ANSWERING THE ACTUAL DEMANDS THROUGH REENGINEERING OF HIGHWAY INFORMATION MANAGEMENT SYSTEM (HIMS) IN SERBIA

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ABSTRACT

According to World Bank initiative, in the year 1990. was started the development of Data base on roads of Yugoslavia, which was designed to be the basis for contemporary management of road network maintenance and development. During year 1991. Road Directorate of Serbia adopted the Program, and it was the beginning of intensive works on development of the first HIMS with integrated Road Data Base, Bridge Data Base and Traffic Data Base. During the nineties, the information system had an important role in road network managing, and, after ten years of experience, the reengineering of the entire system has been started, and today is nearly completed, with the main goal - to fulfill expectations of system users and requests of actual methods and technologies (i.e. HDM 4, new data acquisition devices..). Those activities commenced in year 2000. with detailed analysis of Road Management System Processes, and with special attention to the users expectations and requests. One highly valuable Model of RMS Processes was created. Through development of the appropriate integrated Data Bases, the very powerful HIMS is nearly completed. This report presents in short Model of RMS Processes which is the key step for creation of the appropriate Highway Information Management System, which will fulfill the requests and expectations of users.

KEY WORDS

ROAD MANAGEMENT / MODEL OF PROCESSES / INFORMATION SYSTEM.

1. INTRODUCTION

Preliminary design of the Integrated Highway Information Management System (HIMS) in Serbia was completed in 1992. The Road, Bridge and Traffic data bases, as the basic subsystems of HIMS, were finished and implemented as the first phase during the year 1992/93. In the same time, the methods and devices for fast road data collection and road condition monitoring system has been established and implemented. Up to now, additional business and technical subsystems and applications have been developed and many of them are implemented in practice. Also, the first campaign of road data collection was realized during the period 1993-1996, and today the HIMS in Road Directorate presents one important resource.

The HIMS general solution envisages the main subsystems and modules of the information system which are compatible with the work organization in the Road Directorate. The following four subsystems have been defined:

- information base for business and financial activities
- information and technical base for the road network management system

- development of the information centre and communications
- road toll system

From the above-cited four groups, only the road toll system is developed independently, with indispensable co-ordination by the Information centre, meant to ensure the transfer of data necessary for the business and technical subsystems of the Directorate. All the remaining parts has to be integrated into a unique information system with intention to secure support to both technical and financial services in drafting plans and monitoring their implementation, by the means of controlling the state of the road network and by recording all the activities at necessary levels, regarding the physical and financial extent. The goals were generally reached, but from one to other component, HIMS was more or less successful.

Today the HIMS has stored the alphanumeric and graphic data on 17000 kilometers of roads (road inventory, pavement condition, facilities...), nearly 3000 bridges, nine years traffic flow data from more then 140 automatic counters, many financial and administrative data, the ACAD drawings, pictures of characteristic road details, maps etc. The numerous applications, offer to the client different information, graphic presentations, simple or very complex reports. The connections with Windows applications and with other commercial software products ensure high quality of presentation.

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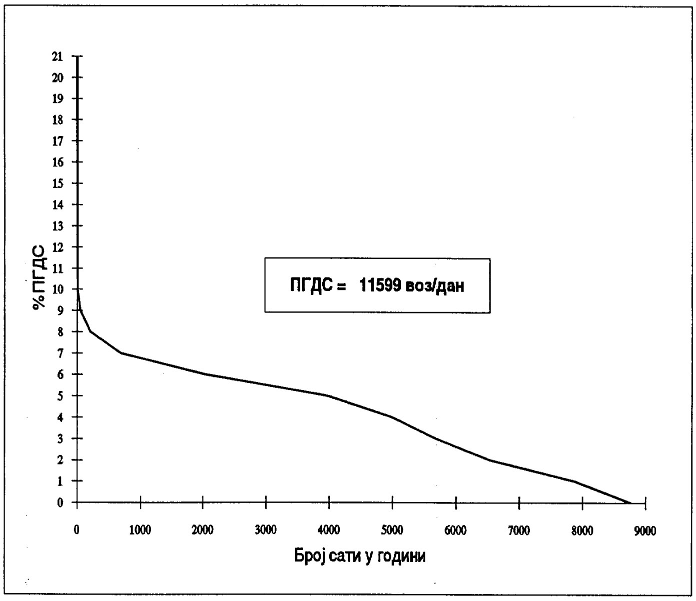

%ПГДС	Возила	Број сати	Кумуланта
0	0	0	8760
1	116	892	7868
2	232	1324	6544
3	348	859	5685
4	464	694	4991
5	580	1029	3962
6	696	1935	2027
7	812	1341	686
8	928	481	205
9	1044	159	46
10	1160	38	8
11	1276	7	1
12	1392	1	0
13	1508	0	0
14	1624	0	0
15	1740	0	0
16	1856	0	0
17	1972	0	0
18	2088	0	0
19	2204	0	0
20	2320	0	0
>20	2320	0	0

Figure 1 - Traffic data base: Annual traffic flow distribution per hours

2. SYSTEM REENGINEERING - ROAD MANAGEMENT SYSTEM PROCESS MODELING

2.1. Basics

Actually, after ten years of experience, the reengineering of the entire system is in development, with the main goal - to fulfill expectations of system users and requests of actual methods and technologies (i.e. HDM 4, new data acquisition devices...). Those activities were commenced in year 2000. with detailed analysis of Road Management

System Processes, and with special attention to the users expectations and requests. One highly valuable Model of RMS Processes was created and through development of the appropriate integrated Data Basses, the very powerful Information System will be completed in next few months.

From Road Network Management System point of view, beside the Traffic Data Base, the information on road sections and bridges (also on other constructions) are of main interest, and this is the basis for implementation of Pavement Management System and Bridge Management System as the important subsystems of overall management process.

The process analyzing and modeling system was generalized by adopting one virtual “Civil Engineering Object - CEO” as the main entity of management process. In the Pavement Management System, the road section is one CEO, for Bridge Management System, the CEO is the bridge, but, model could be applied for any other type of constructions, i.e. buildings, tunnels, antennas.

Under the term ” CEO of particular type” we recognize a group of similar objects, characterized by

- similar technology of design documentation preparation
- similar technology of construction and maintenance
- similar purpose and way of exploitation
- possibility of definition of a reasonable number of elements, which are representative for characterization of entire objects group.

As an example, all bridges in the National road network of Serbia are defined with 26 elements, which have to be examined during the routine inspection.

Usual situation is that one user manages a system with more CEO of similar kind.

The starting point of research was based on technical-empiric aspects of estimation of condition of damaged objects and assessment of their rating (Ri). The condition rating (Ri) would suggest the type of intervention (regular maintenance, need for experts’ estimations, repair projects, repair works, urgent repairs).

The condition rating (Ri) was generally determined as:

$$R_i = \sum_{i=1}^{n} a_i \times b_i$$

Where is:

n -number of representative elements of object

a_i - ponder for the role of (representative) element of object

b_i - estimated element condition

The final objective of this research was determination of priorities in performance of works involved in exploitation management of particular group of CEO (Catalog of works).

2.2. The concept for development of methodology and information system for CEO maintenance management

Information system for CEO maintenance management has to provide support for optimal maintenance management for one particular group of specific objects. It includes financial and operative planning of maintenance works, construction inspections, defining the construction conditions, determining the priorities, and reporting on actual situation.

Defining all necessary activities and database entities through the detailed process analysis is the basic step in model development. After that, the definition of attributes and relationships (Entity-Relationship diagrams) provide general solution for information system.

In accordance with IDEF0 methodology, development of information system is based, first of all, on detailed analysis of processes and activities, which, with defined inputs, under specific controls, produce requested outputs, using available resources (fig 2).

Concept diagram is highest, general level, with:

Inputs:	user requests, and existing data for objects
Controls:	regulations, technical guidelines, norms, etc
Resources:	employees, equipment...
Outputs:	reports on object condition, programs for routine maintenance, reconstruction, financial plans and history of maintenance

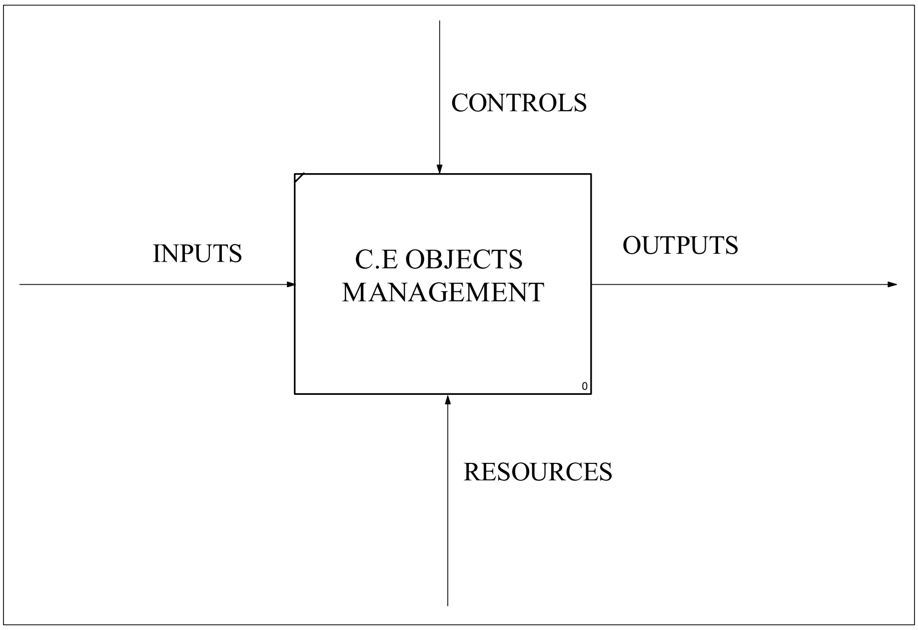

Figure 2 - Processes analysis general concept

In order to complete project applications, it is necessary to follow these steps:

1. Model of processes definition
   - context diagram
   - decomposition of activities (tree of activities)
   - definition of candidates for entities and attributes.
2. Data model definition:
   - identification and definition of informatics entities of the system
   - definition of attributes
   - definition of relationships between entities - data flow diagrams
3. Databases specifications:
   - distributed data processing
   - implementation of system for relational database management (RDBMS), such as ORACLE®, INFORMIX®, SQL Server®, ACCESS® etc.
4. Programming and implementation

It is necessary to underline the importance of reached results concerning CEO management processes analysis, in the part which provides general solutions for organization of a good management system, based on development of appropriate information system.

2.3. Basic solutions of created maintenance management model

In accordance with presented principles and facts, with usage of IDEF0 methodology, the definitions of particular processes, activities, data and their relationships among the model were created.

One of the essential model elements is "inventory data" for objects. Inventory data, first of all are used for assessment of needs for routine maintenance and for definition of objects' elements which have to be monitored. The main parts of "Guidelines for objects condition monitoring" are: Catalog of elements (which have to be inspected), Catalog of possible damages for particular elements and Specifications of repair works. Objects condition monitoring is to be organized as defined in Guidelines, and as result we obtain the data describing actual object condition, assessment of necessary measures/works and elements for list of priorities. Different catalogs definitions allow implementation of different levels of scope, or different methodologies for decision making process (i.e. HDM-4).

2.4. Model structure - activity tree, diagrams

Table 1 - Activity tree

Activity number	Activity name
A0	MAINTENANCE MANAGEMENT SYSTEM DEVELOPMENT
A1	*INVENTORY DATA DEFINITION*
A11	Methodology of data acquisition
A12	Review of existing documentation
A13	Preliminary object examination
A14	Anquets and other
A15	Data preprocessing and import in IS
A2	*DEFINITION OF METHODOLOGY FOR CONDITION MONITORING*
A21	Definition of elements for object group
A22	Definition of potential damages types and intensities
A23	Specifications of repair works
A3	*OBJECT CONDITION MONITORING*
A31	Planning and preparations for inspection
A311	*Analysis of existing data*
A312	*Creating the inspection program*
A313	*Preparation and movement to location*
A32	Object inspection
A321	*Visual inspection*
A322	*Surveying*
A323	*Mechanical tests*
A324	*Photographing*
A33	Processing and importing data
A34	Data analysis and reporting
A4	*OPERATIVE AND FINANCIAL PLANNING*
A41	Object condition analysis
A42	Performing urgent actions

Activity number	Activity name
A43	Routine maintenance planning
A44	Forced maintenance planning
A45	Financial analysis
A5	*MAINTENANCE WORKS EXECUTION AND MONITORING*

The graphic presentations of the model are showed in fig. 3. and 4.

Context diagram (A0)

Context diagram (fig. 3) presents the highest model level, with general descriptions of inputs, controls, outputs and resources.

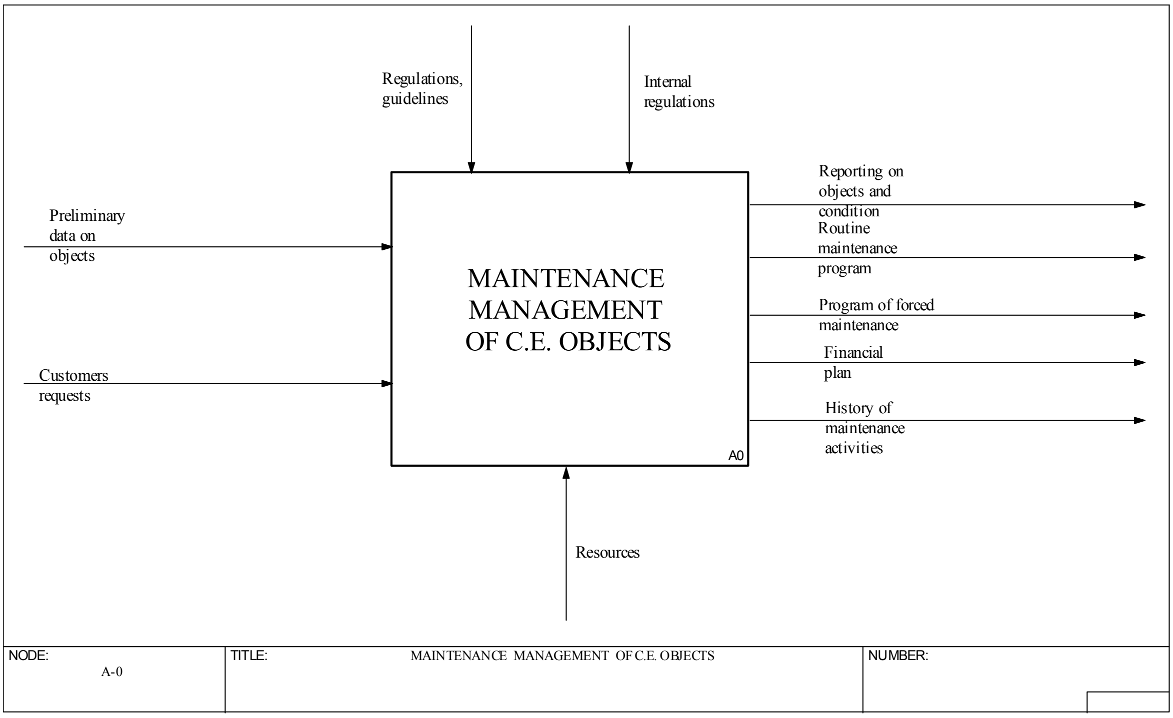

Figure 3 - Context diagram

It is assumed that, at very beginning, we have in our disposal some, incomplete object inventory data, which even might not include a complete list of objects. As inputs, there are also costumer's requests (or request of somebody in charge for maintenance management) on existing documentation, regulations, necessary level of details, inspection frequency, available maintenance budget etc. Controls may be based on existing regulations, specifications, standards or internal documents.

Model outputs are defined as reports on actual objects condition (also for every particular object), plans for routine and forced maintenance, financial plan and history of maintenance actions.

In order to produce requested outputs from described inputs, it is necessary to collect and process large number of data. Therefore, definition of activities, created through process decomposition to sufficiently detailed level, is necessary.

First level of decomposition (A0)

It is sufficient to define five main processes in order to produce requested outputs from context diagram (fig. 4)

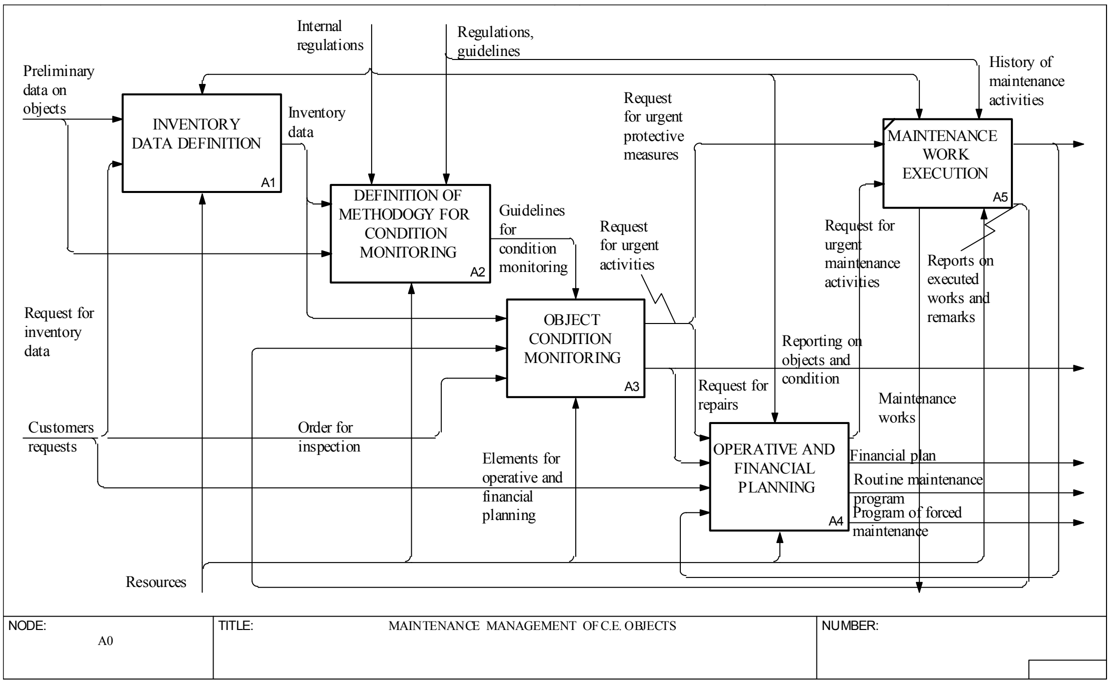

Figure 4 - First level decomposition

Inventory data definition (A1): the aim is to collect all relevant data, including technical description of every particular object / construction, which is significant, first of all, for program of routine maintenance. Those are: historic data - designing, construction, exploitation; location data - macro and micro location; structure data - system, structure elements, infrastructure systems and elements, equipment, materials etc.

Definition of methodology for condition monitoring (A2): this is one of the key processes, with main task to create:

- Catalog of elements for inspection (monitoring) with adequate factors of safety, economic importance and functional importance (FS, FE, FF)
- Catalog of potential damages with instructions for quantitative evaluation (E)
- Specifications of repair (maintenance) works

  After inspection, the particular element impact to object condition is evaluated through:

$$FS \times FE \times FF \times E$$

  This is the general expression, which enables involvement of different criteria, through association of adequate values for particular factors.

Assessment of object condition (A3): it is based on the existing data review (previous inspections data, history data) and on the actual (latest) inspection data with evaluations of particular elements, produced in accordance with methodology (A2). The result is one quantitative assessment of necessary works, and a list of priorities.

Operative and financial planning (A4): the plans and programs are produced using exiting reports on objects condition, price lists, information on available budget and resources.

Maintenance works execution (A5): organization and execution of maintenance works are out of this model, but here is data used from this model necessary for forming maintenance history: evidence of executed works with physical and financial quantification, related to particular object and its particular element. History data are suitable for trend analysis (prediction models), for maintenance scenario optimization, and particularly for updating data on object condition in the time between two inspections (when necessary).

The activities A1 and A2 are important for first phase, when system for maintenance management for particular group of objects is in development. After that, these activities have to be performed only when a new object is added, or for updating data on elements after significant changes. However, the activities A3, A4 and A5 are continuously performed, together with maintenance management processes.

The listed activities, A1 to A5, are further decomposed according to structure presented in the beginning of chapter 2.4.

Beside graphic presentation, every process/activity has textual definition with necessary comments and notes. The definitions of "Arrows" contain textual descriptions, and also the list of related data, which are basic for data base creation.

The part of process definitions for level A0 and for model branch presenting processes of inventory data definition, are listed in the following table.

Table 2 - Activity definitions

Activity name	Activity number	Activity definition	Sources
MAINTENANCE MANAGEMENT SYSTEM DEVELOPMENT	A0	Methodology development and implementation, for a management system of the group of similar C.E. objects.	General data on objects, resources budgetting etc.
INVENTORY DATA DEFINITION	A1	For the particular group of objects, it is necessary to define list of all objects, and after that to collect inventory data. Those are data on location, design documentation, users, history, technical specifications on construction, etc.	Customer and its documentation, design documentation, reports on construction, recognition in the field, anquetes etc.
Methodology of data acquisition	A11	Creation of Guidelines for inventory data acquisition: how to compose the final list of objects, how to review existing documentation, which data to extract and in which format (text, tables, pictures, scanned plans, CAD drawings etc). It is necessary also to define the technology for object examination (in the field), the anquetes	Information from customers and others who may have information on objects, design documentation, preliminary field examination, anquetes, etc.

Activity name	Activity number	Activity definition	Sources
		organization (list of candidates for anquete, work program). It is very important to define optimal level of details, especially for technical data. Here is also defined process of data preparation and import in information system.	
Review of existing documentation	A12	Collection and examination of existing documentation of objects, extraction the necessary data in accordance with guidelines from A11. It is important to pay attention to data on elements and quantities for maintenance.	Proprietors of documentation, object users, managers etc.
Preliminary object examination	A13	Preliminary object examination in order to check the data from documentation and to collect missing data.	Team for object examination, directives and forms in accordance with Guidelines (A11).
Anquets and other	A14	Collection of data which has not been collected from documentation and field examination.	Participants in object designing and construction, maintenance managers, users etc.
Data preprocessing and import in IS	A15	Data processing and input to data bases (scanning, format conversion, input from keyboard etc.).	Roof data collected from different sources.

The “Arrows” are described in the similar way, together with associated entities and attributes. Those are fundamental data for creation of Entity-Relationship (ER) diagram, which is the base for Information System design.

3. CONCLUSIONS

In this report, the key steps and elements of Civil Engineering Object Maintenance Management System Model development are presented. Described model was created with “IDEF0” methodology, through process analysis; information flows analysis and definitions of candidates for entities attributes for databases.

The main result of this work is generated by maintenance management processes analysis. It is a general solution for development and implementation of appropriate, well-organized management system, supported by information system.

Following these results, by implementing described method, it is possible to quickly reach solutions for forming contemporary management system for group of objects with similar structural characteristics, as well as solutions for forming appropriate information support.

This far, all the main problems are solved, and analyses and processing of particular activities and information flows were performed to details, together with definition of candidates for entities and attributes. This brings us to the routine of forming an “ER” model and a precise data glossary, thus easily completing the design of information system for a specific group of C.E. objects.

These results are successfully implemented in Road and Bridge data bases reengineering in Road Directorate of Serbia.

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