A FIELD RESEARCH ON THE NEED OF HIGH CAPACITY VEHICLES TO REDUCE CO_2 AND IMPROVE PROFITABILITY





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Abstract

In order to reduce the current level CO_2 contribution by the global/western European road transport sector, there is a need for more efficient logistics including high capacity vehicles allowing multiples of loading units, fitting with current and future infrastructures. In addition, multimodality need to be explored due to its potential to increase transport efficiency and as a consequence reduce CO_2 emission levels. These explorations involve different stakeholders. To a certain extent they all have their own interests which we believe must be valued. But if we want to help to develop transport efficiency to a higher level, we should establish a common language and a clear structured framework. Such a framework is proposed in this paper, in terms of a questionnaire for further field survey; it helps to determine benefits of high capacity vehicles, creating a sound basis for potential business cases and optimized scenarios for the road transport industry. Creating a fit between new concept vehicles, new logistics concepts based on these vehicles, and infrastructure is important, requiring smart infrastructure access policies, with vehicle approval being based on vehicle performance. Based on that, a project FALCON is described, aiming for deriving these use cases.

Keywords: High Capacity Vehicles, multimodality, performance based standards

1. Introduction

The transport sector contributes to CO_2 emission for 25 %, with a large share from road transport. Several megatrends such as climate change, urbanization, growing transport can be distinguished. In addition, external factors are apparent such as new delivery concepts, connectivity, self-driving vehicles, shareconomy trends and smart energy opportunities. All of these trends have a strong impact on logistic and transport concepts, aiming for more efficient (i.e. low CO_2 and profitable) road transport, with HCV (higher capacity vehicles) being a key factor, allowing flexible, high service frequency, efficient distribution, with standardized multiple loading units for different transport segments (from urban to long haul).
These (new concept) vehicles are part of a future transport framework, fitting with current and future infrastructure. One observes approval of such vehicles to move more and more from descriptive requirements towards performance, in spite of the fact that current and upcoming regulations still do not support the coming need for multiples of loading units and HCV sufficiently. In order to optimize the fit between infrastructure (road aging, bridges, tunnels,..) and vehicles, there is a need for **Smart Infrastructure Access Policy (SIAP)**, based on performance assessment of these new vehicle concepts using **performance based standards (PBS).** In a previous project (HTAS-EMS, see [5]), the benefits of HCV have been studied, followed by a number of ACEA workshops, setting up a roadmap for introduction of HCV throughout Europe. An important element in these discussions was the concept of multimodality. The European Union aims to shift a large part of road transport to other transport modes, and it allows more efficient overall supply chain management when each of the separate modes are exploited to maximum potential, depending on the specific logistic market segment. This brings us to the **objectives** of this paper:

- To set up a clear, structured framework and a common language for analysis of transport performance, accounting for future vehicle concepts, infrastructure and logistic characteristics
- To derive a tool for further real life investigation of transport performance, taking multimodal shift into account
- To fit this tool in a total project roadmap to develop appropriate business/use cases, and scenarios for the road transport industry, with emphasis on the optimization of multimodality, and the impact of SIAP and PBS on road infrastructure and modal choice.

The paper is structures as follows. In Section 2, we describe the challenges for the transport sector, including the megatrends, and external factors. Logistic market segments and related transport patterns are distinguished. The impact on transport and logistic concepts are addressed. In Section 3, the benefits of High Capacity Vehicles are treated on the basis of the HTAS-EMS project and the ACEA workshops. Section 4 discusses the required structured framework for future transport analysis, leading in more detail to a questionnaire for further field survey in Section 5. This questionnaire is put in a broader perspective as part of a project road map, with the intended derivation of business/use cases linked to a project FALCON, being recently launched, and discussed in Section 6. Conclusions are given in Section 7.

2. Challenges of the transport sector

In the European Union, the transport sector contributes 25 % to the CO_2 emissions, of which 78 % is produced by road transport [3]. The further growth in emissions is reported differently in the various references ([5], [6]) but the bottom line is that these emissions remain high in the next 30 years, to a large extent based on an expected 1,5 % increase of the road freight transport per year [5]. With the anticipated reduction in overall GHG (Greenhouse Gases), the transport sector may be the largest source of CO_2 emissions in 2030 [6]. CO_2 emissions means fuel consumption. Consequently, there is a need for more efficient (clean and profitable) freight transport. The European Commission has set ambitious targets for the transport sector in its White Paper [1]. We quote that for road transport, half of the conventionally-fueled cars have to be phased out in cities, achieving CO_2-free city logistics in the major urban centers by 2030. Long haul road freight (> 300 km) should shift to other modes for 30 % in 2030, and for more than 50 % in 2050, facilitated by efficient and green corridors. This will require appropriate infrastructure to be developed, with a fully functional and EU-wide multimodal, high quality and capacity 'core network' by 2030, with a corresponding set of information services.

As mentioned above, new logistic concepts follow the megatrends. This includes intermodal transport, European Modular System (EMS) and hub & spoke systems (H&S). EMS is a concept that allows combinations of mode compatible loading units on vehicles (multiples) and is shown to be in conformity with all defined megatrends. It results in longer and sometimes heavier vehicle combinations (HCV). A hub & spoke system has hubs outside the city, from which products are sorted to spokes in the city, and further to last mile deliveries. See figure 1, which distinguishes between the different transport segments (city, distribution, long haul), with hub and spoke systems connecting these segments. It is only when, by using different modes of transport up to the boundary of an urban environment, that the full potential of EMS (e.g. HCV) vehicles can be exploited. The question then arises about the best policies how to optimize this multi-modality, and what tools and assessment procedure are available or can be derived in order to influence mode choice. What are the specific characteristics of the different modes in terms of flexibility, efficiency, reliability, CO_2-emissions per unit load and distance? Figure 1 suggests to fit vehicle combinations in freight transport to infrastructure, on a performance base, accounting for different types of transport (market segments), and focus on accessibility and emission (zero and downsized in cities, low emission in interurban transport). This leads to Smart Infrastructure Access Policy (SIAP), which is strongly related to PBS for HCV's, with distinction regarding different road network topologies throughout Europe, climate conditions, bridges, pavement characteristics, tunnels. Infrastructure is important in the sense what vehicle should be accommodated, which refers to layout, geometry (maneuverability, access,..), traffic use, safety, congestion, branching and network, environmental restrictions, and road tear and wear. Clearly, performance refers not only to vehicle approval but also to infrastructure design.

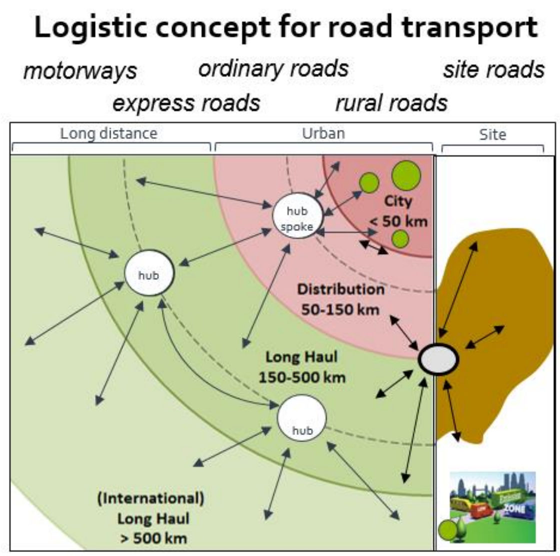

Figure 1.: Vision European perspective (main corridors and regional constraints)

As a consequence of this performance approach, regulations have to be flexible, compared to the present situation. It was concluded during the previous HVTT conference (see [5]) that the current and upcoming European legal framework does not support the coming need for multiples of loading units and HCV. There are EU-wide, country-specific and upcoming vehicle regulations. Sweden, Finland, the Netherlands and Spain (December 20015) have agreed on the use of 25.25 m long and 60t trucks. Denmark, Germany and Belgium are in the test phase for or in discussion about HCV. In a previous symposium on “A flexible regulatory framework for trucks” (July 4, 2016, see [7]), it was concluded that vehicle regulations are tending to move more to this performance base, contributing to clean, smart and profitable freight transport. Examples are the recently proposed European amendment 2015/719 to directive 96/53/EC allowing extended vehicle length and mass (GCW) if contributing to aerodynamic improvement or clean powertrains, respectively. Canada has shown various amendments since 1988, extending the set of standard vehicle configurations, and modifying rules with respect to wheelbase requirements and inter-axle spacing, axle weight limits, and vehicle length, which in combination (enveloping) contribute to better performance. Similar developments in regulations are shown in New Zealand since 2002 with reference to roll-over performance, truck-trailer mass ratio, dimensions and so-called High Productivity Motor Vehicles. In Australia, we have vehicle design approvals based on PBS.

An interesting outline on external factors and trends with a strong impact on how current and future logistic services are organised for higher efficiency, is given in the DHL document [2] and referred to as the Logistics Trend Radar. These factors and trends are not independent but strongly interrelated. They include 3D printing, new on-demand last mile delivery concepts (crowd sourced with high flexibility on time and location, hyper-customization), connectivity and digital identification (internet of things, cloud logistics, big data,..), self-driving vehicles and self-learning systems (with opportunities for further process optimization in container/vehicle handling at ports and logistic platforms, autonomous highway, autonomous last-mile), shareconomy logistics (sharing assets instead of ownership), more and more emphasis on urban logistics (on-demand delivery and shareconomy logistics, omni-channel logistics with optimal transparency for the customer), and finally smart energy logistics. A “Green Trend Survey” by DHL (discussed in [4]), shows that a response of ‘likely/very likely’ was given to the following questions to logistic stakeholders and industry:

- Within the next 10 years, the majority of our customers will favour a company that uses green transport/logistics solutions over cheaper transport/logistics solutions
- Within the next 10 years, green transport of our products will be a decisive factor for our company to win customers

Different market segments have different packaging units (weight, volume), different transport patterns collecting goods (source) or deliver them (sink) (described as source and/or sink consolidation, last mile, long haul,…), and scope of service provision. Some of these transport patterns are illustrated in figure 2. As a result, the transport processes will be different, in terms of number of tours (a total of sources and

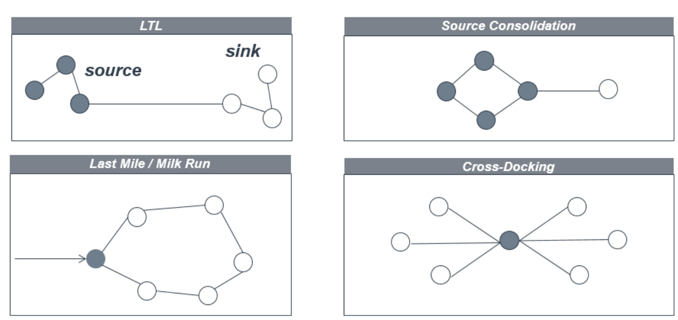

Figure 2.: Some possible transport patterns

sinks), mileage, costs, transport volume, mode choice, etc.
Hence, in order to understand the future of freight transport and the optimal choice in vehicle concepts in relationship to infrastructure and multimodality, the different market segments have to be accounted for. The total logistic volume of road transport in 2014 in Europe amounted € 960 billion with 18.6 billion tons of cargo [3]. Of this, 41 % is *contract logistics* covering the whole range of (large volume) logistic services (transport, warehousing, value added services) within the scope of long-term individual contracts ([4]), carried out by third, fourth, fifth party service providers. Other market segments (with descriptions taken from [4]) are:

- *bulk transport* (raw materials in gas, liquid or granular form)
- *special transport* (requiring special equipment, temperature control, animal transportation, vehicles,..)
- *heavy transport* (with extraordinary dimensions or weight)
- *FTL: general (full) truck load* (one truck/loading unit such as container or swap body for one customer, being typically moved without intermediate break-bulk or consolidation from dock to dock)
- *LTL: less-than-truckload* (with different customers sharing one loading unit, also including groupage, and requiring consolidation through a process of regional collection and distribution)
- *CEP: Courier, Express and Parcel services* (small, time-critical shipments of low weight, compared to the LTL segment)

Now we have described the challenges for the transport sector, distinguished logistic market segments and related transport patterns, also addressing the impact on transport and logistic concepts, we shall discuss the benefits of High Capacity Vehicles in the next section.

3. The benefits of Higher Capacity Vehicles, the HTAS/EMS project

In 2010, the Dutch HTAS organization took the initiative to support a project "Greening and Safety Assurance of future modular road vehicles" to investigate the impact of the global trends of the previous section on the need for new vehicle concepts, meeting the future needs of logistic companies in terms of flexibility, efficiency and TCO (total cost of ownership), based on existing modules to facilitate intermodality, with possible cross-border usage in Europe, being compatible with existing infrastructure. The project was carried out by a consortium including the Eindhoven University of Technology, HAN University of Applied Sciences, MAN, DAF, Wabco, D-TEC (trailers) and TNO, resulting in a 'Book of requirements', being presented at HVTT13 [5]. This included a newly proposed legal framework based on Performance Based Standards (PBS), adjusted for European use. Fourteen different vehicle combinations were analyzed with respect to these standards (mainly referring to safety, maneuverability and infrastructure impact), fuel consumption and transport efficiency (TCO: Total Cost of Ownership). The different groups were selected based on their combination of loading units, GCW and length (including combinations exceeding 25,25 m and 60 ton GCW). The load units corresponded to containers (20, 40, 45 ft), swap bodies (C782), and semitrailers.
It turned out that, using possibly existing technology on chassis control, the performance of these combinations (and therefore the level of vehicle safety) was in the range of conventional vehicle performance. Note that innovative technologies, such as these chassis control measures, will change vehicle performance under different conditions, hopefully for the better. The advantage of PBS is that it sets clear limits for the assessment of these technologies in vehicles, which cannot

be guaranteed by focusing only on dimensions and weights. A second remark is that PBS analysis can be used to show that certain combinations of dimensions and weights will lead to better vehicle performance, therefore enveloping classes of vehicle combinations, being guaranteed to be clean and safe within existing infrastructure and logistic practices.

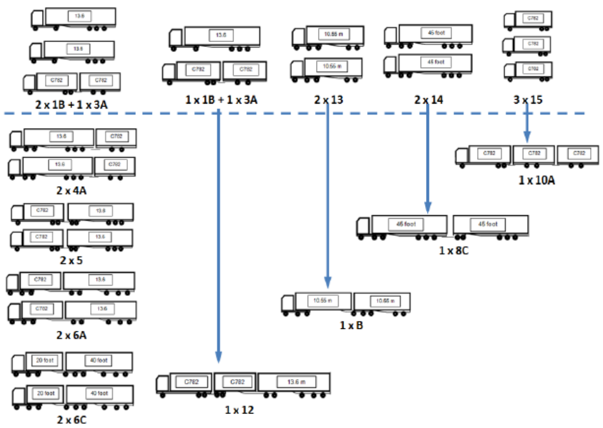

Figure 3.: Replacement of standard vehicles by HCV's

Next, fuel consumption has been investigated for all of these combinations, based on a realistic simulation tool (MAN-Matlab/Simulink) as well as a specified typical route for long-haul transport and an average loading of the vehicles. For a proper comparison, use cases were defined using the assumption that the same load has to be transported – either by standard vehicles or by HCV. See figure 3 how each HCV replaces standard vehicle combinations. For validation on profitable transport the approach of Total Cost of Ownership was used. By considering all direct and indirect costs it gives an overview not only of the initial costs but also of all aspects of use at the customer. The costs have been calculated by using the data of an average fleet owner, the average loading and the calculated fuel consumptions. It was concluded that a potential improvement (per ton-km and per m^3-km) on CO_2 and TCO can be reached by using multiples, between 24 % and 50 %.

In follow-up of the "Book of requirements", three workshops on High Capacity Vehicles were held at ACEA in Brussels, with involvement of consortium partners TU/e, HAN, MAN and DAF, plus VTI, Cambridge University, further major European truck manufacturers, and of course ACEA. The major results of these workshops were:

- HCV have high potential to reduce emissions, maintain road safety and improve transport efficiency. PBS and increased efficiency are base for their acceptance
- Contribution to the TML CO2 report 2030, in which the opportunities of using HCV concepts in Europe will be addressed with indication of relevant corridors
- Definition of a roadmap with clear identified milestones how to have HCV in Europe
- Selection of 6 prime HCV candidates (efficient and clean vehicle concepts, fitting within logistic framework), with the 7.825 m swap body and 45 ft container being the most relevant transporting mode compatible loading units.
- A common understanding that using 6x4 is considered as the best solution in the first step for HCV. Alternative drivetrain technology may allow 6x2 or 4x2.
- A common understanding of PBS (ensuing safe use, and avoidance of road wear and tear) with identification of the most relevant (uniform) PBS criteria for Europe.

4. The next step, setting up a structured framework for future transport analysis.

So far, this research had been a simulation study as part of the HTAS-EMS project, with emphasis on fuel consumption, safety and TCO. Safety and maneuverability have been verified using a special PBS simulation tool, with the models used being extensively validated against experiments.

Obviously, the real world is more complex, and the integrated knowledge and experience of the logistics industry is required to further support and possibly modify the above conclusions. Assuming that transport is carried out with new vehicle concepts with larger transport volume in terms of m^3 or ton, with a larger loading utilization, the research, presented at the last HVTT [5] suggests the following hypothesis:

1. *Through the use of new vehicles concepts, the rolling fleet can be reduced*

to be further investigated on the basis of field research, with transport mode shifts taking into account. These mode shifts, involving new vehicle concepts, will have an (intended positive) effect on transport efficiency, e.g. in terms of time per transport order and loading/unloading time.
With the expected gains in fuel and TCO for new vehicle concepts, and assuming further benefits in handling time, the following hypothesis can be added to the previous one:

2. *There is a market potential for new vehicle concepts*

Whether these hypotheses hold, will be depending on the specific market segment. In order to investigate and verify these hypotheses, stakeholders need to be questioned about their experiences regarding transport volume, utilization, specific transport tour characteristics, the anticipated opportunities to use new vehicle concepts with emphasis on different aspects (costs, service level, public acceptance, development of transport demand, etc.). And opportunities can be assessed in different ways, such as reliability, flexibility, safety, supply chain integration, ecology, plannability and planning effort, and costs of course.

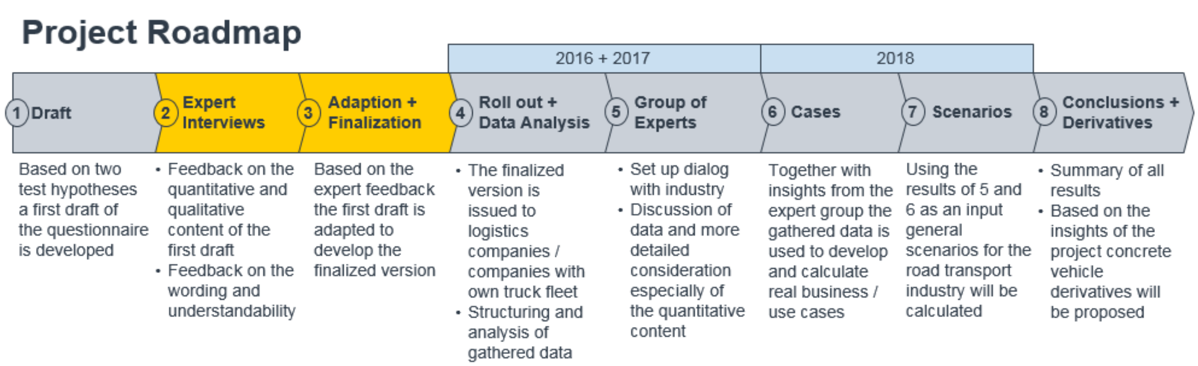

Figure 4.: Field survey and questionnaire as part of a project road map

Hence, one needs a **structured framework**, being well interpreted by logistic stakeholders, to draw up a questionnaire for a field research. The questionnaire must lead to proper data gathered, to be examined with clear conclusions, and further follow-up steps. The questionnaire and field survey are therefore considered to be part of a **project roadmap**, see figure 4.
A structured framework is a necessity for the following reasons:

- to understand the principles of freight market, logistic strategies, and how multimodal transport works, in order to derive reliable transport models, further leading to new policies
- to describe trends and transport issues in a standardized way

- and to define what data is to be collected and how (one has to deal with different 'national' sources, which may not be comparable)

This paper describes steps 2 and 3 of the project roadmap. In a next step, the finalized version of the questionnaire is issued to logistic companies. Results will be discussed with experts, in order to understand better the relationship between vehicle type, logistic activity and market segment, infrastructure, and intermodality. What are real-life business cases that support the hypotheses, and how do they lead to attractive scenario's for the road transport industry, with lower CO_2 emissions.

Starting to work on the questionnaire, it turned out that this was not an easy task. A total of 24 organizations were asked for feedback (50 % response rate) regarding the quantitative and qualitative content, as well as the wording and understandability of the questionnaire, i.e. resulting in this structured framework in terms of the questionnaire questions. These organizations included universities, private commercial and non-profit organizations.
We mention here some of the discussions we had in setting up this questionnaire. How do we define the company role. Companies may be focused on trucks without trailers, or in opposite, they may be acting as trailer operator with hardly no truck in ownership. We mentioned already the option of *contract logistics* covering the whole range of (large volume) divers logistic services within the scope of long-term individual contracts, carried out by third, fourth, fifth party service providers. It was concluded to distinguish between two groups of companies, focusing on own transport with transport of goods not being the primary goal, and shipper/freight agents with transport of good as primary business activity and objective. Another possibly confusing factor is the identification of transport pattern. A company may be involved in different patterns as part of the logistic supply chain (e.g. FTL or LTL shipments, different for ship-in and ship-out), see figure 2. The focus of the questionnaire will be on the most dominant pattern. For fleet size, it was decided to distinguish between different categories in terms of GVW (Gross vehicle Weight). The issue of transport volume was also under discussion, and it was finally related to the specific transport unit (container, swap body,..). Important information refers to tour distance and the tour density (the average distance between two stops) and the number of vehicles simultaneously driving within the same target region, which is however not always directly available. In addition, we also asked for the number of transports (tours) per vehicle per day on average, the loading and unloading time per consignment (on average) and the travel time from source (picking up goods) and sink (bringing goods) per consignment.

The final layout of the questionnaire, being the practical representation (and research tool) of the structured framework, is treated in the next section.

5. A questionnaire, to identify business use cases, and road transport scenario's

A questionnaire is needed for (1) field survey and (2) for a correct, exchangeable transport description (model), including infrastructure, vehicle variants, and performance based criteria for both vehicles and infrastructure. Based on the feedback of the participating parties, the original draft was adapted to a questionnaire being structured as indicated in figure 5, with three categories: company data, transport data and logistics in the future.

Company data covers the following topics:

- position (in the logistic process and supply chain: driver, dispatcher, controlling, sales, being an owner, involved in fleet or corporate management, or other)
- Company role, with distinction to own truck fleet and with transport of goods not being the primary purpose, and companies with primary focus on transport
- The logistics sector (market segment as described in Section 2)
- The most dominant transport pattern for this logistics sector, with some of these patterns (but not all) illustrated in figure 2.
- Fleet size where two categories are distinguished based in GVW (with split at 18 ton)
- The country (member state) in Europe

Cargo includes transport volume (m^3, ton) per transport unit (container, trailer, swap body) per tour, the rate of utilization per transport unit, transport volume per consignment and the share of FTL orders (in total number of orders). **Time** refers to the number of transports (tours) per vehicle per day on average, the time for loading/unloading (incl. waiting time) per consignment, and the average travel time from source to sink per consignment. This is quantitative data which will largely be interpreted in a qualitative comparative way. **Tour characteristics** describe things like overall tour distance, tour density (average distance between subsequent stop during a tour), the overall percentage of empty runs, the number of stops per tour and the number of vehicles that are simultaneously driving to or within a same Target Region. **Planning** includes questions on number of transport units per vehicle per transport, number of delivery points (sinks) and senders (sources) per tour, overall mileage per vehicle per year and operating days per vehicle per year.

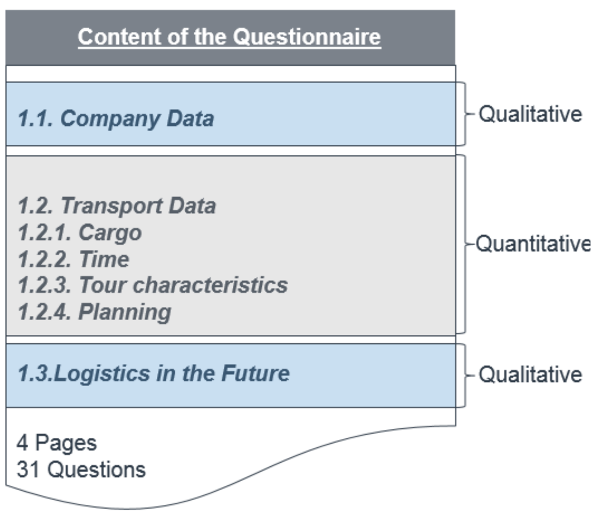

Figure 5.: Structure of questionnaire

The combinations of company and transport data characterizes the logistic process. We want to link that to expectation with respect to logistics in the future, where it is assumed for the questionnaire that the legal requirements for the use of longer / heavier vehicles than allowed today are fulfilled. The questionnaire includes the following categories of questions:

- **View** on longer or heavier vehicles (> 44 ton GVW) and their envisaged opportunities
- **Incentives that may 'initiate' the motivation** to consider utilization of HCV , i.e. with more loading meters or weight capacity (e.g. more transport units) than allowed today.
- The envisaged **potential of HCV**
- The **incentives and their relevance for possibly choosing a transport mode** (road, rail, water, air), and the present share (in %) of already using different modes.

Hence, we have made a distinction between willingness to consider larger vehicles and the potential within a certain market segment. A high willingness (e.g. to reduce costs per unit load per km) doesn't mean that the potential is rated high as well. Response is requested on a five point scale, from low to high.
Together with our participating parties, we derived a list of criteria serving as potentially motivating factors to consider using longer/heavier vehicles in the future, as well as being relevant for assessment of their potential. Please consider also the external factors and trends, mentioned in Section 2 with reference to the Logistics Trend Radar (DHL report [2]), and the earlier observation that the relationship between new concept vehicles (HCV) and infrastructure need to be accounted for in terms of SIAP. The cost level (TCO, transport costs, investment costs) is clearly part of this list. Infrastructure (also including the traffic conditions and the impact on the traffic situation) cannot be neglected either. Furthermore, logistics criteria have been listed such as (anticipated) growth in transport demand and sales, service level, transport capacity, and schedule adherence. External factors such as IT-developments (with the consequences for Supply Chain Management, connectivity, digital identification, self-driving vehicles,…) and public acceptance have been considered to be relevant, as well as the willingness to cooperate (depending on the issues such as shareconomy logistics and new delivery concepts, e.g. LTL).

Criteria for choosing a transport mode have to do with costs and time (and therefore also speed) for the logistics task, which depends on the specific logistics sector and type of freight. Last mile delivery will have strict limits (ordered yesterday, delivered today), whereas the total delivery time is less critical for bulk, at least if the delivery planning is reliable. In terms of plannability, one needs to account for planning effort, reliability, flexibility, safety and security, and the practical level of supply chain integration (where significant work is still to be done). And obviously the ecological compatibility is important here.

This last issue will be further discussed in the next section where we treat the FALCON project, which investigates freight and logistics in a multimodal context, with relationship to infrastructure and performance based standards of vehicles (to optimize multi-modality and transport efficiency), and policy measures (how to assess these with respect to their impact on mode choice).

6. Follow-up, the FALCON project.

In order to fulfill the European emission reduction targets for the transport sector to lower global warning, climate change and better (urban) air quality (White Paper, [1]), a number of steps have to be taken. First of all, more efficient logistics are needed. Secondly, modal shift from road to other modes is needed, which requires multimodal strategies and procedures to be further optimized. And finally, smart performance based standards for vehicles and roads are needed, in order to allow improvement in road transport efficiency. This has resulted in the collaborative project FALCON [8], in assignment of the CEDR Road Director's platform (CEDR: Conférence Européenne de Directeurs des Routes) as part of the CEDR Transnational Research programme, and with the methodology to study Freight and Logistics in a Multimodal Context to improve understanding of:

- the possibilities for optimizing multi-modality and the impact on infrastructure
- assessment procedures and tools that enable National Road Administrations to analyze policy measures and influence mode choice

- the added value of Performance Based Standards for vehicles to increase the efficiency of road transport and the impact on road infrastructure and modal choice.

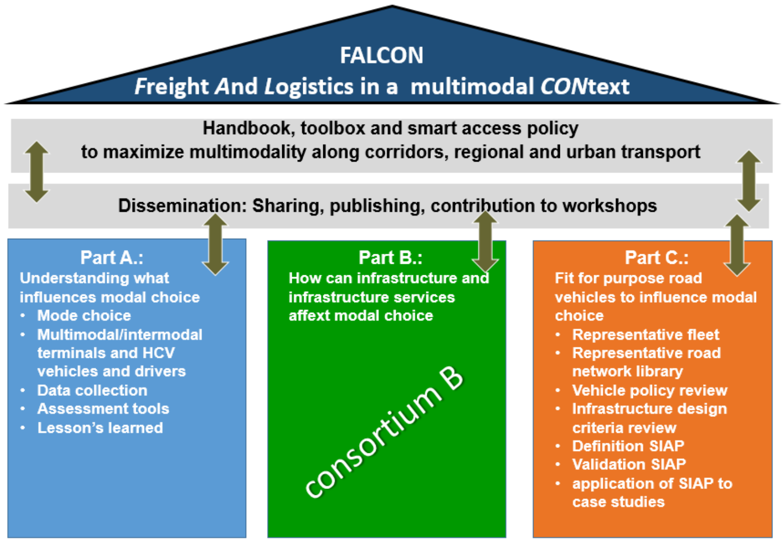

Figure 6.: The FALCON project

The objectives of FALCON are (1) to derive a clearly written handbook on principles of freight markets, logistic strategies, multimodal transport, and how this last transport-shift can be influenced, and (2) to develop Smart Infra Access Policy (SIAP) for current but also for future road freight vehicles, being validated for a number of case studies with assessment of the impact on multimodality, infrastructure (aging), congestion safety and environment. Partners in FALCON are HAN University of Applied Sciences (project manager), VTI, DLR, MAN Truck and Bus AG, TNO, Michelin, IFSTTAR, BRRC, Cambridge University TS, and Panteia. The project FALCON addresses three main parts:

- a part A focusing on understanding what influences modal choice,
- a part C considering the fit for purpose road vehicles to influence modal choice (performance based), with focus on compiling SIAP to selected segments of the infrastructure network for current and future heavy goods commercial vehicles with multimodal use potential
- part B, being an interface with another consortium addressing how infrastructure and infrastructure choice affect modal choice.

A layout of these three parts is shown in figure 6. The structured framework will be exploited for further survey within FALCON. That covers the analysis of national and international mode choice for different segments, including similarities and differences between countries, when it comes to the main factors for mode choice, policies concerning infrastructure, etc. This will be combined with industries and logistic service providers' mode choice and planning. Survey results on freight transport for different segments of the freight market (company and transport data) will be compared with other data, with emphasis on data collection methods, and data exchange between stakeholders and national road authorities (NRA). For part C, representative heavy goods vehicle combinations will be partly based on this survey, and on the ACEA workshops, referred to in Section 3, see also the roadmap in figure 4. FALCON will lead to a report on case studies (step 6 in figure 4), documenting the impact of SIAP (performance based standards) on multimodality, traffic performance and infrastructure criteria.

7. Conclusions

The objectives, defined in the introduction have been fulfilled on the basis of desk research, with involvement of representatives of the logistics world. That means that a structured framework and a common language for analysis of transport performance has been established, with the result presented as a questionnaire, being the research tool for further real life investigation of transport performance. It also means that further application of the questionnaire will give more evidence of the added value of this tool. A project, FALCON, has just been launched, covering a number of research steps, with the application of this questionnaire being one of them. FALCON offers a roadmap to derive appropriate business/use cases, and scenarios for the road transport industry, aiming at higher transport efficiency, with emphasis on the optimization of multimodality, and the impact of SIAP (Smart Infrastructure Access Policy) and PBS (Performance Based Standards) on road infrastructure and modal choice, in combination with High Capacity Vehicles.

References

[1]. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system (White Paper), Brussels 2011

[2]. www.dhl.com/content/dam/downloads/g0/about_us/logistics_insights/dhl_logistics_trend_radar_2016.pdf

[3]. Top 100 in European Transport and Logistics Services 2015/2016. Fraunhofer study, executive summary (http://www.scs.fraunhofer.de/en/studies.html)

[4]. Fact-finding studies in support of the development on an EU strategy for freight transport logistics, Lot 1: Analysis of the EU logistic sector. final report (January 2015)

[5]. B. Kraaijenhagen, T. Barth, K. Kural, J. Pauwelussen, I. Besselink, A. Prati, M. Meijs, H. Nijmeijer.: Greening and Safety Assurance of Future Modular Road Vehicles, HVTT13 (2014)

[6]. E. Daniel.: The 2013 EU Reference scenario: EU energy, transport and GHG emissions trends to 2050, DG Energy (2014)

[7]. L. Aarts (ed.).: A flexible regulatory framework for trucks. Symposium, July 4 2016, Rotterdam.

[8]. J. P. Pauwelussen, K. Kural.: Project description **F**reight **A**nd **L**ogistics in a Multimodal **Con**text (FALCON), January 2016 (HAN University of Applied Sciences)