

Comparing Modes of Transportation with an Improved Kármán-Gabrielli Diagram

Purpose – To find, how passenger and freight transport efficiency depends on vehicle cruise speed. Based on the Karman-Gabrielli Diagram, four new diagrams are investigated. Plotted is a) the lift-to-drag ratio (weight-to-drag ratio) versus cruise speed. b) Vehicle weight is replaced by the weight of the payload. c) Plotted is the inverse of energy consumption per payload and range versus cruise speed. d) Energy consumption is replaced by primary energy.

Methodology – For each of the four new diagrams and for each considered means of transport, the governing equations are derived or obtained from literature. Data is collected and the diagrams are plotted. Results are discussed based on new figures of merit visualized in the form of straight iso-lines in the log-log plot. With normal axis the straight lines turn into a typical Pareto front.

Findings – Faster cruise speed of a vehicle is associated with reduced efficiency. More meaningful results are obtained if vehicle weight is replaced by the weight of the payload. Even better, if energy consumption is used or primary energy consumption compared to a slower vehicle. Freight ships are the best in fuel economy. The best compromise between fuel consumption and speed may be achieved by the hyperloop.

Research Limitation – This poster includes only a selection of vehicles from each category due to limited data accessibility.

Practical Implications – The Karman-Gabrielli Diagrams enable transportation users to make decisions regarding the most suitable mode of transport, considering various factors such as speed, economy, and environmental impact.

Originality – This seems to be the first report that extends the Karman-Gabrielli Diagram in such a way and proposes new transport figures of merit.

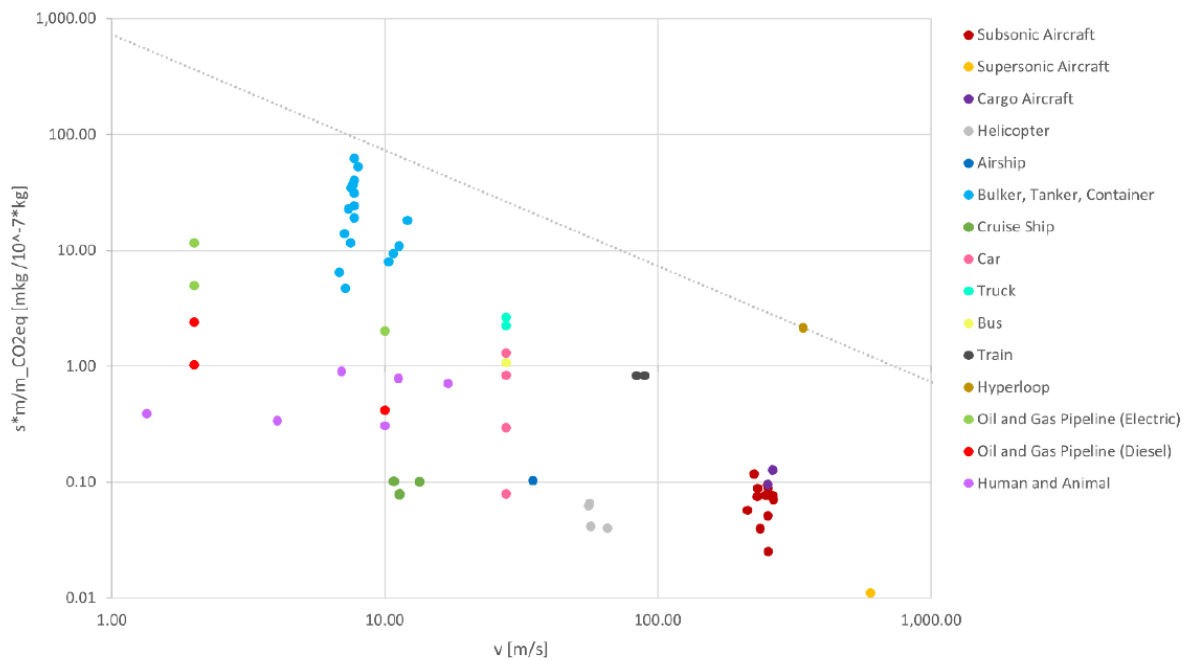


Figure 1: Improved Kármán-Gabrielli Diagram. Inverse of: Equivalent CO2 mass to payload and range plotted versus speed. The hyperloop shows the best compromise between emissions and speed. Transport of goods by ship (bulker, tanker, container) is quite slow, but has the absolute lowest emissions. Aircraft have the highest absolute emissions and score average on the compromise between emissions and speed.

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