Summary of the doctoral thesis on,

Systemic-integrated approach to road safety optimization in Timiș County

Thesis intended for obtaining
scientific title of doctor engineer
to
Polytechnic University of Timisoara
in the field of Industrial Engineering
by

Nicolae Istrat

Scientific leader: Prof.univ.dr.ing.& ec. Dumitru Țucu

Scientific references: Prof.univ.em.dr.ing. Anca-Alexandra Purcărea
                       Prof.univ.dr.ing.   Lucian-Ionel Cioca
                       Prof.univ.dr.ing.   Roland-Iosif Moraru

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Necessity and opportunity. Objectives and structure of the thesis

Road traffic is a major global problem, which is exacerbated over time, without effective accident prevention measures being taken.

According to the World Road Association, **more than 1.24 million people die each year** on the world's roads and many more suffer from illness or other permanent diseases, and between **20-50 million people are injured. (temporary), [170].**

The same source mentions, citing a 2010 study, that injuries caused by road accidents are one of the leading causes of death in children and the first (**most important) cause of death in young** people aged 15 to 29 years. In fact, they are also considered vulnerable social groups, and prevention measures must be the object of activity of most of us.

This thesis is based on the principle that death or serious injury from road accidents can be prevented if the impact energy is managed in such a way that it does not exceed the upper limit of human tolerance to avoid serious or fatal injuries.

The motivation for road safety optimization is also given by the fact that the sum of the overall costs of preventing deaths and / or serious injuries from road accidents is the equivalent of a relative value between 1 and 7% of Gross Domestic Product (GDP-GDP) worldwide.

At the same time, based on the complexity of road systems and processes, the paper aims to discover and suggest new solutions to use the synergy resulting from the involvement of other social groups (with different but competing interests and objectives) in road traffic.

The main objective of the thesis is to **increase road safety in Timiș County** through efficient solutions, transposed from industrial engineering, involving all stakeholders (designated, responsible, interested or potentially affected), in terms of integrated approach to the road traffic system.

In connection with the main objective, the thesis aimed to achieve a set of **secondary objectives**, corresponding to the resources and the approach area, as follows:

- the critical analysis of the current state of the models regarding the road traffic system starting from the classical definition, in the light of the structural conditions of principle;

- identification of the elements of the cause-effect relationship and evaluation of the level and main characteristics of the fundamental components of the road traffic system (road factor, technical factor and human factor), based on an up-to-date bibliographic study, including the flow of major scientific publications;

- evaluation of the level and main characteristics of the fundamental components of the road traffic system (road factor, technical factor and human factor), starting from the consideration of the components resulting from the bibliographic study and their completion with others, whose involvement is decisive for fulfilling the functions essential elements of the SCR (external environment, scientific and technological factor, etc.);

- evaluation of the level and main characteristics of the fundamental components-causes of the road traffic system, considering SCR as an industrial technological system, based on the hypothesis of approaching road traffic as an industrial technological process, trying to transpose specific methods;

- development of an integrated model for the Generalized Road Traffic System (SGCR), which respects the general principles of systemic construction, identifying the main variables and their relationships, in the form of a cyber system;

- Identifying the main causes of road events in Timiș County through an analysis of multiannual dynamics, in order to apply the PDCA method to obtain optimal solutions to reduce the number and consequences of road events, while reducing resources and ensuring continuous improvement of SCR;

- Hierarchy of causes by statistical-mathematical methods and establishment of functional cause-effect relationships based on statistical processing of results and analysis of the significance of influences using ANOVA;

- Elaboration of a PDCA model leading to the reduction of the number and effects of road accidents in Timiș County, based on previous results.

In order to fulfill and cover these objectives, the thesis has an extension of 164 pages, being the author's works and a bibliographic list of 208 titles, of which 45 references online.

Chapter 1 performs a conceptual analysis on the current state of the road traffic system (SCR), starting with the analysis of conceptual elements (road traffic system, fundamental components), presenting the most used models currently in Romania, based on a critical analysis, justifying -is, in part, the need and opportunity of the thesis topic, as well as the methods of approach. In the continuation of the chapter, the entries in the SCR (substantial, energetic and

informational) are analyzed, insisting on some essential components of them: the road vehicle, the road infrastructure and the human element.

Chapter 2, aims to integrate the elements of SCR identified in the bibliographic study in Chapter 1 in a Generalized Road Traffic System (SGCR), which meets a set of conditions and is a basis for optimizing the experimental research program, for identifying and determining the relationships between input, output and regulation variables, applying methods and tools used in industrial engineering. Thus, as an original theoretical contribution of the author, an integrated model for the SGCR is presented, leading to a new approach to the system, but also to the process of optimizing road safety, by generating adequate and effective measures.

The experimental part of the thesis begins with **chapter 3**, which presents the results and interpretation of experimental research on determining the influences of the components of the generalized road traffic system (SGCR) dependent on the decision of the human factor on road safety in Timiș County. After arguing the necessity and opportunity, the presentation of the research objectives and methodology, the results of the study on the ranking of 32 causes of accidents in 2009-2016 in Timiș County are presented, causes grouped on: human entry as driver, human entry as another traffic participant road, causes belonging to the substantial input and causes belonging to the information input. The output dynamics was studied based on the total number of accidents, the total number of accidents, resulting in accidental deaths, the total number of accidents resulting in minor injuries and the total number of accidents resulting in serious injuries, the data being subsequently processed statistically using Microsoft Excell and STATGRAPHICS Centurion, calculating the average values of the number of events / year from 2009-2016 (noted in the tables by the symbol Ma), for each cause proposed to be used in the experimental analysis, statistical relevance, concordance and variance. The chapter presents the results of the ranking of causes according to the annual average of accidents in the period 2009-2016, respectively by the groups considered (total traffic accidents, accidents resulting in deaths, serious injuries and minor injuries). Another essential part of the chapter and, at the same time, the original contribution, is the selection of the main factors generating traffic accidents using the Pareto analysis. The selected factors were studied in the dynamic and relational dimension by regression analysis to identify the existence of a statistically relevant trend. The same trend was studied by introducing the factor of relative influence of the total number of accidents on the number of deaths, seriously injured and slightly injured in traffic accidents, finding a decrease (approx. 50%), the number of deaths and a increase (approx. 10% and 90%, respectively) in the number of slightly injured and severely injured, respectively.

Chapter 4 continues the presentation and analysis of experimental results on determining the influences of the components of the Generalized Road Traffic System (SGCR), for components independent of the decision of the human factor on road safety in Timiș County. After presenting the need, opportunity, objectives and methodology and factors studied, are presented and analyzed the practical results on the influence of the factor "time interval of the day", the factor "day of the week", the factor "road category" , depending on the locality and on the road categories according to the official classification in national, county and communal roads) and the "age category" factor (18-25 years, 26-30 years, 31-35 years, 36-40 years , 41-45 years, 46-50 years, 51-55 years, 56-60 years), all for three types of consequences: total number of accidents, seriously injured and died in accidents. For each analysis, the regression functions were determined for the dependence relationship between factor and consequence, for the independent variable year (interval 2008-2016), verifying by ANOVA analysis the significance of the influence of factors on the consequences. The chapter concludes with a summary of the main conclusions of the analysis.

Based on the results of previous experimental research, **Chapter 5** proposes an original model taken from the industrial engineering methodology for applying the PDCA model to optimize the generalized integrated road traffic system, starting from the finding that there is a large variability in the number of accidents and effects. (minor injuries, serious injuries, deaths, property damage), also explained by the inconsistency or inadequacy of some measures to monitor and correct the SGCR.

Chapter 6 is dedicated to presenting the general conclusions and personal theoretical, experimental and applied contributions, as well as the prospects for research and improvement of the proposed solutions by approaching the generalized road traffic system as an industrial system.

Studies based on the generalized entry-exit model for the road traffic system structured on methods and models from industrial engineering, create perspectives on the development of effective methods to increase road safety and the effectiveness of measures adopted in this regard, with possibilities to develop new mechanisms, better grounded in the scientific dimension.

CONCEPTUAL ANALYSIS REGARDING THE CURRENT STATE OF THE ROAD TRAFFIC SYSTEM

1.1   Conceptual elements

Mobility has always been an important desideratum of man and, later, of human society, knowing various forms, simultaneously with the evolution of society, culture and civilization.

Starting from the classical definition of the notion of system given in DEX, "set of elements (principles, rules, forces, etc.), dependent on each other and forming an organized whole, which puts order in a field of theoretical thinking, regulates the classification of material in a field of natural sciences or makes a practical activity work according to the intended purpose ", it would result that a schematic structure of the system can be conceived, conceived by a correlation between the components of the system, the rules of relationship and transformation, objectives and the adjustment quantities (the general scheme of a systemic approach is presented in figure 1.1).

OBJECTIVES

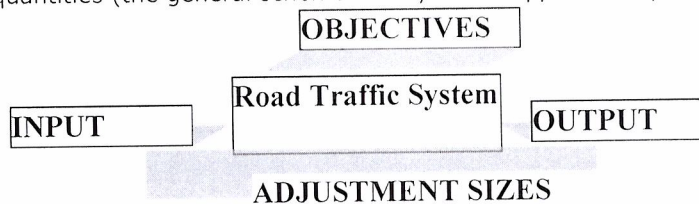INPUT   Road Traffic System   OUTPUT

ADJUSTMENT SIZES

Fig. 1.1 General scheme of a systemic approach

This approach seeks to analyze models for road traffic systems in the light of these structural conditions of principle.

According to https://sites.google.com, [171] the road traffic system includes three fundamental components:

- **the road factor** (road network), which, due to its peculiarities, is estimated to contribute 3% to the occurrence of traffic accidents;

- **the technical factor** (vehicle or motor vehicle), which, by analogy, according to statistics, contributes to the risk of road accident by 2%;

- **the human factor** (driver, man), which, analogously, according to specialized statistics, is the quasi-total part of the 95% risk of road accident.

In Romania, currently, the most used model for the road traffic system is the structural model of SCR.

The main components of SCR introduced by this model are:

1. Infrastructure is the part of the SCR consisting of the road network, a network considered, in turn, a set of other secondary networks, structured on several levels;

2. The subsystem of road legislation is the component that includes all the elements of the legal system (national and / or global), ie laws, orders, normative provisions (not only legal, but also professional), applicable in the SCR, in order to ensure the permanent functioning and, as far as possible, its performance; it is considered that the subsystem of road legislation also includes the set of training / protection / training / instruction programs, designed and implemented to ensure the fulfillment of its own objective presented above;

3. Human resources, includes all human beings actively or incidentally involved in the development of road traffic (such a definition also includes passengers and pedestrians); has a number of specific features such as:

- heterogeneous and differentiated level of professional training, in relation to a set of factors (age, quality of participant in road traffic, position occupied in the system, type of training / assimilated training, etc.);

- long age range;

- large disparity in the experience of the people involved, depending on the dynamic classification in the SCR (some drivers drive daily, others once / several times a week, others once a month or even less often;

- there is a dynamic of the biological / psychological / social characteristics of the drivers, but also of the other people involved (there is a change in these characteristics, in relation to age); hence the need to carry out training activities, in order to assimilate the current essential elements that condition traffic;

- special attention must be paid to a special category of human resources: pedestrians, because they are elements that through their activity participate in traffic directly, but also indirectly, being able to influence (positive or negative), efficiency, safety, security, integrity , perspectives and complexity; thus, any careful analysis of road traffic accidents highlights the fact that the primordiality is held by those whose cause is pedestrian indiscipline, the number of seriously injured pedestrians in traffic in a county ranges between 4 - 12% of all accidents; at the same time, the analysis of statistical data also reveals that, from one period to another, the trend is clearly increasing;

1. Executive management, includes all the activities of persons who are organized in management structures involved in the proper conduct of road traffic (for example: Traffic Police, road administrators, NGOs, specialized companies, training and education entities, etc.); their activity aims to achieve two distinct objectives: the monitoring of SCR under several integrated aspects, which can generate synthetic indicators to determine trends in the overall operation of SCR and the reorganization of activities related to all conclusions resulting from statistical data processing and information from monitoring activity; an essential difficulty for the executive management subsystem is generated by the fact that the SCR is an open system, with permanent connections with the external environment, regardless of its structure and / or characteristics and its mode of action;

2. The logistic subsystem, includes the assembly of the elements that contribute to the assurance / regulation of some important groups of functional parameters of the SCR; may include all vehicles participating in maintenance, monitoring, steering and protection activities or real-time information systems on elements of continuous traffic improvement, elements supporting the transfer to intelligent traffic, autonomous vehicle, etc .; (In view of the development of the concept of intelligent traffic, a strong development is expected for this subsystem, in correlation with the adaptation or creation of specific elements of compatibility with IT&C systems).

The key advantage of this model for SCR is **simplicity**.

On the other hand, such a model is characterized by **accessibility** and the ability to identify certain internal links, which can become very useful when a rapid optimization of the SCR is desired, approached as a particular case of industrial system. The small number of variables managed by this type of model, allows the use of classic methods, simple and fast, which can provide acceptable and easily accessible results for an immediate optimization process.

From the analysis of the present system model, however, several **disadvantages** can be concluded.

The main disadvantage is related to the total non-compliance with all the content requirements of the main systemic model, exposed in figure 1.1.

First of all, no reference is made to the objectives of the SCR, as a subsystem that generates its basic, structural, but also functional reasons.

Secondly, there is no distinct structure of inputs and outputs from the SCR, so that many confusions between independent and system-dependent variables can be made quite easily.

An important deficiency of the proposed model for SCR is given by the diminishing influence of the external environment, even its exclusion from SCR, given that it is known that it exerts a significant influence on traffic (rated with a level between 0 (appropriate good weather, acceptable temperature etc.) and 1 (blocked traffic)). Unfortunately, the current interpretations, in all statistical references, show a similar trend. For example, the influence of the external environment is included in the generic category of causes "non-adaptation of speed to traffic conditions", along with elements belonging to other subsystems (congested traffic, road conditions, logistical deficit, etc.).

The paper will attempt an analysis of components and subsystems, so that, in the end, a comprehensive scheme of the SCR model can be built.
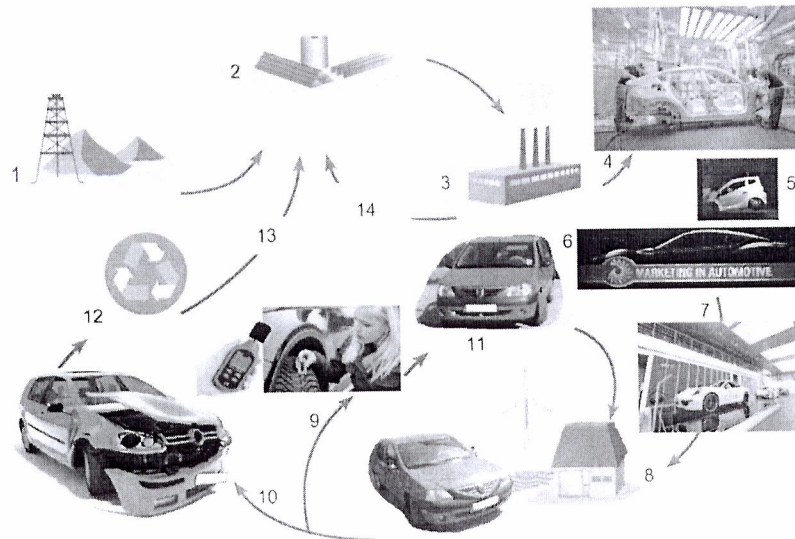
Fig. 1.3 Car life cycle (after [35])

If we consider the life cycle of the vehicle as an integrated system, starting from the extraction of raw materials used in their manufacturing process and ending with recovery and / or recycling activities, several stages can be identified, as illustrated in Figure 1.3 , [35], where the meaning of the step numbering is as follows:

1-extraction of raw materials;
2-primary processing;
3-secondary elaboration;
4-manufacturing and assembling components;
5-testing-continuous improvement-research-development;
6-presentation, marketing, public awareness;
7-trading;
8-use, operation;
9-technical verification, example analysis of noise, vibration, discomfort, etc .;
10-injury;
11-repair and reuse;
12-decommissioning;
13-disassembly, recovery of useful components;
14-recovery and recycling of industrial waste and scrap. Another dimension of the vehicle's input is fuel, a dimension that generates more effects in the SCR.

1.3 Conclusions

From the analysis of the structure and components of the SCR carried out in this chapter, interesting conclusions can be drawn, useful for the subsequent outlining of the research proposed for this thesis.

1. The current approaches are carried out from quasi-majority positions external to the traffic system, opinions having the quality of observer, manager, manager, evaluator, etc., largely ignoring the opinion of direct users (drivers, pedestrians) or those directly affected (persons in the vicinity of the traffic space, etc.);

2. The current approaches to SCR are mostly performed for monofactorial and monoobjective relational models, no approach has been found for the multiobjective multifactorial model;

3. Most of the measures taken aim at objectives set "a priori", without a complex correlation with the other actors and with the interests of all the elements involved in the functioning of the SCR;

4. It is necessary to generate a new model, which, taking methods from the practice of industrial engineering (for example, worker-centered, in this case the driver), can allow the user a systemic-integrated approach to the issue of SCR, so that the use of models and simulation programs to take into account on a large scale those directly involved or affected

Chapter 2

INTEGRATION OF ELEMENTS INTO THE GENERALIZED ROAD TRAFFIC SYSTEM (SGR)

1.1 Integrated model for the generalized road traffic system
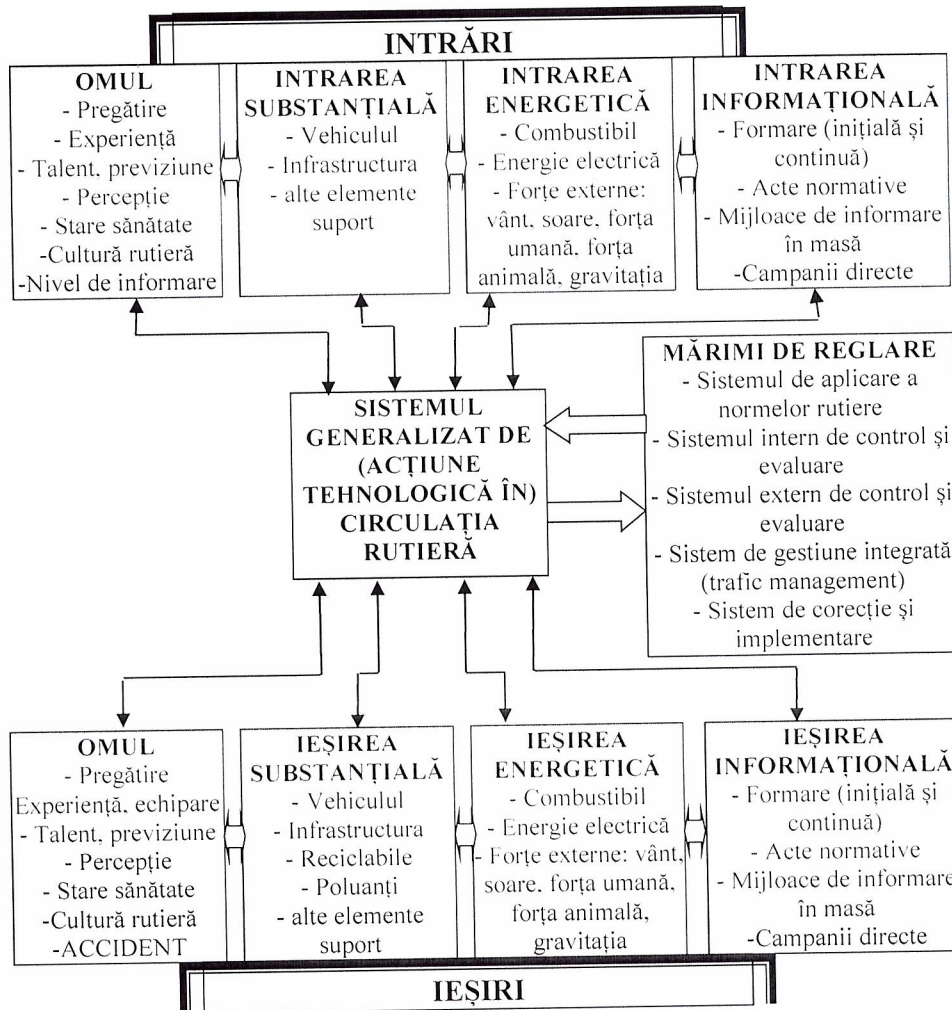
Fig. 2.1 The model of the generalized road traffic system

In the group of **INPUT** it was considered that **the main position belongs to the human variable**, approached as a vector variable, characterized by a complex of properties, from which the following were selected as having maximum adequacy:

- Preparation for the quality of driver (categories held, training unit, training program, including continuing education or training cycles, etc.), passenger or person in accidental contact with SGCR;
- Experience of the person as a participant in the road traffic system, as well as their appropriate equipment (number of km traveled, area traveled, correlation with the type and equipment of the vehicle, correct equipment of pedestrians, etc.);

- Talent, foresight, made explicit by the individual qualities correlated with the specific needs required by the quality of participant in road traffic, the spirit of foresight (correlated with the previous criterion)

- Perception, generated by the acuity of the person's senses, but also by the formation, consciousness and mental state of the moment;

- Health status, often one of the key variables that substantially influences human participation in SGCR;

- Road culture, in the conditions of modern traffic, has an increasing importance, because the complexity, dynamics and structure of road traffic become more and more important elements in the formation of an appropriate attitude;

- The level of human information on the risks posed by the SGCR can seriously affect the road traffic system, especially in the case of low values below the critical information limit.

Another input variable, considered an important vector is the substantial input, which includes the following important dimensions:

- The vehicle (vehicle) is, along with man, the essential element in the SGCR, contributing substantially to changes in output variables, including its own transformation (the analyzes performed previously in this paper will not be repeated);

- Infrastructure is another important dimension of the substantial input, a determining factor in the proper functioning of the SGCR, but also the most expensive element (materially), among the dimensions of the SGCR variables;

- Substantial input may also include other material components that help the functioning of the SGCR, such as: dedicated advertising systems, filling stations, accommodation and public catering objectives, etc.

The energy input to the SGCR includes a set of variables that contribute vital to the functioning of the system and which, implicitly, generate other components (dimensions) in the output variables (eg pollution).

The following dimensions are associated with this input, also approached as a vector variable:

- Fuels, are a main source of energy for the propulsion of the vehicle system, but at the same time, and an element generating influences for other input and / or output variables;

- Electricity becomes an important component of energy input from the Generalized Road Traffic System (SGCR), with the increasing share of hybrid and electric vehicles, but attention must be drawn to the need to analyze the balance of global effects of the use of such vehicles;

- Other sources of energy generated by external factors (also called renewable energy), such as: wind force, solar radiation, gravity, animal force, human traction.

Information input has recently been considered the most important component of the SGCR, with a spectacular evolution, which can lead to the replacement, in large part, of the functions of the human operator.

Respecting the precepts, concepts, methods and conditions related to information, this entry, considered analogously also a vector quantity, includes the following important dimensions:

- Training (initial and / or continuous), is the main source of information for the SGCR, through the human operator (qualification, authorization, review, remedial sanction, etc.), but also of those trained for design, implementation, maintenance, recovery and optimization road infrastructure and information systems use;

- The normative acts, through the contained provisions, are elements of informing all the actors involved in the SGCR, in the declared purpose of optimizing their functioning, in accordance with the public interest;

- Mass media are sources of information through which messages of public interest specialized in the field of road traffic can be transmitted to a large number of listeners, good practice cases can be presented, debates can be organized, etc., through which the level is increased. perception of issues and current issues in the SGCR;

- Direct campaigns are dedicated actions aimed at informing information focused on certain issues of SCR, using specific methods: displays and billboards (panels, banners, masks, classic posters, etc.), brochures and flyers, short messages broadcast through audio-visual means placed in areas of heavy traffic, thematic contests, messages on social networks, etc.

In the OUTPUTS group, it was considered that the main position belongs to the human variable, also approached as a vector variable, transformed as a result of contact with SGCR and characterized by the same properties, which underwent some transformations:

- The training of the driver (categories held, training unit, training program, including elements of continuing education, etc.), of the passenger or person in accidental contact with the SGCR has changed as a result of the transformations undergone in the system;

- The experience of the person participating in the SGCR, including their proper equipment, relative to the indicators presented above (number of km traveled, area traveled, correlation with

vehicle type and equipment, correct pedestrian equipment, etc.), has changed (NOT ALWAYS WELL !);

- Talent, the spirit of foresight, does not change, but can acquire new facets, by changing the framework of manifestation;

- Perception, as defined in the introductory chapter (generated by the acuity of the person's senses, but also by the formation, consciousness and mental state of the moment), is different from the initial state;

- Health status, as previously stated, substantially influences the person's participation in the SGCR, being a dimension that must be constantly monitored with evolved and adapted methods;

- Road culture should evolve after passing through the SGCR, although there are no certainties or guarantees, as the complexity, dynamics and structure of road traffic can change attitudes;

- The level of human information about the risks posed by the SGCR obviously increases after completing the SGCR, especially in the case of values below the critical information limit.

Substantial output, which obviously includes the same dimensions as the input (vehicle, infrastructure or other elements do not disappear, only changes by wear (inevitable) or accidents (undesirable)):

- The vehicle (vehicle) is subject to transformations caused by wear or other accidental elements, but other modifications are also possible, all of which contribute substantially to changes in the output variables as a whole and / or to the transformation itself;

- The infrastructure goes through the same process, but the influences have a less predictable degree of manifestation than in the case of the vehicle; remains a determining factor in the proper functioning of the SGCR, but also the most expensive element (in material terms), among the dimensions of the SGCR variables;

- Material components that help the functioning of the SGCR, such as: dedicated advertising systems, filling stations, accommodation and public catering objectives, etc.

The energy output of the SGCR includes the same type of variables that contribute vital to the functioning of the system and which, implicitly, generate other components (dimensions) in the output variables (pollution (direct but also as ecological risk), road safety, etc.).

Approached as a vector variable, it is associated with the same dimensions as the input, in order to evaluate and verify the technological effect of the SGCR, but also the influence and correlations:

- Fuels are the main source of energy for the propulsion of the vehicle system, simultaneously and the element generating influences and risks for many of the variables of the SGCR;

- Electricity is the current beneficiary of a public promotion campaign, being an important component of energy input from the SGCR, Apparently the transition of other energy sources to the category of energy outputs from the system could be classified as forced, but recent research has shown their use can affect the macroclimate and, as a consequence, are altered by the effects of SGCR.

The information output continues to structure the corresponding entry, but with the incorporation of all the elements deriving from the experience of going through the SGCR, including the resulting measures and consequences.

Respecting the same precepts, concepts, methods and conditions imposed on the information, this component of the outputs, vector size, includes the same important dimensions as at the input:

- Training (initial and / or continuous) is usually improved by the direct participation in the SGCR of the human operator (qualification, authorization, review, remedial sanction, etc.) or of the operators trained for the competing activities of the SGCR (design, implementation, maintenance). , recovery and optimization of road infrastructure and information systems);

- The normative acts are periodically reviewed in terms of the provisions contained, in order to bring information elements considered important and / or of public interest to the attention of all actors involved in the SGCR, in order to optimize its operation;

- The media, through their specific mission and objectives, take the relevant and urgent information elements from the SGCR and can transmit it to a large number of people, operationally and efficiently; these messages are specialized in road traffic issues, presenting cases of good practice, debates, etc .;

- Direct campaigns, although designed as inputs, also have the effect of exits, through the additional experience generated, which leads to the improvement of future actions specialized in informing all participants in road traffic.

3.2 Research objectives

The main objective of this research is the study of the influence of the main components of the generalized road traffic system (SGCR) on road safety in Timiș County, in order to optimize it.

Achieving this main objective involves pursuing a set of subsumed secondary objectives, as follows:

- Identifying the main components of the SGCR and the corresponding causes that influence the dynamics of road accidents in Timiș County;
- Establishing the dynamics of these causes over a significant period;
- Identifying the main and secondary causes that generate the risk of manifestation of these causes;
- Identifying possible correlations between these sizes in order to eliminate, reduce or inform the existing risks;
- Development of effective related measures, the effect of which can be directed, evaluated and / or corrected systemically, actively and dynamically.
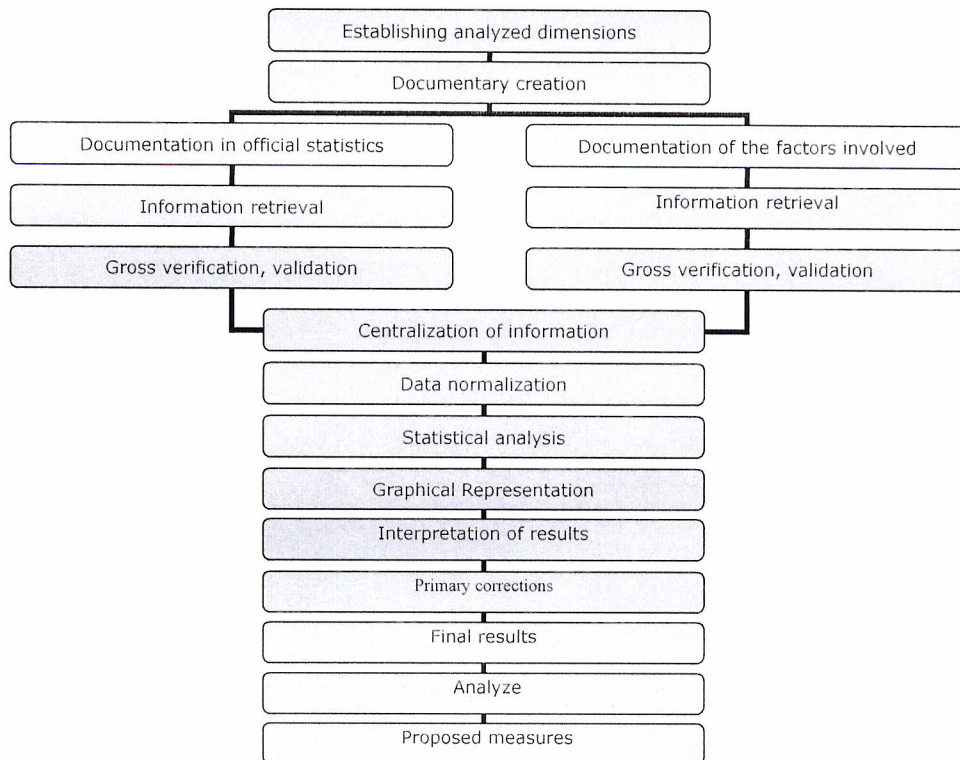
The option for Timiș County can be justified by the following arguments:

- The representativeness of the county is justified by the fact that Timiș is the county with the largest geographical area (belt) among the counties of the country (8697 km2), [169];
- The road network comprises: motorways (A1 and A6), European national roads (E), (221 km), national roads (DN), (533 km, of which on a length of 416 km the running surface is made of concrete asphalt, and the 4-lane sectors are executed on a length of 42 km), county roads (DJ), (in total 1,145 km, of which 500 km asphalt concrete) and communal roads (DC), (in total 1,222 km, from which 459 km of cobbled roads and 624 km of land), as well as city center bypasses, [169];
- Timiș County is located in the vicinity of customs points that make a direct connection with Western Europe (direct customs points: Moravița, Jimbolia (on DN) and Lunga, Foieni, Beba Veche (on DJ or DC);
- The intensity of road traffic is high being justified by the high values of traffic, for all categories of vehicles;
- In connection with the previous justification, but also approached as independent, can be considered the economic development of Timiș County (which places it in one of the leading positions in terms of road network), but also the fact that in the county there are two municipalities (Timişoara, Lugoj) and a number of 8 cities (Făget, Buziaş, Deta, Gătaia, Ceacova, Jimbolia, Sânnicolau Mare, Recaş) with a relevant economic development, [131].

3.3 Material and method

The present research analyzed the dynamics of road accidents for roads in Timiș County, figure 3.1 shows the map of Timiș County and the road network, according to the site http://hartaromaniei.eu/judete/Timis.jpg, [168], during 2009 -2016 (because at the date of the study, the official information on the dynamics of road accidents in Timiș County corresponding to 2017 was not centralized).

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│ statistics                     │    │ involved                       │
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3.5 Pareto Selection of main factors by Pareto analysis

This paper starts from the study of accident dynamics and the hierarchy of their causes, based on hypotheses and statistical verifications. As the measures taken to prevent accidents are not known and there is no assessment of their impact (it is difficult to achieve because the dependence analyzed is multifactorial), in a first phase an algorithm can be designed to select the main factors for each accident category by **applying the Pareto** principle and analysis.
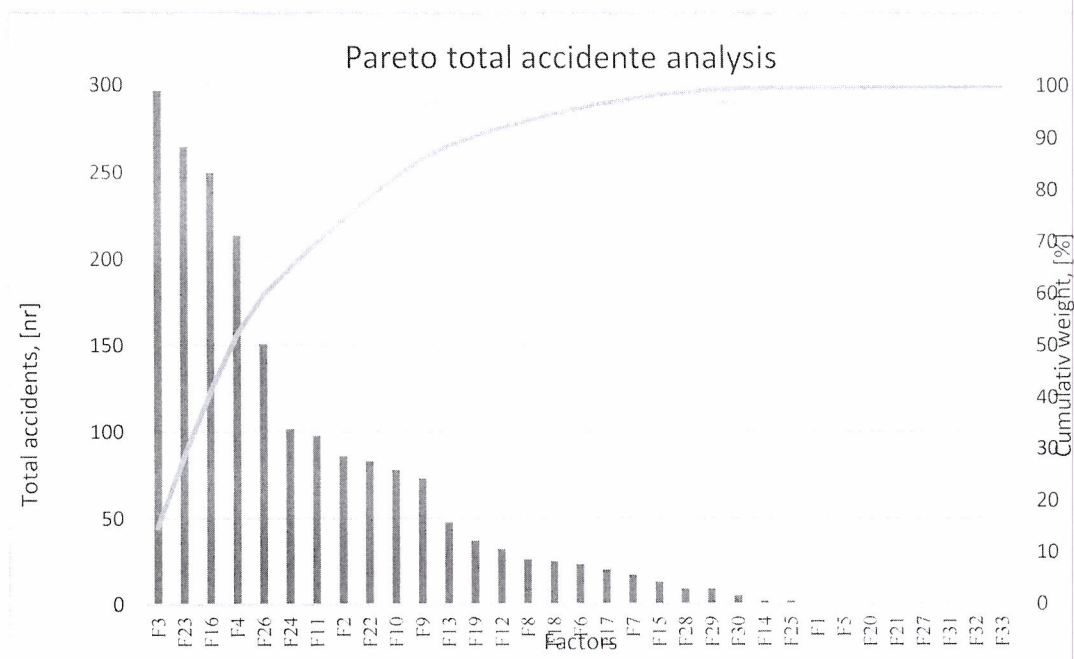
Pareto total accidente analysis

Figura 3.4 **Pareto analysis** *of the causes for the total number of accidents in 2009-2016*

4.2 Research objectives

Achieving this main objective involves pursuing a set of subsumed secondary objectives, as follows:

- Identifying the main components of the SGCR and the corresponding causes that influence the dynamics of road accidents in Timiş County;
- Establishing the dynamics of these causes over a significant period;
- Identification of the main and secondary components independent of the decision of the human factor that generates the risk of road accidents (RA);
- Identifying possible correlations between these components in order to eliminate, reduce or inform the existing risks generated by competition (incidence) with these components;
- Development of effective related measures, the effect of which can be directed, evaluated and / or corrected systemically, actively and dynamically.

Content elements presented in the previous chapter remain valid, justifying the option for Timiş County

4.3 Material and method

Since this time too the study refers to the entire road network in Timiş County, the research analyzing the dynamics of road accidents for roads in Timiş County, in the period 2008-2016 (because at the time of the study were not centralized and official information on the dynamics of road accidents in Timiş County corresponding to 2017).

It is specified that the data were collected according to the statistical evidence of traffic accidents prepared by the Timiş Road Service within the Timiş County Police Inspectorate.

The algorithm of the experimental research methodology is presented schematically in figure 4.1. The sequence of steps followed in the applied research was correlated with its objective and particularities.

The following dimensions from the category of SGCR entries were considered for the study:

- **The time interval factor**, structured on 4 levels, as follows: interval 0-6, interval 6-12, interval 12-18 and interval 18-24, considering as a null hypothesis that there is an influence of the time interval on the number total accidents, accidents resulting in deaths, accidents resulting in serious injuries and accidents resulting in minor injuries;

- **The day of the week factor,** structured on the 7 classic levels (Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday), considering as a null hypothesis that there is an

influence on the total number of accidents, accidents resulting in deaths, accidents resulting in serious injuries and accidents resulting in minor injuries;

- **The road category factor**, structured on the levels of national road, county road, communal road, busy streets and secondary streets, considering as a null hypothesis that there is an influence on the total number of accidents, accidents resulting in deaths, accidents resulting in seriously injured and accidents resulting in minor injuries;

- **The location factor**, considering as a null hypothesis that there is an influence on the total number of accidents, accidents resulting in deaths, accidents resulting in serious injuries and accidents resulting in minor injuries, the approach considering three generic situations: rural, urban and outside the localities;

- **The driver training factor**, structured on the levels of amateur drivers and professional drivers, considering as a null hypothesis that there is an influence on the total number of accidents, accidents resulting in deaths, accidents resulting in serious injuries and accidents resulting in minor injuries , the approach considering two generic situations: guilty drivers, respectively innocent drivers;

- **The nature factor of the guilty person**, structured on the following levels: drivers who do not have a driving license, drivers foreign nationals, drivers mopeds and motorcycles and pedestrians, considering as null hypothesis that there is an influence of the time interval on the total number of accidents, accidents resulting in deaths, accidents resulting in serious injuries and accidents resulting in minor injuries;

- **The sex factor of the guilty traffic participant**, structured on nine levels (male and female), Considering as a null hypothesis that there is an influence of the time interval on the total number of accidents, accidents resulting in deaths, accidents resulting in seriously injured and accidents lightly wounded;

- **The age factor of the guilty participant**, structured on the following levels: 0-18 years, 18-25 years, 25-30 years, 30-35 years, 35-40 years, 40-45 years, 45-50 years, 50-55 years , 55-60 years, 60-90 years, considering as a null hypothesis that there is an influence of the age of drivers on the total number of accidents, accidents resulting in deaths, accidents resulting in seriously injured and accidents resulting in minor injuries;

- **The aronadat territorial factor**, structured on corresponding levels in the territory of Timișoara, Drumuri Europea, Lugoj, Făget, Buziaș, Recaș, Sânnicolau Mare, Jimbolia, Deta, Ciacova, Gătaia, considering as a null hypothesis that there is an influence on the time interval the total number of accidents, accidents resulting in deaths, accidents resulting in serious injuries and accidents resulting in minor injuries.

Chapter 5

APPLICATIONS OF THE PDCA MODEL FOR OPTIMIZING THE GENERALIZED INTEGRATED ROAD TRAFFIC SYSTEM

5.1 Background

This research is approached as an additional section, correlated with the results obtained and analyzed previously, a specific stage of the reconstruction of the management system of the generalized road traffic system.

From the analysis of the elements and the results in the field, for the period 2008-2016 a great variability of the number of accidents and their effects was observed (slightly injured, seriously injured, deaths, material damages), also explained by the inconsistency or inadequacy of some monitoring measures. and SGCR correction.

5.2 Research objectives and methodology

Starting from the premises presented above and from the well-known fact that there is no travel / traffic without danger of accidents, regardless of the category of road, driver or motor vehicle. The main generating factor of such road events is generically called road risk, being approached as a component of risk in a society organized or not legally (global, continental, national, regional, etc.).

Hence the need to manage road risks through an adequate integrated management system, whose purpose is to identify hazards, assess their level and establish prevention and control measures.

This result becomes, at the same time, a fundamental need of risk management to optimize the decision-making process because it allows, in a scientifically substantiated way, to take into

account the effects of uncertainty on the materialization of objectives and to establish the necessary measures and actions.

This results in the **main objective of the research which aims to reduce the frequency of accidents, while increasing the safety and performance of roads (speed, traffic conditions, etc.).**

At the same time, the following subsequent **objectives can be stated**:

- Capitalizing on the results of hierarchies and analyzes in the planning stage of the continuous improvement process through the PDCA method;

- Generating a package of solutions and the related implementation plan, leading to the achievement of efficient results in terms of cost / effect;

- Verification of the effectiveness of the proposed solution (pilot) and simultaneous collection of the necessary improvements, their area of application or the need to repeat the steps;

- Ensuring the conditions for the resumption of the adopted improvement solutions, as the cycle is repeated, simultaneously with the extension of the improvement area.

Chapter 6

CONCLUSIONS. PERSONAL CONTRIBUTIONS. RESEARCH PERSPECTIVES

6.1 CONCLUSIONS

A number of conclusions have been drawn, including:

- The action to optimize road safety is motivated primarily by the fact that the sum of the overall costs of preventing deaths and / or serious injuries from road accidents is equivalent to a relative value of between 1 and 7% of Gross Domestic Product (GDP) at world

- The paper aimed, based on the complexity of road systems and processes, to discover and promote new solutions, using the synergy resulting from the involvement of other social groups in road traffic issues (generically with different interests and objectives, but competing in road safety)

- An important shortcoming of the currently proposed models for SCR is the diminution (sometimes even exclusion) of the influence of the external environment on it, given the significant influence of the external environment on traffic, including the condition and response of the human factor; for example, in all statistical references, the influence of the external environment is included in the generic category of causes "non-adaptation of speed to traffic conditions", without being separated from other elements belonging to other subsystems (congested traffic, road conditions, logistical deficit, etc.), being reserved for the human factor cause

- there is a widespread perception that the number and effects of traffic accidents can be reduced to the point of elimination by using autonomous vehicles and / or including their construction elements (systems), but the integrated approach and documentation have proved superficial of the current approach to such an issue

- The individual influence of the road elements cannot be accurately assessed from the point of view of road safety, the current assessments being made by statistical analysis of the relationship between the number of accidents, the nature of victims (consequences on the human factor), type of damage and contribution , at the level of generating cause

- The human factor can be influenced by two groups of conditions: vocational training, education and / or training, correlated with the quality of the person in the SCR (driver, driver, pedestrian, etc.), regardless of other personal criteria or geographical and social affiliation; and the effect and application of the law, inside or outside the location and / or time frame of law enforcement

- The application of the law is approached analytically, in order to optimize and limit the negative effects that may accompany it in case of exaggeration; the law enforcement sector on road traffic mainly includes law enforcement on-site and off-site, and law enforcement tasks and requirements fall to the police, with law enforcement policies becoming increasingly difficult elements. complex

- All current approaches identified by the author are performed from quasi-majority positions external to the traffic system, opinions having the quality of observer, manager, manager, evaluator, etc., largely ignoring the opinion of direct users (drivers, pedestrians) or those directly affected (persons in the vicinity of the traffic space, etc.)

- The initial bibliographic study concluded that the need to generate a new model, which, taking methods from the practice of industrial engineering (eg worker-centered, in this case the driver), could allow the user a systemic-integrated approach to SCR so that the use of simulation models and programs takes into account on a large scale those directly involved or affected.

The development of a generalized model should be a basis for optimizing the programming of experimental research, in order to identify the relationships between the components of inputs and

outputs, the degree of interdetermination and independence of variables and the influences they have on the elements of control / management of road safety. ; the approach taken allowed to open to the introduction as important factors the appropriate opinion of the direct users (drivers, pedestrians) and of the other persons directly affected (for example, the persons in the vicinity of the traffic space, etc.).

- The current management of the road traffic system is partially devoid of a scientific basis, and its organization could be substantially improved if methods, procedures and models from industrial engineering are applied.

- The analysis of the first three causes of accidents in Timiș County shows that "speed not adapted to road conditions" is among the causes for all 4 criteria (total accidents, deaths, seriously injured and slightly injured), "irregular pedestrian crossing" it is present in the first three criteria (total accidents, deaths and serious injuries), and the cause of "non-priority giving to vehicles" is present in three other criteria (total accidents, serious injuries and minor injuries); in the other situations the traffic on the opposite direction appears as a cause (it is not about overtaking but about other situations)

- It has been shown that there is a clear need for a management system that generates continuous improvement processes, necessary for the efficiency of preventive actions and other types of interventions in the SGCR

- The influence of the time interval on the number of deaths and injuries from accidents, for the analyzed period, is maximum in the time interval 12-18

- There is no relevant influence of the day of the week on the total number of accidents, deaths and serious injuries, but there is a relevant influence of the year, 2008 being the year with the highest number of accidents, followed by 2015; there are local maximums for Mondays and Fridays (for 2011) and Wednesdays (for 2012)

- There is a statistically relevant link, for the 0.05 confidence level, between the road category and the annual number of traffic accidents, injuries and deaths produced in Timiș County during 2008-2016, the highest number being in the urban area in the case the total number of accidents, the highest number of accident deaths being on the roads outside the locality, and the highest number of injured being also on the roads in the urban area

- There is a statistically relevant influence of the road category (national, county, communal) for the confidence level 0.05, for all cases studied (total accidents, deaths and injuries), the highest number of accidents, deaths and injuries being on national roads, with a downward trend, but also grouping for deaths and injuries.

6.2 PERSONAL CONTRIBUTIONS

Through the research within the doctoral training activities related to this thesis, a series **of personal, theoretical, experimental and applied contributions** were made, resulting from the documentary study, from the theoretical modeling and from the experimental researches and elaborated models.

6.2.1 Theoretical contributions

Among the theoretical contributions are:

- conducting a documentary study on the current state of research on strategies and models applied in road traffic systems;

- critical analysis of the main models used for the road traffic system, in accordance with the methods and solutions applied in order to increase road safety and minimize road risk;

- critical analysis of the main elements of the cause-effect relationship by assessing the level and main characteristics of the fundamental components of the road traffic system (road factor, technical factor and human factor), based on an up-to-date bibliographic study, including the flow of major scientific publications ;

- analysis and evaluation of the level and main characteristics of the components / fundamental causes of the road traffic system (road factor, technical factor and human factor), starting from the consideration of the components resulting from the bibliographic study and their completion with others, whose involvement is decisive for fulfilling the essential functions of the SCR (external environment, scientific and technological factor, etc.);

- assessment of the level and main characteristics of the fundamental components of the road traffic system, considering SCR as an industrial technological system, based on the hypothesis of approaching road traffic as an industrial technological process, trying to transpose specific methods

- elaboration of an original integrated model for the generalized road traffic system (SGCR), which respects the general principles of systemic construction, identifying the main variables and the relations between them, in the variant of a cybernetic system.

6.2.2 Experimental contributions

This paper brings a number of practical and experimental contributions, including those with significant impact:
- analysis of multiannual dynamics to identify the main causes of road events in Timiş County, in order to apply the PDCA method to obtain optimal solutions to reduce the number and consequences of road events, while reducing resources consumed and ensuring continuous improvement of SGCR;
- determining by applying statistical-mathematical methods the specific influences and the significance of the main causes for road accidents, considered from the category of those dependent on the human factor and traffic conditions;
- determining the specific influences and significance of the main causes for road accidents, considered in the category of those independent of the human factor and traffic conditions;
- ranking the causes by statistical-mathematical methods and establishing cause-effect functional relationships based on the statistical processing of results and analysis of the significance of influences using ANOVA;
- the realization of a PDCA model that would lead to the reduction of the number and effects of road accidents in Timiş County, based on the previous results;
- analysis and prioritization of the main causes of accidents and proposal of appropriate packages of associated measures, corresponding to all factors involved in ensuring road safety;

6.2.3   Applied contributions in practice

- establishing the optimal values of accident factors by calculating the overall accident risk rating for a factor, at an analyzed consequence, on the basis of an original model;
- the determination, based on the results from the accident statistics for the period 2008-2016, of the cumulative effect of the most important accident factors, as well as of their global indicators of influence, in order to rank the factors and the associated measures.

6.3 RESEARCH DEVELOPMENT PERSPECTIVES

The main study directions identified as a result of the experience gained through this research are:
- the opening of a new research direction, related to the study of the impact of the measures resulting from the hierarchy of accident factors (proposed in the paper), on road safety in Timiş County;
- extension of experimental research for other categories of accident factors, but also of areas (counties, national, regional, etc.);
- expanding the use of the proposed models for organizing integrated actions, involving a greater number of actions and other categories of factors involved;
- development and implementation of models based on "poke yoke" methods (traffic calms, separators, etc.), which significantly reduce the effect of accident factors, leading to increased road safety.

AUTHOR'S SCIENTIFIC PUBLICATIONS

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2. Ionela Adriana Tisca, Nicolae Istrat, Constantin Dan Dumitrescu, Georgica Cornu **Issues concerning the Road Safety Concept**- 3rd GLOBAL CONFERENCE on BUSINESS, ECONOMICS, MANAGEMENT and TOURISM (BEMTUR-2015) 26 - 28 November 2015 Quality Hotel Rouge et Noir Convention Center Roma - Italy
3. Alina Melnica, Nicolet Trandafira, Constantin Dumitrescua, Nicolae Istrat **Development of School Governance to Support Engineering Education** - 4th World Conference on Business, Economics and Management, WCBEM
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