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# ASSESSING THE ENVIRONMENTAL IMPACT OF LARGE VEHICLE SUBORBITAL POINT TO POINT TRANSPORTATION

**Abstract**

The development of large methane or natural gas rockets is a new feature in the launch vehicle sector, with two large vehicles currently under development (SpaceX BFR and the Blue Origin New Glenn). Both of these vehicles are reusable and the SpaceX BFR will be larger than any other rocket built to date. SpaceX intends to use its vehicle as the launch platform for its Mars exploration plans, which require up to 6 BFR launches per interplanetary vehicle. SpaceX also intends to use the BFR for suborbital hops to transport people and cargo around the world in less than 60 minutes with most trips shorter than half an hour.

The economic advantages of a 60 minute flight from London to Sydney are obvious, but the environmental cost of this approach compared to conventional subsonic aviation or even conceptual hypersonic vehicles is not. In order to fully understand and regulate the use of BFR-like vehicles for suborbital long-distance transport, the environmental impact, and other operational concerns should be investigated.

In this study possible main routes will be analysed, obtaining the optimal flights paths of the vehicle using trajectory optimisation and the atmospheric emissions at different altitudes through the simulation of the engine operation. The vehicle will be modelled with a point-mass dynamic model with controls for the angle of attack and bank angle. The engine throttling is an additional control variable for the ascent and landing phases. The Raptor engine design parameters will be estimated given publicly available data, and modelled using a quasi-one-dimensional model, with chemical equilibrium for the chemistry. This will provide performance characteristics and first-order estimates of the emissions.

The emissions and the location of their release will be quantified and analysed, providing a useful metric to study and compare the environmental impact of the BFR vehicle for suborbital and orbital trajectories with other vehicles.