Using COMSOL® for the Development of the UK's Second Hyperloop Prototype

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Introduction: Hyperloop is a revolutionary mode of transport which uses EM propulsion to accelerate passenger or cargo pods through a low-pressure tube. The UK's second prototype that uses EM propulsion and levitation systems was developed by HYPED (The University of Edinburgh's Hyperloop Team). Simulations were required to determine design parameters for these systems.

Computational Methods:
The AC/DC module was used to calculate the thrust and levitation forces generated from the electrodynamic wheels (EDW), shown in Figure 1, and levitation arrays.
- Halbach Wheels (EDWs): Time dependent and static EM simulations were performed for the calculation of the forces and magnetic fields, using the Rotating Machinery, Magnetic interface. (Figure 1)
- Levitation Arrays: A time dependent parametric study was conducted to calculate the drag and lift forces using the Magnetic Fields interface. (Figure 2)

A thermal simulation using the Electromagnetic Heating interface in the Heat Transfer module was also conducted for the EDWs in the case where emergency brakes are used and the pod stops abruptly with the wheels still spinning next to the rail. The thermal map is shown in Figure 3.

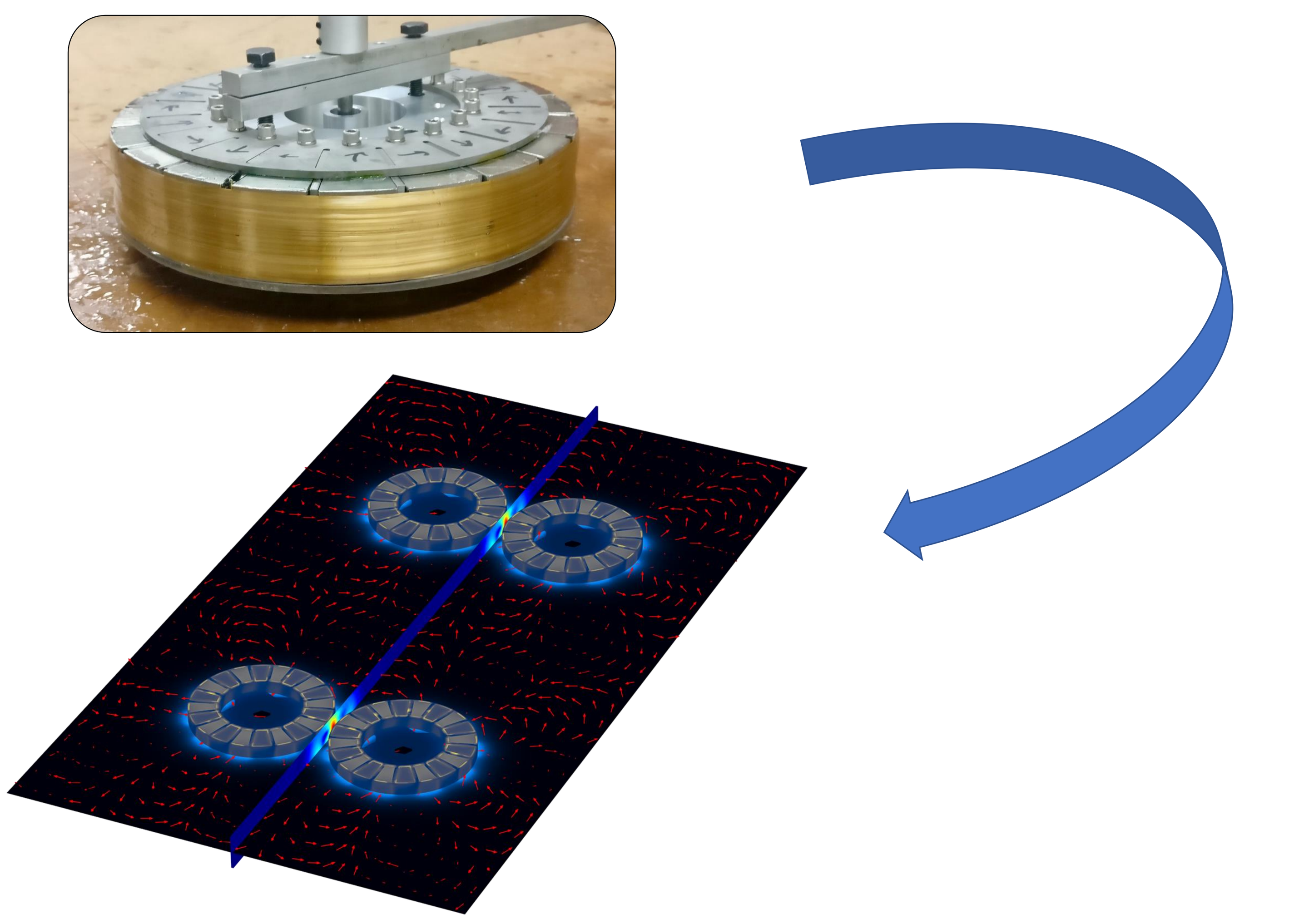

Figure 1. (Top) Finished halbach wheel. (Bottom) Magnetic field produced by all four halbach wheels with the aluminium track in between.

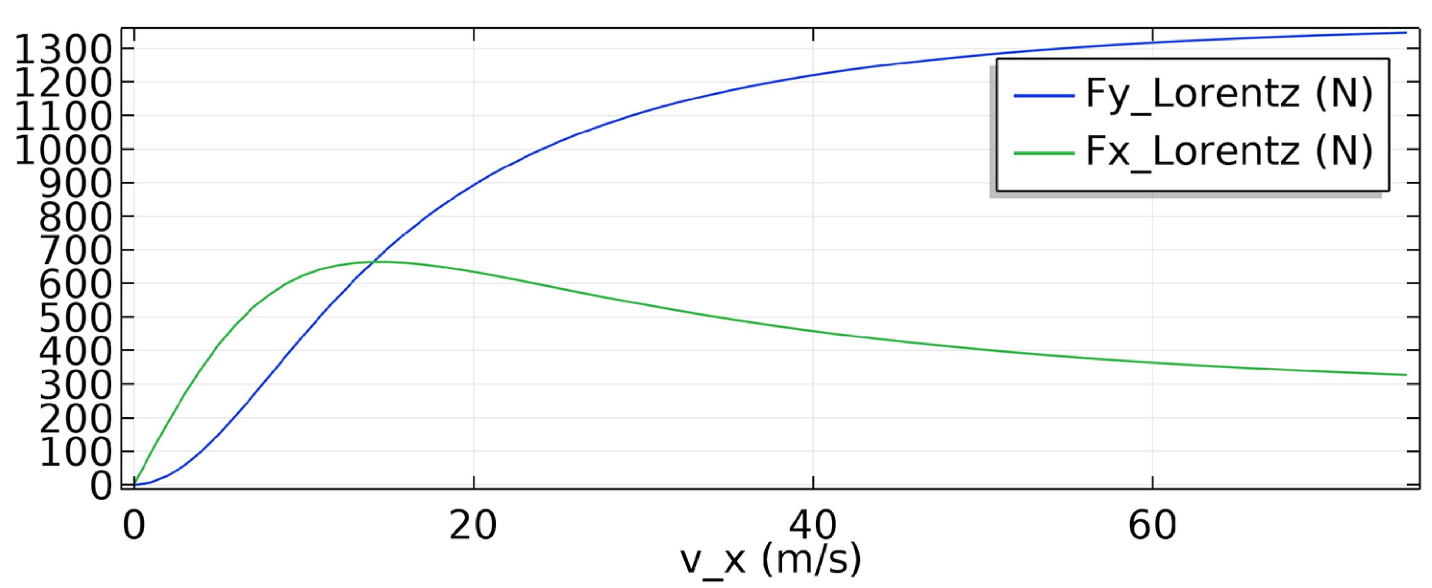

Figure 2. Forces on the Levitation Array against velocity.

Results: Magnetic flux and current density distributions for four EDWs and a linear halbach array are shown in Figures 1 and 4 respectively. The maximum magnetic flux value near the surface of an EDW is ~0.7 T. In the case of an unexpected stop of the system, the aluminium rail would heat up by 600K in 3s, due to the free spinning EDWs.

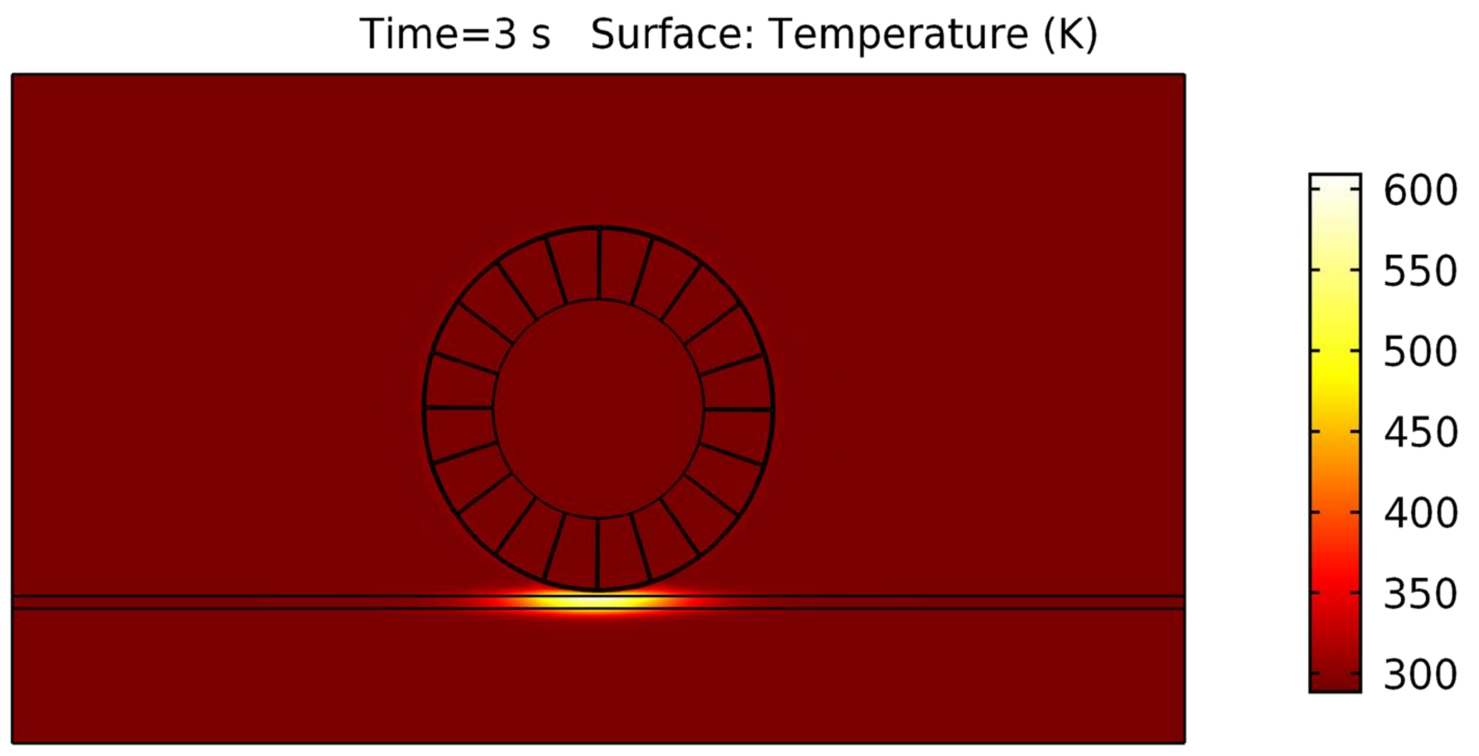

Figure 3. Heating induced on the aluminium track due to the free spinning EDW.

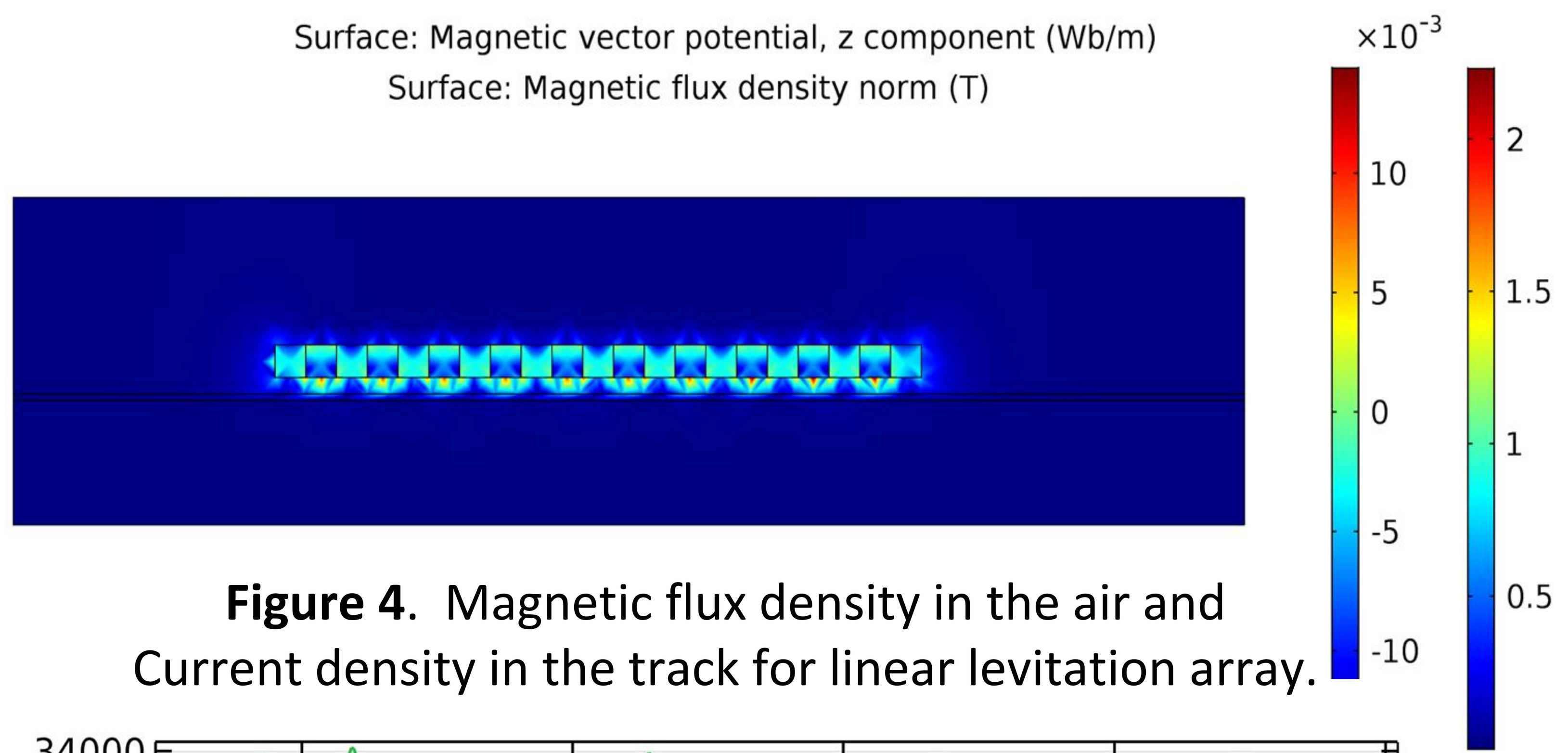

Figure 4. Magnetic flux density in the air and Current density in the track for linear levitation array.

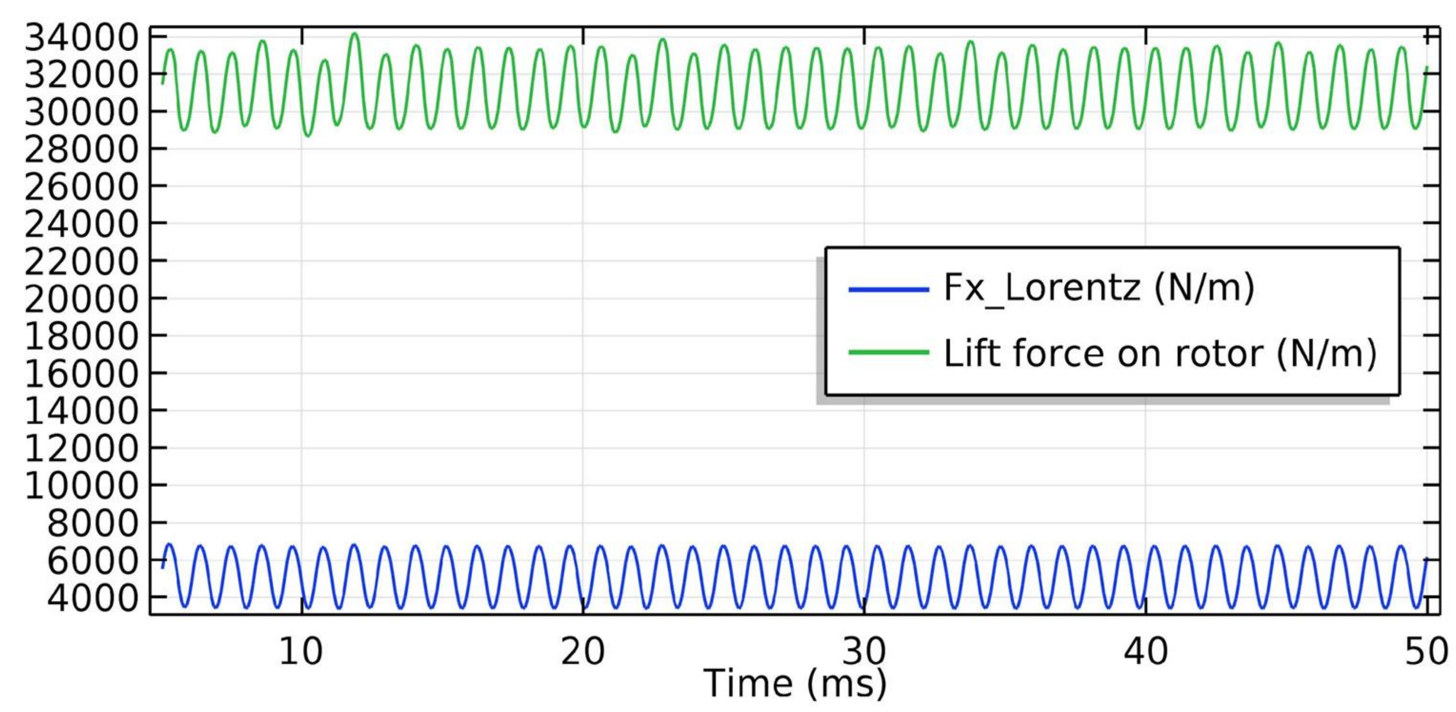

Figure 5. Lift and Drag forces of a rotating EDW against time.

Conclusions: Drag and lift force distributions over time show oscillatory behaviour due to the gaps between the magnets in EDW.
In case of emergency braking, the heating of the track would be within normal range and thus would not cause any structural damage.

References:

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[2] Paudel, N. and Bird, J.Z., 2012. General 2-D steady-state force and power equations for a traveling time-varying magnetic source above a conductive plate. IEEE Transactions on Magnetics, 48(1), pp.95-100.

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