

An ontology-driven approach for modelling TMS fuel consumption information subsystem

V Kurganov¹, M Gryaznov², A Dorofeev^{3,4}

¹Tver State University, 33 Zhelyabova Street, Tver, 170100, Russia

²Nosov Magnitogorsk State Technical University, 38 Lenin Street, Magnitogorsk, 455000, Russia

³Financial University under the Government of the Russian Federation, 49 Leningradskiy Avenue., Moscow, 125167, Russia

⁴National Research University Higher School of Economics, 33 Kirpichnaya Street, Moscow, 105187. Russia

adorofeev@hse.ru

Abstract. The use of information technologies for the automotive transport and logistics management has opened game-changing opportunities for business, providing solutions to critical problems of sustainable development in turbulent environments. Today, the data for transport operations can be processed and used for the managerial decision-making, actually, on-line. However, despite abundance of TMSs on the market, many transport companies use them for solving operating management problems only. There are also lots of companies which do not use TMSs at all. Practice shows that managers of numerous transport companies have a little idea of how the records management data can be transformed into the awareness of improving efficiency of the transportation process. In our opinion it may be explained by the fact that different management levels use the knowledge from various domains, such as transport, IT, economic, and financial areas. Accordingly, the transformation of contemporaneous data into the managerial decisions requires an approach which is discussed in this paper using an example of introduction of TMS fuel consumption information subsystem.

1. Introduction

Motor transport is one of the most important economic sectors providing operation of many supply chains. Most of the production and commercial facilities, public industries and organizations depend on stable, efficient and uninterrupted operation of these chains. Today's information technologies offer exciting opportunities to transform business processes of both large and small enterprises, including transport and logistics companies. Nowadays, multiple transport management information systems commonly named as Transportation Management Systems (TMS) are present today both on the Russian and foreign markets. It should not go unnoticed that large companies use special modules of ERP enterprise systems for transport management. It has been affirmed that TMSs as a separate class of information systems generated historically from the SCM solutions; and SCM, in turn, generated from the ERP systems [1, 2]. It is well known that ERP systems continued the MRP and MRP II concepts, which had been created for the effective industrial production management. And now these



large ERP systems, such as the SAP or Oracle, include transportation process management subsystems [3].

Thus, according to this chronological review we can see that the electronic document management and the supporting IT solutions were created initially for the information support of material flows, and later for the support of financial flows. Accordingly, the data of the electronic workflow generally described operations with goods and money. Now, under conditions of extreme competition in the commodity and trade markets, and the development of e-commerce featuring a glut in the commodity market, the role of transportation has significantly increased, because the customer's requirements for timely delivery, reliability and appropriate costs has also increased [4, 5].

The special transport and cargo monitoring systems based on GPS/GLONASS/RFID technologies have become widely used with the development of satellite-based object tracking facilities and wireless telecommunications. They provided an opportunity to obtain real-time data about the location of vehicles, fuel consumption, vehicle failures and driver behaviour [6, 7]. And it became the impetus for the development of ad hoc subsystems for fleet management - Fleet Management System. And generally, as follows from the literature review [8], the transportation management system (TMS) should include solutions for a broad spectrum of tasks.

2. The most important tasks of transportation management

We have questioned 3,712 Russian companies, and the questionnaire showed that the most of respondents gave priority to fuel recording systems. However, it should be noted that Excel spreadsheet tables are very popular, despite the widespread acceptance of transport management software solutions developed by 1C, Russian company (see figure 1). Whereby, the percent of companies having small stock of vehicles (10 to 50 vehicles) and using various IT solutions is higher than for large companies. And the owners for mixed fleets of vehicles, including not only trucks and passenger cars, but also road construction machinery, prevail among the large companies.

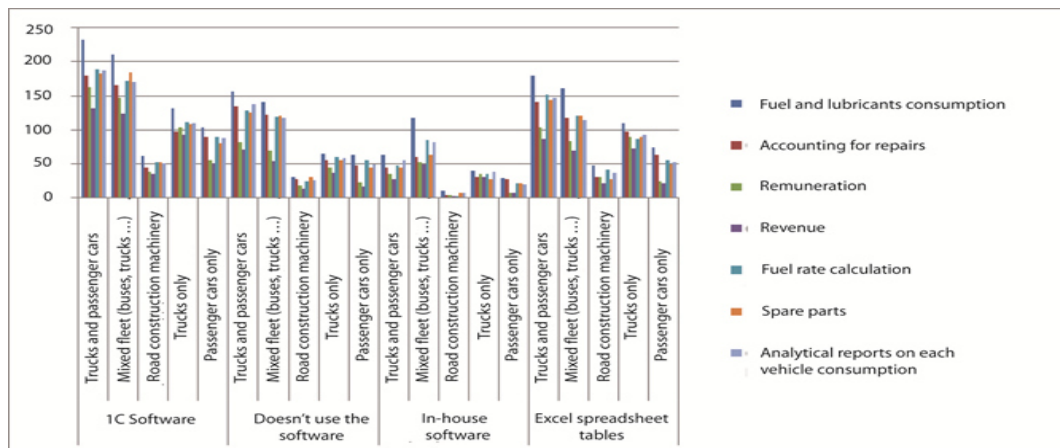


Figure 1. Use of information applications in various transport companies

Thus, the variety of vehicle types at the fleets generates the diversity of data. And in the current context, we should note that the diversity of data, its accessibility and speed of receiving, in turn, have generated the problem of transformation of these data into information required for the managerial decision-making and knowledge. Accordingly, the large number of studies reveals the gap between real needs of business and current TMSs, which is number of studies reveals the gap between real needs of business and current TMSs, which is particularly indicative for large companies. It takes

place because such abundance of various information systems providing records management has no analytics and decision support. This, in turn, leads to the inefficient investments into the information technologies on the part of business operating the road transport, as well to the disappointed expectations and disillusion for the owners of these companies [9, 10, 11]. In this regard, the transport and logistic companies as well as other enterprises do not hurry to invest into the development of their actual TMSs and to set about for introduction of innovative IT-solutions.

However, it should be noted that the decisions for selection of one or another TMS are accepted on the basis of both functional and non-functional criteria which include the reputation of IT solutions on the market, total cost of ownership, system flexibility, etc. An organizational structure of a company as well as the body of employees knowledge about the management for transportation process shall play the important role [12]. And, as practice shows, the successful introduction depends generally on how the transport business is ready to consider TMS as the assets which can generate additional value for a transport company [13]. Whereon the owners of cargo-carrying companies have seen and realized that the TMS provides the business transparency and transportation reliability control, we can observe the unflinching interest to the further data extraction using the daily business transactions fixing the transport operations and knowledge which are necessary for important strategic decision making [14]. Thus, the introduction of IT solutions leads to the transformation of transportation business providing the competitiveness through the quick and effective solutions using the data from information systems [15, 16].

3. Modelling and development of the fuel consumption subsystem

Unfortunately, practice demonstrates a lot of cases when the transport companies don't see their benefits in the introduction of TMS; they don't realize the opportunities they create for managerial decision-making at operations, tactic and strategic level, as well as the additional value that can be created for the transportation business. This is especially true for small and medium-size transport and logistic companies both for Russia and other countries of the world [17]. Usually, the large companies have the experience of implementing ERP systems; they understand the approaches to IT project implementation in general terms. However, the success of TMS deployment within a company often depends on the efforts of various specialists with high qualifications and solid hands-on experience. It is worth noting that these experts should not have the similar level of interest in deploying TMS. It is not unusual when their interests do not overlap or are directed differently.

For example, when we consider the task of fuel metering, we can distinguish the following actors. It is known that the fuel consumption of a truck depends on a host of factors, such as specifications of the vehicle itself, payload, driving speed, road and weather conditions, tyre pressure [18], as well as on driving skills. [19]. Consequently, the analysis of these factors impact on the transportation process, transport business as a whole as well as their mutual influence requires their hierarchical description and determining the semantic connections between them, all in order to provide the creation of knowledge necessary for managerial decision-making. Thus, we come to the need of forming an ontological model for fuel consumption. It is well-known that an ontology is described using the following data set:

$$O = \langle T_0, R, P \rangle \quad (1)$$

wherein

T_0 is the set of domain terms;

R is the semantically valuable relationships;

P is the defining functions for interpretation.

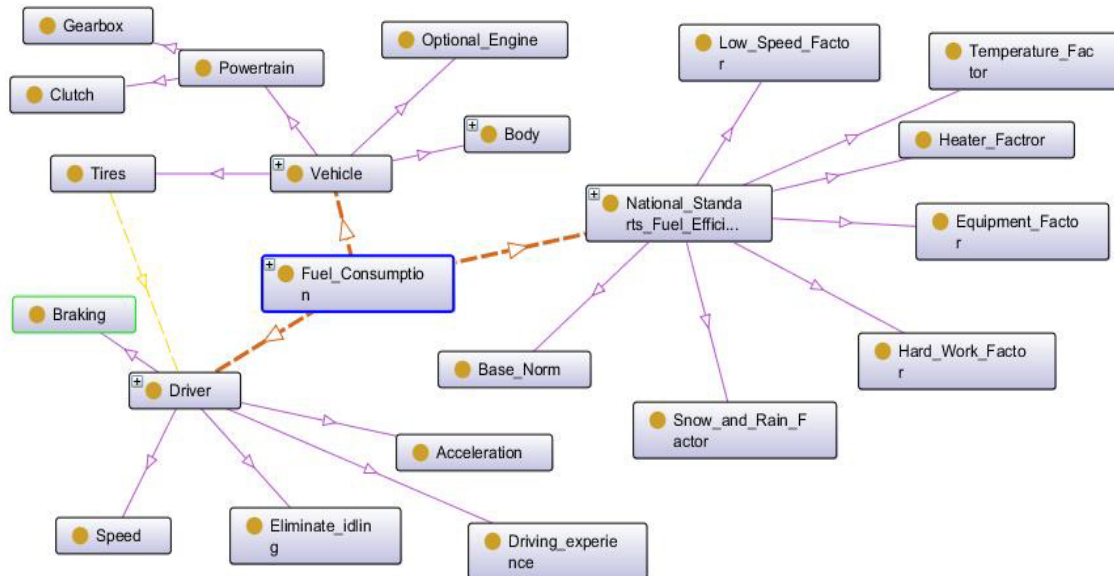


Figure 2. Ontological model of fuel consumption

A literature review shows that driving style causes up to 30% of fuel consumption [20]. In [21], the following key driving factors that increase fuel consumption are highlighted

- engine performance at increased RPMs;
- frequent speedups and brakings;
- tickover;
- suboptimal route, in terms of the road traffic;
- poor skills of driver during the maneuvering in tough road conditions;

Based on truck design, we conclude that fuel consumption is impacted by following factors: type, power and other characteristics of the engine; parameters of clutch and gearbox; tyre pressure and tyres themselves; number of center shafts; aerodynamic qualities, etc. Besides, in Russia as well as in many other countries there are standards of fuel efficiency with the basic rate dependent on the make and model of vehicle. The multiplying coefficients exist, too; they depend on the road and weather conditions, traffic in the city, tough driving conditions, age of vehicle, etc. The fuel consumption depends on the payload and the dead weight of the semitrailer.

Thus, we have built the ontological model of fuel consumption (see figure 2). The ontological model allows to evaluate the relationships between the objects associated with the fuel consumption in TMS. As a result, for example, the owner of the company understands that the design characteristics and the age of vehicle have significant impact on the fuel consumption; he would make balanced decisions concerning the renewal of fleet and selection of vehicles. An extra attention should be paid to the selection and further training of drivers as well. The dispatcher should take a more responsible approach at the operating level to the selection of a driver for every individual cruise, taking into account the route, weather and climatic conditions and road traffic. The driver, for example, should be ordered to make a periodic inspection of tyre pressure in case an automated monitoring device is not available.

4. Conclusion

The development and deployment of information systems for transport management require all the stakeholders at various levels to adhere to a common interpretation of the fundamental concepts as well as the cause and effect relations between them. Eventually, the developing architecture of TMS should not only meet the current requirements of business objectives, but also enable to jump-start the business of a specific transport company. Despite the fact that our ontological method requires closer cooperation and trust from all concerned parties, it allows the effective use of knowledge and expertise of various specialists. Thus, it creates the prerequisites for successful application not only of the technological and financial capital, but the social one as well. In the current context of information economy, often called the "knowledge economy", the role of people's competencies, human relations and cooperation increases dramatically. In this regard, the example discussed above shows that relying on the cooperation between a transportation business employees creates not only the ability to formalize and optimize business processes, but also ensure their engagement and motivation. As you know, the question why certain management events and operations happen is a key to development of any enterprise architecture. The proposed method was applied successfully in a number of large and medium-sized Russian businesses, and proved its effectiveness.

5. References

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