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# Assessing the potential of truck platooning in short distances: the case study of Portugal

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**Abstract.** Truck platooning is receiving increasing attention from both companies and politicians. The former benefits from lower fuel consumption and enhanced productivity; while the latter benefits from safer traffic conditions, less congested road or lower carbon emissions. The discussion regarding the introduction of truck platooning has thus far been largely centred on the long-haul segment. Yet, at the European Union level, many freight routes are of short distance, spanning few hundred kilometres. Grasping the limits of truck platooning utilisation is therefore needed.
This paper reports a research aimed at assessing the feasibility of truck platooning on short-distance routes. The method is based on a case study of the largest Portuguese logistic operator. On average, the company serves around 250 destinations from seven warehouses. Due to the reduced dimension of the country, maximum length is below 250 kilometres. A micro-simulation model, using discrete events, was developed to estimate the length of truck platooning segments. Calculations for a typical day suggest that trucks could run around 70% of the distance platooned. The fuel savings could pay off technology costs (i.e. on board equipment) in a time frame of around seven years.

## 1 Contextualisation

Nowadays, road transport is responsible for carrying about 75% of all the freight handled in the European Union (EU) [1] and for more than 70% [2] of the pollutant emissions produced by the transport sector. At the EU level, the volume of cargo transported is expected to increase by about 20% between 2008 and 2025, with no significant changes in the modal split of the various modes of transport [3]. In this context, the European Commission has set as a goal of reducing at least 60% of the pollutant emissions until 2050, in comparison to the levels of 1990, with a significant contribution expected from road transport to this reduction [4]. To this end, more efficient solutions are meant to be found.

The concept of platooning refers to a group of trucks that circulate in a coordinated way, cooperating and constantly communicating with each other through wireless technology [5], [6]. In this type of formation, trucks have the possibility to move safely within a shorter distance [7], around 25 times faster [8]. Although it is already technologically possible to set up platoons with multiple vehicles, there are several barriers and challenges to overcome [5], [9].

The introduction of truck platooning brings benefits for both companies and society: i) for transport companies, by improving working conditions for drivers, improving their productivity, and reducing costs with fuel and with vehicles involved in accidents, and ii) for society, by reducing environmental impact and improving road safety and traffic flow. As the vehicles can travel at a constant speed and with a smaller gap between them, it leads to a decrease in the aerodynamic resistance felt by the vehicles in the platoon, which translates into a more efficient consumption and reduction of CO2 emissions [10]. In general, the authors report fuel savings in the order of 5-15% [11]–[13], and reductions in pollutant emissions up to 10% [14],

[15] depending on the characteristics of the platoon and the position each vehicle occupies.

Literature on truck platooning is relative recent and growing at a fast pace. Examples of EU co-funded research projects in this area include: CHAUFFEUR I and II (1996 and 2003), KONVOI (2005), SARTRE (2009), COMPANION (2013) or iQFleet (2011). At the EU level the biggest event on this topic is the Truck Platooning Challenge, which aims at promoting truck platooning and collaboration between the agents[a].

Optimal conditions for truck platooning occur in steady state flow traffic conditions with speed above 50 km/h. Arguably, long haul services, using high speed roadways, offer the most favourable conditions. Yet, at the EU level, around 50% of freight transport demand is for distances up to 400 km [16]. It is thus relevant to about short distance routes and the feasibility of truck platooning. We found no references related with the minimum length for platooning

## 2 Problem Formulation and Case Study Description

This paper presents the results of a study aimed at estimating the potential of truck platooning on the long-haul transport network of the largest Portuguese logistics operator Luís Simões (LS). LS transport network contains seven warehouses and 360 distribution points scattered across the country and a few in Spain (Figure 1). As a result, the routes are around 150 to 350 kilometres in length, with exception of those heading towards Spain. The fleet consists of IVECO and MAN trucks (Euro V and Euro VI). The study considered the routes scheduled on a typical day. Routes are designed according to the daily demand in each destination.

The study developed a micro-simulation model using discrete events. The model is applied to estimate the potential overlap between routes. A route overlapping constitutes an opportunity for truck platooning.

**Figure 1.** Road network of Luís Simões (circles represent locations).

[a] Website: https://www.eutruckplatooning.com

## 3 Micro-Simulation Model

The micro-simulation model was developed using the AnyLogic [b] multimethod simulation software. Anylogic is a user friendly but comprehensive integrated development environment for developing discrete event simulation models. Discrete event was adopted, as both the truck dispatching process and the platooning process can be represented as an ordinated sequence of steps (Figure 2).

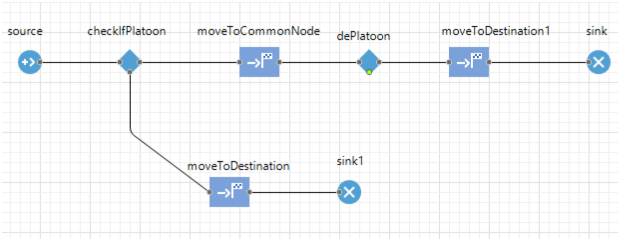


**Figure 2.** Process view of truck platooning.

The following assumptions and simplifications were considered on the development of the model:

1. There are seven origins and 360 destinations.
2. There are 1527 routes. Each route starts in one warehouse and has one destination.
3. Trucks' speed is randomly determined at the beginning of each run. It follows a continuous triangular distribution function (Table 1).

**Table 1.** Triangular Distribution Functions of Trucks' speeds

| | Lower Limit [km/h] | Mode [km/h] | Upper Limit [km/h] |
|---|---|---|---|
| Highways | 60 | 80 | 90 |
| Other roadways | 20 | 30 | 40 |

4. Platooning only occurs when speed is greater than 50km/h. Hence, only on highways, it is viable.
5. Each truck has perfect knowledge about the location and headway of other trucks.
6. Platooned trucks follow 15 meters apart.
7. Platooning is of 2 trucks.
8. Trucks follow the fastest route.
9. Only one-way traffic is considered. Return trip are not considered.
10. Trucks departure from 20:00 and 00:00 and they must arrive between 03:00 and 05:00.
11. Departure hour is randomly determined, according to a uniform distribution function. This is similar to what happens in reality, as loading process does not follow any order

[b] Website: http://www.anylogic.com

and trucks leave as soon as they are loaded.

Owing to the inherent random nature of the model (see assumptions 3 and 10 above), the model was re-run 1000 times. This meant that we also conducted a limited search within the domain of possibilities for the maximum (and minimum) of platooning opportunity.

The model is organised in two interrelated layers. Layer 1 is the Geographical Layer containing the properties of the road network and location of origins and destinations. Figure 1 presents the geographical scope of the simulation model. Layer 2 is the Discrete Event Layer containing the truck dispatching and platooning processes (Figure 2).

The platooning process is now briefly presented. A truck is generated at a given time. Truck follow on fastest route, as this is the approach used by LS. When approaching a highway, the truck scans for other trucks, which are platooned and follow on the same direction. If available, the truck waits for the arriving truck, provided delivery time is not jeopardised. Upon arrival, both trucks links and follow at same and constant speed. If no truck is available, then the truck continues journey available for platooning with another truck. Platooned trucks follow together until one or both exit the highway, or until following different directions at a junction. If a truck continues on the highway, then it becomes available for platooning with other truck. A truck may enter the highway more than once. At each entry the process is repeated.

## 4 Results and Conclusions

Table 2 evidences the substantial opportunity for platooning in LS's network (93.3%), owing to the dense network of highways. Table 3 and Figure 3 presents the results. On average of 68% for the total platoon distance, with a standard deviation of 1.6%. The maximum platoon distance recorded value is however well below the maximum possible, resulting from the need to departure at different time and following different routes.

The results suggest the presence of maximum and minimum limits for platooning. The minimum bound limits can be achieved without major changes in the logistics processes, while the maximum bound will likely impact the logistic processes and truck loading order.

For the calculation of the benefits of truck platooning, we considered an average value of 12.5% for fuel savings on platoons of two trucks, based on [11]. Also, for the calculation of the fuel cost, it was adopted the monthly reference price for gas oil, mentioned on the website of the National Entity for the Fuel Market (ENMC); and (vii) the pollutant emissions were calculated on guidelines available in [17]. Table 4 presents the reference values. Table 5 presents the key results (assumings the mean values).

**Table 2.** LS's network

| Item | Distance [km] | Percent. [%] |
|---|---|---|
| Total Distance Travelled by trucks | 272 422 | - |
| Maximum Possible Platoon Distance | 254 169 | 93.3% |

**Table 3.** Key Results of the Simulation analysis (considering the 1000 runs)

| Item | Distance [km] | Percent. [%] |
|---|---|---|
| Mean platooned distance | 186 126 | 68.3% |
| Standard Deviation | 4 228 | 1.6% |
| Maximum platoon distance | 19 8807 | 73.0% |
| Minimum platoon distance | 173 785 | 63.8% |
| 95% value | 193 102 | 70.9% |
| 5% value | 179 150 | 65.8% |

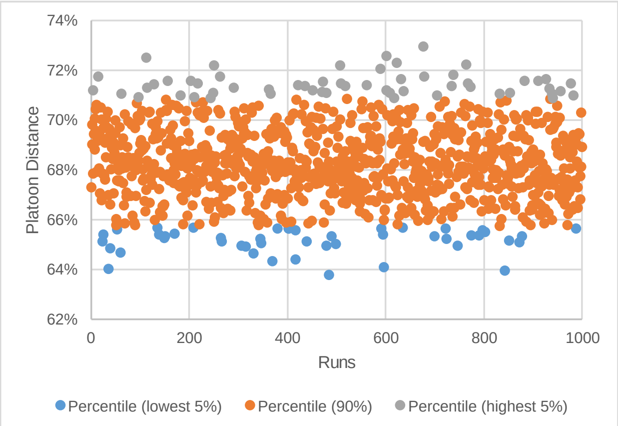


**Figure 3.** Platooned distance total runs.

**Table 4.** Economic and Environmental Parameters

| Item | Reference Value] |
|---|---|
| Average consumption (L/km) | 0.34 |
| Conversion factor (gas oil) | 2.9 |
| Fuel cost (€/L) | 1.098 |
| Trucks in platoon | 2 |
| Cost of technology (€/day/truck) | 5.71 |

**Table 5.** Economic and Environmental Savings

| Item | No platoon | Platooning(*) |
|---|---|---|
| Fuel Consumption (litres) | 172 835 | 151 231 |
| Fuel cost (€) | 189 773 | 166 051 |
| CO2 Emissions (tons) | 501 | 439 |
| (*) Assumed savings of 12.5% on average | | |

The estimated average daily fuel savings per truck is of 15.5€. Considering a total of 1 527 trucks, the average daily savings is of 23 668€. According to [5] the pricing of truck platooning equipment was, in 2014, of around 10 000€. Considering this value, each truck would need 646 days of working to pay off the equipment, which corresponds to around to 2.5 to 3 working years. A time frame acceptable.

Concluding, the main conclusions are: i) truck platooning can be of added value in short-distances routes, ii) the cost savings pay off cost of technology in an acceptable table frame, iii) platooning does not necessarily require changes in the logistics processes and active planning. The last conclusion is likely related with the reduced size of the country that brings together the locations and limits the routing options to a few highways.

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