INTEGRATED ROAD MANAGEMENT SYSTEM – CONCEPT AND PATTERN OF ROAD STRATEGIES

L. G. A. UDVARDY
Professional Association for Roads and Bridges of Romania, Branch of Banat
udvardylaszloga@hotmail.com

ABSTRACT

The paper presents certain *innovative* aspects of the *concept and methodology* of an operational pattern for the development and systemic operation strategy of the public road network. The *global pattern*, called "*Integrated Road Management System*" (IRMS), is a cybernetic and complex *Large System*, with specific functions and structure (operational and/or structural systems-subsystems). It is made up of *pattern types*, resulting from the combinations of the multiple *point views*, ranged in *levels-variants-versions-references/users* patterns, with the *post-simulation and pre-simulation* of the strategies. We realize the informative-logical-mathematical-cybernetic-informatic integration of the functions and systems-subsystems. We define and operate a system that ensures the underlining and processing of technical-economical-social-ecological-aesthetic *indicators*. It lays at the foundation of the *Road Technical Data Base* which is today generalized in Romania, proposed by the author for development. IRMS is theoretically and operationally defined, *epistemologically, informatively, comprehensively*. The IRMS approach includes the entire *heterogeneous* network from the point of view of the administration and multi-reference. It is *purpose*-oriented (including concerning the *environment protection* and the *quality of the life*) towards a *sustainable development* of the *global macro-system*, also ensured by the organization of a *pre-auditing* of the analysis-design and an *auditing* of the implementation-development of the strategy, multifunctional.

1. PATTERNS OF ROAD STRATEGIES

1.1. Policy-strategy-planning concerning the development of the Road Network

Within a nation-state *social-economical macro-system*, the organization and management of the activities in the *public road field* is realized through the *phase* succession concerning the *policy-strategy-tactics/planning* of the development and operation of the *Transportation System* for the *Road Traffic System*, and within this organ, of the *Road Traffic Infrastructure System*, that is the *Road Network System*.

The underlining of the *road network functions* ranges, on the one hand, within the general organic functions of the *Road Traffic System*, and on the other hand, it concretizes according to the *users' expectations* (respectively, the *references* of the policy environment and road strategy), as well as and not least according to the *population's expectations*.

In the case of our approach, these *functions* are, first: • to ensure the quality of the construction and connected installations; • to ensure comfort; • to ensure traffic safety; • protection and restoration of the natural environment; • improvement of the life quality for the participants to the traffic; • improvement of the life quality for the population in the area along the road; • protection of the built environment; • cumulated efficiency (economics + efficiency) of road and transportation; • framing into the area development plan; •

optimization of global energetic profitableness (road + transportation); and others. (The relatively reciprocal systemic direction-inclusion specific to these functions is realized within the present approach.)

1.2. Road strategies

In many countries, today are known – a great number and with very different methodological solutions -, projects and implementations in the field of drawing up and realizing *road strategies* [1], [2] etc. The approach presented in this paper – without denying the knowledge of several such projects -, is characterized by a *proper* continuous evolution process; it does not take over directly or explicitly, totally or partly, their features. Thus, our IRMS approach can be proposed for a short presentation, with the view to retaining some aspects likely considered original and useful.

In Romania, the elaboration of road strategies is signalized during 1984-1994, activities within which, in the research realized by IPTANA-SA during 1990-1992, ordered by ANDR, there is approach of the partial valorization of the HDM-III pattern, for a certain prioritization of the rehabilitation of main roads, through international financial collaboration [3], [4].

The condition of the network is generally unacceptable. The (verbal) *road strategy* includes at present a presentation of the objectives and specific criteria [5]. In the same time, the strategy includes an experimental development of a PMS pattern [6] (Stelea), [7], [3] (Schînteie), and respectively it tries in parallel to implement territorially and locally the Pattern HDM-III. and 4, level of strategy [3] (2002, 2006).

At present, it is outlined – in the *Development Strategy for the Western Region*, 2007-2013 – including the *road strategy* of the region. In the case of ARD V West, the road strategy ("Strategic Axis I.") includes "priorities – areas of intervention – operations" in an ordered manner, but essentially the same as in the case of the national strategy 2006 [5], in a *simple listing* of the development needs and wishes, *without a spatial-temporal-functional-operational prioritization of the activities, without harmonizing the withes with the resources, without defining and multi-criteria optimization-rationalization* of the development actions.

1.3. RS-IRMS approach

Under the coordination of the author of the present paper, *a first PMS type version* is elaborated, experimented and territory regionally applied (D.R.D.P. Timisoara, since 1976) under the symbol PRERAN-STRATEG [2] (1979), [8], [2] (1991, Udvardy), [4]. This is generally operated country-wide in the case of the national road network (14,000km, 1978-1984). The pattern is operational on a *historic road technical data bank*; it operates on a *5, 15 and 30 years time horizon*; it underlines the *mutual influences* of strengthening works and the maintenance activities on the road network; it offers information concerning the *dynamic evolution of the technical condition*; it *prioritized multi-criterially the succession* of the execution of strengthening works and maintenance-reparation on the analyzed road sections; is presents calculation concerning the *direct and indirect efficiency* of activities and road works and of *simulated-defined* strategies [2] (1991, Udvardy), [4].

The pattern develops successively, proposing the *global pattern* – as well as its *composing patterns* -, generically called *Integrated Road Management System* (IRMS), *operational informative* part of the Road Strategy – RS-IRMS – [3] (1982, 1994, 2006), [4], [9], [10].

The IRMS pattern also treats the TEM and TEN routes, but not the inter-modal transportation systems or the ITS issue.

Chapter 2 presents a *short description* of the main characteristics of Road Strategy - IRMS, respectively Chapter 3 exemplifies certain important *innovative aspects* concerning the concept and methodology of the approach.

2. SYSTEMIC ROAD STRATEGY - SHORT DESCRIPTION OF RS-IRMS

The *road strategy* – respectively, the *road strategies*, as will be specified farther on (chapter 3.3.) – include operatively the *general systemic pattern* as well as the family of the *component-particular associated patterns*, of the *Integrated Road Management System type* (IRMS) of the technical-econometrical operational character of the strategy. An IRMS type associated pattern belonging to a given road strategy represents a concrete way of effectively and usefully introduce the approached road strategy; the IRMS pattern is part of this strategy as an *applicative essential methodological and executive* component both in the approach of the elaboration and in the process of implementing the strategy. In the context of formulating the concept and the operational applications, generically, the "Road Strategy with IRMS" (RS-IRMS) is first characterized by the following significant features:.

RS-IRMS is the c o m p o n e n t of the social-economical macro–system, • ranging *organically* in the structure of the social-economical macro-system, that includes (in a *direct* successive inclusion) the *policy of the social-economical macro-systemic development – the transportation policy – the road policy – the road strategy – road tactics – road planning – design of road activities, road works and road installations – procedure of realizing road activities, road works and road installations – operation of road works and road traffic devices*, RS-IRMS targeting within this structure the existence and continuous development of the *Traffic System*, the *Road Traffic System* and the *Road Network System*, • RS-IRMS being designed, elaborated and applied according to the *requirements of the functions* modalities and conditions of *traffic* and road *transportation*, of the road *traffic* devices and the road *networks*, the functions including first the traffic comfort; traffic safety; material and social-spiritual quality; technical and technologic compliance; road terotechnics; economics, efficiency, usefulness; providing logistics; protection of the natural, built and spiritual environment; road aesthetics; improvement of life quality and finally, ensuring the *sustainable development of the road traffic and transportation system*, respectively ensuring from this system both its *proper sustainable development* and a *global sustainable development of the social-economic macro-system*, • RS-IRMS determines for itself, according to the indications and obligations imposed by thee road policy and according to its proper considerations, taking into account the object and objective of its actions (general objective – direct targets - derived objectives – aims – purposes – final purpose – criteria), • the road strategy realizes, besides its proper functional requirements, both the *interdependence* in the field of the action *planning* (plan – planning – calendar planning – composition planning – territorial planning – etc.), and an important *feed-back* role towards the dynamic complex rational definition of the road policy; • taking into account the ensemble of the *explicit references* of the system (*generators-receptors-recipients-beneficiaries* of the strategy),

In the same time, • RS-IRMS exists in the materialization of *time dimensions* – philosophical time, physical, spiritual, cybernetic and economical-optimal -, with virtual applications and real *historic, present* ones and prognosis-forecast-prediction-hope

mathematic for the *future*, materialized on *short, medium and long term*, with conceptual and operational significance within the *time-space-function* three-dimension realities and • *at any well determined administrative structural-hierarchical level, technical and purpose-functional*, including at any complexity of *heterogeneity of the road network* made up of the diversity of *administrators, road categories and technical classes* specific legislated and instructed, • the organization and management of the approach and procedures being ensured by a *hierarchical* administrative structure – including an adequate structuring of the management system -, belonging to the organization of the *autonomy* of the functional-structural *sub-systems*, • that also ensures the continuous *training-self-training* of the analysis, design, implementation, management and RS-IRMS proper element development staff, as well as the staff of the reference environment (*generators-receptors-receivers-beneficiaries*) of this approach.

RS-IRMS is a "L a r g e S y s t e m" • made up of *notions, categories and procedures*, respectively of *principles, concepts, features, methodologies, methods and techniques of analysis, operation, pre-auditing-auditing, design, implementation, application-operation, of control-inspection-auditing and of successive development* proper to the theory and practice of "*large systems*" dynamic, cybernetic, complex • *composed, concordant, coherent, connected, spatial-temporal-operational complex*, • RS-IRMS per se being defined *gnoseologically, praxeologically* and not least *axiological*, - approached *multi-sectional*, respectively *pluri- and interdisciplinary* -, respectively, • defined *epistemological-informatively comprehensive* principle and operation, • having ensured for this approach and these procedures the evolved informatics-informative support by an adequate *logistics*; • the real and modeled system being *aggregated-disaggregated* from and in *sub-systems* and systemic structural-operational *components* (strengthening; maintenance; safety; ecology, road traffic; graph-network; quality; economics; efficiency; etc.), respectively, • RS-IRMS being, by definition, an *open system*, it cannot be considered (according to the purpose of the research) isolated from the natural and social-economical environment; this can be brought to such conditions to be able to realize a *condition of dynamic balance with the environment* – the system having constant structure -, in the process of interaction with the environment it realizes an *equi-final condition*, • in the same time, the system realizes the *negentropy* required by its vitality; respectively being RS-IRMS, in some of its specific composing parts a *closed system*, it requires the realization of analyses concerning the character and the effects of the *maximization* of their *entropy*; • RS-IRMS being a large system, in its case it is ensured the *stability* of the types of systems and composing sub-systems; the *hierarchy* of the systems structure; the *balance* of the systems; the technical-economic-social *homeostasis* and the organic connection in *super-systems*; • RS-IRMS shows the *specific informative-logical-mathematical-informatics-cybernetic integration* of the *functions, criteria, variables, restriction limits*, as well as the *cybernetic modulus* at the level of the *general system* and the one of the *sub-systems* and the *systemic structural-functional components*; • the road strategy being realized by presenting an *ensemble* of theoretical *pattern types* and/or *standard* practical, and in their context even through *autochthonous and/or autonomous* pattern types, • the pattern *type* being generated from the necessary and possible, adequate combinations of *levels, variants, versions and references* (*generators-recipients-receptors-beneficiaries*) of the particular patterns, in the same time, • the pattern *types* being elaborated – in the assessing and decision processes – including with the view to realizing the *post-simulation* and *pre-simulation* of *virtual and/or real* roads strategies;

respectively, • within which it is constituted and operated a *system of indicators for economics and efficiency of the activities, works and road networks*, that ensure the

concept and procedure of underlining the *indicators – informative* indicators belonging to the material and decisional reality – *technical-economical-social-ecological-aesthetic*; • indicator system that includes – additionally – the *results-output of the previously simulated strategies*, as well as those *previously implemented-applied*, • indicator system upon which an operational *Road Data Bank* is constituted, made up of *date bases* and *libraries of informatics-informative programs-applications*, • collection of information within which is dynamically underlined the *evolution of the road condition* – history, static and prognosis -, including concerning the analysis of the *behavior in situ* of the constructions and road installations, respectively concerning the *residual conditions* and the *effects* that will be registered at the end of the approached time horizon; • realizing adequate diversified methodologies of *mathematical, forecasting, foreseeing, prognosis hope*; ensuring the tehnometric and econometric processes of *self-correlation* and *self-correction of the patterns*; • elaborating and solving the *trend* patterns and the *lag* character; the simulation of *admissible, stationary, optimal/sub-optimal/rational trajectories*.

RS-IRMS is, in this systemic context, a c y b e r n e t i c s y s t e m, in whose case: • the *cybernetic pattern* is endogenously explicated through the *managed, analyzed, decision, command object modulus* respectively through *input, perturbations and output* from and towards the exosystem, • the *exogenous input* and the *endogenous commands*, as well as the *perturbations in the exosystem* being underlined and valorized through the *algorithms of the programs-applications* proper to the *cybernetic managed object modulus*, • the applied strategy being with the *performance-finality* (output) from *technical, economical, social, ecological and aesthetic* system required by *references* (*generators-recipients-receptors-beneficiaries*, including from the *stakeholders*) endo- and exosystemic, respectively performances-finalities – *direct, indirect and propagated* generators of the *impact* resulting from the system for the users and the environment – also *systemically* coordinated, • with the *concrete* specification of the *activities, works and road installations* indicate for the execution-operation-maintenance, in a *pluri-criterial prioritization, essential* for the value of the performances-finalities of the system;

also, • the RS-IRMS is constituted with the treatment and application of the proper methodology specific to the theory of efficiency (efficiency and usefulness; synchronic efficiency; criteria of general, local and sequential efficiency; harmonization of interests; equifinality; • taking into account the specific complex aspects concerning the *life span*; the operation period; the use period; the design life; the remnant life; - respectively -, the period of investment recovery, concerning the road infrastructure and the devices of the road traffic system, • the specific *econometric methodology* including econometric analyses for the index of the life cost; use value; profitableness; profitableness threshold and economic threshold; benefit and profitableness; value analysis; replacement value; residual value, up-dated value/discounted value – including concerning the values of the power balance sheets -; • including also the *sensitivity* analysis and the analysis of the *balance of significance-degree of detail* of the disaggregate patterns;

respectively, • performances-finalities resulting from the system continuously analyzed also by the *analysis cybernetic modulus* of the cybernetic system, • analyses with results valorized through multi-attribute, multi-objective, mixed and iterative *decision processes* – quantitative and qualitative – specific to the *cybernetic decision modulus*, decision processes realized concomitantly/parallel/successively for *optimization or sub-optimization*, respectively, in given cases, for *cvasi-objective or subjective rationalization* (according to their promotion through the wishes of the references), • *dynamic* optimization-sub-optimization-rationalization regarding also the *trajectory* of the foreseen

or designed *evolutions* of the *behavior* of the system, decisions • following which there are provided the *commands* of the alterations generated endogenously in time of the *intrinsic elementary features-characteristics* of the *criteria of dynamic-cybernetic transformation* of the system, through the *command cybernetic modulus*, • *alterations* which are *adequately, relevantly underlined* within the data base and the library of programs and informative applications of the object cybernetic modulus, • to reach (through performances-finalities) *goals, purposes*, concretely determined and guided *obligations* from the *general social-economical policy*, the *road policy* and from the *endo- and exo-systemic natural, social and artificial (built) environment*, • including within the development of the ensemble of methodologies and methods applied in the *decision making process*, in the direction of the systemic treatment for harmonizing the *antagonisms* and the *mutually aggravating or attenuating characters* existing among the *decision makers, objectives-purposes* and decision *criteria*, • analysis methods where, among other aspects, there are performed studies concerning the *ergodicity* of the phenomena concerning the alteration of the nature of the condition of the dynamic technical condition of road infrastructures.

Concerning the m a t h e m a t i c d e v i c e of RS-IRMS, it is worth mentioning that: • the conception and informative cybernetic pattern has attached the *generally* enlarged *mathematical pattern* and the *specific mathematical patterns* of the cybernetic modulus belonging to the operational-structural sub-systems-components, • inclu-ding the multitude mathematical relations which express *operational and/or empiric/statistic dependences*; which participate in the ensembles and description, analysis, decision and command mathematical systems, • finally, the approaches owning the emergent *character and the mechanisms of the synergetic effects* of the *system of analysis criteria indicators* concerning the technical, economical, ecologic and aesthetic field, part of the *complex function-objective*, as well as of the same character of the system *output*.

RS-IRMS representing a c o m p o n e n t of the social-economic macro-system, it is: • in a *systemic organic connection* with the systems-structures of the *upper systemic level of road traffic-transportation* (complementary, successive, combined, intermodal), and of *other movement forms* for persons and freight, • in the conditions of *ensuring virtually and effectively*, with especial priority, the *road traffic safety for the traffic participants* and the *safety for the social environment*, • in a complex level of the social-economic macro-system, defining for the *favorable continuous evolution of the quality* of the persons' and the society's *life*; • SR-IRMS represents an informatics-informative system with *universal and publicly-interactive informative access* to the informative system an continuous evolution of the *development of road strategy*, of *road network development*, and the *road traffic system*; respectively at other economical-social systems including concerning the environments of the system references, • SR-IRMS also offers a *feed-back* of maximum professional importance multi-disciplinary towards the continuous evolution of the road policy.

Finally, RS-IRMS represents a pluri-functional approach, with s e l f – c o r r e c t i o n and with complex p r e – a u d i t i n g / a u d i t i n g: • on the one hand, with general finality oriented towards an unavoidable *sustainable development*, and on the other hand, with unanimously desired results-finality, • ensuring systemically a complex *auto-correction* system for the data bases and the methodologies-algorithms in the system, • also ensuring the *complex pre-auditing* of the road strategy being *analyzed and designed*, respectively the *complex auditing* of the road strategy being *implemented and developed*; pre-audit/audit including *concomitantly and correlated* the pre-auditing/auditing of the *road network quality* and the pre-auditing/auditing of the *traffic safety*, pre-auditing/auditing of

the *environment protection* and the pre-auditing/auditing of the *life quality*, finally the *sustainable development of the road network proper system*, as well as the sustainable development ensured for the *social-economical macro-system from the roads and road traffic*; • within the approach and SR-IRMS procedures realizing concomitantly the *description* of an ensemble of road strategies and a multitude of operational patterns, in an *adequate comprehensive treatment*.

The present shortly formulated *principle definition* (and unavoidably presenting a complex aspect of the *heterogeneity* at this level of formulation), is *operatively and complexly developed* within the research and operations of the *family* (*class*) of the IRMS type, depending on the requirements of the concretely analyzed and application cases concerning the *types of road strategies*, which in practice, are concretely imposed even by the references of the system (see chapter 3.3.).

Concerning the *heterogeneity* in the short definition, we must acknowledge the fact that actually, in the practical reality, any road complex nation-regional strategy, including concerning its degree of mathematics-cybernetics-informatics – and especially the strategies in the case of road traffic in the countries with evolving road networks in a today unfortunate condition of the operational qualities – present anyway, in their whole, a *strong effectively heterogeneous character* from several points of view.

Considering this short presentation, it results that any approach concerning the elaboration, implementation and operation of a *real* road strategy must tend to – sooner or later – including successively all the above mentioned aspects.

We stress the fact that, all the theoretical and applicative aspects included in the approach outlined by the stated *simplified definition*, are carefully developed, these developments showing an innovative character for the approached applicative fields. For example, in the chapter 3. of the present article, several significant particular considerations are shortly presented.

3. CERTAIN SPECIFIC INNOVATIVE ASPECTS

3.1. Condition – operational qualities – multifunctional qualities

In our complex *calimetric studies*, with successive informatics developments [3] (1982, 1998), [11], [2] (1995), [4], we formulate certain considerations and concrete propositions concerning an ensemble of *specific aspects*, out of which we want to mention the following: • reconsideration of the operational use of *visual assessment of the roads' technical condition*; • axiological-praxeological and epistemological delimitation in the terms of condition (relevant *intrinsic features of characteristics*), of *operational qualities* and *multifunctional quality* in roads; • conceptual and applicative application in the assessment of the condition and qualities of roads, of the *procedural modeling* in the research of the *developing degradation*, including by *baysienne estimation* of the repartition law parameters of the operation time; • definition of elements concerning the condition and *static and dynamic-cinematic* quality (ordinary static assessment, and assessment of the *speed and acceleration* of the development of condition and quality; *methodology* proposal); • the research of the *effects of heavy and very heavy traffic* on the roads condition; including the *concomitant* optimization-rationalization of the types of heavy transportation means and the intensity of the road traffic with heavy and very heavy transportation means, respectively in correlation with these, the constructive dynamic

structures of the road complex, dimensioning compared to the given volume and the given transportation duration (service roads); • analysis of the *reliability, maintenance and availability* of roads – the road-element and the road–structure-system -; • adaptation of the analysis methodology of the road works quality through the *pattern of the breaking down tree* (structural pattern for underlining the week points of road structures); • experimental definition of the *safety coefficients* in construction determined through the methodology of *work reliability*, included based on the *accelerated tests* and *in situ studies* on the works;

respectively: • definition of the *operational-multifunctional qualities* in a different way included compared (and according) to certain *natural or artificial operational conditions*, such as the time period of the day, the seasons of the year, the traffic loading level on the route, the direction of the traffic, etc.; • econometric analysis of the quality costs – *economics and efficiency* of quality -; direct, indirect, propagated quality; analysis of the *updated/rate* techno-metrical specific quality; • multi-parametrical systemic definition concerning the *life span*, design, operation, service life, respectively the estimated duration and the foreseen duration of road constructions; and in all these cases, the systemic definition concerning the optimum life, consumed life, remaining life, etc.; • the *systemically coherent correlated treatment* of the quality function and, respectively, of the functions of environment protection of the road traffic system and the social-economic macro-system (*sustainable quality*); • development of the quality language *specific* to the road field epistemology; etc.

Concerning the issue of the *developing damage*, as a result of the realized research, is is specified (acknowledged) that, the road structure – as a system/element subjected to the reliability analysis -, shows *positive wearing, positive average wearing, is degradable and average degradable* – in the situation when it is not yet subjected to current and periodic renewals compared to certain given condition characteristics (interested for purposefully underlined operational qualities).

We consider that, in the case of damaging road structures or elements of road structures, the damage in time shows a *static* condition characteristic at a given moment, as well as a *speed* and, respectively, an *acceleration* of the evolution of damage in the same moment. In this context of underlining the *cinematic of damage*, two situations having the same static value may show two different speeds, and in the case of two identical situations with static condition and speed, the acceleration of the damage evolution can show different values. This consideration ensures a new element in the analysis and decision of "*prioritization*" the actions and intervention-improvement-reconstruction works within the design of the road strategy.

Based on the results of specific studies concerning the *ergodicity* of developing damage phenomena in road structures, the realization of certain *decision Markov process type* applications was possible, considering that such strategies may be common only to preventive and/or current maintenance activities, between two rehabilitations or successive reconstructions of roads.

The RS-IRMS approach includes a number of methodologies and methods for *forecasting, foreseeing, predicting, mathematical expectations*, etc. concerning the future possible and/or probable evolution of the *stress* in the system, respectively, the alteration of its *condition* and *operational-multi-functional qualities*, and – based on these -, the nature and size of the *effects* (positive or negative) of the applied road strategies. Subsequently,

during the application of the strategies, the *correction-selfcorrection* of the indices (data) is ensured, also with a view to continuously improving the forecasts.

3.2. SITEER-BDR information base

The condition, operational-multifunctional qualities, respectively the performances of the *whole* and of the *parts* of the RS-IRMS system are reported at and to the coherent and unitary system of information-data, through the "*System of Technical, Economical and Efficiency Indicators for the Road activities, works and networks*" (STEEIR) [3] (1982), [2] (1987), [4]. Its promotion is imposed – *concomitantly* epistemologically – at the levels of policy-strategy-tactics/planning-programming/design-execution procedures in a coherent approach.

The concept and STEEIR characteristics must be transmitted, operational-applicative, to the informatics *Road Data Bank* (BDR) – in the given case by developing the existing generalized BCDTR -, both proposed by the author [3] (1982), [2] (1975, 1987), [4], [12].

STEEIR includes the indicators describing the *things, beings and notions*, respectively the *conditions, features, events and actions* considered *specific, assessable* and *relevant* for the defined, analyzed, simulated and/or guided system. Concerning the mathematical pattern of IRMS, the ensemble (multitude) of indicators includes *all the parameters of the system* (criteria, variables, constants, restriction limitative values).

The information and STEEIR indicators are *classified* in *technical, economical, social, ecological and aesthetic* indicators. At the base of the *indicator pyramid* there are the three framing aspects: *operation, space and time* of information location. On the indicator pyramid height, are grouped the *three composition levels* of information: the level of *analytical* information (intrinsic features of characteristics, elementary relevant), the level of *synthetic* indicators (indicators made up of several analytical and/or composed according to important evaluation and function-objective criteria, for example operational qualities), and at the top, the level of the *complex* indicators (*global* indicators, significant complexity indicators, generally oriented towards *recipients* who operate the information base at general level, for example multifunctional qualities).

Within STEEIR, a bit of *Information* is a *Vector*, to whose composition participate the following components: the functional of the indicator; the attribute; the measurement unit; the value (measured or assessed); the reference time (of the value's birth); the moment of recording; the place of existence; the level of trust concerning the certitude, accuracy and precision of information generation.

Our propositions – direct or implicit – formulated in the articles issued in the national and international publications during the last three decades, have initiated the *continuous epistemological-technical-econometric systemic lexical enrichment* of the road technical-econometrical vocabulary.

3.3. IRMS global pattern and the class of road strategy types

A complex *operational approach* for the definition of the road strategy presents – in essence and in fact – an *ensemble* of definition, requirement, analysis, design, implementation actions, respectively of operation and development of a *class of strategy types*.

The *types* of road strategies are outlined and imposed by the strategies' *references (generators-recipients-receptors-beneficiaries)*, on the one hand concerning the complexity of the led object (networks-road sub-networks, etc.), and on the other hand concerning the purposes, respectively the functions (objectives-criteria) of the general or concrete particular strategies. The objectives of the road administration, the objectives of the transporters, the objectives of the adjacent social environment, etc., etc. differ among themselves (generally non-harmoniously or even antagonistic), therefore it is necessary to draw up and implement *specific types of strategies*. But in the same time, it is imperiously necessary to constitute a *global pattern* of the strategy *types,* which realize the harmonization of the interests of all the references-strategies effectively and concomitantly realized and operated [8], [3] (1982, 1994), [12], [2] (1991), [4], [9], [10].

The *global, basic pattern* of the strategies was elaborated in the same time in the *conceptual, physical, operational, computational, informational, cybernetic, mathematic and informatic* context.

The IRMS *structure* is combined, with subsystems-components – operational and structural – *in series, in parallel and specific connected*. The *operational subsystems* can be specific IRMS patterns elaborated compared to *one or concomitantly more functions* of the RS-IRMS (comfort, safety, physical quality, life quality, etc., etc.). The *structural subsystems* of the first complexity level are: "Maintenance Management System" (MMS); "Pavement Management System" (PMS); "Infrastructural Management System" (IMS); "Bridge Management System" (BMS); Road Capacity Management System" (CMS); "Road Safety Management System" (SMS); "Ecological Management System" (EMS); "Economical-Financial Management System" (FMS) and others. The development degree of the main structural subsystems is and may be different in historic context; for instance MMS-PMS has developed in stages and first in our approaches.

The *adaptation of the features* of modeled strategies, their *calibration* and *validation* were possible through large volume (in space, in time and in functions) and complex *fidelity experimental* research.

The road strategy *type class* is to be elaborated *concomitantly* from *several relevant points of view*, realizing in this context several *levels* (networks, functions, genres, hierarchies), *variants* (complexities, fields, etc.), *versions* (informatisations, heterogeneities, simulations, etc.) and *references (generators-receivers-receptors-beneficiaries*) of the patterns, useful to different hierarchies and decision makers, respectively useful to the users' variable space. The internal integration of the system is necessary due to its *significant structural-operational composition-decomposition*, previously underlined aspect (respectively aspect to be dealt with in subchapter 3.4).

The *development of the class* of *type* ensemble for *particularized functional-structural patterns,* even *autonomous and/or local* of road strategy is generally not solved in the case of operative patterns of the known PMS-RMS *type*, *experimentally of applicative* operational. In the case of the pattern classes with generic names such as Road Network Strategies; Integrated Road Management System; Road Strategies; etc., the *concomitant existence* within them of certain *functional-structural subsystems-sub-patterns* such as PMS, MSM, BMS, etc., etc., these – in their *system coexistence* – do not show the systemic coherence according to our propositions concerning the *class* of the IRMS *pattern type* and respectively, concerning the *internal multiple* macro-systemic *integration* [1], [6].

It is obvious that all the *combination cases* generated in this context concerning the patterns of road strategy (combinations of different levels-variants-versions-references) constitute concomitantly the *whole* or *coherent, connected, correlated part* of the *basic global* IRMS pattern.

The concretization of these *cases of combinations* of possibilities and wishes, in the case of any *given situation*, results in the fact that it *can be (or even has to be) realized a significant number* of *types* (of levels-variants-versions-references) of applicative road strategies and – in fact – the models-designs of road strategies *should exist* in this context, in such a really useful and accessible context.

Out of the class of road strategy types, we can put into light the following *functionally-defined* RS-IRMS types, from the applicative point of view for example: • functional-specific RS-IRMS concerning the description of the dynamic evolution (historic-present-future) of the condition and operational qualities of the road network (sub-network), without planned interventions; (this pattern type can also outline road strategies "without allotting resources"); • functional-specific RS-IRMS for analyzing and improving the global energetic balance of road activities and works, concomitantly and connected to the energetic aspect of road transportation, both concerning the optimization of power consumption per se, and concerning the significant reduction of environment pollution from road transportation due to the characteristics of road and transportation means (see the author's works in CNDPR [3], 1986); etc.

In the same way, we can underline the following *structurally-defined* RS-IRMS: • RS-IRMS structural part of the Road Maintenance Management System (MMS) subsystem type within a road sub-network, concerning the complex maintenance of the infrastructure; • RS-IRMS structural part of the Pavement Management System (PMS) subsystem, in the case of a road sub-network, concerning the strengthening-rehabilitation of the infrastructure; etc.

In the *practice of the administrations* of public or private road networks – taking into account the *permanent issue of ensuring the adequate financing level for the maintenance-development of the road infrastructure* -, the analysis of designing specific road strategies can be useful, such as: • road strategy for realizing the condition of "*the least damaged*" road network; • road strategy for realizing the "*most adequate*" road network, compared to a standard of minimum acceptable (admissible) level of the priority operational quality ensemble; etc. In these cases, we try to find out the *succession (stage developing*) in time and space, concerning the required size (minimal value) of the *volume of financial resources*.

Thus, the road strategy types can be classified, respectively, - according to the requirements of the references -, even in the following two distinct groups: having *unknown constructive elements* (geometrical, physical, mechanical, chemical, etc.), in which case the space of the resources is known, respectively having *unknown exactly the succession and the volume of the necessary resources* (financial, material, human) belonging to predetermined strategies, in which case the space of the constructive elements is admissible predetermined.

The concretization of these *cases of combinations* of possibilities and wishes, in the case of any *given situation*, results in the fact that it *can be (or even has to be) realized a significant number* of *types* (of levels-variants-versions-references) of road strategies and – in fact – the models-designs of real road strategies *should exist* in this context, in such a

really useful context. We mention the fact that, even if these classifications seem to, at first, superfluous of “philosophical” for the actual (or virtual) *references* (*generators-recipients-receptors-beneficiaries*) of the systemic road strategy patterns, in fact, even these demand – always, continuously and insistently – the *effective* operationalization of the autochthonous patterns classified as above, during the implementation-operation of a systemic road strategy.

Considering our experience – also the international one – concerning the real life of road strategies, it has been found that (generally), the strategies implemented for a *medium* operation period or a *long* operation *period*, registered *significant alterations* in time concerning the value and/or nature of their parameters of initial design or initial prognosis. The alterations have been imposed by the *references* of the strategies, or by the *natural* operational conditions (these alterations constitute serious perturbations in the dynamic behavior of the system).

In this real context, the trajectories of the strategies are to be *permanently examined*. As such, the application of *trajectory corrections* is imposed, which means the effective realization in time of a *dynamic approach* of RS-IRMS *analysis-redesign*, specifically its components, belonging to the instituted class of IRMS pattern types.

3.4. Multiple internal integration

Within the RS-IRMS approach, the entire *structure* and the ensemble of the *relations* concerning IRMS is conceptually, *functionally and informatively integrated*, respectively presently applicative (partially) integrated *mathematically, cybernetically and informatively*. Within the IRMS, the *Internal Integration* is systemically all-embracing [3], [4], [9], [10], [12].

The mentioned approaches propose the *concomitant, correlated, connected and coherent dealing with the management system types*, through a *multi-integrated global pattern of road strategy, Integrated Road Management* (IRMS).

The *multi-integration* is concomitantly realized on the criteria and operations concerning the *conceptual, functional, informative, mathematic, cybernetic, informatics* field, as well as from the *spatial-temporal, territorial, administrative, operational, normative, referential* point of view.

The *multi-integration* of the composing operational patterns of the elaborated management system *supposes and ensures* the genesis, singleness, complexity, dynamics, coherence, complementarities, professionalism, etc. of the IRMS *large system*, complex, dynamic and cybernetic, respectively of the functional and structural *subsystems* specifically outlined within it.

The integration is concomitantly reported to the *superior levels of the macro-systems* (as much as possible) and to the *aspects of the dynamics of the network condition*, the *dynamics of the optimal trajectory correction* and of the *dynamics of the self-corrections in the development-validation of the patterns*. The *operational* multi-integration is realized at the level of the definition of the patterns’ *design parameters*.

The performance of the whole and of the system *parts* is reported to the requirements of the road strategy functions, specified through objectives and decision criteria. Operationally, this is *evaluated theoretically and applicative* through the *component and/or the subsystem* Economical-Financial Management System (FMS), respectively practically

through the *omnipresent specific function* FMS, included in all IRMS systems-subsystems. The applied *methods* are known (*matrix* methods; *benefit-cost ratio; condition index; cost-effectiveness; maximizing benefits,* etc.) but *adapted* to the requirements of development specific to a road network, on the one hand in the context of its participating in *an international network*, on the other hand, in the context of the *state-local heterogeneous network in modernization and in transition*.

In the process of optimal/rational systemic management on medium and long term of road strategies of different type and genres, designed through the global pattern, the *subsequent operation* within the approached time horizon raises complex problems concerning the *dynamics of requirements and decision criteria*. The *dynamic adjusting* in this context of the *real trajectories* requires the continuation of research and application concerning also the *integration* of the operational approaches in the *dynamics*.

The particularization of the application types (*levels, variants, versions* and *references*) is autonomously ensured for the *diversity of references* (*generators / recipients / receptors / beneficiaries*). The integration in the IRMS of *purposes, requirements, decision criteria* and *systemic management practices*, formulated and followed up from the *references* part in general *antagonistically*, constitutes one of the most difficult problems of the required intervention of RS-IRMS on the *integration of road strategies in road policies and in the reality of the social-economical life*.

Integrated IRMS also means systemic integration specific for the development conditions within the general and concrete *instructional frame* for design, implementation and operation of road strategies, as well as the special *training frame* of the staff – including the elaboration of *practical application handbooks* and respectively *university and post-graduation courses* for the specialization in the field.

The presence of an endo- and exogenously integrated RS-IRMS approach in the daily economical and social life *requires and ensures* – starting with the realization of the *analysis-design pre-auditing* and the *implementation-development auditing* proposed in the RS-IRMS – the *possibilities for public control*.

In the context of the promoted *systemic multi-integration*, the road strategies of any type and origin *are not dealt with in an isolate non-concordant manner*. In order to solve a viable coordination of the actions, it is imperatively necessary to adequately organize the *coordinator* from the administrative point of view.

3.5. Pre-auditing and complex auditing of the road strategy

Within the RS-IRMS approach, *we formulate* – finally – *considerations and innovative propositions* concerning the need to *introduce* in the practice of specific field actions of the "*independent pre-auditing" of road strategies which are being analyzed and designed*, respectively the "*independent auditing" of road strategies which are being implemented and developed* (see the author's articles in: [3] (2006, Udvardy); respectively, [12]).

During the last decade, the worldwide practice witnessed the instauration of the *auditing* concerning *road traffic safety, protection and restoration of the natural environment from the ecological point of view*, etc. The *auditing* aims mainly at ensuring the best functional operation of the given road network. At the *design level* and at the *execution level* of the road project, it follows the definition and the observation of several *exigencies criteria* which are explicated in the system.

Compared to the present system of the *ordinary audit for road work design* and compared to *the ordinary audit for operational existing roads, the pre-auditing and auditing* of the network development-modernization *strategy* in a *systemic strategy*, includes objectives (questions in the questionnaire) – among others – concerning the *existence of the spiritual, financial, material and technological modernization conditions-sources*, concerning the *specificities* as to the exosystem, concerning the systemic *multi-integration* as well as concerning the *level of the aptitudes in the social environment*, respectively concerning the *forecast of the evolution of the modality and degree of motorization* for the population in the analyzed area.

The *pre-auditing and auditing of road strategies* constitutes a *formal examination* of the performance of a future strategy, respectively of an existing strategy. If the *reviewing of the projects and of the roads is reactive, the pre-audit and audit of the strategy* – somehow the same, as the *Audit* of projects and roads – *is pro-active, the pre-audit and audit of the strategy* – like the audit of work projects and existing operational roads – *does not represent* the control of the sociometrical, econometrical or technical quality of the analyses and projects, respectively of the implementation and development of the strategy and *does not realize their supplementary approval*.

RS-IRMS must include in this context professional and administrative-organizing instructions in the *pre-auditing handbooks* (for the analysis-design phases) and respectively *auditing handbooks* (for the implementation-development phases) of the road strategies, ensuring in the main time the conditions for training-specialization of *auditors* in the fields of the functions of road traffic systems. The training of auditors, respectively the *plan, stages, questionnaire, procedure* of pre-auditing/auditing road strategies, represent and will represent *continuous dynamic processes*, aiming at *perfecting* their adequate complexity and efficiency in the RS-IRMS.

The results of pre-auditing/auditing road strategies are to be valorized starting with *improvement dispositions* for the functional qualities and ending with the *alterations of the instructional framework* (technical, economical, social, ecological and aesthetic). The importance of using the results of the actions is underlined also for ensuring an *essential feed-back* towards the evolution of the transportation policy and the coherent development policy for the entire road network.

It is worth noting that the descriptions of the existing road strategies patterns in the international informative environment [1], [2], [6] etc. *do not inform* upon the existence in their approach of certain methodologies, methods or procedures concerning the *pre-auditing/auditing strategies* as to the priority functional qualities of road traffic systems or of system infrastructures; as such, *our propositions contribute to the development of this important aspect*.

4. SOME CONCLUSIONS

4.1. Complex efficiency

The complex efficiency (*economics* + *efficiency*) of the systemically corroborated approaches is superior to that of the result of the actions of procedures-elements-components belonging to defined systems-subsystems, even in the *really* registered *case* of the "*management of the systems with limited resources"*, if the *performance functional* is systemically approached.

The delay of the generalized implementation of a real PMS or IRMS system, as resulting from the practice observed by the author – respectively from the worldwide specialized literature -, must be sought for in the evident and insurmountable *antagonisms* in the family (also heterogeneous) of the beneficiaries (or even the *references)* of the real road traffic system.

The efficiency of road strategies is determined by variants of *interests* and *methods*. Our generalized and/or experimental applications demonstrate that the *connected economics* road-transporter can ensure up to 15-20% direct and implicit economy in the case of a systemic strategy led on *medium term* (compared to the programming and helter-skelter execution of actions and road works), in the case of a *multi-heterogeneous transition* road network in modernization, in the case of a *relatively significant funding*.

It is anyway important the fact that, in the case of an ensemble of *systemic road strategies*, their *utility* is shown, first, by the following: • ensures the *objective knowledge* of the condition and multifunctional qualities, static and dynamic-cybernetic, of the road network; • assesses-simulates technically-economically the *necessities* in financial-material *resources* with a view to altering the condition and quality of the road network to *meet an accepted or imposed requirement*; • acquires the *specific professional language* of the road strategy approach and realized s the *comprehensive character* of theoretical and operational patterns; • implements and operates, successively, the *class* of road strategy *types* required by the *references*; • realized in stages, unitary and collectively, the *integrator global pattern* of viable road strategy, multi-attribute and complexly efficient, connected to the exosystem.

4.2. RS-IRMS implementation

The activities undertaken in a multi-heterogeneous network allowed to *ensure the adequate informative conditions* for a possible preparation of the *generalized implementation (or local), in stages in its complexity and in area of the objectives chosen by the decision makers*, of certain concrete *types* of road strategies. It is worth noticing that – what in fact represents a common feature for any worldwide known approach -, RS-IRMS is proposed and *implemented successively and stage auto-developed*. The approach includes, in the same time – inevitably *concomitantly* -, research phases, experiments, local applications, generalized applications, etc. concerning the components of the global RS-IRMS.

The design, implementation, operation and development of certain road strategy *types begin with the creation of a road data bank*. It successively and continuously develops the space of the *functions* (requirements, purposes, and objectives), the area and the volume of the *data bank*; it extends and develops in stages the complexity of the informatics *application library*.

The implementation of the systemic road strategies *never* ends, on the one hand because it must be *continuous,* as to the evolution-development of the *behavior trajectory* of the approached objective, and on the other hand because the *references* are always reported in a divers way, antagonist or selfish, *heterogeneous*, to the ensemble of the functions already approached in the system.

The presented RS-IRMS approach may constitute – even *only* through some of its features -, a *source of information* worth analyzing in a design-implementation-

development process of a *class of road strategy types* inevitably useful to the *transportation macro-system* and the economical-social macro-system.

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