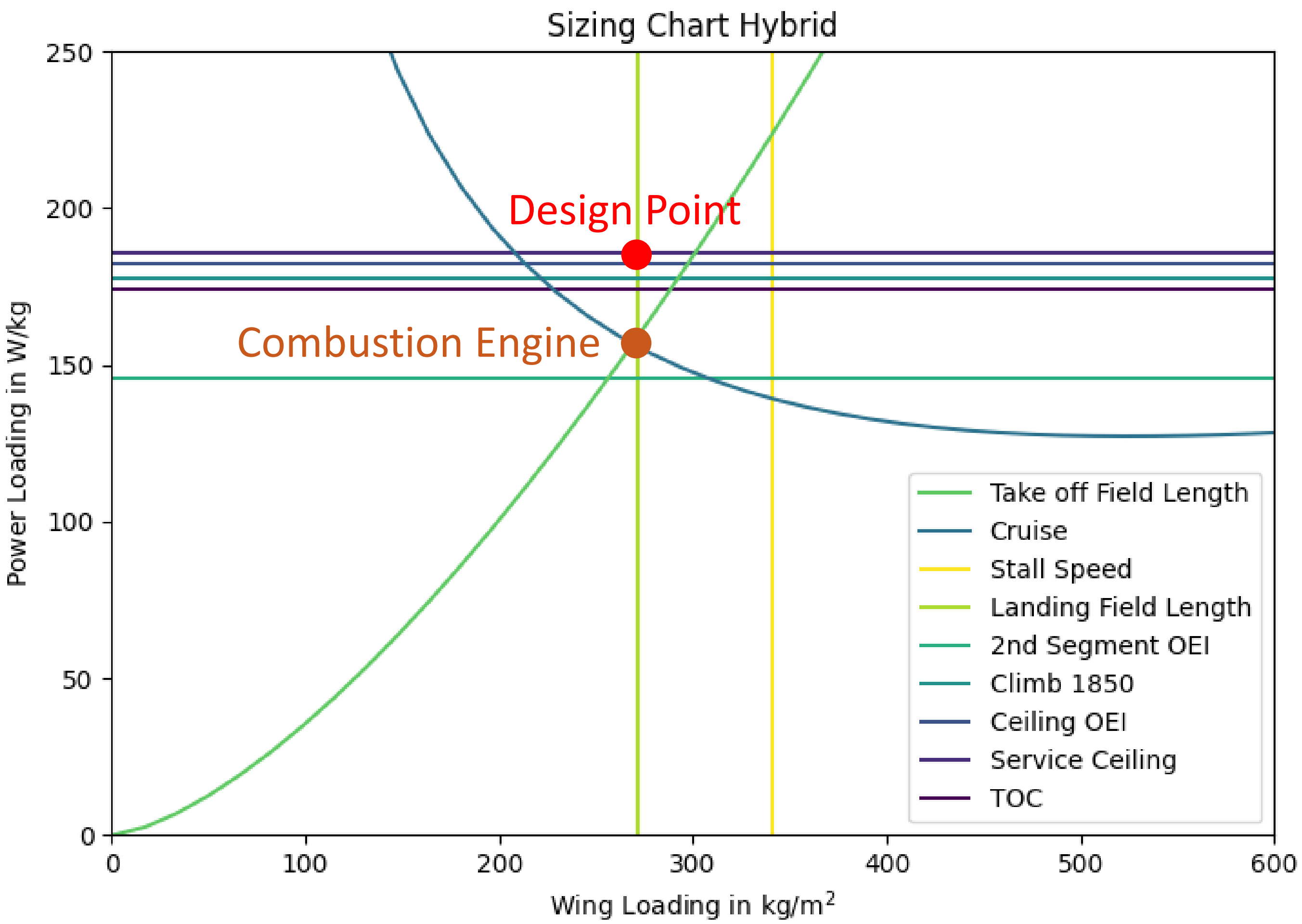
Sizing Chart and Implications for Power Distribution

Hybridization factor of power H_P

- $$H_P = \frac{P_{electric}}{P_{Combustion} + P_{electric}} = \frac{P_{electric}}{PowerLoading \cdot MTOM}$$

$\rightarrow \boldsymbol{H_P = 0.14}$

→ **How to deal with the power distribution?**



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Energy Management Strategies: Definition and Possibilities

Definition

- through Throttle of each electric motor
  - Boosting
  - Generating or harvesting
- For each mission segment

→ **Results in matrix** (2 x mission segments) $\begin{bmatrix} 1 & 1 & 1 & -1 & 0 & -0.5 & -1 \\ 1 & 1 & 1 & 1 & 0 & 0.5 & 1 \end{bmatrix}$

Possibilities:

1. Constant throttle
2. During cruise using "no" battery
3. Using "no" battery

→ **Combination of EMS and Power defines energy source**

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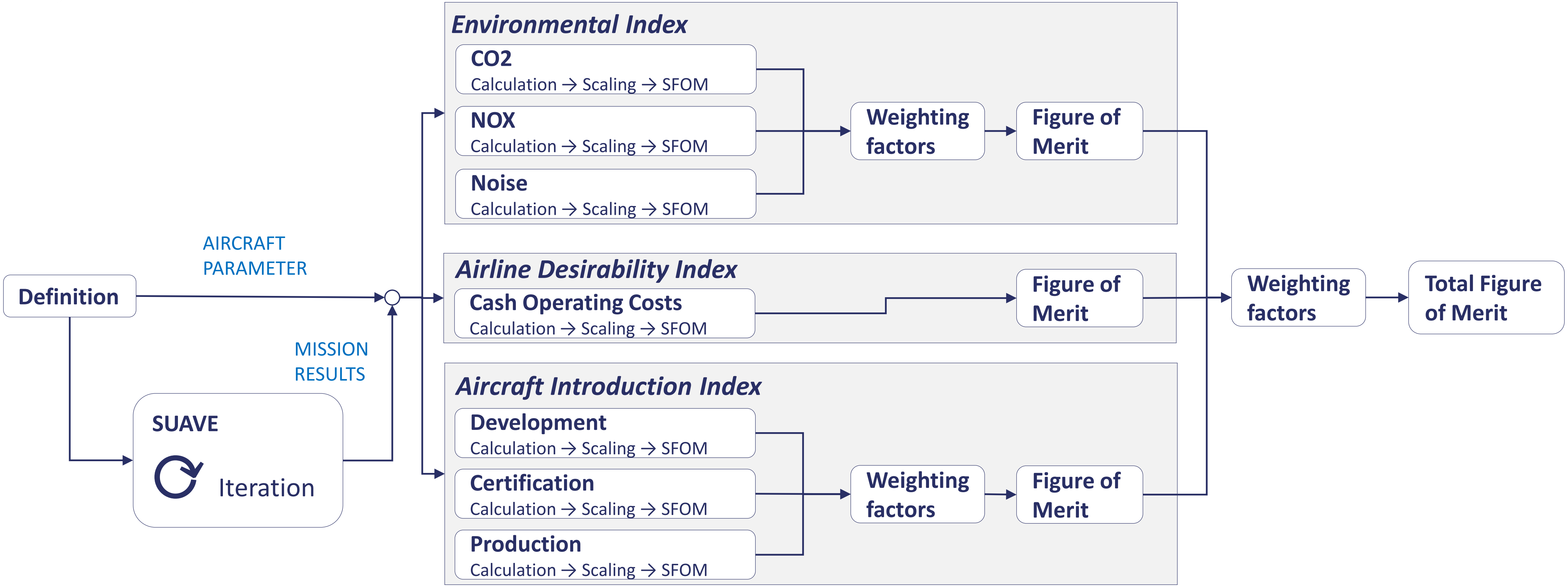
Postprocessing: Assessment through Figures of Merit



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Conclusion

Sizing for many different propulsion architectures easily adoptable

→ Fidelity levels interchangeable

EMS and H_P directly related to each other

→ not meaningful separated from each other

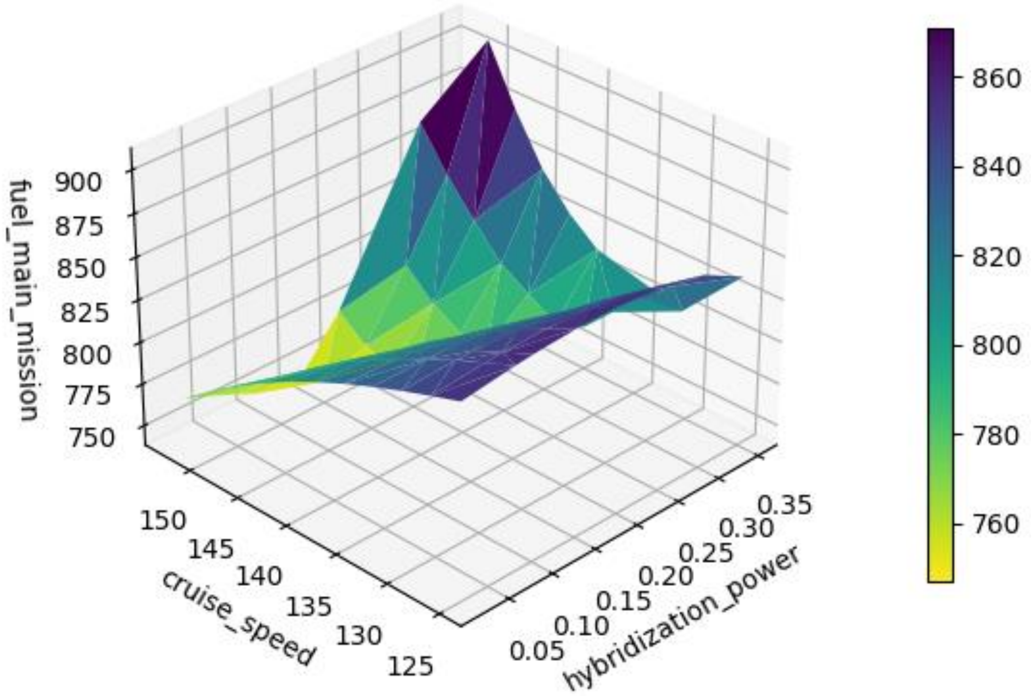
→ Easy adoptable Energy Management Strategies

Post-processing and assessment with Figures of Merit

→ split in 7 Single Figures of Merit

Challenge: Find reasonable EMS in combination with H_P

→ see next presentation by **Dominik Eisenhut**



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mangold@ifb.uni-stuttgart.de

www.ifb.uni-stuttgart.de

Pfaffenwaldring 31, 70569 Stuttgart, Germany

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