ANALYZING FACTORS AFFECTING SPECIAL TRANSPORT WITHIN INDUSTRIAL PRODUCTION LOGISTICS USING INTELLIGENT SYSTEMS

Doctoral thesis – Summary
In order to obtain the doctoral grade at the
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INTRODUCTION

The current doctoral thesis has the objective of improving the level of knowledge of the functional processes of the special transport (traffic component), in the field of the logistics activity, approached as a component of the industrial production processes, so that staff involved in developing the projects and industrial production systems can clearly understand the specific conditions of the road special transport, where the modern technology is used (through integration of intelligent systems), to be familiar with the secondary obtained products and to have the necessary information regarding the costs and their environmental impacts.

The importance and the necessity of the chosen theme

At the level of the European Union (EU) the road transport is facing now more than ever a strong competition of utmost demanding in all his aspects, in permanent contact with current challenges (some representative examples being: the effects of the COVID-19 pandemic, Ukraine war, the geopolitical situation, in general, the unjustified rising of the fuel and maintenance prices, the environmental impact etc.)

All this factors have created problems in managing exploiting costs and maintaining a qualitative management in accordance to the market requirements, even though delivery times should be kept as low as possible and there are futile trips, while improving the interoperability of road transport.

Usually, priority domains of the road transport interoperability are:

- support for users transport and information;
- guaranteeing the effectiveness and the fairness of the road transport for all its users, in the context of increasing the security of the road transport;
- Rising the volume of the interregional and international circulation, which means cross-border regulatory compatibility solutions that must comply with all measureas in the regulations chains, including the fees;
- implementation of different regulations between the frontiers of the countries which generate:
  - ✓ Legal aspects regarding the traffic regulations and possible crimes;
  - ✓ Defining a common data exchange form regarding the crime;
  - ✓ Establishing an operation agreement in order to enforce the regulations.
  - ✓ A special attention should be granted to the fact that the conventional energetical resources are limited, which means switching the perspective to renewable energy resources, so that the development of the road transport goes hand in hand with the current environment legislation and aims for a sustainable development direction
  - ✓ Regarding the fact that mankind, in order to save itself, takes all the necessary measures for a sustainable transport, the logistics systems must also pursue these goals.
  - ✓ The implementation of an ecological approach for the supply chain brings together a set of sustainable and efficient practices, reunited under the term of ”green logistics”.
  - ✓ With the help of the ecological management, the green logistics implies a special thorough attention of the impact on the environment
  - ✓ The objective of the green logistics is to find the appropriate methods to save resources and reduce waste. It is therefore proposed to minimize the carbon footprint of the products and services, together with rising the efficiency and improving the working condition for the human resource.
  - ✓ An essential observation: in the field of logistics the potential of the artificial intelligence has been recognized a long time ago and there are new interesting

evolutions which the transport companies should closely monitor and use for their own benefit.

- ✓ An important role have the independent operation sensor 5G for the location of the mobile car body (telematics) or the automatization of the warehouses with autonomous vehicles (AGV).
- ✓ The whole activity of the transports should take into consideration respecting some values of transparency, honesty and integrity
- ✓ All these aspects help identify the suitable intelligent systems and technology for the implementation.
- ✓ Another current problem is the precision of the localisation systems, used in order to optimise the travelling routes with the help of satellite support [1]. It is also necessary to statistically analyse the precision of the localisation according to the monitoring satellite systems [2, 3, 4].
- ✓ It is proposed a study of the transport activities – components of the logistics of the industrial production processes – done on different routes and products under different environmental conditions and should be observed, for the most important steps, the influence of the main factors on the process.
- ✓ Starting from experimental results, has been proposed to develop an original model for estimating the fuel consumption at different values for transport temperature, road conditions, traffic and wind speed.

The research objectives

The main objective of this doctoral thesis is:

OBJ1 Improving the logistics activities of production processes by rising the interoperability of the road transport systems in Europe through efficient solutions, which may involve multiple possibiities under conditions of integration of smart systems in the system of the road transport.

In order to achieve the main objective it is necessary to achieve the following secondary objectives, corresponding to the activities carried out in this research internship:

- OBJ 1- a critical analysis of the current stage of the models regarding the integration of the transport systems within the logistics activities of the industrial production processes starting from the classical definition, through the lense of fundamental structural conditions;
- OBJ 2 – evaluating the level of main characteristics of the fundamental components of interoperability of the road transport system (RTS), based on a bibliographic up-to-date study, including the flow of the main scientific publications;
- OBJ3- evaluating the level of the main features of the fundamental components of transport system integrated in the logistics activity of production processes, starting with taking into consideration the components included at the previous objective and adding others, whose involvement is decisive for fullfilling the essential functions of the interoperability;
- OBJ 4 – evaluation of the level of the main characteristics of the fundamental components of the interoperability of transport system RTS, considering the transport system RTS as an industrial technological system, based on the hypothesis of approaching the interoperability as an industrial technological process and attempting to transpose methods specific to them
- OBJ5- developing an integrated model for the general road transport system (GRTS), which obeyes the general principles of a systemic construction, through identification of the main variables and the relationship between them, in the version of a cybernetic system;
- OBJ6- identifying the main technical solutions applicable for improving the interoperability through a multi-annual dynamics analysis, in order to identify the optimal solutions for reducing the costs and the consequences on other factors (quality, environment, occupational risk, social responsability etc.) and simultaneously reducing resources consumption;
- OBJ 7- ranking the factors through statistical-mathematical methods and setting of some functional cause-effect relationships based on a statistical processing of the results and analysing its meaning using ANOVA (chapter 2.1.3).

The structure of the thesis

The thesis has 3 chapters.

In chapter 1 is made an analysis of the current stage regarding the place and role of the special transport in the logistics of the production processes. The methods of capitalization and a full analysis of the technological processes from the special transports integrated in the logistics of the production processes are also analysed in this chapter.

Chapter 2 represents the essential contributions of the author due to the experimental part, processing and interpretation of the results, but it also includes a part allocated to the preliminary conclusions

In subchapter 2.1. is made a constructive, functional and economic analysis regarding the influence of external factors upon the functional characteristics of the used equipments in the special transport and the way these work during the transport under certain conditions given by concrete, real itineraries with means of transportation specific for the goods being transported [1].

In subchapter 2.1.2 the following stages have been monitored:

- The identification of the influence factors and of the functional characteristics of the equipment;
- The identification of the constructive and functional characteristics of the means of transportation from the ADE.KÜHLTRANSPORTE park being used in the experiment;
- The presentation of the conditions for handling goods and of the transport conditions;
- The correlation between the influence factors and the functional characteristics
- The analysis of the factors that influence the equipments of the means of special transportation;
- Setting objective itineraries.

The goal of this research was to analyse the factors that influence the equipments of the means of special transportation, following their variation during the procceses of loading unloading, respectively during travelling more itineraries, according to the facts presented in table 2.1. and highlighted in figures 3.1 ÷ 3.50.

Based on the obtained results, in the final part of chapter 2, the results are analysed using statistical methods, observing statistically significant differences in the variable distribution of data due to additional traffic conditions, determined by road characteristics (national road or highway), differences of trailer load, as well as differences related to the specific nature of the goods (for instance: type of chocolate, nature and condition of meat etc.)

Subchapter 2.1.3 Part 3 of chapter 2 is dedicated to statistical processing of the experimental results and impact assessment, and part four is dedicated to a synthesis of theoretical, experimental and with industrial applicability contributions, already used within the framework of ADE.KÜHLTRANSPORTE.

Chapter 3 is dedicated to general conclusions and a synthesis of the personal theoretical, experimental and applicative contributions. A presentation of research perspectives and improvement of recycling technologies and the perspectives opened for the future research projects which may complete the issues addressed in this thesis is also included.

1. THE ACTUAL STAGE OF INFORMATION IN THE SPECIALIZED LITERATURE REGARDING THE PLACE AND ROLE OF THE SPECIAL TRANSPORT IN THE LOGISTICS OF PRODUCTION PROCESSES

The objective of this chapter is a general evaluation of the actual stage of technological processes from special transports integrated in the logistics of production processes, the scientific approach was structured around the special transport system as a logistics subsystem integrated in the production process.

The structure of the special transport, integrated into the logistics processes of a production system is represented in figure 1.1.

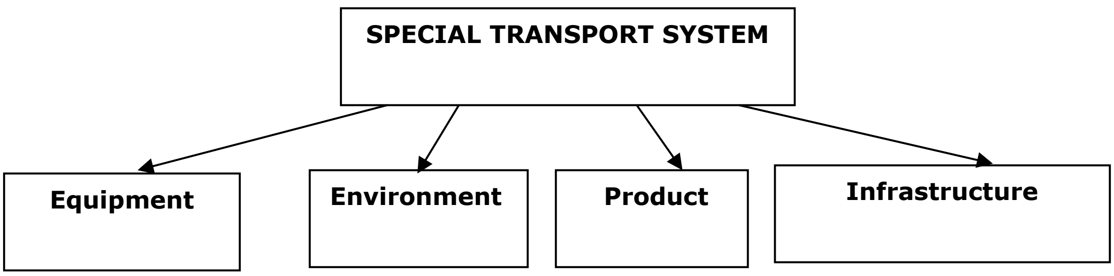

Fig. 1.1 The structure of the integrated special transport

1.1 The analysis of special transport

The special transport is also considered a complex technological process which ensures the movement of people and goods from the place of dispatch to destination by suitable means of transportation [5, 6, 7].

In order to achieve his role, regardless of whether it takes place in a public or private setting, in economical-social domain (integrated in a business) or personal area, the transport has to meet four essential requirements, fundamental characteristics: to be where (principle of localization), when (principle of temporality) and how (principle of functionality), it is also necessary to accomplish an optimal quality/cost ratio (principle of economic efficiency).

As active essential activities, special transport services providers have to ensure these services at the level requested by the beneficiary in terms of quality, quantity and costs.

1.2. The analysis of solutions and the impact of logistics utilization and sustainable development

Given the fact that a vast majority of humanity considers that to save itself it is necessary to take all measures in order to ensure a sustainable development, by default performing a sustainable transport, the logistics system have to directly or indirectly pursue these goals [5, 6, 7]..

From a sustainable logistics point of view, a lot of opinions from those involved are first of all directed towards modern vehicles technology with zero emissions or at least low emissions, or to reconversion of transport to ecological railways.

In practice, logistics world and the options in order to implement measures for a sustainable logistics are complex.

Implementation of an ecological approach for the supply chain brings together a set of sustainable and efficient practices, reunited under the name of green logistics.

With the help of ecological management, green logistics means a special, detailed attention of the impact on the environment.

The objective of ecological logistics is to determine the appropriate measures in order to save resources and reduce waste. It aims to minimize carbon footprint of products and services in addition to the need to increase efficiency and improve working conditions for human resource.

Logistics was formulated pragmatically by Reinhard Juenemann in 1989 as functioning according to six rules [11]:

- *right amount;*
- *suitable items and objectives*
  - ✓ Transport;
  - ✓ Persons;
  - ✓ Energy;
  - ✓ Information.
- *appropriate place in the system for:*
  - ✓ Source;
  - ✓ Collecting;
  - ✓ Evacuation.
- at the right time;
- *suitable quality;*
- fair and reasonable costs.

To streamline logistics it is necessary to timely plan the distribution taking into consideration:

- general traffic restrictions;
- public holidays;
- driving times;
- storage spaces with good control assurance during storage;
- traffic authorizations for special transports.

For areas outside EU customs documents and international traffic authorizations are necessary.

2. ORIGINAL CONTRIBUTIONS REGARDING INTELLIGENT SYSTEMS APLICATIONS FOR SPECIAL TRANSPORT OPTIMIZATION IN THE LOGISTICS OF PRODUCTION PROCESSES

2.1. THE ANALYSIS OF THE INFLUENCE OF EXTERNAL FACTORS ON FUNCTIONAL CHARACTERISTICS OF THE EQUIPMENTS USED IN THE SPECIAL TRANSPORT

The objectives and the object of this research, due to particularities of the special transport, especially of temperature-controlled transport, represents *the identification of external influence factors on functional characteristics of equipments used in special transport and the way they act* in the case of transport under given conditions, specific, real itineraries by means of transportation specific to the goods transported [1]..

2.1.1. Research metodology

The current study of temperature-controlled freight transport assumes several factors which influence the functional characteristics of the equipment of the transport unit, tractor head-refrigerated trailer.

The determining factor in order to choosing a mean of transport is cargo itself-its nature, the quantity, the presentation of goods and the temperature conditions requested on the entire logistics chain.

Transporation of temperature-controlled freight involves serious factors which influence the functional characteristics of the equipment of the transport unit, tractor head-refrigerated trailer.

Correlation between influence factors and its functional characteristics is presented in figure 2.2.

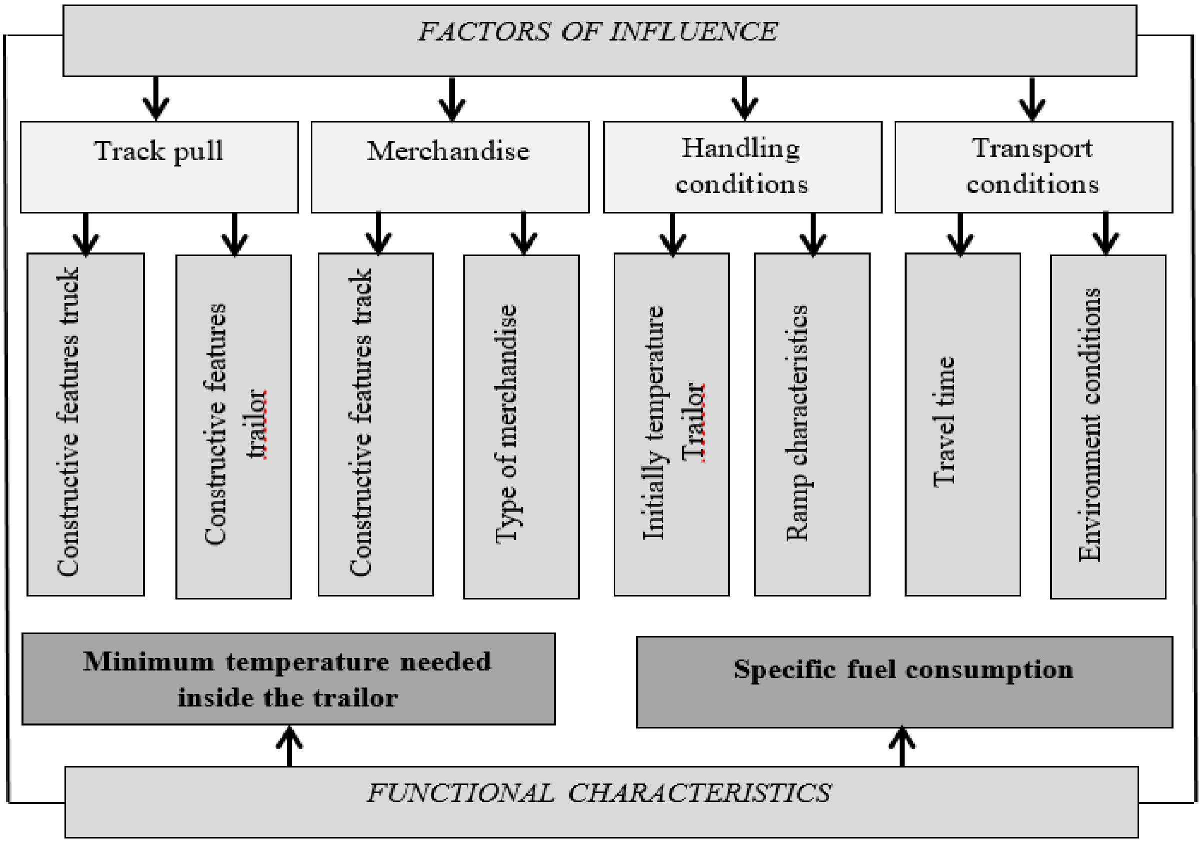

Fig.2.2. Correlation between influencing factors and functional characteristics of equipment

2.1.2 Constructive analysis of means of transportation

Construction and operation of Schmitz Cargobull trailer is based on the modern Smart Trailer concept which integrates the advantages of *telematic system* with proved efficiency equipment of the vehicle in order to assure an efficient transport solution.

Goods which quality and validity degrade if they are transported under inappropriate conditions need one or more controlled temperatures.

2.1.3 Handling conditions (restrictions) of goods

During the transport of goods, in general, and the temperature- controlled transport, the operation groups which were monitored were (taking into consideration the recommendations from [60])):

- Loading;
- Travel from the loading point to unloading point; unloading.

Therefore is is necessary to find technical and organizational solutions capable of reducing the loading, unloading time or transshipment and in this way to increase the speed (traffic) of goods transport.

It is considered that Total transport duration t_t (fig.2.9) is a sum of three distinct elements (rel. 2.1):

$$t_t = t_î + t_m + t_d \text{ [ore = hours]} \quad (2.1)$$

where:

t_l[ore = hours] – (duration of loading);
t_m[ore = hours] – (duration of travelling between loading und unloading);
t_d[ore = hours] – (duration of unloading).

According to the relation 2.2., the duration of loading has two elements: actual travel time t_{mo} and the dwell time t_s along the way, due to several reasons can be very long because of certain technical operations which take place during the distance between the initial loading station and the final destination station, respectively due intermediate stations along the way.

$$t_m = t_{mo} + t_s \text{ [ore = hours]} \quad (2.2)$$

The actual travel time is determined by the formula 2.3., where v_t represents the transport speed:

$$t_{mo} = l_m/v_t \quad (2.3)$$

2.1.4 Transport conditions

It is considered that temperature-controlled road transport is significantly influenced by two categories of factors:

- Travelling time: handling time; travelling time
- Environment conditions:
  - ✓ geographical location;
  - ✓ climate;
  - ✓ season;
  - ✓ weather conditions;
  - ✓ road conditions;
  - ✓ temperature variation during travel.

2.1.5 Correlation of influence factors with functional characteristics

The transport, the actual journey is made out of the need to bring a transported object from an expedition point (origin) to a final destination point (punctus terminus).

If the transported object are goods that need to be transported at temperature-controlled conditions it is necessary to build optimal traffic networks:

- to ensure the minimum required temperature inside the trailer;
- to ensure a minimum fuel consumption.

2.1.6 THE ANALYSIS OF THE FACTORS WHICH INFLUENCE THE MEANS OF SPECIAL TRANSPORTATION EQUIPMENT

2.1.6.1 Objective routes planning

The goal of this research was to analyse the factors that influence the special means of transportation equipment, tracking their variation during the processes of loading unloading, respectively during the time of travel on multiple routes, according to data presented in table 2.1 and stressed out in figures 3.1 ÷ 3.50, for instance figure 2.10

Tab.2.1 Analysed itineraries

No. crt.	Itinerary definition	Figure
1	2	2
1	Ulmer Schokoladen GmbH & Co. KG - Knoop & Söhne GmbH & Co. KG	2.10
2	Ichenzell - Knetzgau	2.11
3	Hamburg – Bremen	2.12
4	Werne – Drolshagen	2.13
5	Wedermark - Seesen	2.14
6	Grunberg - Wiesbaden	2.15
7	Herrenberg – Karlsdorf-Neuthard	2.16
8	Borgholzhausen - Emstek	2.17
9	Frigo Coldstore Logistics, Hamburg – Anton-Tucher Strase, Bremen	2.18

10	Cloppenburg – Samern	2.19
11	Leherheide est, Bremerhaven – Emstek	2.20
12	Holdorf – Bradewede, Bielefeld	2.21
13	Badnnenberg - Knullwald	2.22
14	Bettenhausen, Kassel – Fulda Fulda	2.23
15	Fulda – Gochsheim	2.24
16	Frigo Coldstore Logistics, Hamburg – Walsrode	2.25
17	Walsrode - Bockenem	2.26
18	Gottingen - Kirchheim	2.27
19	Roadhausen Riedner Wald West – Hardthausen am Kocher	2.28
20	Bramsche – Hamm	2.29
21	Hamm – Olpe	2.30
22	B277 Horborn – Morfelden-Walldorf	2.31
23	Hansestrase, Sittensen - Grosenkreten	2.32
24	Wilhelmshaven – Friesenwerder, Bremen	2.33
25	Manhdorf, Bremen – Wilhermsburg, Hamburg	2.34
26	Bockel, Gyhum – Bakum	2.35
27	Grosenkneten – Ladbergen	2.36
28	Constituency of Munster – Ludenscheid	2.37
29	Ludenscheid – Aslar	2.38
30	Aslar – Darmstadt West, Darmstadt	2.39
31	Frigo Coldstore Logistics, Hamburg – Hemelingen, Bremen	2.40
32	Versmold – Hamburg	2.41
33	Warburd – Niederaula	2.42
34	Bamberg – Hipoltstein	2.43
35	Holtinghauser Ring 34 – Schiffdorferdamm	2.44
36	Bothfeld, Hanovra – Ostingersleben	2.45
37	Glindow – Schonhausen	2.46
38	Melle – E 37, 59387 Aschenberg	2.47
39	Ascheberg - Burscheid	2.48
40	Leverkusen – Mendig	2.49
41	Mendig – Riol	2.50
42	A8 – Stupferich, Karlsruhe	2.51
43	Mendig – Burscheid	2.52
44	Schwerte – Tecklenburger Land	2.53
45	Bremerhaven – Emstek	2.54
46	Grosenkneten – Nahne	2.55
47	Herne – Sassenberg	2.56
48	Borgholzhausen – Hamm	2.57
49	Im Grosen Klei – Meinenzhagen	2.58
50	Freudenberg – Ober-Morlen	2.59

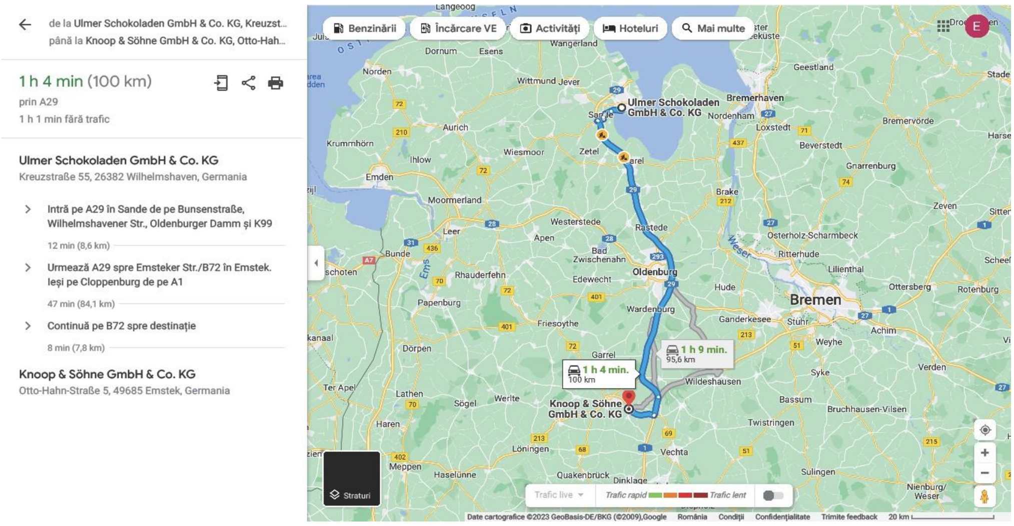

Fig. 2.10. Itinerary 1, Ulmer Schokoladen GmbH & Co. KG - Knoop & Söhne GmbH &Co. KG (processing according to Google Maps)

2.1.6.2 Experimental results obtained by using "trailerconnect" telematic system

In order to monitor the required temperature during the transport with temperature-controlled trailers, the *TRAILERCONNECT* telematic system from *Schmitz Cargobull* was used.

The control unit TrailerConnect (fig.2.60) represents the central piece of the telematic system. A well integraded SIM Card contributes to avoiding interuptions and the covered structure confers safety and protection against a possible manipulation

The main characteristics of the telematic system are:

- maximum functionality by automotive standards according to protection class IP69K;
- function without problems between -40 °C and 85 °C;
- robust structure for a long lifespan and use under extreme conditions;
- simple and comfortable diagnosis by using a proffesional software for shorter visits to service centers;
- Modular scalable system: from basic solutions to complete equipment.

Fig.2.60. TrailerConnect Command Unit[61]

Fig.2.61. Items monitored on the trailer by telematic system [61]

2.1.7 Research results

2.1.7.1 Results regarding monitoring during transport

The analysed itinerarires represent a multitude of traffic currents, with one single origin and one single terminal point

For each traffic current the telematic system records the distance traveled and the travel time. Thus photo 1-2 presents the recorded results from the board of the truck head for itineraries 1-2.

Through the central unit of telematic system TrailerConnect® from SmartTrailer some simple wireless functions and updates are accessed. All SmartTrailer vehicles are adapted to the latest inovations without the need for visits to service centers.

A trailer that uses telematic system, monitors the marked parameters from figure 2.61 and has the following components

- temperature recorder:
  - ✓ the central unit of telematic system and a maximum of 6 sensors from loading space ensure a safe registration of the temperature according to DIN EN 12830
- the battery of the telematic system:
  - ✓ the battery of the telematic system, with heating function for loading operations, ensures a standby period even during disconnected state.
- operating data for the transport refrigeration unit:
  - ✓ the connected transport refrigeration unit sends data about state, functioning and diagnosis
- operating data of EBS:
  - ✓ the connected break system sends data about state, functioning and diagnosis
- motion sensor:
  - ✓ An acceleration sensor from the command unit of the telematic system sets dwell times and travel times of the vehicle
- WiFi:
  - ✓ a WIFI integrated module from the command unit allows messages display and vehicle handling by beSmart application. The integrated WIFI module of the semi-trailer establishes communication between command unit of the telematic system and mobile phone (fig.3.53) and tracks:
- the analysis of the temperature from the loading place:
  - ✓ The current temperature is accessed from the mobile phone and is controlled from the temperature printer directly from the mobile phone.
- the supervision and command of the transport refrigeration unit:
  - ✓ The control over the operating data of the refrigeration unit is maintained.
- Checking brake pad wear:
  - ✓ technical problems are avoided and visits to the service centers are planned efficiently;
  - ✓ beSmart application displays the status of the brake pad.
- aggregate load:
  - ✓ Road safety and reduction of the semi-trailer wear level.
- checking tire conditions of tyres
  - ✓ Technical problems of the tyres and a high level of wear are avoided by a permanent control of their pressure and temperature
- rear door locking system:
  - ✓ Easy and comfortable control of the locking system of the door by PIN code by accessing beSmart application

Photo 1: *Results recorded on board of the tractor unit Itinerary 1 (Tour kilometer = distance traveled, Tourzeit= travel time, Durchschnittsgeschwindigkeit = average speed, Kraftstoffverbrauch = Fuel consumption)*

Photo 2: *Results recorded on board of the tractor unit Itinerary 2 (Tour kilometer = distance traveled, Tourzeit= travel time, Durchschnittsgeschwindigkeit = average speed, Kraftstoffverbrauch = Fuel consumption)*

Temperature variation in the refrigerated trailer is also controlled, so that the minimum required temperature for the transported goods is ensured throughout the whole travel time, in this analysis for each of the considered itinerary .

An example of this is the recording made for itinerary 11 (fig 2.63.)

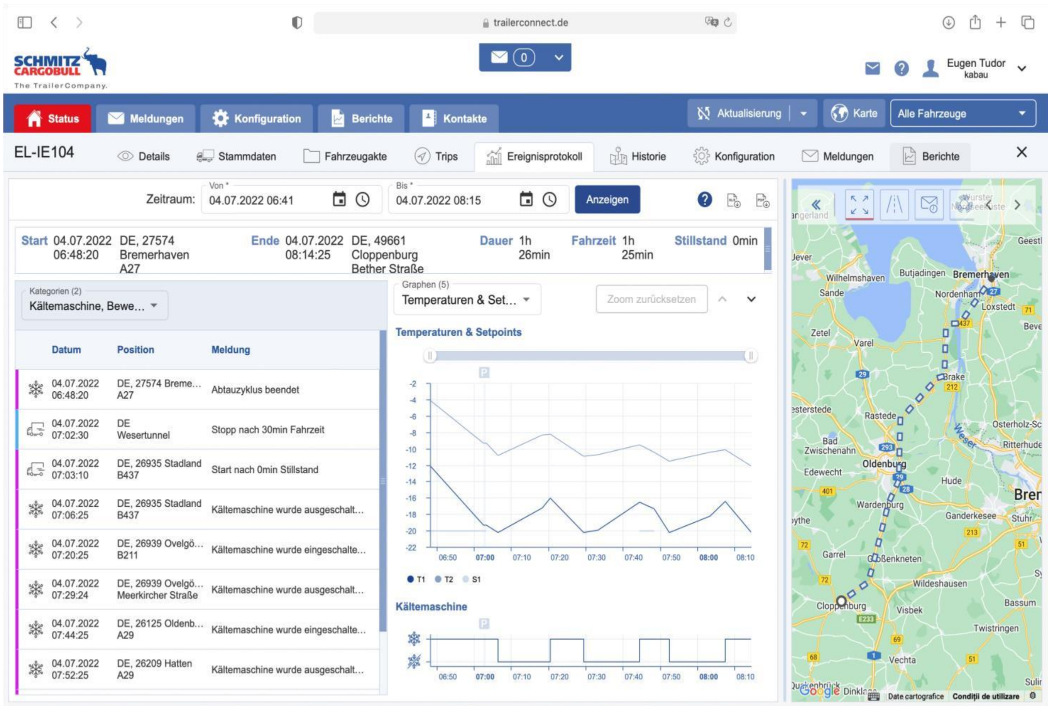

Fig.2.63. Temperature variation in the trailer during itinerary 11

During time travel fuel consumption was also monitored, one of the indicators of transport efficiency

2.1.7.2 Centralization of experimental results

The required temperature inside the trailer is a fundamental element of the temperture-controlled transport which has to be ensured and depends on several factors, the most important being:

- technical state of the trailer;
- type of merchandise;

- weight of merchandise;
- temperature of the merchandise at loading;
- temperature of the environment;
- handling conditions of the merchandise at loading;
- travel time, and bad weather conditions are considered as disruptive factors that can appear during transport:
    - sudden variations of temperature;
    - storm;
    - wind;
    - rain

as well as unexpected traffic diversions that may increase the time travel.

Given the fact that the period with the highest temperature variations differences between trailer interior and environment are summer months, the analysis took into consideration the monitoring during the months of june, july, august 2022.

The registered data is found in table 2.2. From the analysis of data,
the following is noted:

- the analysed itineraries are heterogeneous;
- the monitoring is made on a traffic flow length of 100km, regardless of the analysed itinerary
- regardless of the itinerary there is a fuel consumption increase with heavier cargo weights.
- The weight of the goods also influences the energy consumption necessary to mantain the trailer temperature

Apart from the collected presented data from table 2.2, a series of other useful information have been collected in order to complete the results analysis by statistical methods, looking at the significant statistical differences in the variable distribution of data due to additional traffic road conditions (national road or highway), weight differences of the cargo from the trailer, but also due to the specific nature of the goods (for instance: type of chocolate, nature and state of the meat etc.).

2.1.8. The analysis and interpretation of the experimental results

2.1.8.1. The study of the influence of load, mean speed and transport temperature on fuel consumption during the transport of frozen meat

Given the multifaceted importance of fuel consumption (economic, environment, strategical stability etc.) in the following interpretations and analyses, the fuel consumption is considered the main dependent parameter (variable), looking for the influence of other factors on it. On these grounds, the registered data during the whole experiments have been restructured in order to ensure each time, on one hand, the independence of the primary considered factors and on the other hand the exclusion to the maximum extent possible of other influences from main factors which are not studied in the analysed case, regarding the influence of other itinerary factors as being negligible (only one weather condition, the same slope of the road, the same type of traffic, road curves etc.)

The following independent parameters are considered to be stable: traffic conditions corresponded to light traffic, without blockages and/or congestion that could slow down, the weather was sunny, without rain, the routes did not contain any steep slopes more than 1%, the transported product was frozen meat at a temperature of -20°C.

The statistical analysis was made with STATGRAPHICS Centurion software, version XVI, using multiple regression to determine the optimal equation for the dependence of fuel consumption on two independent factors (variables) with simultaneous action, load [t] and mean speed , Vm.

The values of usual statistical parameters were:
R-squared = 84.3051 %
R-squared (adjusted d.f.) = 80.3814 %
Standard Error of the estimated data = 1.73201
Mean absolute error = 1.2279
Durbin-Watson statistic = 2.3547 (P=0.7008)
Residual autocorrelation = -0.263406

The obtained results show that it exists a model obtained by multiple linear reggresion which can describe the two-factor dependency of fuel consumption: it depends on trailer load and mean speed of tractor head. The model equation is:

Consumption = 27.56 + 0.790824*load - 0.150844*Vm **(2.4)**

Given the fact that P-value from ANOVA analysis is lower than 0,05, it can be stated that there exists a statistically significant relationship between the variables at a confidence level of 95.0%.

The R-squared value shows that the determined statistical model explains for 84.3051% from variables the dependence mentioned beforehand, but a more reliable statistical measure is R-squared corrected, 80.3814%, which more accurately describes the coverage area of the proposed model.

The standard error of the estimates shows a standard error of residues of 1.73201, value which can be used in order to build the limits of prediction interval when new observations are incorporated into the specified model.

The mean of absolute values, value of 1.2279, represents the mean of the residues.

Because the value of the Durbin-Watson test is 2.3547, coresponding to a value of P=0.7008, which is bigger than 0,05, it can be said that there are no indications regarding the existence of a significant autocorrelation of residues for a trust level of 95%.

On the other hand, the model can be simplified because in the particular case of mean speed the P-value is 0.0821, bigger than 0,05, which means that the variable is not in a significant statistical relationship for a trust level of 95%. In other words, based on the model in question the mean speed variable, Vm can be replaced.

The mean level for a single data point = 0.272727

From the analysis of the presented data, it can be concluded that the mean value of the data points has a level of 0.272727 and there are no data points which are three times bigger than this average. Nevertheless there are two data points which have values bigger than the usual DFITS value.

Based on the previous considerations, figure 2.64 presents the graphic of predicted values for fuel dependence = f (load).

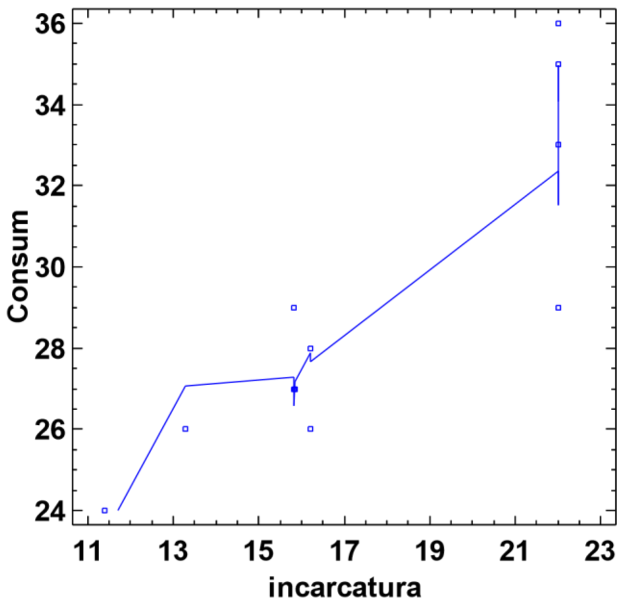

Fig. 2.64 The graph of predicted values for the dependence consumption= f(load)

2.1.8.2. The study of the influence of load and mean speed on fuel consumption for the transport of frozen meat

The statistical analysis results available until now indicate the need to conduct a variational analysis on the three series of data (consumption, load and mean speed, Vm).

The F test has a value of 435,21. Because the P-value is lower than 0.05, it can be said that there is a significant statistical difference between the average value of the three series of variables for a level of confidence of 95.0%.

The intervals of the minimum significant difference (LSD) are presented in the table of 95% confidence intervals, where are presented the mean values, standard errors and the limits of the determined values, in order to determine which means differ significantly from each of the others, using multiple-ranged tests.

This method indicates that there is a risk of 5,0% that each pair of averages is considered significantly different when there is a real difference equal with 0.

The results of the variational analysis refers to testing the null hypothesis for the same standard deviation. If P-value is lower than 0,05 there is a statistically significant difference between the two values of the standard deviations for the pair of columns analyzed.

The Kruskal-Wallis test verifies the nul hypothesis for the mean values in the three columns of data (table 2.16).

Because P-value = 6.34095E-7<0,05, it can be stated that there is a statistical significant difference between the mean values in the three columns of data at a confidence level of 95.0%.

In the figure 2.65 is presented the Box-Whisker graphic for the C, I, Vm analysis and in the figure 2.66 the graphic for the analysis of the mean values with a decisional limit of 95% for the same model.

In the figure 2.67 is presented the median graph with a confidence level of 95% for the studied model (C, I, Vm) and figure 2.68 the Quantile Plot graph for the same studied model.

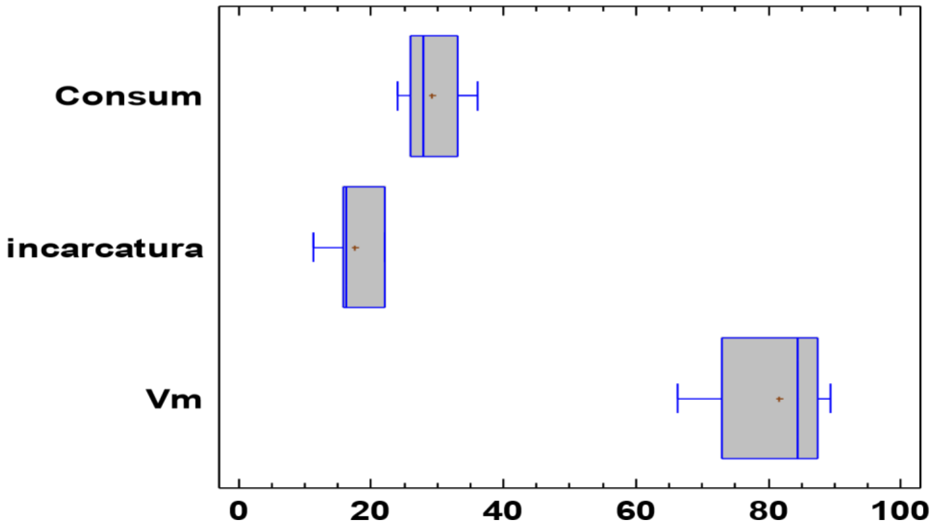

Fig. 2.65 Box- Whisker graph for the analysis of C, I, Vm

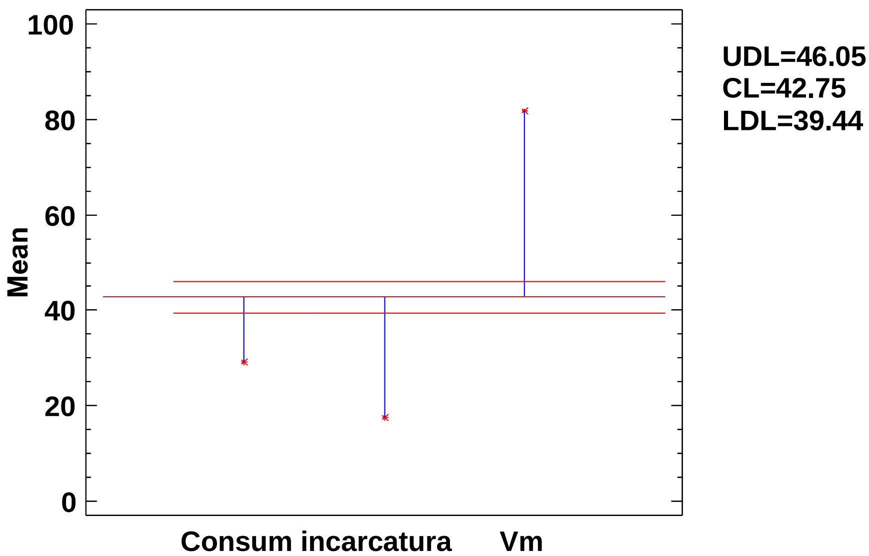

Fig. 2.66 Chart for median analysis with a decision limit of 95% (C, I, Vm)

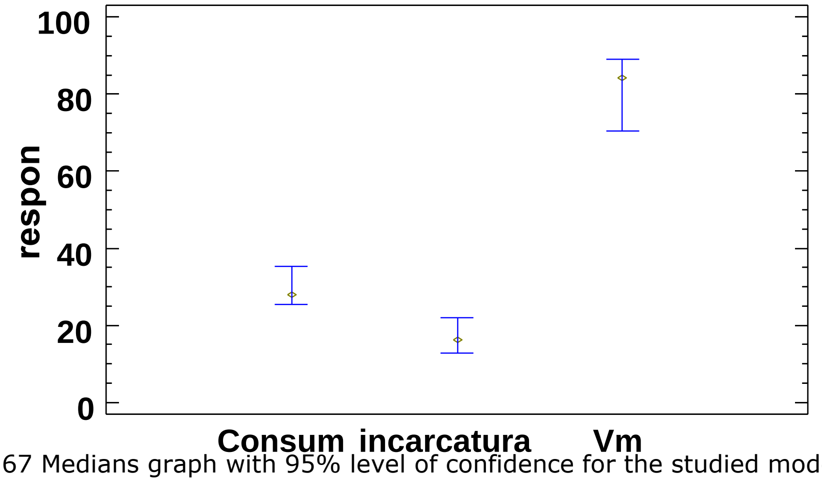

Fig. 2.67 Medians graph with 95% level of confidence for the studied model

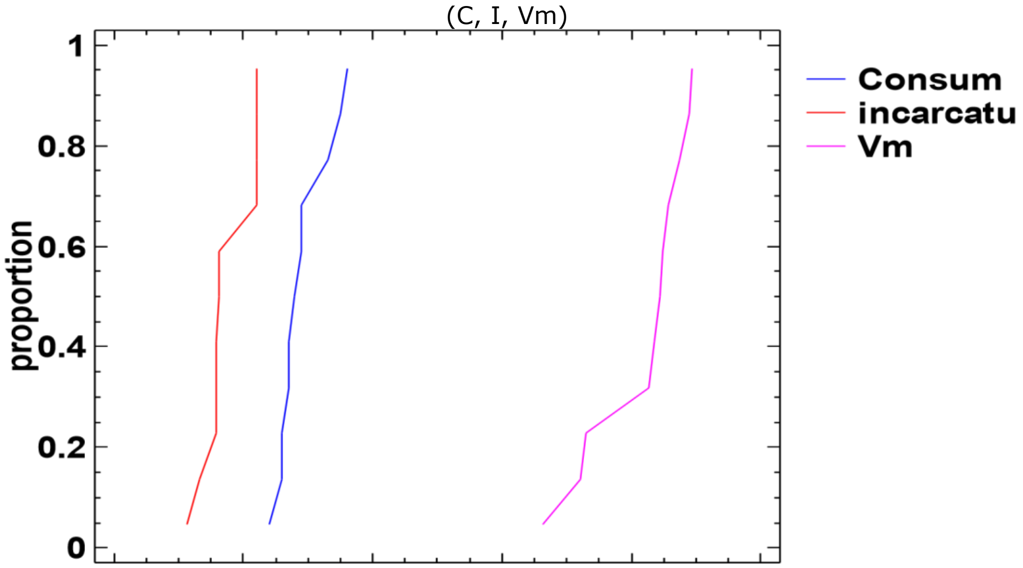

Fig. 2.68 Quantile Plot graph pentru for the studied model (C, I, Vm)

In can be concluded that in the case of the transport of the frozen meat at -20^{0}C, for conditions of sun, without steep slopes (under 2%), without wind, light traffic conditions, for the equipment level of the tractor unit with the intelligent systems beforehand presented, the most appropriate model ist the one presented in the equation 2.4. This means that there is a linear variation of fuel consumption according to semi-trailer load, noting that between the average speed and the load value there has been identifed a statistical significant relationship. This default value of the two variables at first considered independent can be explained by the existence of optimisation algorithms, that there are pre-programmed into the intelligent functional parameter management system of the tractor head, but also of the the semi-trailer's refrigeration unit.

2.1.8.3. The study of the influence of the load and average speed on fuel consumption during chocolate transport

In the second part of this analysis the data, in order to analyse the influence of the load and average speed on fuel consumption during chocolate transport have been selected by analog means

The following independent parameters have been considered stable: traffic conditions have been standardized, without traffic jams or congestions which may slow down, the weather was sunny, the routes do not contain slopes steeper than 1%, and the transported product was chocolate or marzipan at a transport temperature of 15^{o}C

Table 2.17 The experimental data to analyse the influence of the load and average speed on fuel consumption (chocolate)

Itinerary	Distance [km]	Consumption [l]	Load [t]	Vm, [km/h]	Goods	Temperature (C)
IT_ 1	100	31.3	17.325	82.7	Ciocolata	15
IT_ 2	100	26.9	7.1	87.4	Ciocolata	15
IT_ 24	100	25	7.82	76.3	Ciocolata	15
IT_ 25	100	23	7.82	80.4	Ciocolata	15
IT_ 37	100	28	12.745	70.7	Marzipan	15

The statistical analysis was made with STATGRAPHICS Centurion software, version XVI, under the same assumptions as in the previous case, using multiple regression to determine the optimal equation for the dependence of fuel consumption on two independent (variables) factors with simultaneous action, the load, [t] and average speed, Vm.

Starting from table 2.17 the results of the variational analysis on the three series of data (consumption, load, average speed) are presented below.

The analysis has to be multivariate for the 5 rows of data across the three columns.

Table 2.19 The results of ANVOA analysis for chocolate

Source	***Sum of squares***	***Df***	**Mean of squares**	**F test**	**P-value**
Between the groups	12983.6	2	6491.8	280.09	0.0000
Inside the groups	278.128	12	23.1773		
Total (corrected)	13261.7	14			

The F test has a value of 280.09. Because P-value is lower than 0.05, it can be said that there is a significant statistical difference between the averages of the three series of the variables at a confidence level of 95.0%.

Intervals of the minimum significant difference (LSD) are presented in table 2.20, where the following are presented: the averages, the standard errors and the limits of experimentally determined values.

To be taken into consideration is the fact that this method has once again a risk of 5% that each pair of averages is considered significantly different when the real difference equals 0.

The results of the variational analysis refer to testing the null hypothesis that the standard deviation is the same for the three columns. Because P-value is greater than 0.05, a significant statistical difference between the two values of standard deviations for the pairs of columns analysed at a confidence level of 95% doesn’t exist.

In order to verifiy the null hypothesis for the median values in the three data columns the Kruskal-Wallis test was made.

In this case too, because P-value = 0.00190899<0,05 it can be stated that there a statistically significant difference betwenn the median values in the three data columns at a confidence level of 95.0%.

Statistical test = 12.5224 P-value = 0.00190899

The Box-Whisker graphic to analyse the C,I, Vm group data for the case of chocolate transport is presented in the figure, and in the figure 2.69 the graphic for the analysis of the medians values with a decision limit of 95% for the same determined model.

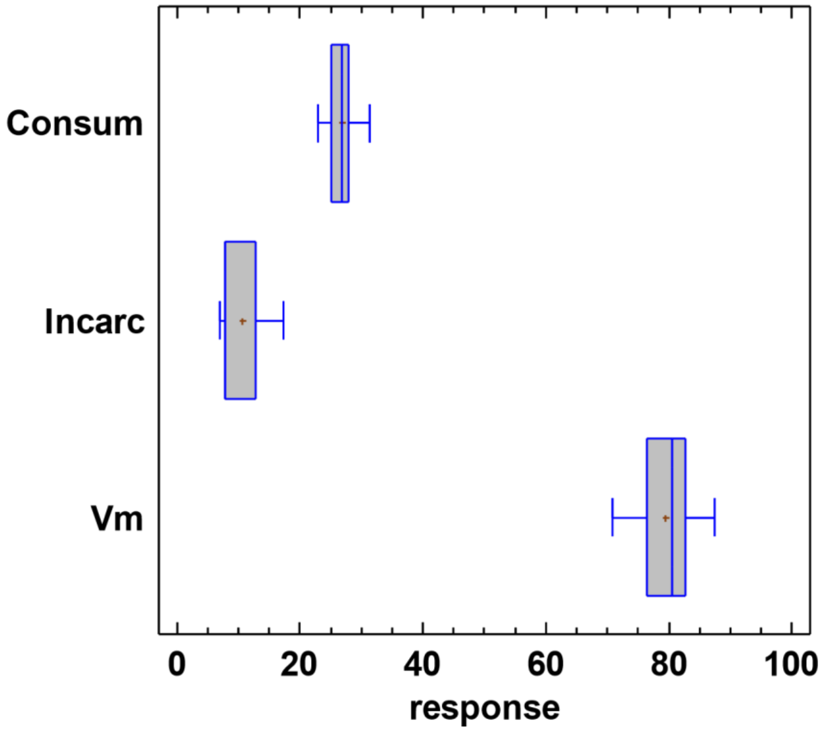

Fig. 2.69 Box-Whisker graphic for the analysis of C, I, Vm for the case of chocolate transport

The summary results for the multiple regression analysis are presented in table 2.25, and those for the analysis of variance in table 2.26.

Table 2.25 summary results for the multiple regression analysis (chocolate)

Parameter	Estimated	*Standard error*	T-statistic	*P-value*
CONSTANT	10.597	12.8338	0.825712	0.4958
Load	0.647983	0.221231	2.92899	0.0995
Vm	0.11821	0.153539	0.769903	0.5219

The values of the usual statistical parameters were:
R-squared = 81.2393 % R-squared

R-squared (adjusted d.f.) = 62.4786 %
The standard error of the estimated data is = 1.92178
Mean absolute error = 0.988339
Durbin-Watson statistic = 2.5452 (P=0.9207)
The residual autocorrelation = -0.320374

Table 2.26 The summary results for the analysis of variance for chocolate

Source	Squares sum	*Df*	*Squares mean*	*F-Ratio*	*P-Value*
Model	31.9855	2	15.9928	4.33	0.1876
Residual	7.38646	2	3.69323		
Total (corrected)	39.372	4			

The obtained results show that it exists a model obtained through liniar multiple regression that can describe the two-factor dependence of fuel consumption on trailer load and average speed of the truck head whose equation is:

Consumption = **10.597 + 0.647983*load+ 0.11821*Vm (2.5)**

Because P-value in the ANOVA analysis is less than 0.05 it can be stated that it exists a statistically significant relationship between the variables for a confidence level of 95.0%.

The value of R-squared shows that the determined statistical model explains for 81.2393 % of the variables the dependence previously mentioned, but a statistical value better to be used is the corrected R-squared, 62.4786 %, which more accurately describes the scope of the proposed model.

The standard deviation of the residues is 1.92178, value which can be used to build up the limits of the prediction interval in the case of a new integrated observations into the determined model.

The mean of absolute error (MAE), with the value of 1.2279, represents the residues mean.

Because the value of Durbin-Watson test is 2.5452, coresponds to a P-value = 0.9207, which is greater than 0.05, it can be said that there are no indicators of the existence of a significant autocorrelation of residues for a trust level of 95%.

On the other hand, the model can be simplified because in the case of avearage speed P-value is 0.5219, which is bigger than 0.05, which means that the variable is not in a statistically significant relationship for a trust level of 95%. It results that the variable can be excluded from the model given by the equation (2.5.) which can be a single variable equation as follows : consumption = f(load).

2.1.8.4. The study of the influence of the load on fuel consumption during the transport of chocolate

Initially a comparative analysis of the alternative models has been made, the results are presented in table 2.27.

From the comparative analysis of the alternative models, from the obtained results it can be concluded that the most appropriate type of equation is:

Y = (a + b*sqrt(X))^2 ***(2.6)***

For this type of model the value of R-Squared is with 8.66341% bigger than the currently selected model.

For the experimental data, the determined model registered the following values of the statistical parameters:

The correlation coefficient = 0.850579 The correlation coefficient
R-squared = 72.3484 % R-squared
R-squared corrected for the significant differences = 63.1313 %
The standard error for the estimates = 0.183216
The mean absolute errors = 0.105158
Durbin-Watson statistic = 1.67669 (P=0.3080)

Because P-value is greater than 0.05 it can be stated that it doesn't exist a statistically significant relationship between the fuel consumption and the size of the load for a confidence level of 95.0%.

On the other hand, the model covers in a proportion of 72.3484% the dependent relationship proposed for the equation (2.6) after a logarithmic transformation that linearizes the model.

The value of 0.850579 of the correlation coefficient indicates a strong relationship between the variables, and the standard error value for the estimations is 0.183216 in order to build up the used limit for the construction of the future predictions.

The summary of the results for a simple regression in the case of the specific model C=f(I) indicates a single-variable, optimal model, which has the statistical characteristics described in the specific equation as follows:

Consumption =***(3.90602 + 0.396372*sqrt(Load))^2*** ***(2.7)***

A variational analysis (ANOVA) with unequal variances was performed in order to detect the existence of systematic trends (on a nonlinear form), which the model, additional to the random variation, doesn't capture, thus being verified if the statistically proposed model (relation 2.7) fits appropriately the data or a more complicated model has to be searched, obtained through separating the variations between the group and inside the group.

Because P-value =0.4481 is greater than 0.05, the model seems to be appropriate for the observed data, having a trust level of 95%.

The graph resulted from the equation (2.7) is presented in the figure 2.71, where the intervals of variation for the variables values can be observed.

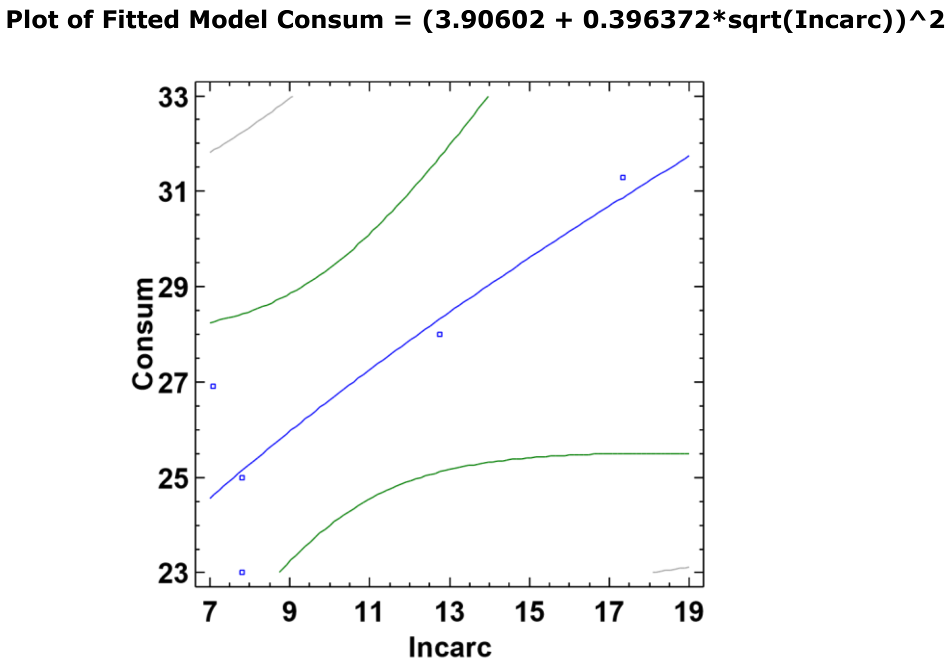

Fig. 2.71 The graph of the model derived from the equation C=f(I) for chocolate

Based on the analysis it results that practically a directly proportional relationship between the load and the fuel consumption can be established, but with a slight tendency to flatten out as the load increases. It can be concluded from this that it is more efficient to transport goods in as large loads as possible, provided that this is feasible from an organizational and technical standpoint.

On the other hand, if the fuel consumption would be analysed across multiple sections, there would be a part necessary for moving the empty unit and one necessary to transport the load.

The proposed model can be utilised to estimate the fuel consumption according to the load with a high level of confidence (above 95%), under normal traffic conditions.

2.1.8.5. The study of the influence of load, average speed and transport temperature on fuel consumption

In order to reach a general model a more in-depth study is necessary through simultaneous consideration of other parameters which may influence the fuel consumption in a statistically significant manner, in order to evaluate the influence of these factors under actual road conditions.

The practical transport conditions also mean the emergence of additional factors, whether predictable or not, systemic or incidental, with different meanings and influences etc.

From the initial bibliographical studies resulted that the independent influence factors, significant for the fuel consumption are the weight of the loaded equipment (load), C, average speed, Vm and transport temperature, T.

Therefore a variational analysis (ANOVA) of the global results for the four groups of factors was performed.

The summative results of the variational analysis by multiple-sample comparison, for the experimental varibles C, I, Vm, T, s, ANOVA divides the option into two groups: intergroup and intragroup.

The F-ratio test has a value of 687,941 and because P-value =0,000<0,05 it can be stated that there is a statistically significant difference between the means of the four groups of variables for a level of confidence of 95%.

The analysis of the meaning of this conclusion results from the Multiple Range Tests through the method 95% LSD.

Note that this method, this time as well, has a risk of 5.0% that each pair of averages is considered significantly different when the real difference equals 0.

Because P-value is less than 0.05, there is a statistically significant difference between the mean standard deviations for the analysed pair of columns for a level of confidence of 95%. This violates one of the key assumptions underlying the variational analysis and can invalidate the majority of the standard statistical tests.

In order to check the null hypothesis for the median values in the case of the four columns of data, Kruskal-Wallis test was done.

The processing of the rank in each column was done by ordering the data from the smallest to the largest.

Because P-value<0,05, there is a statistical difference between the median values of the four columns of data at a level of confidence of 95.0%.

Calculation of the significant medians was performed from the Box-and- Whisker graph figure 2.72.

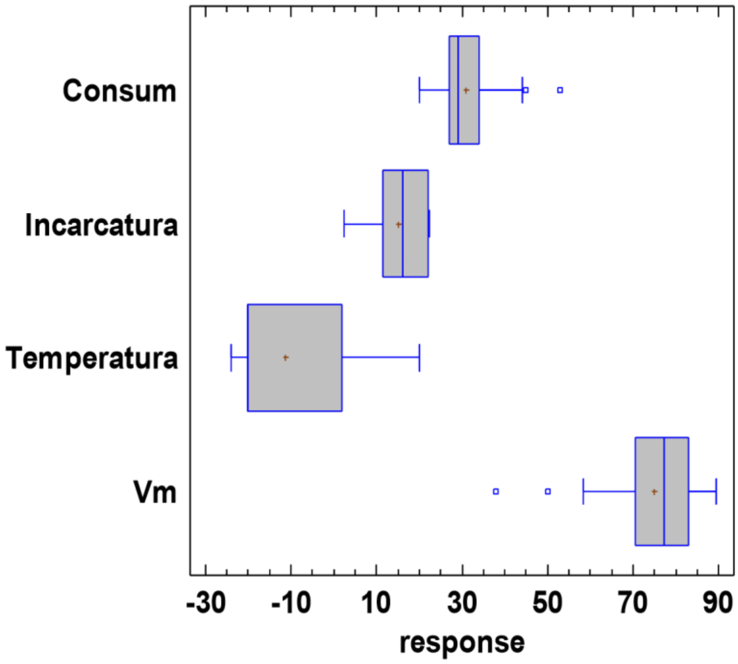

Fig. 2.72 Graficul Box-and-Whisker pentru variabilele C, I, Vm, T
Box-and-Whisker graph for C, I, Vm, T variables

In order to visualy compare the probability distributions of the four groups of values corresponding to the values C, I, Vm și T the quantile plot graph for the four variables was drawn up (figure 2.73).

This representation allows a visual verification of the distributions according to the normal distribution, which has to be linear.

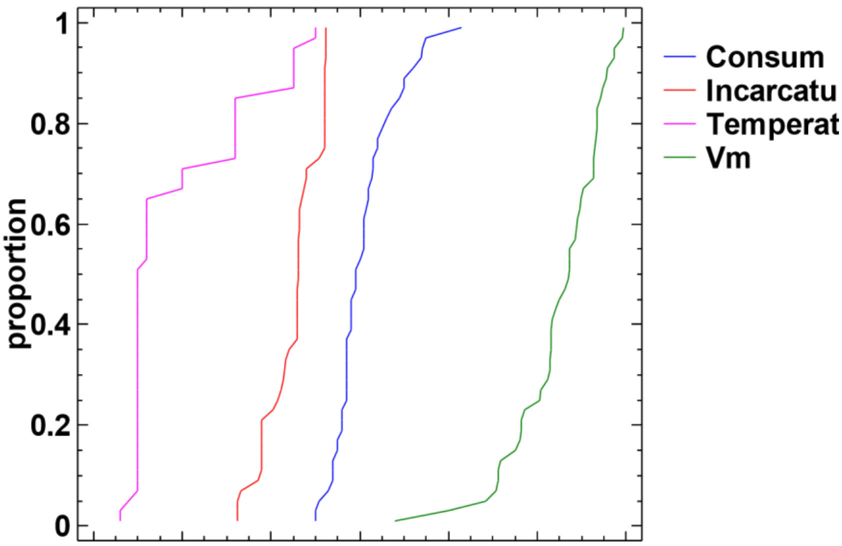

Fig. 2.73 Quantile graph for variables C, I, Vm, T

In order to find the normal variation zone of the group of variables, the median graph was plotted with a decision limit of 95%, demonstrating, through statistics, the validity of the interest in the model of a dependency of the type C=f (Î, Vm,T).

For this statistical study an multiple reggresion analysis using STATGRAPHICS Centurion, version XVI was made.

The summary results for the analysis of the regression and the value of the usual statistical parameters were:
R-squared = 57.4654 %
R-squared (adjusted d.f.) = 54.6914 %
Standard Error of the estimated data = 4.6444
Mean absolute error = 3.29427
Durbin-Watson statistic = 1.85291 (P=0.2400)
Residual autocorrelation = 0.0734453
The obtained results show that it exists a model obtained by multiple linear reggresion which can describe the three-factor dependency of fuel consumption: it depends on trailer load, mean speed of tractor head and the mantained temperature inside the transport unit. The model equation is:

Consumption = 37.5509 + 0.742089*Load + 0.0377532*Temperature – -0.233952*Vm (2.8)

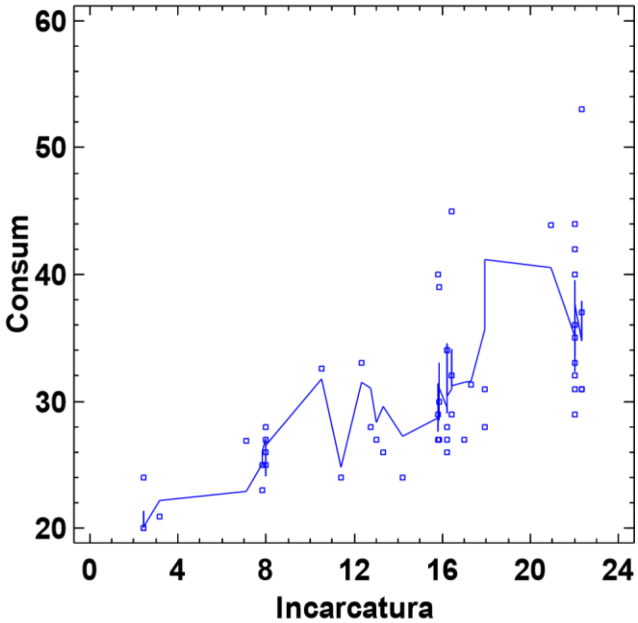

Fig. 2.78 Graph of the predicted values for the simplified model C=F(Î)

2.1.8.6. Determination of the function of the influence of the load on fuel consumption by polynomial regression

Below are presented the results of the polynomial regression for the simplified model C=f(Î), for all the itineraries.

A grade 5 polynomial model was chosen, for which general statistical results were obtained

The obtained results appropriately describe the grade 6 polynomial model for the functional description of the analysed dependence.

The polynomial equation of the model will be:

Consumption = 30.5295-7.56567*Load + 2.00058*Load^20.20492*Load^3 + 0.00930104*Load^4 – - 0.000153735*Load^5 (2.9)

Because P-value in the ANOVA analysis is less than 0.05 it can be stated that it exists a statistically significant relationship between the fuel consumption and the load for a confidence level of 95.0%. The value of R-squared shows that the determined statistical model explains for 46.6694 % of the variables the dependence previously mentioned, but a statistical value better to be used is the corrected R-squared, 40.6091 %, which more accurately describes the scope of the proposed model.

Because the value of Durbin-Watson test is 2.147, coresponds to a P=0.5709, which is greater than 0.05, it can be said that there are no indicators of the existence of a significant autocorrelation of residues for a trust level of 95%.

The mean of absolute error (MAE), with the value of 3.78195, represents the residues mean.

In order to determine the most appropriate level of the polynomial function the variational analysis of the searched model was performed.

Because P-value for the highest order of the polynomial is 0,626868, bigger than 0.05, the term is not statistically significant for a level of confidence of minimum 95%.

Based on the analysis it results that practically a directly proportional relationship between the load and the fuel consumption can be established, but with a slight tendency to flatten out as the load increases.

The suggested model by the statistical analysis was a grade 1 polynomial. Based on the statistical analysis the following statistical model resulted:

Consumption = 19.0912 + 0.777477*Load **(2.10)**

The main statistical parameters are:

Correlation coefficient = 0.674802
R-squared = 45.5357 %
R-squared (adjusted d.f.) = 44.401 %
Standard Error of the estimated data = 5.14485
Mean absolute error = 3.88772
Durbin-Watson statistic = 2.2115 (P=0.7476)
Residual autocorrelation = - 0.108625

The statistical parameters verify all of the above conditions, and the graph of the estimated model is presented in figure 2.81

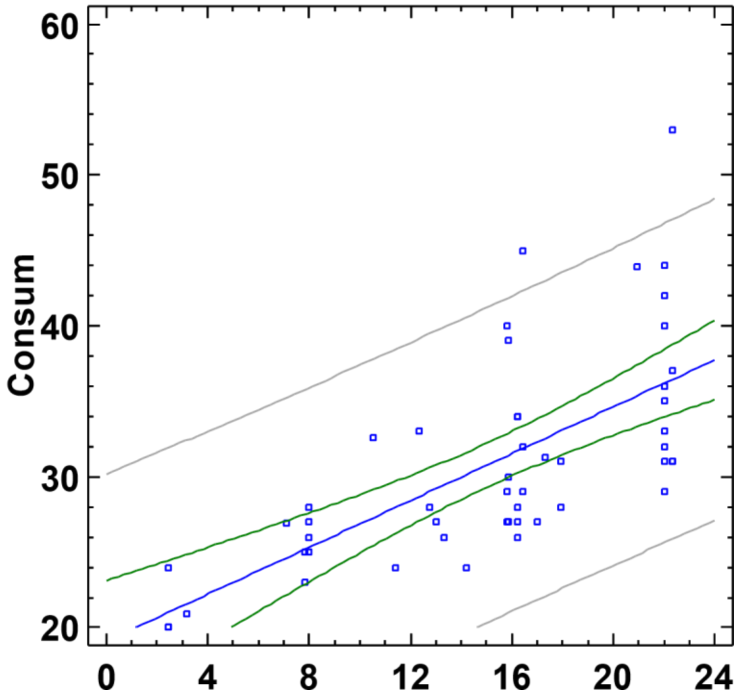

Fig. 2.81 The graph of the resulted grade 1 polynomial C=F(Î)

Therefore the simplified model, a grade I polynomial, best satisfies the condition of representing the dependency C=f(Î), for 67,1% from the experimental values. The actual interpretaton of the single-variable polynomial models shows that the influence of the other disturbing factors (weather conditions, transport temperature, slopes/ramps along the routes and sometimes even traffic jams) can be attenuated as the load increases, fuel consumption may even decrease in the case of loads heavier than 20t.

This conclusion applies only provided that the maximum permissible weight (total or per axle) is not exceeded, taking into account the vehicle's specifications and applicable traffic regulations.

2.2 The synthesis of the original contributions of the chapter

As a result of the performed research activities throughout the doctoral training (theoretical, experimental and applicable), this thesis brings a substantial series of original contributions, based on a meticulous documentary, but also a serious completion, the result of advanced theoretical modelling, starting with experimental research that took advantage of the unique conditions provided by its own facilities, which complemented the existing conditions from UPT, throughout the entire doctoral research.

As a synthesis, the most important personal contributions are presented below.

2.2.1 Theoretical contributions

1) defining the main and secondary objectives of the research, starting from the priorities and the challenges identified through the bibliographic studies;
2) identifing the current challenges in the field of managing all operating and maintenance expenses to ensure an effective high-performing management in the production processes domain which require the integration of some inteoperable systems of transport;
3) optimal utilization of intelligent systems of transport (ITS) through integrated applications into the logistics of production systems, in accordance to economic and environmental criteria
4) a documentary study regarding the actual phase of the place and role of the special transport in the logistics of production processes, based on up-to-date global market data by completing with synthesis and scientifical papers/studies from the main informational flow
5) a critical analysis of the special transport system integrated into the logistics of the production processes, from a technical point of view (equipments), an organizational perspective, a functional aspect, an economic and ecological point of view, but also identification of the associated weak and strong points;
6) the development of an original package of conditions in order to optimise the transport at controlled temperature, based on a study of the applicable regulations, but also after the evaluation and analysis of practical examples from the own activity;
7) the development, based on market research and on scientifical literature of a general system for the special transport, integrated into logistics processes from the corresponding production systems;
8) the development of original methods to determine the correlation between fuel consumption and the trailer load capacity, under current circumstances of other disturbing factors related to the conditions of special transport (the particular case of temperature-controlled transport);
9) the identification, based on a variational and regression analysis of some relevant general models, which may allow to determine some functional relations between fuel consumption, load, travel speed and transport temperature of the load, for several route conditions: itinerary, slope/ramp, weather conditions, traffic conditions;
10) the creation of a mathematical model which may allow to determine the fuel consumption according to predefined values of the independent variables: load, average speed and transport temperature in the trailer
11) the determination of the influence of enviromental factors on the proposed model by verifing the statistical significance of over 50 different itineraries, but also for some simultaneous different conditions
12) the development of a calculation model designed to determine some solutions and factors which may be used under specific conditions in order to optimise fuel consumption;

2.2.2 Experimental contributions

The main impactful experimental contributions are:

1) Determination of the percentage of influence of the fuel consumption for weather conditions (sun, rain, wind), traffic conditions and road slope for 50 routes of special transport, which have been studied in-depth;
2) Development of an original methodology for using the components of intelligent transport system from the supply of the special transport in order to determine and validate some significant influence factors on fuel consumption approched as both an economic and an ecological factor;
3) Use of intelligent transport system components from the equipment of the special temperature-controlled transport vehicles, in order to determine and validate the factors that

significantly influence fuel consumption for different routes and traffic conditions (itineraries and climate);

4) Study of the influence of the loads, avearage speed for a distance of 100km and transport temperature of the load on fuel consumption in the case of temperature-controlled special transport – on a global level, for various types of goods;
5) Study of the influence of the loads, average speed for a distance of 100km and transport temperature on fuel consumption in the case of temperature-controlled special transport for the special situation of frozen meat transportation (-20^{0}C) and chocolate (15^{0}C);
6) Verification by statistical-mathematical methos of the proposed mathematical models solutions for the influences of the loads (t), average speed Vm (in km/h) for a distance of 100km and transport temperature T (^{0}C), on fuel consumption;
7) Comparative study by statistical methods of the suggested models in order to identify the significantly statistical solutions, as well as to identify the limits regarding their practical application;

2.2.3 Contributions with industrial applicability

The complexity of the experimental researches, their permanent integration into the industrial field, the direct relationship with production systems have determined that an important part of the experimental and theoretical research results could be transfered in practical applications of a company specialised in temperature-controlled special transport.
Below some of these results are mentioned, as follows:

1) development of new mathematical solutions in order to predict the influences of load (t), average speed Vm (km/h) on a distance of 100km and transport temperature (^{0}C), on fuel consumption C (l);
2) development of own simplified models for predicting the influences of the load(t), on fuel consumption C (l);
3) development of an original ready to use set of original conclusions, statistically verified, which may be integrated into a best practices guide to optimise the activitiy of temperature-controlled special transport;
4) development of an innovative and effective method to determine the fuel consumption according to the load with an acceptable level of accuracy (correlation above 70%);
5) development of an innovative method to compare and identify optimisation opportunities in temperature-controlled special transport

3. CONCLUSIONS AND PERSPECTIVES OF THE RESEARCH

3.1 Conclusions

This research has as its starting point the current limitation on energetic resources, the need to focus on renewable energies, so that the development of road transport corresponds to environmental laws and follows policy of a sustainable development, as well as the sharp increase in requests for special transport, especially of refrigerated products or the transportation under frozen conditions.

This doctoral thesis has focused on improving the level of knowledge of the functional processes of special transport (road component), in the case of logistics activity, approached as a component of the industrial production processes, so that the personnel involved in developing the projects and industrial production processes, can clearly understand the specific production conditions of special road transport, where modern technology is being used (through integration of intelligent systems), gets to know the secondary obtained products and has information regarding the costs and its effects on the environment.

The paper proposed and carried out a study of transport activities- component of the logistics of industrial production processes- for various routes and products, transported under different environmental conditions, so that it can be observed, for the most important stages, the influence of the main factors on the entire process.

In the first part was conducted an analysis of the actual stage of the place and role of special transport in the logistics of production processes and of the methods for fully utilizing and analyzing the technological processes involved in the special transport operations integrated in the logistics of production processes by approaching the special transport system as a subsystem, logistic-related, integrated in the production process. The integrated transportation system is being enhanced through various technologies (general presentation) and afterwards a personalized critical analysis of the main technologies and systems is made.

The second part has focused on studing the influence of external factors on the functional characteristics of the used equipments in special transport, by using the resources and the infrastructure of an economic agent from Germany (ADE.KÜHLTRANSPORTE), afterwards identifing the influence factors and the functional properties of equipments, presenting the handling conditions and transport conditions, correlating the influence factors with functional characteristics, analysing the factors that influence the equipments of means of special transport and setting target itineraries for the experiments that analyse the factors that influence the equipment of the means of special transport, watching the variation of parameters during the processes of loading unloading, namely during travel on 50 itineraries.

In the third part an analysis by statistical methods of the results was done, following the statistically significant differences in the variable distribution of the data due to additional road conditions, determined by the characteristics of the road (national road or highway), differences in the weight of the trailer load, as well as those related to the specific nature of the goods (for instance: type of chocolate, nature and condition of the meat etc.)

At the end of this part, the results of statistical analysis for the obtained experimental data were interpreted by evaluating their impact and significance as well as practical use through the generalization of the results obtained.

The research performed in this thesis involved significant material resources and time consumption in order to perform the experiments, the interpretations and the statistical and mathematical modeling which allow drawing conclusions from the obtained results.

A part of them are cited below:

- Through an integrated analysis of the concepts of special transport and logistics, approached as integrated elements of the production system, the functions of the specialized transportation system, as well as the processes and factors influencing the optimization of production systems, were identified;

- The main special transport systems and elements of sustainable logistics were analyzed, in order to identify their initial optimization criteria, as well as the selected influence factors for further experiments, with a focus on temperature-controlled transport;

- An individual constructive analysis of specific temperature-controlled equipments was performed, as well as their particularities and critical elements in the production process in order to correlate the information with the equipment used during the research process;

- The solutions for improving the thermal insulation of the specific equipments were analyzed, for Schmitz Cargobull company in the case of insulation panels manufactured using our own technology - FERROPLAST Tehnologia Thermo;

- The solutions for increasing the interoperability were analyzed, concluding the discussion on towing equipment, including steep ramps and vehicles parked close to the edge, but also on the possibilities of attaching the refrigerated trailer to railcars an driver/sea vessels, due to its sturdy clamping edges and corrosion-resistant stainless steel plates, which make the loading on trains safe and a foldable guard that adjusts to the shape of the car when it is loaded into the train;

- Through a constructive, functional and economic analysis of the main characteristics of transport systems, including trailer's informational system which can constantly observe the tires pressure, the brake pad assistant and the immobilizer etc. the vechicle safety, the transport and goods conditions are ensured;

- From the structural and functional analysis of the transport network resulted the decisive role of infrastructure, an essential component of special transport integrated in logistics process, mainly that of road infrastructure, highlighting the transportation network that supports all necessary travel, according to the requests, independent of the object being transported, but also the benefits of an intelligent transport system (ITS), an advanced application an advanced application designed to provide services for various modes of transportation and traffic management, because the bigger the complexity of road networks and heavier traffic are, the more information displayed on billboards, special display boards and signs;

- An important conclusion regarding ITS is the fact that in the costs of implementing an intelligent transport system, distributing and collecting the data represents, generally speaking, the main cost; given the fact that the processing of data is done by software, it has a smaller cost in comparison to the hardware;

- The main conclusion of the documentary study ist that the main objective of the thesis is justified: evaluation of the influence of external factors on the characteristics of refrigerated/frozen transport equipment, under temperature-controlled conditions for food products, which vary according to different conditions;

- Given the fact that the period with the biggest temperature differences between the inside of the trailer and the outside environment is represented by summer months, the analysis took into consideration monitoring for the months of june, july and august;

- This research has examined the statistical significant differences in the variable distribution of data due to additional traffic conditions due to road properties (national road or highway), load weight differences from the trailer, as well as those related to the specific nature of the load (for instance: type of chocolate, nature and condition of the meat etc.);

- The obtained results have shown that it exists a model obtained by mutiple liniar regression, that can describe the two-factors dependence of fuel consumption on the load of the trailer and the avearage speed of the tractor head with a resolution better than 80.3814%, model which can be simplified, because the P-value of average speed is 0.0821, bigger than 0.05, which means that the variable is not in a statistical significant relationship for a confidence level of 95%, in other words in the considered model the average speed variable Vm can be replaced;

- The results of a variational analysis of the three data sets (consumption, load and average speed, Vm) in the study of the influence of the load and average speed on fuel consumption for frozen meat transport demonstrate that a statistical significant difference exists between the three series of variables at a confidence level of 95.0%, that means that in the case of frozen meat transport at a temperature of -20C, for sunny conditions, with no steep slopes (less than 2%), and no significant wind, under relatively light traffic conditions, given the level of equipment on the tractor unit with the intelligent systems described above, the most suitable model is the one obtained by multiple liniar regression, which can describe the two-factor dependence of fuel consumption on trailer load and average speed of the tractor head;

- The study of the influence of the load and average speed on fuel consumption during chocolate transport shows that there is a statistical significant difference between the means of the three series of variables at a confidence level of 95.0% and that it exists a model obtained through multiple liniar regression that can describe the two-factors dependece of fuel consumption on trailer load and average speed of the tractor head, the relationship being explicit for 81.2393 % of the variables;

- After the study of the influence of the load, average speed and transport temperature on fuel consumption it has been concluded that there is a model obtained by mutiple liniar regression that can describe the three-factor dependence of fuel consumption on trailer load, average speed of tractor head and the temperature maintained inside the transport unit for a confidence level of 95.0%, valid for 57.4654% of variables;

- At the end of the experimental research it was concluded that the models and proposed method allow the detection of some exceptional situations where for an itinerary, significant disturbing factors existed, requiring a closer examination of the history of this experiment, and the existence of slope portions on the route significantly influences fuel consumption; but, for the present experiment we do not posses enough data in order to draw a statistically relevant conclusion;

- Based on the conclusions and final observations it was also stated that it is need a detailed study on the influence of the level of congestion on fuel consumption, but also that the simplified polynomial type 1 model, best suits the condition for representing the dependency C=f(Î), for 67,1% of the experimental values;

- The practical interpretation of the single-variables polynomial models shows that the influence of other disturbing factors (weather conditions, transport temperature, slopes/ramps along the routes and sometimes even traffic jams) attenuated as the load increased, even fuel consumption decreases were registered in the case of loads above 20t.

The paper generates a series of theoretical and experimental personal contributions, with practical applications, based on a documentary study, numerous experiments, and statistical-mathematical modeling supported by specialized software.

3.2 The perspectives of the research

As a result of this theoretical, experimental and applicative research, and based on the experience gained, the following main areas of study have been identified:

- expansion of experimental researches through a detailed study on the influence of the congestion level from the road infrastructure on fuel consumption;
- conducting additional statistical- mathematical analysis by polynomial regression for a simplifed model C= f(I), because in the study of mutiple dependence by simplifing with section C= f(I), the graph of the forecasted values can be generated;
-

- correlation of the functional performance of transport systems with other special conditions on the route by perfoming special experiments for this conditions (the presence of slopes along a route etc.);
- Expanding the experimental researches by analyzing the influence of driving style, real conditions, real-world psychosocial factors etc. in order to increase the safety, efficiency and performance control of the proposed system
- Development of a digital tool for estimating and even predicting fuel consumption in various models and travel conditions (consumption simulators).

BIBLIOGRAPHY

[1] Tudor, E., Lontis, S. N., Tutunaru, E. N., Țucu, D., (2025). Evaluation of remote sensing technologies for measuring the accumulated precipitation, 50th Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 2025.
[2] Neuner, J., (2000). Sisteme de poziționare Globală, Editura Matrix Rom, Bucuresti, ISBN 973-685-180-X.
[3] Bota, C., Caruntu, B., Tucu, D., Lapadat, M., Pasca, M.S. (2020). A Least Squares Differential Quadrature Method for a Class of Nonlinear Partial Differential Equations of Fractional Order. In: Mathematics, 8(8). DOI10.3390/math8081336
[4] Artés, F., LiDAR and Digital Imaging. Multi-Sensor Technology for a Streamlined Digital, Environment, Applanix Corporation
[5] Raicu, Ș., Popa, M., Mocuţa, G. E., Burciu, Ş. (2011). Logistica Transporturilor, Editura Academiei Oamenilor de Ştiinţă din România, Bucureşti 2011, ISBN 978-606-8371-29-0
[6] Bălan, C. (2017). *Logistica transporturilor şi distribuţiei*. Editura Universitară, București.
[7] Rushton, A., Croucher, P., Baker, P. (2017). *The Handbook of Logistics and Distribution Management*. Kogan Page, London.
[8] Vasiliu, C., Felea, M., Maruntelu, I., Gheorghe Caraiani, G. (2008). Logistica si distributia marfurilor. ISBN: 978-606-505-148-5.
[9] Vasile, D. & Georgescu, M. (2018). *Logistică și transporturi speciale*. Editura ASE, București.
[10] Regulamentul (CE) nr. 852/2004 al Parlamentului European și al Consiliului privind igiena produselor alimentare.
[11] Jünemann R. (1988). Logistische Systeme: Automation als Erfolgsfaktor. Verlag TÜV Rheinland, Köln 1988, ISBN 3-88585-548-8.
[12] –Acord referitor la transportul rutier internaţional al mărfurilor periculoase – ADR- Vol I., Vol II., 2023.
[13] ***, Regulamentul CLP (Clasificare, Etichetare, Ambalare): Regulamentul (CE) nr. 1272/2008, accesat ,10.09.2025
[14] Maiorino, A., Petruzziello, F., Aprea, C. (2021). Refrigerated Transport: State of the Art, Technical Issues, Innovations and Challenges for Sustainability. Energies, 14, 7237. https://doi.org/10.3390/en14217237.
[15] Mota-Babiloni, A., Barbosa, J.R., Makhnatch, P., Lozano, J.A. (2020). Assessment of the Utilization of Equivalent Warming Impact Metrics in Refrigeration, Air Conditioning and Heat Pump Systems. Renew. Sustain. Energy Rev., 129, 109929.
[16] Fabris, F., Fabrizio, M., Marinetti, S., Rossetti, A., Minetto, S. (2024). Evaluation of the carbon footprint of HFC and natural refrigerant transport refrigeration units from a life-cycle perspective. International Journal of Refrigeration, 159, 17–27.
[17] Mercier, S., Villeneuve, S., Mondor, M., Uysal, I. (2017). Time–Temperature Management Along the Food Cold Chain: A Review of Recent Developments. Compr. Rev. Food Sci. Food Saf., 16, 647–667.
[18] Selvnes, H., Allouche, Y., Manescu, R.I., Hafner, A. (2021). Review on Cold Thermal Energy Storage Applied to Refrigeration Systems Using Phase Change Materials. Therm. Sci. Eng. Prog., 22, 100807.
[19] Awad, M., Ndiaye, M., Osman, A. (2020). Vehicle Routing in Cold Food Supply Chain Logistics: A Literature Review. Int. J. Logist. Manag., 32, 592–617.
[20] Minetto, S., Fabris, F., Marinetti, S., Rossetti, A. (2023). Towards sustainability of road refrigerated transport in the food chain. 26th International Congress of Refrigeration, 21-25 August, Paris, France. https://doi.org/10.18462/iir.icr.2023. 1156.
[21]Dima D., Pamfilie R., Procopie R., 2001, Mărfurile alimentare în comerțul internațional. Editura Economică, Bucureşti
[22]Aberle, G. (2003) Freight Transport and Logistical Imperatives for the Modal Split. 50 Years of Transport Research: 50 Years of Transport ResearchExperience Gained and Major Challenges Ahead, 333-353
[23] Mihăilescu, R. (2020). *Managementul lanțului frigorific în industria alimentară*. Editura Agroprint, Timișoara.

[24] FAO & WHO – *Codex Alimentarius – Recommended International Code of Practice for the Transport and Storage of Food Products under Refrigeration*.
[25] Dincer, I., & Kanoglu, M. (2020). *Refrigeration Systems and Applications*. Wiley.
[26] Popescu, I. (2016). *Tehnologii moderne în transportul rutier de mărfuri perisabile*. Editura Universitară, București.
[27] Vasile, V., & Voicu, M. C. (2018). *Impactul tehnologiilor de transport frigorific asupra lanțului logistic al produselor alimentare perisabile*. Revista Română de Transporturi și Logistică, 3(2), 15–24.
[28] Sorescu, L. (2021). *Sisteme frigorifice în transportul auto*. Editura MatrixRom, București.
[29] Arhivă personală realizată pe durata cercetării Tudor Eugen
[30] ***. https://frigobody.ro/furgon-izoterm/ accesat 19.08.2025
[31] ***. Refrigerated Trailer Rental | Petit Forestier accesat 19.08.2025
[32] ***. Refrigerated Trailer Rental | Petit Forestier accesat 19.08.2025
[33] ***. Refrigerated vehicles 820 kg | Petit Forestier accesat 19.08.2025
[34] ***. Refrigerated vehicles 7,100 kg | Petit Forestier accesat 19.08.2025
[34] ***. Refrigerated vehicles 780 kg | Petit Forestier accesat 19.08.2025
[36] ***. Petit Forestier présente un triporteur électrique accesat 19.08.2025
[37] ***. Refrigerated vehicles 14,000 kg | Petit Forestier accesat 19.08.2025
[38] ***. 150 Schmitz Cargobull S KO COOL Executive - Schmitz Cargobull accesat 19.08.2025
[39] ***. dsc_1801_production_sko-cool.jpg (6048×4024) accesat 19.08.2025
[40] ***. production_scu_production-line_.jpg (4024×6048) accesat 19.08.2025
[41] ***. dsc_1727_production_side-wall.jpg (6048×4024) accesat 19.08.2025
[42] ***. production_scu_production-line_.jpg (4024×6048)accesat 19.08.2025
[43] ***. Schmitz Cargobull – Refrigerated semitrailer – SKO 24/L-13.4 FP COOL V7 – LET WEB SMEs accesat 19.08.2025
[44] Broșură Semiremorcă Schmitz Cargobull SCU accesat 19.08.2025
[45] ***. SmartTrailer accesat 19.08.2025
[46] ***. Refrigerated semi-trailers accesat 19.08.2025
[47] ***. Hegelmann transporte, UAB. Contacts, map. Rekvizitai.lt accesat 19.08.2025
[48] ***.Tratatul de la Maastricht, https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:11992M/TXT&from=EN, accesat 10.09.2025
[49] Banciu, D., s.a. (2003). Sisteme inteligente de transport, Editura Tehnică, Bucureşti

[50] ***. Directiva 2010/40/UE, http://data.europa.eu/eli/dir/2010/40/oj, accesat 10.09.2025
[51] Merchant, D. K., Nemhauser, G. L., (1976). A model and an algorithm for the dynamic traffic assignment problem.In Traffic Equilibrium Methods; Springer: Berlin, Germany, 1976; pp. 265–273.
[52] ***. https://tirmagazin.ro/vehicule-comerciale/video-schmitz-cargobull-smart-trailer-days-eficienta-durabila-si-conexiuni-digitalizate accesat 28.08.2025
[53] ***. S.KO COOL SMART EXECUTIVE PLUS accesat 28.08.2025
[54] Wu, L., Liu, S., Liu, D., Fang, Z., Xu, H. (2015) Modelling and forecasting CO2 emissions in the BRICS (Brazil, Russia, India, China, and South Africa) countries using a novel multi-variable grey model. Energy, 79, 489–95.
[55] Karakurt, I., Aydin, G. (2023). Development of regression models to forecast the CO2 emissions from fossil fuels in the BRICS and MINT countries. Energy, 263. 125650. https://doi.org/10.1016/j.energy.2022.125650.
[56] International Institute of Refrigeration (IIR). (2021). 7th informatory note on refrigeration and food. The Carbon Footprint of the Cold Chain. https://doi.org/10.18462/iir.INfood07.04.2021.
[57] Tucu, A., Purcarea, A.A., Crisan, G.C., Vasilica, A., Tucu, D. (2021). Quality evaluation of occupational health & safety (OHS) risk management systems from agriculture. In Book Series: Actual Tasks on Agricultural Engineering-Zagreb, vol.48, 527-534.
[58] Tucu, D., Golimba, A.G., Mnerie, D. (2010). Grippers design integrated in handling systems destinated to agriculture mechanization. Actual Tasks on Agricultural Engineering-Zagreb 38, 447-454.
[59] International Institute of Refrigeration (IIR). (2021). 7th informatory note on refrigeration and food. The Carbon Footprint of the Cold Chain. https://doi.org/10.18462/iir.INfood07.04.2021.
[60] Tudor, E. (2018). Aspecte ale activității ADE.KUHLTRANSPORT, Lucrare de dizertație, Facultatea de Mecanică, UPTimișoara, 2018.
[61] ***. SmartTrailer accesat 28.08.2025

[62] ATP - Acord privind transporturile internaționale de produse perisabile și echipamentele speciale utilizate pentru aceste transporturi – actualizat (Geneva, 1970, cu amendamente ulterioare).
[63] ISO 1496-2:2018 – *Container equipment – Reefer containers – Specification and testing*.

[64] Ministerul Transporturilor din România – Ghid privind omologarea echipamentelor frigorifice pentru transport rutier.
[65] European Commission – *Cold Chain Management in Food Logistics*, Raport tehnic, 2022.
[66] Kuranovič, V., Ustinovichius, L., Nowak, M., Bazaras, D., Sokolovskij, E. (2025), Improving the Freight Transportation System in the Context of the Country's Economic Development – *Sustainability* Un articol nou care discută cum sistemul de transport de mărfuri poate fi îmbunătățit în contextul dezvoltării economice a unei țări. MDPI
[67] Intermodal Transportation Challenges in Eastern Europe: Case Study of Romania, (2024) Studiu de caz important pentru România, care examinează provocările transportului intermodal, terminale, apă interioară etc. Paradigm+1
[68] Cristea, A. (2016). *Transporturi rutiere. Teorie și practică*. Editura MatrixRom, București.
[69] Hîncu, D. (2019). *Sisteme logistice integrate în transporturi*. Editura ASE, București.
[70] McKinnon, A. C., Browne, M., Whiteing, A., & Piecyk, M. (2015). *Green Logistics: Improving the Environmental Sustainability of Logistics*. Kogan Page.
[71] Stroe, A. (2015). *Instalații frigorifice și climatizare pentru transportul rutier de mărfuri*. Editura AGIR, București.
[72] ASHRAE (2021). *ASHRAE Handbook – Refrigeration*. American Society of Heating, Refrigerating and Air-Conditioning Engineers.
[73] Arora, C. P. (2016). *Refrigeration and Air Conditioning*. Tata McGraw-Hill.
[74] European Committee for Standardization (CEN). (2020). *EN 12830: Temperature recorders for transport, storage and distribution of temperature sensitive goods*.
[75] Codul internațional pentru transportul alimentelor perisabile – FAO/WHO Codex Alimentarius.
[76] ISO 22000:2018 – *Food Safety Management Systems – Requirements for any organization in the food chain*.
[77] James, S. J., & James, C. (2014). *The food cold-chain and climate change*. Food Research International, 57, 91–98.
[78] Jedermann, R., Nicometo, M., Uysal, I., & Lang, W. (2014). *Reducing food losses by intelligent food logistics*. Philosophical Transactions of the Royal Society A, 372(2017).
[79] Zhang, Y., et al. (2020). *Optimization of refrigerated transport systems using IoT-based monitoring*. *International Journal of Refrigeration*, 118, 132–145.
[80] Barlow, T.J., Latham, S., McCrae, I.S., and Boulter, P.G. (2009).A reference book of driving cycles for use in the measurement of road vehicles emission.
PPR354, (2009) TRL, Crowthorne UK
[81] Barth, M., Feng, An., Younglove, T., Scora, G., Levine, C., Ross, M., and Wenzel, T. (2000) Development of a
Comprehensive Modal Emissions Model. NCHRP Web-only document 122.
[82] Brundell-Freij, K., Ericsson, E., (2005). Influence of street characteristics, driver category and car performance on urban driving patterns.
Transportation Research Part D: Transport and Environment 10 (2005) 213–229.
[83] Chamberlin, R., Swanson, B., Talbot, E., Dumont, J., Pesci, S, (2011). Analysis of MOVES and CMEM for evaluating the emissions impact of an
intersection control change. In: 90th Transportation Research Board Annual Meeting, #11-0673 (2011), Washington, D.C.
[84] Frey, H, C, N.M. Rouphai and H. Zhai, (1987). Speed- and Facility-Specific Emission Estimates for On-Road Light-Duty Vehicles on the Basis of Real-
World Speed Profiles. Transportation Research Record: Journal of the Transportation Research Board, No. 1987, Transportation Research
Board of the National Academies, Washington, D.C., 2006, pp. 128–137
[85] HCM, Highway Capacity Manual (2010) Transport Research Board Washington D.C.
[86] Hirschmann,K., M. Fellendorf A,(2010). Toolbox to quantify emission reductions due to signal control. 89nd Annual Meeting TRB, (2010) Washington
DC.
[87] Jimenez-Palacios, J.L, (1999). Understanding and Quantifying Motor Vehicle Emissions with Vehicle Specific Power and TILDAS Remote Sensing, PhD
Dissertation (1999) MIT
[88] Joumard, R, Jost P., Hickman, J., Hassel, D, (1995). Hot passenger car emissions modelling as a function of instantaneous speed and acceleration.
Science of The Total Environment, Volume 169, Issues 1–3, 8 July 1995, Pages 167-174
[89] Li, J., Van Zuylen, H.J., Chen, Y., Viti, F., Wilmink, I,(2013). Calibration of a Microscopic Simulation Model for Emission Calculation, Transportation
Research Part C, Vol.31, 2013, pp. 172–184
[90] Li, J., H.J. van Zuylen, X, (2015). Xu Driver type categorization and Microscopic Simulation Model Calibration. Transportation Research Record:

Journal of the Transportation Research Board, No. 2491, Transportation Research Board of the National Academies, Washington, D.C., 2015,
pp. 53–60.
[91] Nam, E.K., Gierczak, C.A., Butler, J.W, (2003). A comparison of real-world and modeled emissions under conditions of variable driver aggressiveness.
82nd Annual Meeting of the Transportation Research Board, (2003) Washington, DC
[92] Robertson, D. I., (1969). TRANSYT, a traffic network study tool. Ministry of Transport, Crowthorne, U.K., 1969 RRL Report LR253.
[93] Scora, G., Barth, M, (2006). Comprehensive modal emissions model (CMEM) user's guide (version 3.01).
http://cmscert.engr.ucr.edu/cmem/docs/CMEM_User_Guide_v3.01d.pdf
[94] Shabihkhani, R, and Gonzales, E.J, (2013). Analytical Model for Vehicle Emissions at a Signalized Intersection: Integrating Traffic and Microscopic
Emissions Models, 92nd Annual Meeting TRB, 2013 Washington DC.
[95] Smit R, Smokers R and Schoen E, (2005). VERSIT+ LD: Development of a new emission factor model for passenger cars linking real-world emissions to driving cycle characteristics, Proceedings of the 14th Symposium Transport and Air Pollution, Vol. 1, 1-3 June 2005, Graz, Austria, ISBN 3, 902465 16 6, pp.177-186.
[96] Song, G., L. Yu, Z. Geng, (2015). Optimization of Wiedemann and Fritzsche car-following models for emission estimation. Transportation Research Part
D 34 (2015) 318–329
[97] Traffic Management Bureau of the Ministry of Public Security. The total number of motor vehicles reached 233 million and the total number of
licensed drivers reached 247 million. [http://www.mps.gov.c/n16/n1282/u3553/3413423. html], accessed August 2013
[98] U.S. Environmental Protection Agency. User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source EmissionFactor Model. U.S.
Environmental Protection Agency, Aug. 2003, pp. 9–22.
[99] Uhlik, K., *et al*., (2012). Elaboration of a Program to Facilitate the Implementation of the directive 2009/33/ec
on the Promotion of Clean and Energy-Efficient Road Motor Vehicles, *International Journal for Traffic and Transport Engineering, 2*, (2012), 3, pp. 170-177
[100] Medar, O.M., *et al*., (2014). Assessing the Impact of Transport Policy Instruments on Road Haulage Energy Efficiency, *Thermal Science, 18*, (2014), 1, pp. 323-337
[101] Wang-Helmreich H., Lochner, S, (2012). The potential of natural gas as a bridging technology in low- emission road transportation in Germany, *Thermal Science, 16*, (2012), 3, pp. 729-746
[102] Alam, A., Hatzopoulou, M., (2014). Reducing transit bus emissions: Alternative fuels or traffic operations?, *Atmospheric Environment, 89*, (2014), pp. 129-139
[103] ***, Technical Assessment of Advanced Transit Bus Propulsion Systems for Dallas Area Rapid Transit, 2002, Battelle, Columbus OH, USA
[104] Chandler, K., Walkowicz, K.,(2006). King County Metro Transit Hybrid Articulated Buses: Final Evaluation Results, Technical Report NREL/TP-540-40585, National Renewable Energy Laboratory, Golden CO, USA, 2006
[105] De Almeida d'Agosto, M., Ribeiro, S.K., (2004). Performance evaluation of hybrid-drive buses and potential fuel savings in Brazilian urban transit, *Transportation, 31*, (2004), pp. 479-496.
[106] Barnitt, R., Chandler, K., (2006). New York City Transit (NYCT) Hybrid (125 Order) and CNG Transit Buses. Final Evaluation Results, Technical Report NREL/TP-540-40125, National Renewable Energy Laboratory, Golden CO, USA, 2006
[107] Chandler, K., *et al*., (2006). Washington Metropolitan Area Transit Authority: Compressed Natural Gas Transit Bus Evaluation, Technical Report NREL/TP-540-37626, National Renewable Energy Laboratory, Golden CO, USA, 2006
[108] Pelkmans, L., *et al.*, (2001). Influence of vehicle test cycle characteristics on fuel consumption and emissions of city buses, SAE Technical Paper Series 2001-01-2002, Society of Automotive Engineers, Warrendale PA, USA, 2001
[109] Frey, H.C., *et al*., (2007). Comparing real-world fuel consumption for diesel- and hydrogen-fueled transit buses and implication for emissions, *Transportation Research Part D, 12*, (2007), pp. 281-291
[110] Wang, A., *et al*., (2011). On-road pollutant emission and fuel consumption characteristics of buses in Beijing, *Journal of Environmental Sciences, 23*, (2011) 3, pp. 419-426
[111] Zhang, S., *et al*., (2014). Real-world fuel consumption and CO2 emissions of urban public buses in Beijing, *Applied Energy, 113*, (2014), pp. 1645-1655
[112] Ma, H., *et al*., (2015). Effects of driving style on the fuel consumption of city buses under different road conditions and vehicle masses, *Transportation Research Part D, 41*, (2015), pp. 205-216

[113] Stefanovi´c N., Miliji´c S., Hristi´c ND., (2020). System approach in process of planning and project documentation preparation for highway corridors as an instrument for establishing the Trans-European Transport Network. Transp Res Procedia 2020;45 (2019):491–8. https://doi.org/10.1016/j.trpro.2020.03.043.

[114] Tudor, E., Lontis, S. N., Tutunaru, E. N., Țucu, D., (2025). Evaluation of remote sensing technologies for measuring the accumulated precipitation, 50th Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 2025.

[115] Kazomir, E. C., Tudor, E., Tutunaru, E. N., Țucu, A., Țucu, D., (2025). A comparative analysis of domestic biomass combustion systems, 50th Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 2025.

[116] Farzaneh, R., Johnson, J., Jaikumar, R., Ramani, T., Zietsman, J., (2020). Use of Vehicle Telematics Data to Characterize Drayage Heavy-Duty Truck Idling. Transp Res Rec 2020;2674(11):542–53. https://doi.org/10.1177/0361198120945990.

[117] ***. Regulamentul (UE) nr. 1169/2011 al Parlamentului European și al Consiliului din 25 octombrie 2011 privind informarea consumatorilor cu privire la produsele alimentare, accesat 10.09.2025

[103] ***, Technical Assessment of Advanced Transit Bus Propulsion Systems for Dallas Area Rapid Transit, 2002, Battelle, Columbus OH, USA

[104] Chandler, K., Walkowicz, K.,(2006). King County Metro Transit Hybrid Articulated Buses: Final Evaluation Results, Technical Report NREL/TP-540-40585, National Renewable Energy Laboratory, Golden CO, USA, 2006

[105] De Almeida d'Agosto, M., Ribeiro, S.K., (2004). Performance evaluation of hybrid-drive buses and potential fuel savings in Brazilian urban transit, *Transportation, 31*, (2004), pp. 479-496.

[106] Barnitt, R., Chandler, K., (2006). New York City Transit (NYCT) Hybrid (125 Order) and CNG Transit Buses. Final Evaluation Results, Technical Report NREL/TP-540-40125, National Renewable Energy Laboratory, Golden CO, USA, 2006

[107] Chandler, K., *et al*., (2006). Washington Metropolitan Area Transit Authority: Compressed Natural Gas Transit Bus Evaluation, Technical Report NREL/TP-540-37626, National Renewable Energy Laboratory, Golden CO, USA, 2006

[108] Pelkmans, L., *et al.*, (2001). Influence of vehicle test cycle characteristics on fuel consumption and emissions of city buses, SAE Technical Paper Series 2001-01-2002, Society of Automotive Engineers, Warrendale PA, USA, 2001

[109] Frey, H.C., *et al*., (2007). Comparing real-world fuel consumption for diesel- and hydrogen-fueled transit buses and implication for emissions, *Transportation Research Part D, 12*, (2007), pp. 281-291

[110] Wang, A., *et al*., (2011). On-road pollutant emission and fuel consumption characteristics of buses in Beijing, *Journal of Environmental Sciences, 23*, (2011) 3, pp. 419-426

[111] Zhang, S., *et al*., (2014). Real-world fuel consumption and CO2 emissions of urban public buses in Beijing, *Applied Energy, 113*, (2014), pp. 1645-1655

[112] Ma, H., *et al*., (2015). Effects of driving style on the fuel consumption of city buses under different road conditions and vehicle masses, *Transportation Research Part D, 41*, (2015), pp. 205-216

[113] Stefanovi´c N., Miliji´c S., Hristi´c ND., (2020). System approach in process of planning and project documentation preparation for highway corridors as an instrument for establishing the Trans-European Transport Network. Transp Res Procedia 2020;45 (2019):491–8. https://doi.org/10.1016/j.trpro.2020.03.043.

[114] Tudor, E., Lontis, S. N., Tutunaru, E. N., Țucu, D., (2025). Evaluation of remote sensing technologies for measuring the accumulated precipitation, 50th Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 2025.

[115] Kazomir, E. C., Tudor, E., Tutunaru, E. N., Țucu, A., Țucu, D., (2025). A comparative analysis of domestic biomass combustion systems, 50th Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia, 2025.

[116] Farzaneh, R., Johnson, J., Jaikumar, R., Ramani, T., Zietsman, J., (2020). Use of Vehicle Telematics Data to Characterize Drayage Heavy-Duty Truck Idling. Transp Res Rec 2020;2674(11):542–53. https://doi.org/10.1177/0361198120945990.

[117] ***. Regulamentul (UE) nr. 1169/2011 al Parlamentului European și al Consiliului din 25 octombrie 2011 privind informarea consumatorilor cu privire la produsele alimentare, accesat 10.09.2025

[118] ***. Regulamentul (CE) nr. 178/2002 al Parlamentului European și al Consiliului din 28 ianuarie 2002 de stabilire a principiilor și a cerințelor generale ale legislației alimentare, de instituire a Autorității Europene pentru Siguranța Alimentară și de stabilire a procedurilor în domeniul siguranței produselor alimentare ;accesat 10.09.2025

[119] ***. Regulamentul (CE) nr. 852/2004 al Parlamentului European și al Consiliului din 29 aprilie 2004 privind igiena produselor alimentare;accesat 10.09.2025

[120] ***. Regulamentul (CE) nr. 1333/2008 al Parlamentului European și al Consiliului din 16 decembrie 2008 privind aditivii alimentari (Text cu relevanță pentru SEE);accesat 10.08.2025
[121] ***. Regulamentul (CE) nr. 178/2002 al Parlamentului European și al Consiliului din 28 ianuarie 2002 de stabilire a principiilor și a cerințelor generale ale legislației alimentare, de instituire a Autorității Europene pentru Siguranța Alimentară și de stabilire a procedurilor în domeniul siguranței produselor alimentare.accesat 10.08.2025
[122] Merchant, D. K., Nemhauser, G. L., (1976). A model and an algorithm for the dynamic traffic assignment problem.In Traffic Equilibrium Methods; Springer: Berlin, Germany, 1976; pp. 265–273.
[123] Yagil, D., (1998). Gender and age-related differences in attitudes toward traffic laws and traffc violations. Transp. Res.Part F Traffic Psychol. Behav. 1998, 1, 123–135. [CrossRef]
[124] Panafieu, B., (1994). Les essais de recepteurs GPS; L'onde Electrique, ian.- febr. 1994, pp. 3-8 2.
[125] ***, Recepteurs GPS; Le Haut-Parleur; aug. 1993; pp. 28-31.
[126] Li, S.E., Peng, H., (2012). Strategies to minimize the fuel consumption of passenger cars during car-followingscenarios. Proc. Inst. Mech. Eng. Part D J. Automob. Eng. 2012, 226, 419–429. [CrossRef]
[127] Haworth, N., Symmons, M., (2018). Driving To Reduce Fuel Consumption And ImproveRoad Safety. Monash UniversityAccident Research Centre. Available online:http://acrs.org.au/files/arsrpe/RS010036.pdf (accessed on3 March 2018).
[128] Alam, M.S., McNabola, A., (2014). A critical review and assessment of Eco-Driving policy& technology: Benefits &limitations. Transp. Policy 2014, 35, 42–49.
[129] Wills, A, R., Watson, B., Biggs, H, C., (2006). Comparing safety climate factors aspredictors of work-related drivingbehavior. J. Saf. Res. 2006, 37, 375–383.[CrossRef] [PubMed]
[130] Carrese, S., Gemma, A., La Spada, S., (2013). Impacts of Driving Behaviours, Slope and Vehicle Load Factor on Bus Fuel Consumption and Emissions: A Real Case Study in the City of Rome. Procedia-Soc. Behav. Sci. 2013, 87,211–221. [CrossRef]
[131] Shafaghat, A., Keyvanfar, A., Manteghi, G., Lamit, H., (2016). Environmental-conscious factors affecting street microclimate and individuals' respiratory health in tropical coastal cities. Sustain. Cities Soc. 2016, 21, 35–50.
[CrossRef]
[132] Sun, L., Karwan, M. H., Kwon, C., (2016). Incorporating driver behaviors in network design problems: Challenges and opportunities. Transp. Rev. 2016, 36, 454–478. [CrossRef]
[133] Wåhlberg, A. E., (2002). Fuel efficient driving training—state of the art and quantification of effects. E141 Proceedings of Soric'02.
[134] Wåhlberg, A.E., (2007). Long-term effects of training in economical driving: fuel consumption, accidents, driver acceleration behavior and technical
feedback. Int. J. Ind. Ergon. 37 (4), 333–343.
[135] Ang, B.W., (1991). Statistical evaluation of fuel consumption of buses with specific operational changes. Energy 16 (10), 1225–1230.
[136] Ang, B.W., Deng, C. C., (1990). The effects of maintenance on the fuel efficiency of public buses. Energy 15 (12), 1099–1105.
[137] Ang, B.W., Fwa, T.F., (1989). A study on the fuel-consumption characteristics of public buses. Energy 14 (12), 797–803.
[138] Ang, B.W., Fwa, T.F., Poh, C.K., (1991). A statistical analysis of the fuel efficiencies of public buses. Energy 16 (5), 823–831.
[139] Beusen, B., Broekx, S., Denys T., Beckx, C., Degraeuwe, B., Gijsbers, M., Scheepers, K., Govaerts, L., Torfs, R., Panis, L.I., (2009). Using on-board logging devices tostudy the longer-term impact of an eco-driving course. Transport. Res. Part D: Transp. Environ. 14 (7), 514–520.
[140] Clark, N.N., Vora, K.A., Wang, L., Gautam, M., Scott Wayne, W., Thompson, G.J., (2010). Expressing cycles and their emissions on the basis of properties and
results from other cycles. Environ. Sci. Technol. 44 (15), 5986–5992.