Integration of Novel Electric-Wheel-Driven Hybrid-Electric Propulsion Systems on Standard Short Range Passenger Airplanes

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Electric and Hybrid-Electric propulsion technologies have been proven to be both feasible and beneficial and are already sporadically in operation in today's General Aviation segment.

Implementing fully electric propulsion on heavier commercial airplanes however will remain challenging for the foreseeable future, especially due to the weight of the electric onboard energy storage devices. To overcome these challenges, new hybrid-electric propulsion systems, using only a certain share of electric power onboard, and novel architectures are highly desired.

The main objectives are to improve the aircraft's overall efficiency as well as to considerably reduce the environmental impact in terms of noise and emissions, while maintaining or, if possible, even improving aircraft performance.

In the scope of this technical paper a novel invention in the implementation of a hybrid-electric propulsion system is presented and demonstrated on a standard short range airplane, in which the thrust of the aircraft engines is effectively combined with an electric-driven wheel propulsion system while the aircraft operates on the ground. Besides improving the aircraft's overall efficiency, this hybrid-electric system enhances the field performance of the aircraft. The field performance e.g. covers ground-based aircraft performance like take-off and landing field-length, the accelerate-stop distance, and additionally airborne flight phases like the initial climb performance, dependent on the operation mass of the aircraft. An aircraft equipped with the described system will feature a variety of operational advantages.

Integrated in the overall hybrid-electric architecture the electric propulsion system comprises several electric motors installed at the main landing gear of the aircraft. Corresponding with the concept of distributed propulsion, each electric motor propels at least one wheel of the main landing gear either directly or via a reduction gear, e.g. a planetary gear. In contrast to aircraft using electric motors only for taxiing, the motors are of a suitable rated performance level, so that they can beneficially be used for the aircraft's operating phases of higher velocity and performance, especially during take-off and landing.

During the take-off run the electric driven wheels can contribute to the overall thrust of the aircraft depending on the percentage share of onboard installed electric power. The increased overall thrust level results in higher acceleration of the aircraft and therefore shorter take-off distance for a certain given take-off mass. Alternatively, increased thrust can also be used to accelerate a higher take-off mass at a certain given take-off length. Depending on the subsequent climb requirements and regulations, this can enable aircraft operation with higher payload.

After touchdown the electric motors can be operated in generator mode to decelerate the aircraft in addition to the mandatory mechanical braking system. As a result of the increased braking force two alternatives are possible, either obtaining a shorter landing distance for a

certain operating mass or achieving a higher landing mass on a certain given landing distance.
As a consequence of both increased acceleration and deceleration capabilities of the aircraft the accelerate-stop-distance as well as the Balanced-Field-Length of the aircraft is shortened, allowing aircraft to operate at airports with limited runway-length either in general or with increased take-off mass.

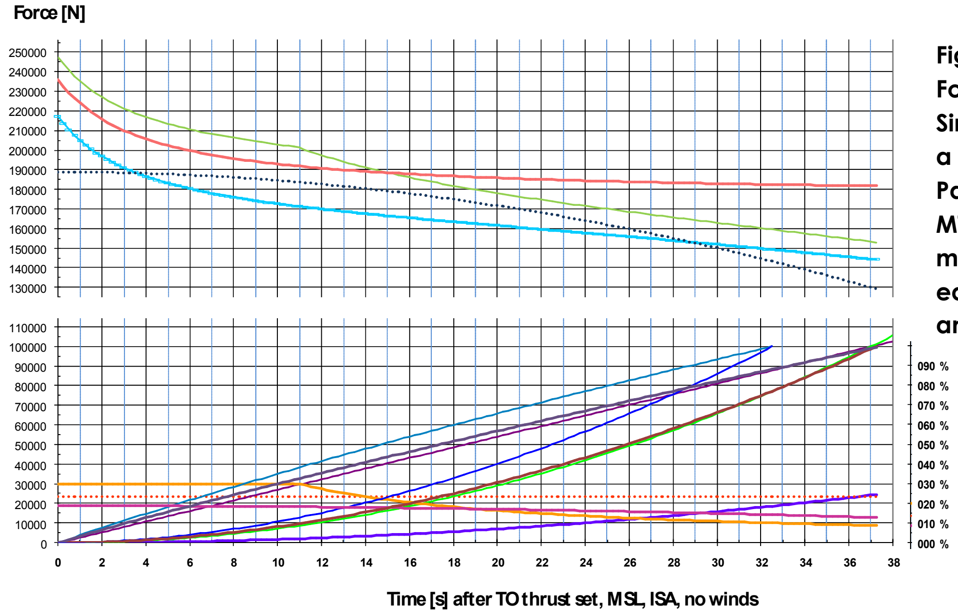
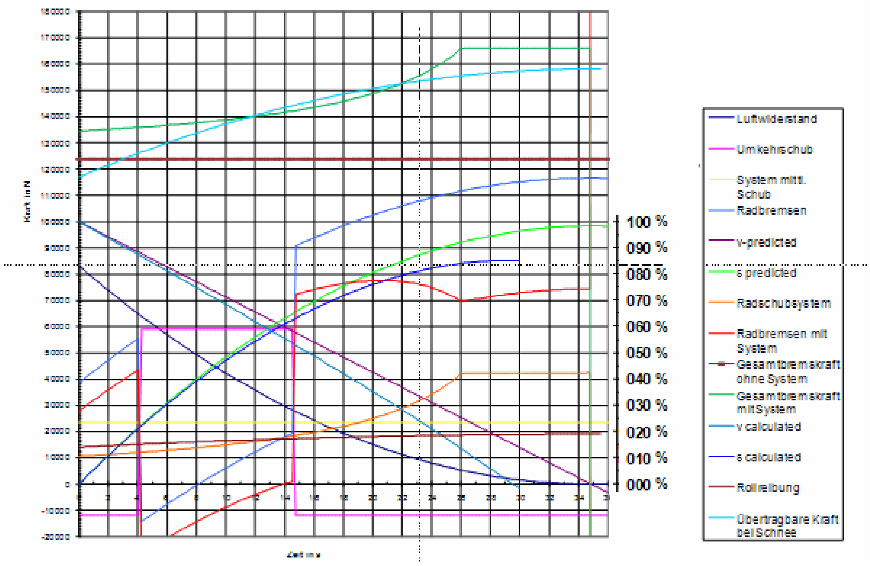


Fig.1: Example of the Forces accompanying a Simulated Take-off Run of a Standard Short Range Passenger Aircraft, 77t MTOW, with 4 electric motors in operation, each delivering 350kW and a torque of 400Nm

The E-Wheel* system can also be used during take-off to decrease the thrust level of the aircraft's engines. This can help to significantly reduce engine wear and thrust-related engine maintenance costs.



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* E-Wheel : Electric Wheel

Fig.2: Example of the Forces accompanying a Simulated Landing-off Run of a Standard Short Range Passenger Aircraft, 64,5t MLW, with 4 electric motors in operation, each braking by 350kW and a torque of 1120Nm

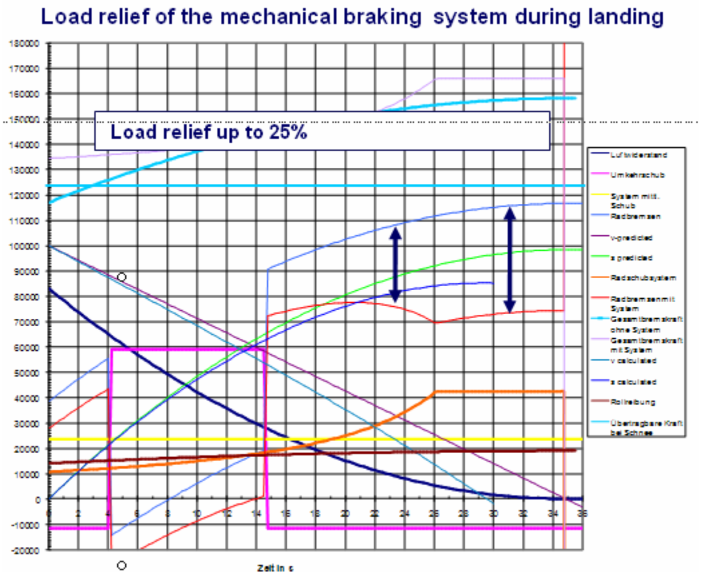

Fig.3: Possible Load relief of the mechanical braking system due to the E-Wheel integration on a Standard Short Range Passenger Airplane

Within the scope of this paper the general architecture of a hybrid-electric system is presented, its intregation on a standard short range aircraft is demonstrated, its feasibility is evaluated, multiple applications of the hybrid-electric propulsion system are being discussed, an overview of the enhancements in field performance is given, and substantial safety as well as operational considerations are undertaken, followed by a final evaluation.

Finally a short future outlook is given, showing the possible operation of an Electric-Wheel – Driven Hybrid-Electric Propulsion System on a Standard Short Range Aircraft together with further hybrid-electric onboard propulsion systems.

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