Next generation of aviation
- Energy management for electrically propelled aircraft &Urban Air Mobility

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Energy management for Electrically propelled aircraft

- Battery models with distinct fidelities
- Design trajectories for All-Electric aircraft to minimize operating cost
- Design a power allocation algorithm for Hybrid-Electric Aircraft
- Compare two hybrid-electric architectures based on fuel consumption

Battery dynamics

Integrate different battery model into optimal control problems(OCP):

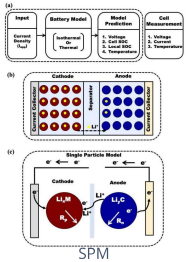
- Ideal battery with constant voltage
- Empirical Circuit Model
- Single Particle model

$$\frac{d\theta_{\text{cell}}}{dt} = -\frac{I_{\text{cell}}(t)}{Q_{\text{cell}}}$$

$$U_{\text{oc,cell}}(\theta_{\text{cell}}) = \sum_{k=0}^{8} \alpha_k \theta_{\text{cell}}^k$$

$$U_{\text{cell}} = U_{\text{oc,cell}}(\theta) - R_{\text{cell}}\, I_{\text{cell}}(t),$$

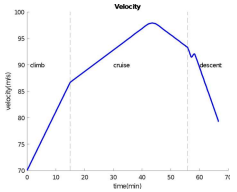
ECM

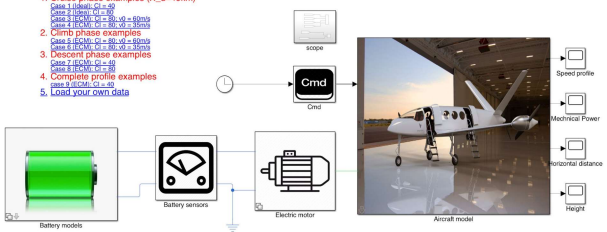


SPM

Trajectory optimization for All-Electric Aircraft

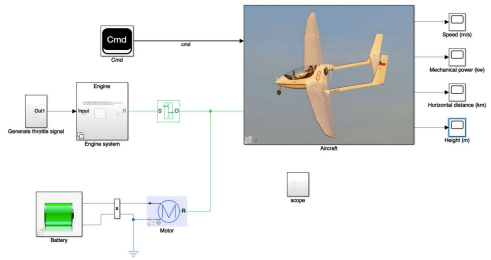
- Minimize the direct operating cost (combination of time cost and battery charge cost) for multi-phase flight missions
- Combine battery and flight dynamics
- Build Simulink model to testify distinct battery models



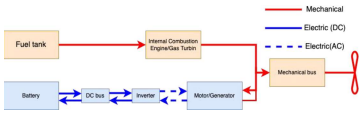


Power allocation for Hybrid-Electric Aircraft

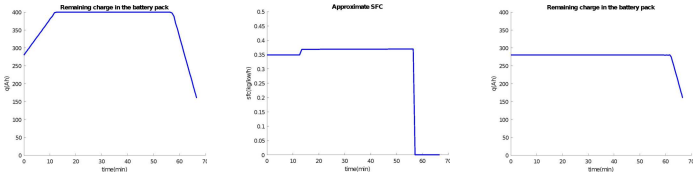
- Formulate the power allocation for a hybrid-electric propulsion system as OCP to save fuel
- Results show the optimal control approaches steer the engine to work in its highly efficient region where the specific fuel consumption is low

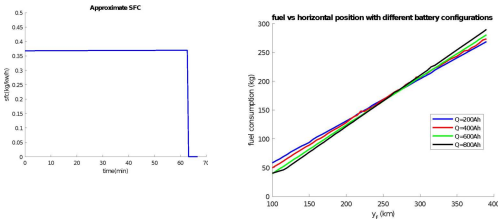


Comparison of two hybrid-electric architectures



- Two architectures: connected and independent.
- Results show that the fuel saving by charging the battery during flight is very limited

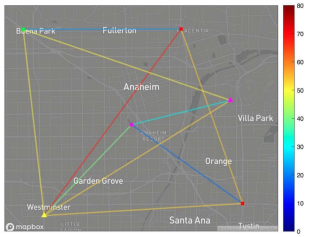


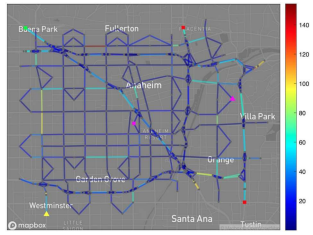


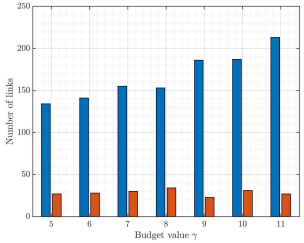
The fuel consumption when carry more battery pack before take off is very close to charging the battery during flight

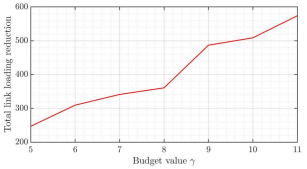
Urban Air Mobility-network design

- Select vertiport locations and capacities that minimize the traffic congestion in hybrid ground-air transportation networks
- The model is based on a mathematical program with bilinear equilibrium constraints









Future Work, References, and Acknowledgments

- Take battery degradation into consideration
- Sensitivity analysis of fuel consumption for hybrid electric aircraft
- Network design for large-scale traffic model

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