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Characterization of the Usage of the Swiss Heavy Duty Trucks with the purpose of assessing the sectorial Energy Demand

Road-based freight transportation already accounts for more than 16% of the total CO_2 emissions in the mobility sector. However, its growth in terms of performance and emissions proceeds at a higher pace than passenger transportation [ARE 2016] and serious initiatives have be taken. To produce sensible and effective strategies an appropriate characterization of the trucks usage profiles is required. This implies a deep understanding of the key mechanisms governing the sector and an accurate management of the available data. An educated processing of such information can offer new interpretation keys of the freight transportation sector and suggest alternative solutions.

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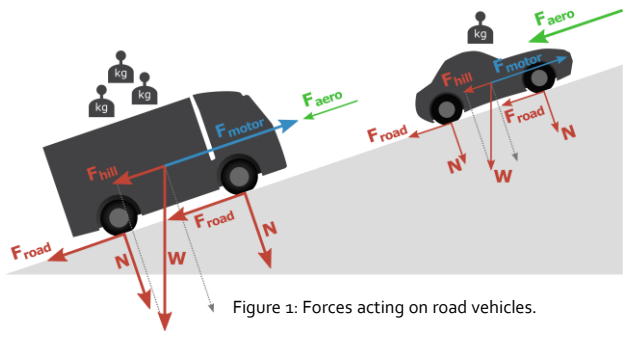

Figure 1: Forces acting on road vehicles.

Understanding

The physics behind trucks is the very same as for cars, but the relative importance of the forces the engine has to win changes radically. The higher weight of trucks increases the relevance of the mass-related terms (in red in Fig. 1), while their lower average velocity reduces the impact of aerodynamic drag (in green). This means that elements such as topology, trailer attachment and loading factor become extremely important when estimating the traction energy to be supplied by the truck. Moreover, being all mass-related terms linearly correlated to the weight, the total traction energy of a truck can be approximated as directly proportional to the total weight of the vehicle.

Processing

The main source of the currently processed data is the result of GTE 2013 (Gütertransporterhebung), a survey on Swiss heavy duty trucks (m > 3.5 t) from BFS. While many valuable quantities such as payload and good class are supplied, others equally important like topology and trailer details are missing. In order to overcome this shortage enhancement through other datasets has been considered. In first place MOFIS is used to complete the set of vehicle specifications when needed. A further option being investigated is the employment of the data collected by BFS through LSVA, a tax on heavy duty trucks proportional to their performance. Its added values would be more detailed information about trailers and the expansion from the subset of trucks inspected in GTE to almost the entire heavy duty fleet. Finally, data provided by specific fleet operators could provide notable levels of detail, with information on driving cycle, elevation and fuel consumption; clearly, any derived conclusion could be extended only to fleets operating in the same sector. Fig. 2 shows the good agreement between the usage profiles from a specific construction company and the ones from GTE belonging to the same sector (good class 'stone and earth').

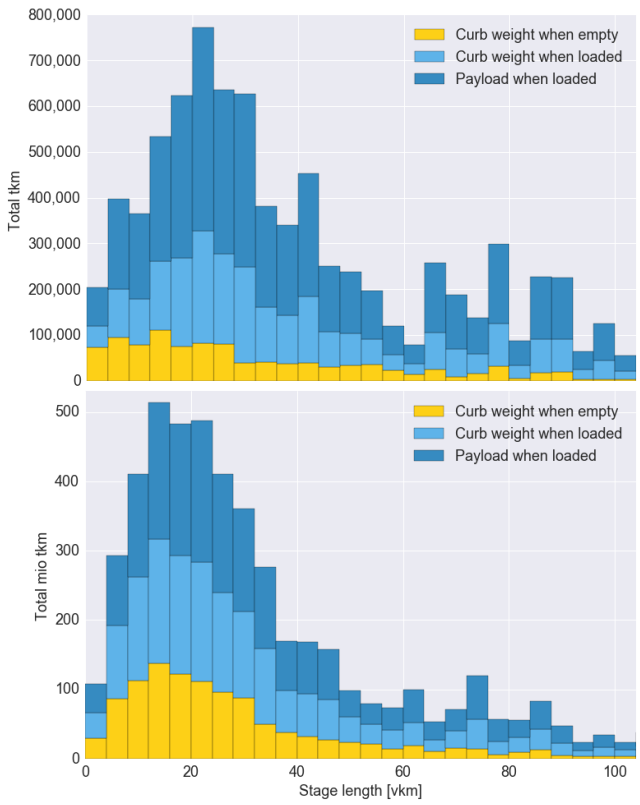

Figure 2: Sum of tkm performance by stage (constant payload) length. Blue bars are tkm in loaded stages, yellow bars are tkm in empty ones. Also the curb weight of the truck accounts to the tkm.
Top: single construction company.
Bottom: all truck from GTE in 'stone and earth' business.
From the higher share of dark blue bars it is possible to infer that the construction company is optimizing its logistics better then its competitors.

Offering

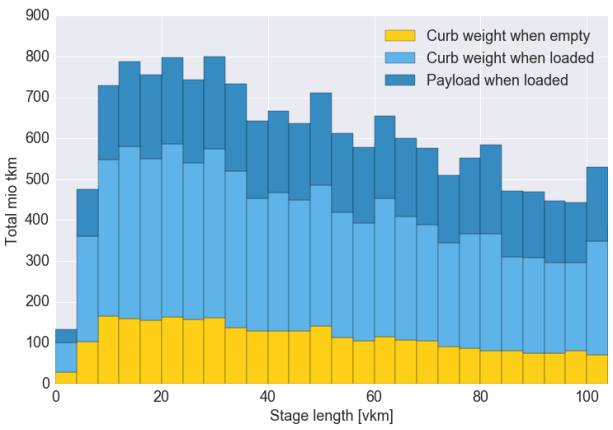

Figure 3: Same as Fig. 2, but for all GTE trucks which do not belong to the 'stones and earth' business.

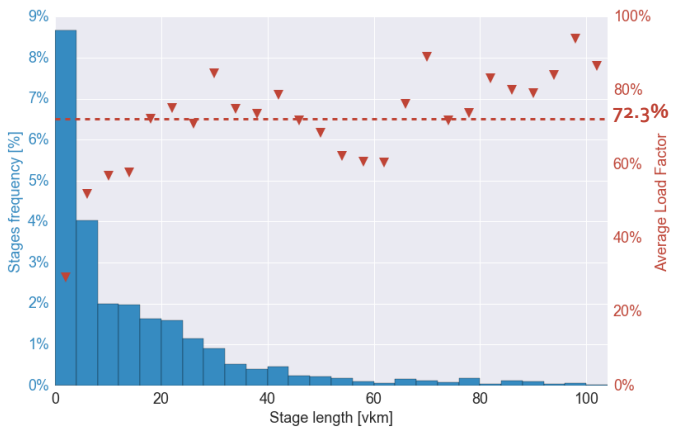

Figure 4: Blue bars: relative frequency of stages by stage length.
Red triangles: average loading factor for those stages.
Dashed line: overall average loading factor.

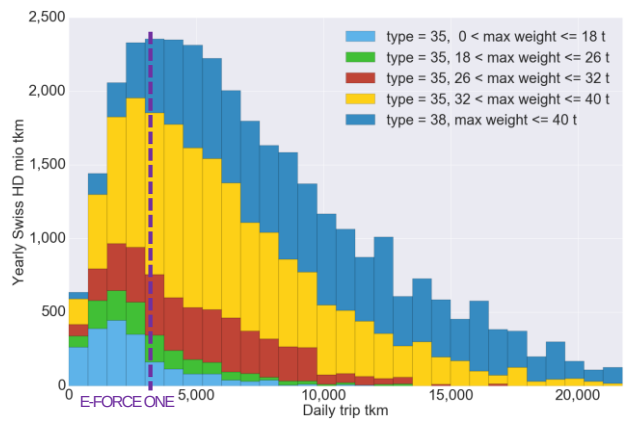

Figure 5: X-axis: effective tkm (curb weight + payload) performed by a truck in a day (= trip). Y-axis: sum of tkm of all trips within a range of daily tkm performance, by truck type and maximum permissible weight.

Fig. 3 shows the same quantities as Fig. 2, but for all trucks in GTE not belonging to the 'stones and earth' business. The difference with Fig.2 proves that the presented usage profiles are strongly related to business segment and might be used as unique identifiers. The lower share of dark blue bars and the different total profile confirm that the 'stones and earth' business is characterized by the higher loading and by the shorter stages (due to the lower value of the carried good).

Private companies might provide more detailed data than federal surveys: when this is the case, processing such information can provide great insights. For instance, the data from the construction company reveal the existence of a strong correlation between stage length and average load factor. This is a direct consequence of smart logistics, where long empty stages are minimized, being short ones often unavoidable.

From the considerations above, the x-axis can be thought as proportional to the daily traction energy produced by the truck. For a given powertrain technology, the x-axis is thus proportional to the fuel storage capacity required to perform that trip (assuming 1 refueling per day). Similarly, the y-axis shows the sum of the traction energy required by all trips falling in a bin. For a given fuel/hydrogen tank or battery, a vertical line for the permissible tkm range can be drawn, and the area below the curve on the left of the line represents the total amount of traction energy which can be satisfied (or replaced) with that storage technology and capacity (e.g. E-FORCE ONE 18t electric truck has about 3100 tkm range and could satisfy 5% of the total traction energy).

References

[ARE 2016]: Perspektiven des Schweizerischen Personen und Güterverkehrs bis 2040

About us

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LAV's energy systems group specializes in the technology assessment of energy conversion technologies and the analysis of interconnected energy ecosystems, including mobile systems and their supporting infrastructure(s). Further activities revolve around stationary power generation, in particular decentralized, biogenic CHP plants.

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