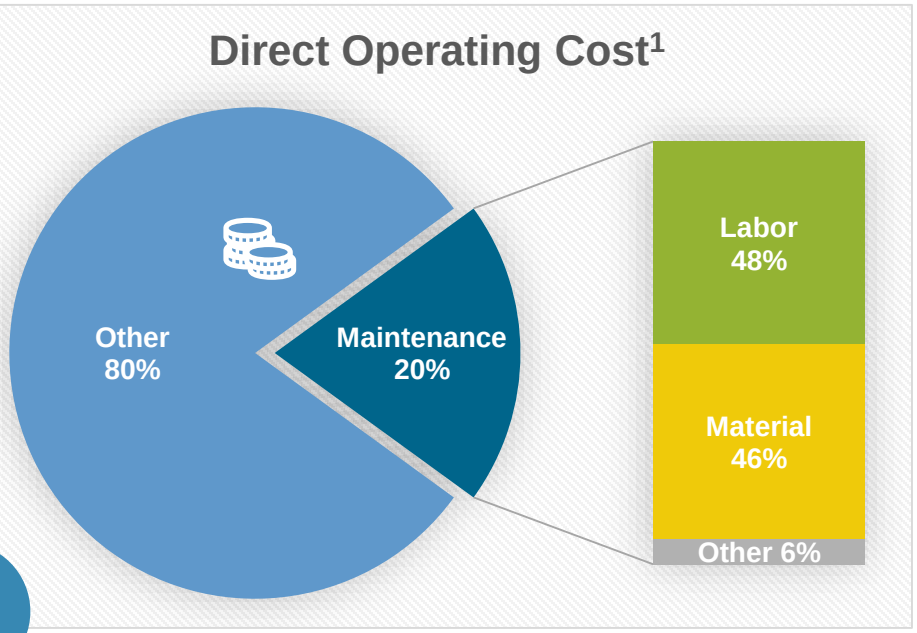
Economic implications for battery-electric aircraft concepts from a maintenance perspective

MRO Monday – Jan-Alexander Wolf & Ricardo Dauer

DLR

What will maintenance of new drive concepts cost?



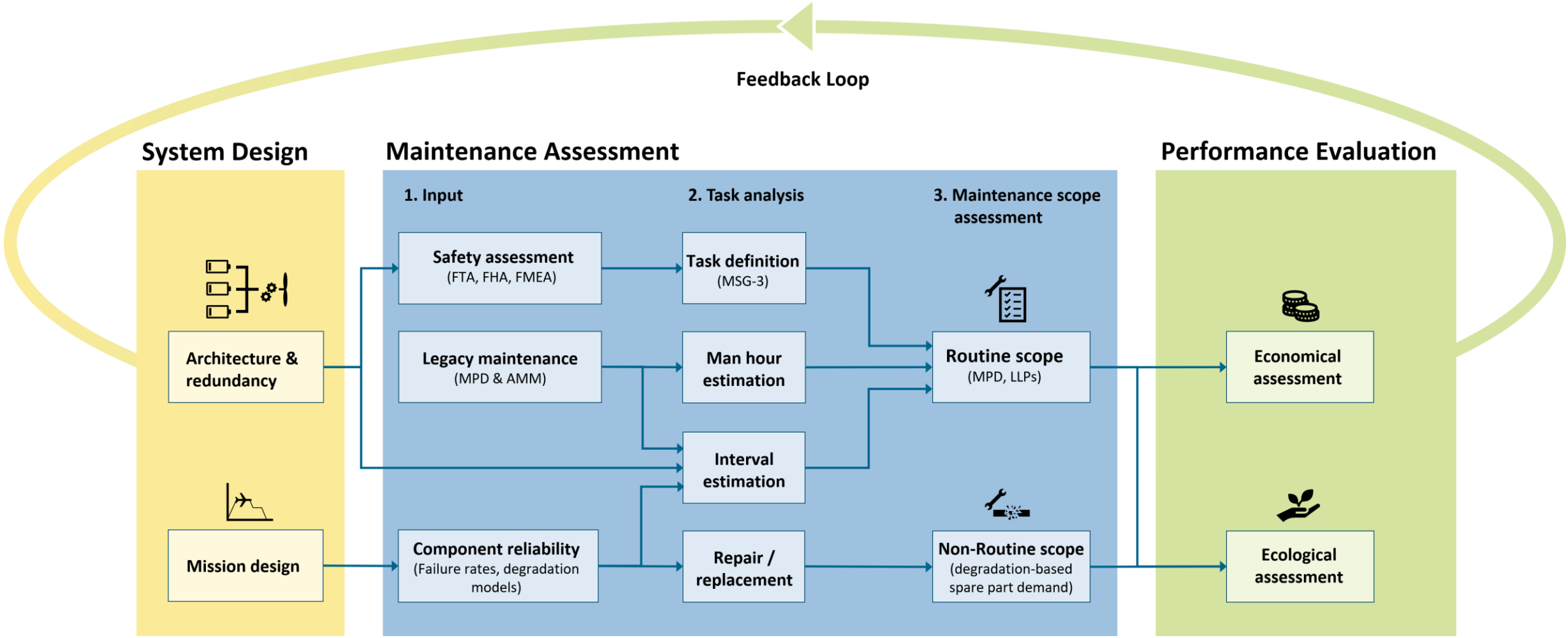
?

Enabler or Showstopper

System Design → Maintenance Assessment → Performance Evaluation

1 Sources: R. Meissner et al. (2023) Towards climate-neutral aviation: Assessment of maintenance requirements for airborne hydrogen storage and distribution systems. DOI: 10.1016/j.ijhydene.2023.04.058
T. Hoff et al. (2023) Implementation of Fuel Cells in Aviation from a Maintenance, Repair and Overhaul Perspective. DOI: 10.3390/aerospace10010023

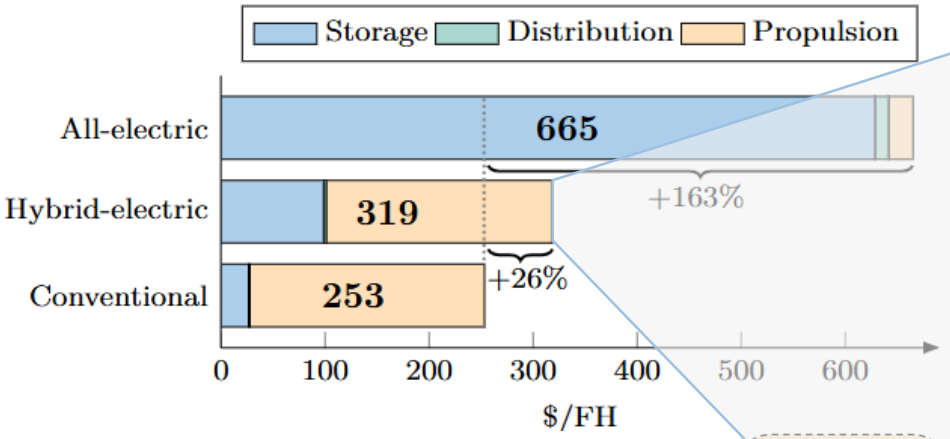
The approach – A reliability-based maintenance analysis



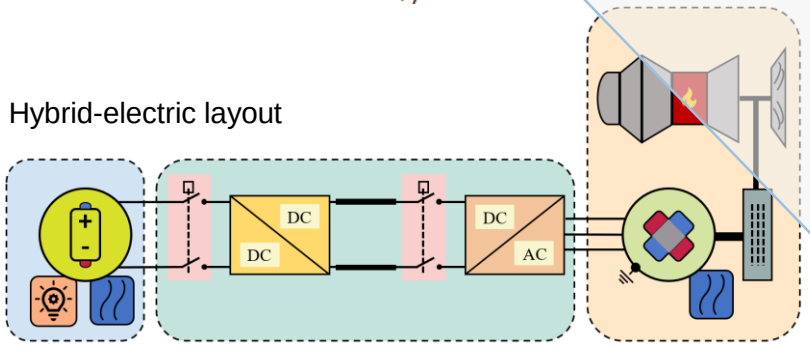
How would the material cost change for a battery-powered propulsion system?

The impact – Material scope

Comparison of material cost for a battery-powered A320 equivalent drive train



Hybrid-electric layout



Material cost for the hybrid-electric drive system. Averaged values per flight hour and aircraft, including all installed units.

System	Drive train	Component	Cost	Unit	Share
Storage	Conventional	–	–	–	–
	Electric	**Battery cells**	96.91	$/FH	**30.4%**
		BCS	1.66	$/FH	0.5%
		BMS	0.08	$/FH	0.03%
	Sub-total		**98.65**	**$/FH**	**30.9%**
Distribution	Conventional	FQIC	0.83	$/FH	0.3%
		Miscellaneous	0.65	$/FH	0.2%
	Electric	Circuit breakers	0.62	$/FH	0.2%
		Inverters	0.36	$/FH	0.1%
		Converters	0.26	$/FH	0.1%
	Sub-total		**2.72**	**$/FH**	**0.9%**
Propulsion	Conventional	**Main engines**	204.91	$/FH	**64.3%**
		ECU	4.08	$/FH	1.3%
		TRU	3.08	$/FH	1.0%
		Miscellaneous	3.79	$/FH	1.2%
	Electric	MCS	1.11	$/FH	0.3%
		Electric motors	0.34	$/FH	0.1%
		Gearboxes	0.15	$/FH	0.05%
	Sub-total		**217.46**	**$/FH**	**68.2%**
Total			**318.83**	**$/FH**	**100%**

Expected impact

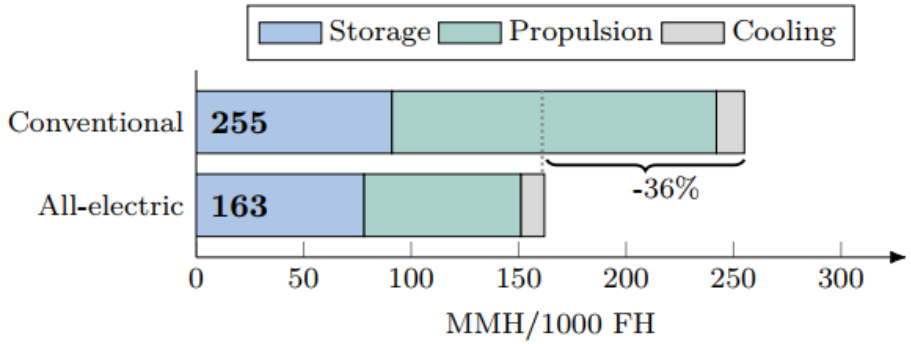
Increase in material cost of 163% for all-electric and 26% for hybrid-electric configurations

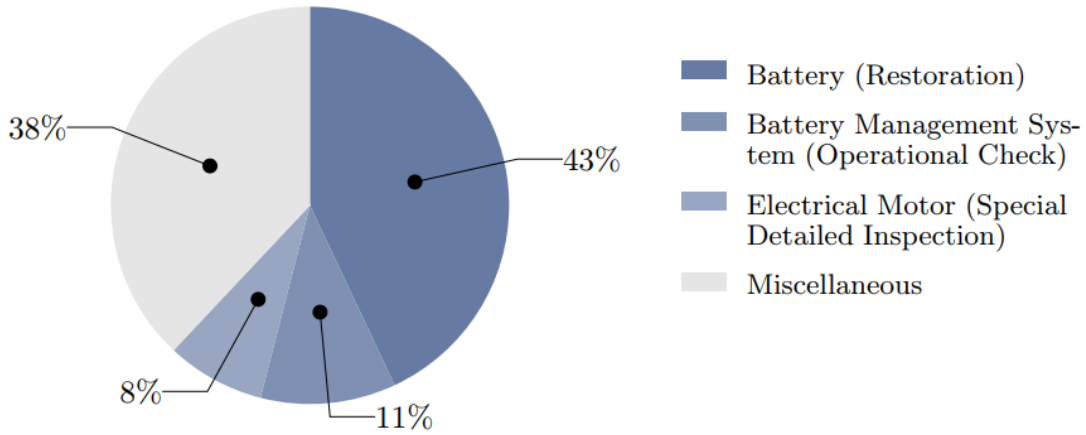
How would the labor scope change for an all-electric propulsion system?

The impact – Labor scope

Task description	Task Code	Interval	Units	MMH per unit	MMH total
Perform Fault Diagnosis for BMS sensors via BITE	OPC	1000 FH	3	0.3	0.9
Perform Operational Check of BMS via BITE	OPC	350 FH	3	0.3	0.9
Remove Battery (BAT) pack for In-Shop Restoration (RST) of Cells and Cooling	RST	4000 FC OR 180 MO	3	24.0	72.0

- Continuing -





Expected impact

Decreasing maintenance costs in terms of labor

… but specialized equipment needed
… but higher qualification standards

Our roadmap & vision

Defining maintenance scopes and assessing maintenance needs for novel aircraft systems in early design stages

We know ... the correlations between design specifications, operating conditions, and resulting maintenance implications.

We perform ... holistic maintenance assessments of novel systems and improve established evaluation methods.

We support ... technology experts in the development of viable and cost-efficient designs from a maintenance perspective.

Publications

Assessing the Feasibility of Hydrogen-Powered Aircraft: A Comparative Economic and Environmental Analysis

Jennifer Ramm,* Antonia Rahn,* Daniel Silberhorn,† Kai Wicke,‡ and Gerko Wende§
German Aerospace Center, 21129 Hamburg, Germany

Hydrogen-based aircraft auxiliary power generation: Economic and ecological comparative assessment of preventive maintenance implications ⋆

Robert Meissner * Antonia Rahn * Anne Oestreicher *
Kai Wicke * Gerko Wende *

Towards climate-neutral aviation: Assessment of maintenance requirements for airborne hydrogen storage and distribution systems

Robert Meissner [a,], Patrick Sieb [a], Eric Wollenhaupt [b], Stefan Haberkorn [c], Kai Wicke [a], Gerko Wende [a]*

Life Cycle Assessment of Aircraft Maintenance: Environmental Implications of Battery Electric Propulsion Systems

Antonia Rahn, Jan-Alexander Wolf, Ricardo Dauer, Robert Meissner, Ahmad Ali Pohya, Gerko Wende

Flying electric: A comparative analysis of spare part demands and material cost for all-electric, hybrid-electric, and conventional aircraft propulsion systems

Jan-Alexander Wolf[1,*], Robert Meissner[1], Ahmad Ali Pohya[1], Gerko Wende[1]

And many more…

Imprint

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