

A First-Order Analysis of Direct Operating Costs of Battery Electric Aircraft

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EPSRC

Engineering and Physical Sciences
Research Council

Airline Industry

- ❑ Air transport CO₂ emissions increased by 3.6% per year since 1980
- ❑ Demand is expected to grow by 5% annually
- ❑ Technology advancement leads to efficiencies improvement by 1-2% per year
- ❑ Hybrid-electric aircraft would alleviate emissions
- ❑ Fully battery powered aircraft would eliminate all direct emissions

Battery Electric Aircraft (BEA)

SAECA project

Li-air batteries
(1500 Wh/kg)



180 Wh/RPK



Short-medium narrow-body



Jet-A fuel



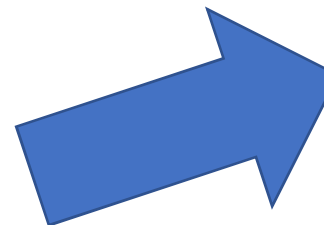
0.84 MJ/RPK

Cover 75% of
A320s global
market share

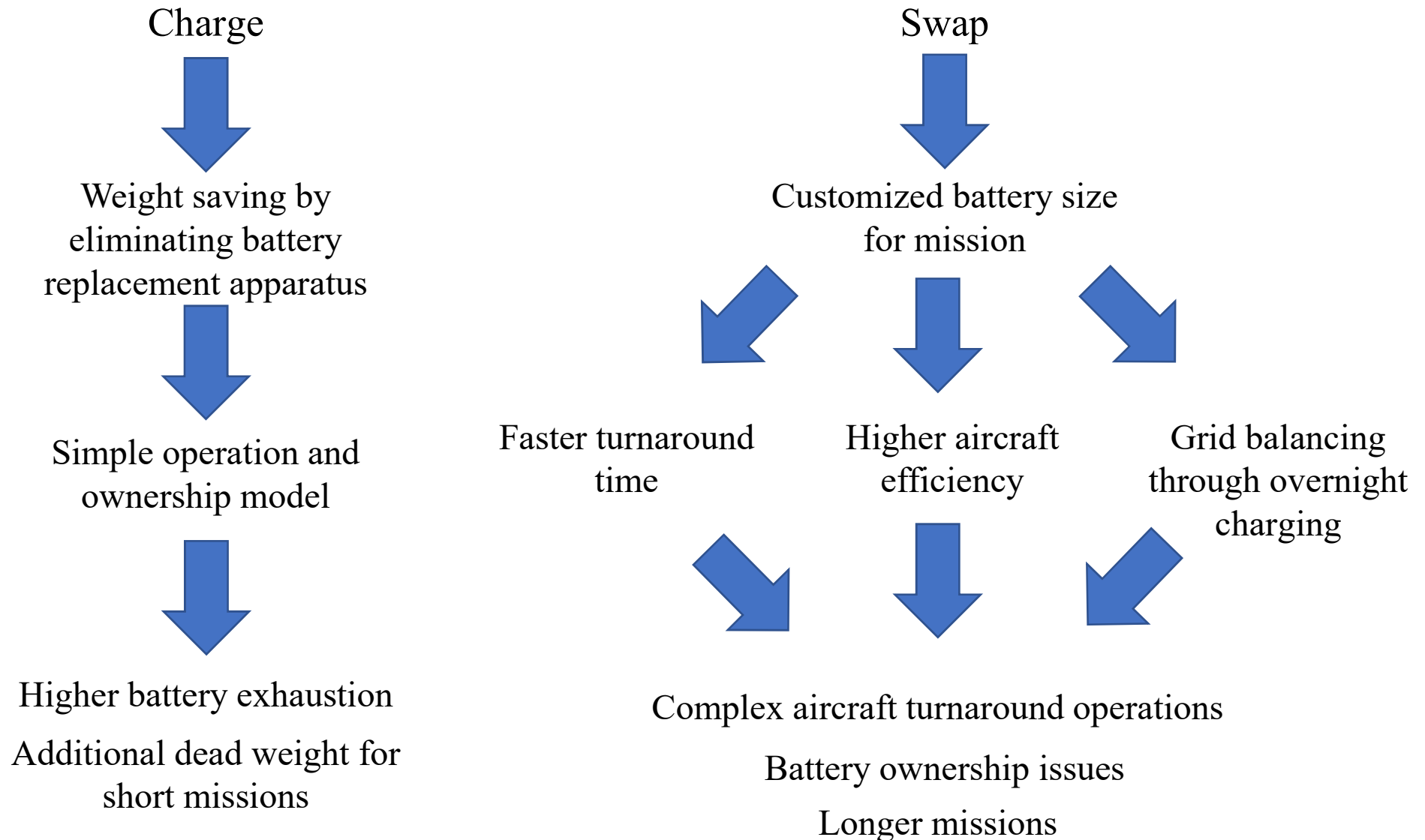
Maximum range
900nm



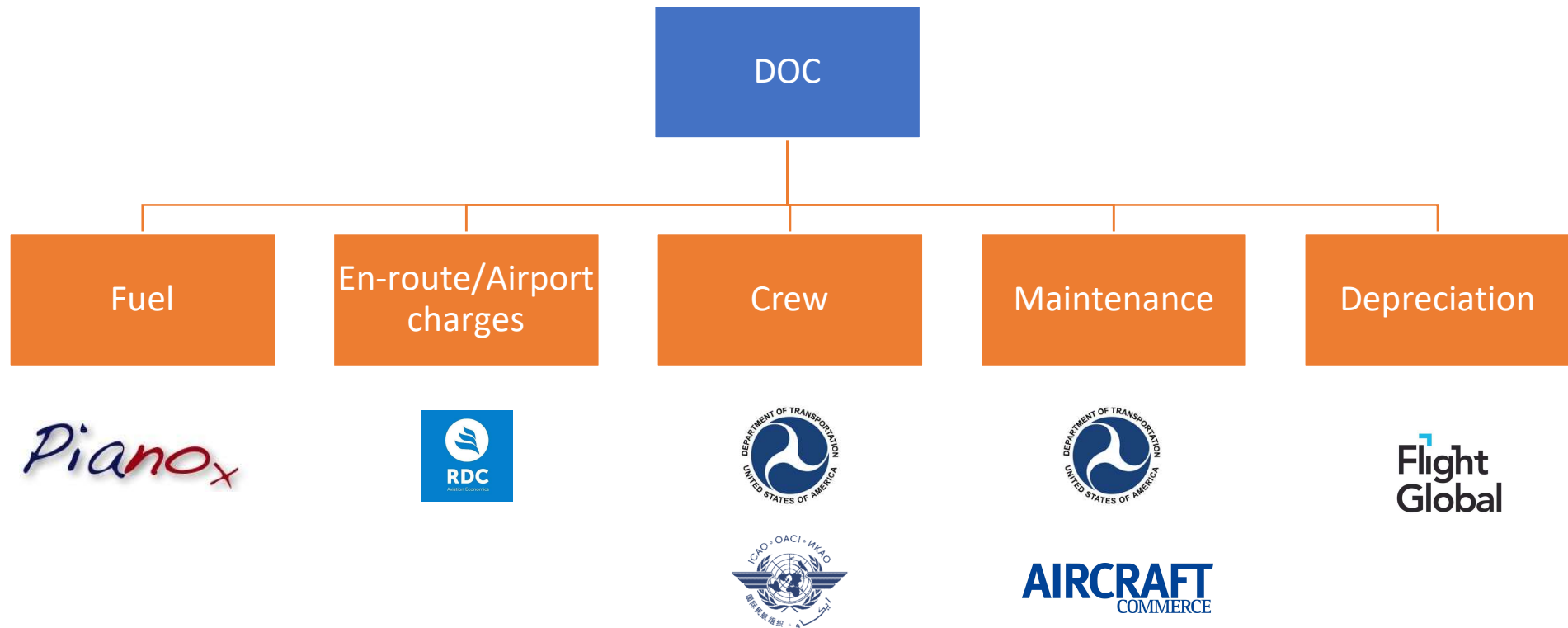
Present-day battery
energy density
250Wh/kg



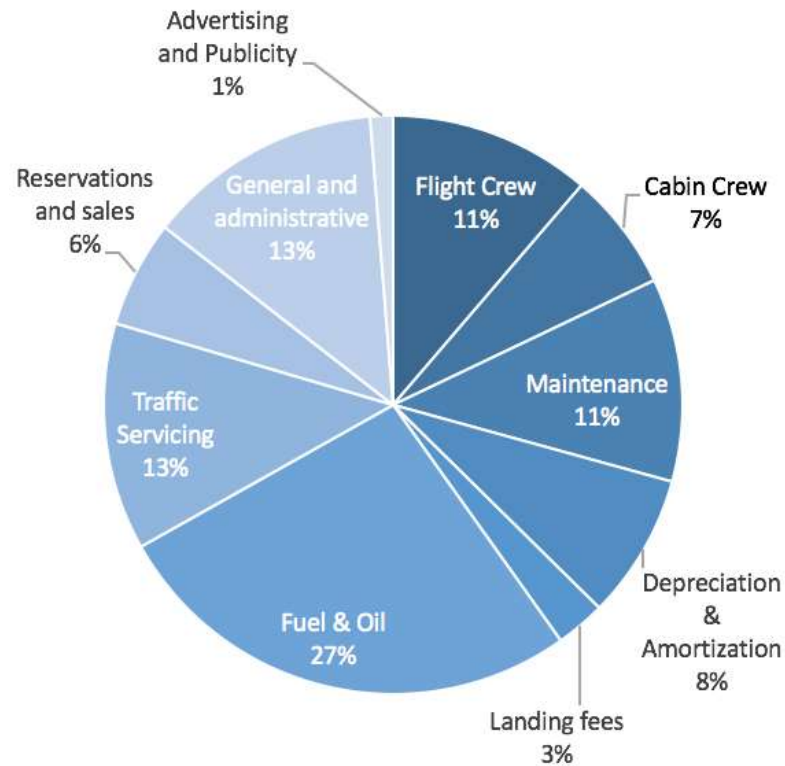
Battery Installation Options



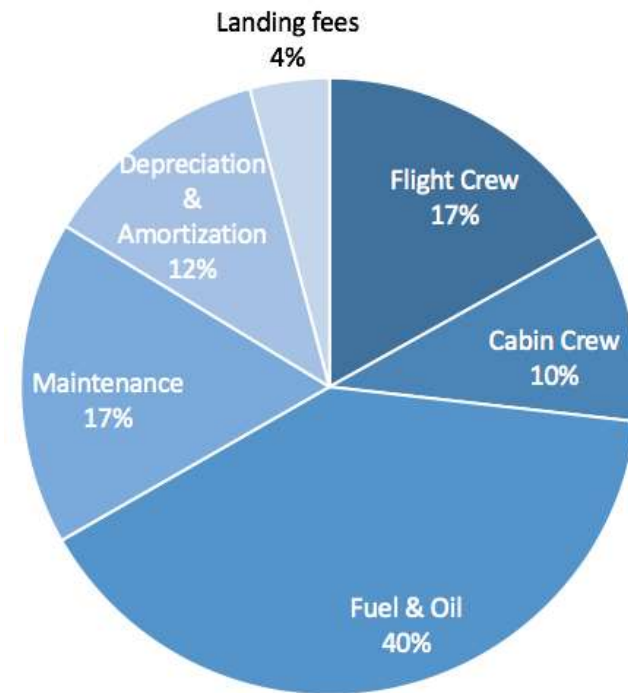
Cost Components and Key Sources



DOC for US Airlines

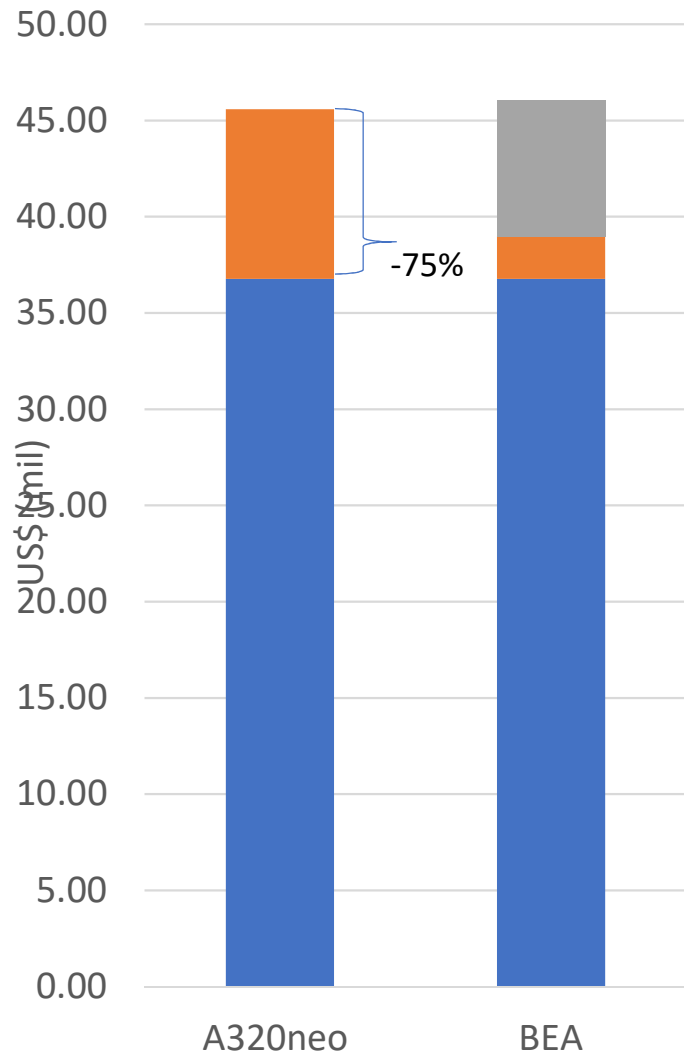


Total Operating cost



Direct Operating Cost

Depreciation



15% + Electric Motors
Inverter
HTS material
Cryogenic cooling } ~10%

■ Battery

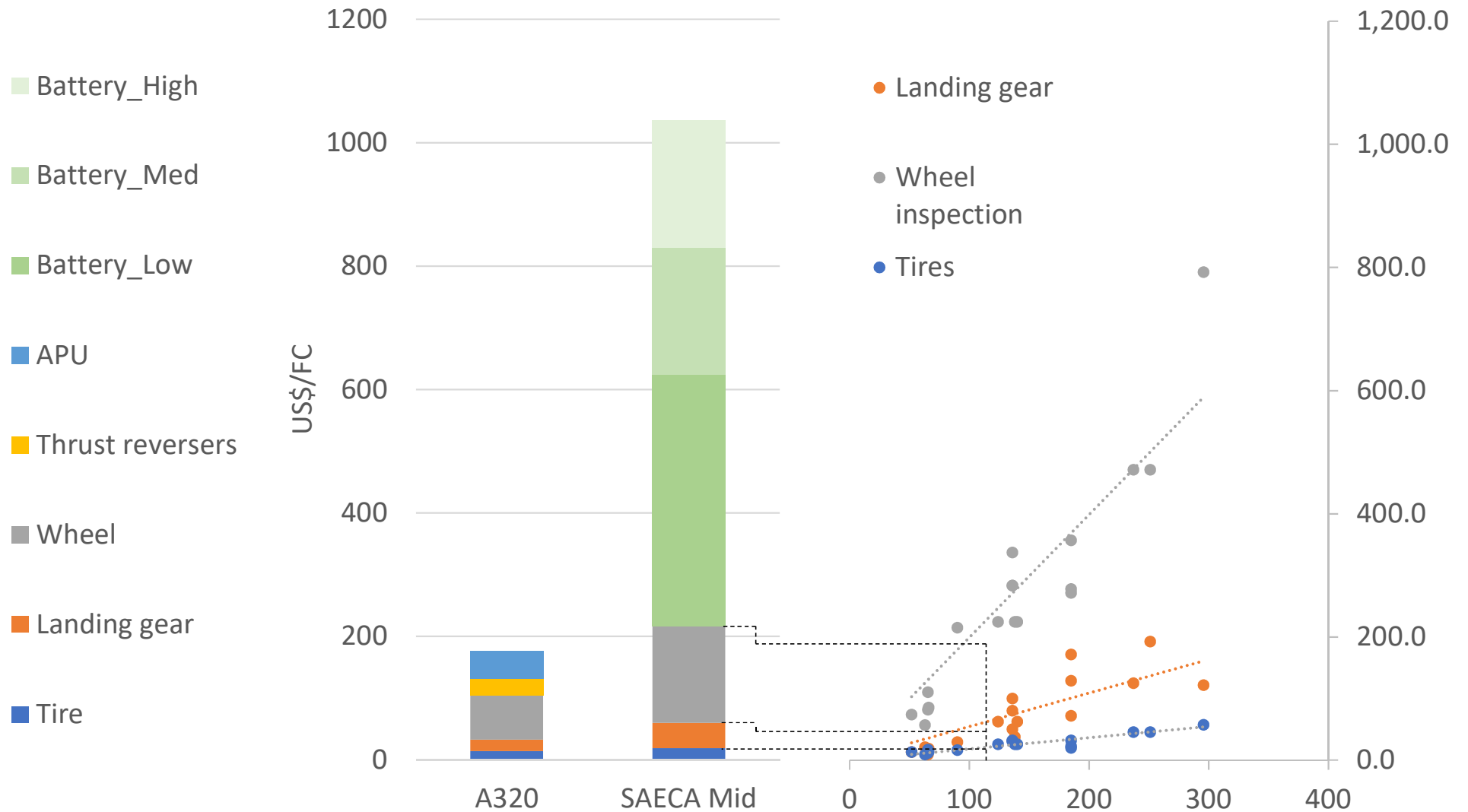
■ Propulsion

■ Airframe

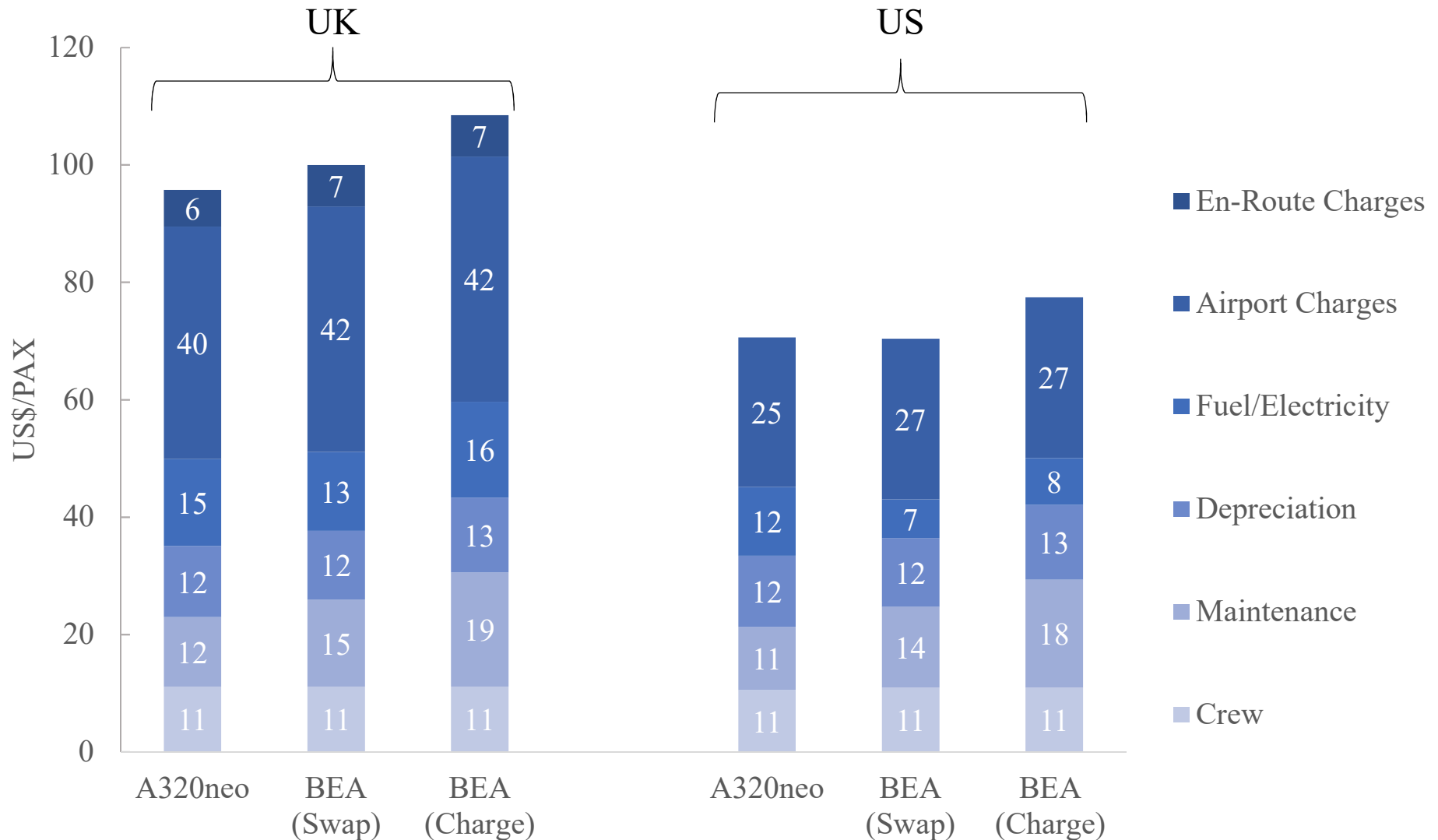
Battery Max Capacity	37.6 MWh
Battery cost	150 \$/kWh
Battery lifetime lifecycles	5,000
Initial number of batteries	1

Source: Flight Global, Tesla, Own assumption

Airframe Maintenance: Heavy Components

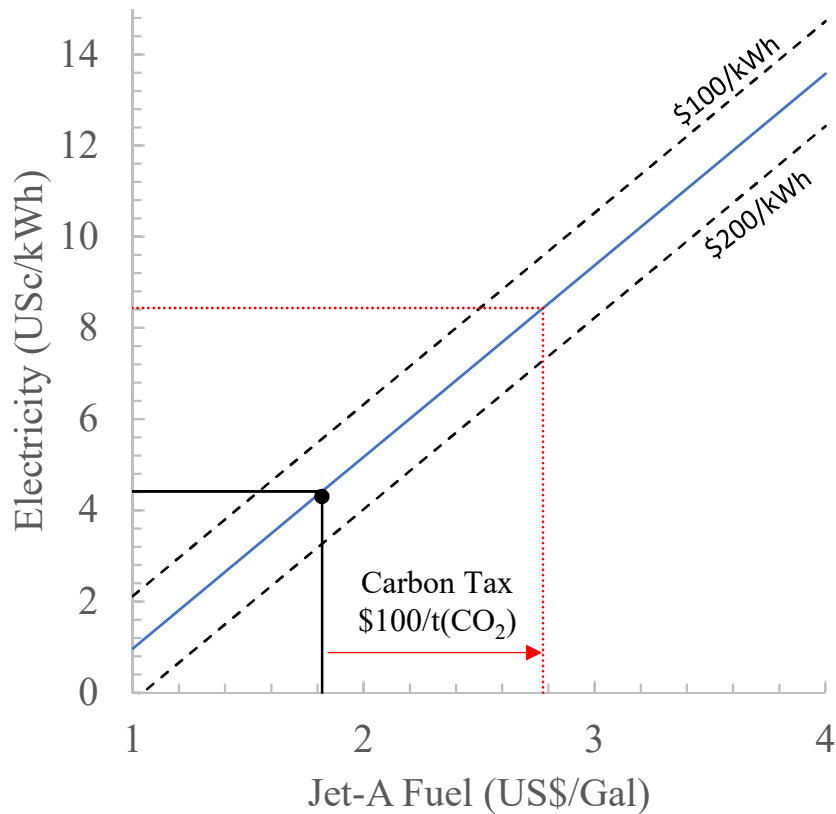


DOC Per PAX One-Way Trip (450nm)

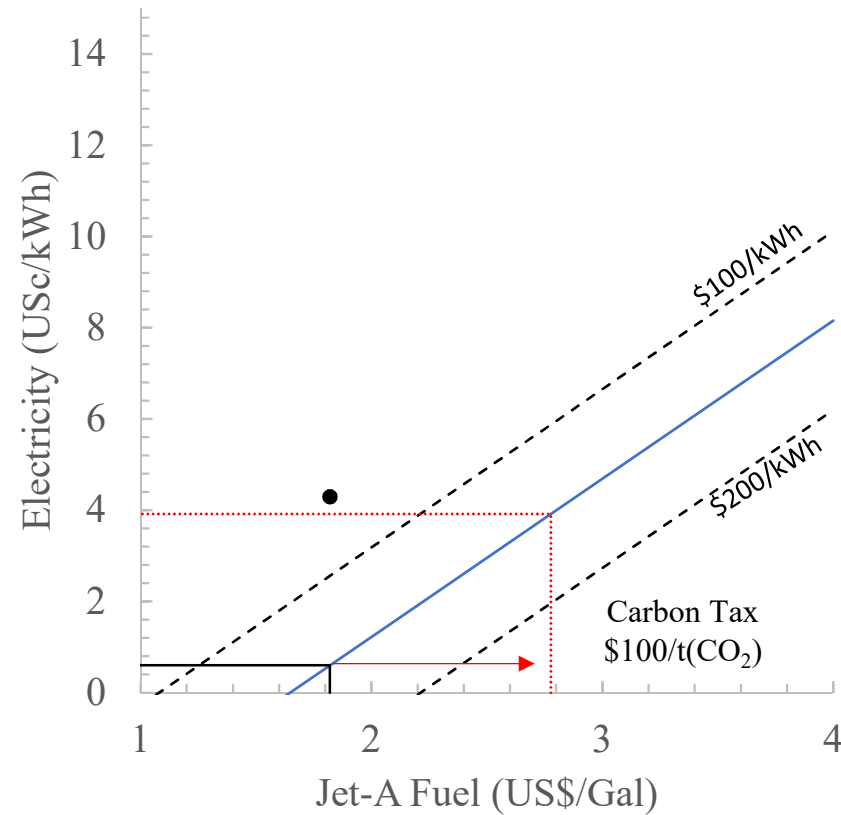


Break-Even Cost Analysis (450nm)

US Swap



US Charge



Conclusions

- ❑ The cost-effectiveness of battery electric aircraft strongly depends on battery performance and costs, in addition to jet fuel and electricity price. Based on this study, a feasible economic window seems to exist
- ❑ A number of additional factors can improve the cost-effectiveness of battery electric aircraft. These include optimized battery management (including battery swapping and load-levelling the electricity grid), a carbon tax, and emissions charges other than CO₂
- ❑ Better understanding these trade-offs requires a whole-systems model approach

Questions

www.atslab.org/data-tools/