2. INTERNATIONAL CO-OPERATION ON EXCHANGING DATA AND KNOWLEDGE FOR ROAD SAFETY MANAGEMENT

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SUMMARY

One of the most important problems of road transportation is road safety.

The present computation technology, Geographic Information Systems (GIS) and Expert Systems (ES) have become suitable to handle large-scale transportation problems.

For traffic safety ESs more accident data are necessary, which requires international co-operation. The standards for the treatment have also to be internationally similar, because the traffic itself is also becoming more international.

In this paper, a Road Safety Management System (RSMS) is drafted on the basis of an ES and a high-performance GIS as an integrator. It could also integrate other ESs in the transportation domain, becoming in its extended form a 'total' Transport Management System. Due to the GIS, the system could integrate or communicate with the data of other domains which have influence on the traffic itself, or on the evaluation of traffic circumstances. The user interface will be created according to the general professional skills, providing the wide-range suitability of the system.

To create the RSMS, international collaboration is proposed to exchange data and knowledge and to use the most advanced technologies.

This paper is based on the booklet, which have been circulated to institutes and experts all over the world in the second half of '92. After the processing the returned questionnaires (which were attached to the booklet) the author will give further information about the recent results of the project, drafted here.

2.1 INTRODUCTION

Today the satisfaction of the basic travel demand is no longer a problem in the developed countries. The improvement in the level of service causes difficulties, because the present transportation demand on the road network is higher than at any other time.

If we look at the evolution of transportation we will see that road traffic is dynamically increasing, while rail and waterway traffic stagnate. This shows that the desired changes (e.g. in modal split) will be slow, and besides the above mentioned management, we must also focus on the improvement of road traffic.

Although experts continuously work in this field, the results seem to be only relative:

In spite of the increasing car ownership and road traffic performances the number of accidents and the amount of losses (human and material) stagnate, or decrease slightly in the last two years. Nevertheless in the European Community every year around 55,000 people are killed on the roads, 1.7 million are injured, and 150,000 permanently handicapped. The financial cost of this is estimated to be more than 50 billion ECU per year; the social cost in human misery and suffering cannot be measured.[2]

Many factors play a role in accidents. To improve safety conditions these factors must be modified, and consequently, their particularities have to be analyzed.

In most countries all the accidents are reported and collected in a national database. These are usually very detailed and contain both the accident data themselves, and the local conditions.

The road and traffic conditions belong to the factors involved in accidents. By analyzing these data, searching for connections between them and accidents, it becomes clear that even though we find the number of accidents to be very high, in many cases it is not high enough to obtain a significant correlation.

Although conflicts technique could be useful for analyzing the traffic safety conditions of given network elements, it is not a solution, when a wider range of accident data is required. This is possible only with the availability of accident databases of different countries, by international exchange of information.

This data exchange could help to create Expert Systems (ES) which are internationally applicable. This is very important, because an increasing proportion of the traffic generated is crossborder, so part of the problems have become international. In practice, this means that in the not too distant future a complete and internationally co-ordinated Transport Management System (TMS) is necessary, which is flexible enough to integrate national characteristics.

The internationally distributed Data and Knowledge Bases, their exchange, a Road Safety Expert System, a transport oriented GIS - these will be the parts of a Road Safety Management System (RSMS), which could be the basis of a "total" Transportation Management System.

2.2 EXPERT SYSTEMS - TRANSPORT MANAGEMENT SYSTEM

As a final and future goal we have mentioned the Transport Management System. Firstly, let us see what a TMS is in reality, and what kind of activities have to be integrated into it.

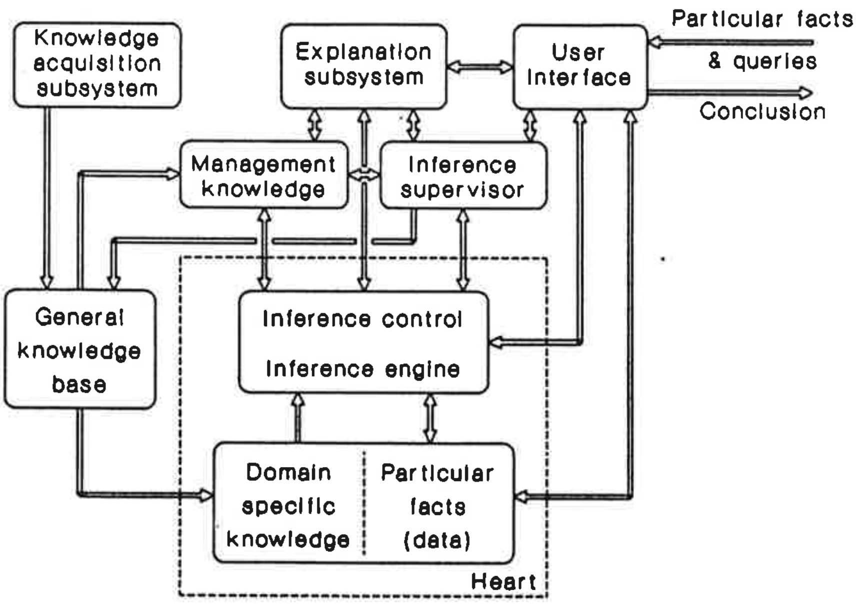
Transport management is the process of controlling and co-ordinating a comprehensive set of activities in order to achieve the optimal balance of the interest of different classes of road (transport network) users, taking into consideration different transport modes. The general target of the optimization is to make the best possible use of resources available, to maximize the benefit to society.

This "total" Transport Management System consists of several subsystems, such as:

- Pavement Management
- Transport Information Management
- Safety Management
- Trip Management
- Environment Management
- Forecasting Systems, etc.

The expertise of these fields is combined to expert systems (ES), which are practically the utilized and exchangeable forms of knowledge. In the TMS every subsystem is represented by an expert system.

In the case of the TMS the several subsystems are represented by their own knowledge base, an ES, but the inference procedure could be controlled by the same algorithm. The results in one domain have influence on the others. For this feedback another co-ordinator routine is required to supervise it, define the order of the procedures, activate the necessary knowledge; so controlling the communication between the several parts of the system. In the knowledge base there has to be a 'domain-independent' part, too (management knowledge), which represents the expertise on the interrelationships between the integrated domains. The draft of this 'multi-expertise' management system is shown in Figure 1.



2.3 ROAD SAFETY MANAGEMENT SYSTEM

In an accident four main factors play a role:

- human factors,
- vehicle design,
- environmental factors (weather ...),
- road and traffic characteristics.

The crucial role of 'human factor' in traffic safety can be reduced by creating circumstances which in themselves induce the drivers to drive more safely. Besides keeping to the general design standards (visibility, etc.), this is the role of the traffic engineers, and the road and traffic characteristics in traffic safety.

In the last decade much effort has been made to find closer connections between accidents and road and traffic characteristics. Many accidents (and conflicts) data have been collected and analyzed from several points of view. As a result, there exist some Expert Systems created by several different institutions around the world. (5)

2.3.1 The necessity of GIS

It is evident that a transportation system could not exist without a graphic tool. The only question is, what kind of graphic tool is necessary; is a CAD (Computer Aided Design) system enough, or is a GIS (Geographic Information System) required?

The definitions of the two types of software do not cover every aspect of the systems. But the difference is clear that GIS is mainly an analytic tool, and CAD is chiefly developed for graphic visualization. Nevertheless the evolution of CAD systems shows that in some aspects they approach GISs. This means that an advanced CAD system with an additional data processing system can work like a GIS, but with certain restrictions coming from the original characteristics of CAD systems.

Generally speaking a GIS is required, when frequent and extended analysis of the data is necessary, and geographic information is used.(6,7)

The solution in GIS is more effective, and it gives wide perspectives. The claim is getting stronger for combining more or all spatial information into one identification system, where both the location of every facility and the interrelationships between different domains could be clarified.

The advantages of an entire system are evident, where all the information relating to geographical locations are combined. In our case this means that e.g. for our "network-oriented subsystem" the environmental data could be derived from an "area-oriented spatial subsystem" which also serves the forestry, agricultural, geological, etc. purposes.

Taking into consideration the arguments for and against, the needle of the scales tilts definitely to the side of GIS. This means that for the flexibility and efficient use of TMS a GIS has to be integrated.

Beside the arguments of the present, we have to have a look into the future. There are some more arguments for GIS.

2.3.2 Future of GIS

People working in the forefront of computation development, see quick (r)evolution of Information Technology (IT) and GIS itself (10-13); some important examples:

- Large use of Expert Systems (as previously described).
- Effective (relational) Distributed Database system, where the user anywhere in the system will have information anywhere on the network without having to know anything about where that information physically resides, how it is structured or how it is maintained. These require a better performance of IT networks.
- Instead of the present specialized software, the actual trend (e.g. within IBM) is to develop one GIS software covering the various application types.
- The concept of GIS database will disappear, and instead of the actual two databases (a proprietary and specialized one for the management of geographic data, and a standard one for the management of alphanumeric data) only one database will remain in future.
- Fully Distributed Database support will become a strong need. This demand has already appeared, but it is not yet reality, because several critical components of the technology are simply not yet available.

2.4 PRESENT SITUATION

2.4.1 Database

As it has been mentioned, TMS requires an entire database. Besides the methodological difficulties, the creation of the database generally causes the problems. In spite of the fact that first we focus on traffic safety, for providing the consistency we have to prepare the database for every operation. For this reason we need all data belonging to one domain in the same structure. The lack of harmonization will cause many problems in the future data exchange.

In the transportation field the necessity of computer databases appeared many years ago. They were created for given purposes, and were getting more detailed and entire in parallel with the evolution of computation (analysis and graphics).

At the determination of the necessary content of the database we have to consider the need of the other fields of road safety (education, vehicle design, assistance of injured etc.). Taking into account the extent of the database required, and the fact that there are existing digital databases, we have to use them instead of creating a new one.

2.4.2 Knowledge base

In the transportation field there are many calculating, analyzing, simulating and decision preparing methods based on computing. The simple ones deal with one aspect only (travel time, air pollution, capacity of junctions etc.). There are combined ones for pavement management and cost-benefit analyses, or complex ones like multi-modal forecasting methods, completed sometimes with multi-criteria analysis, also taking environmental effects and imponderabilia into consideration.

Expert Systems have appeared in the second half of the '80s, solving mainly deterministic problems (Traffic signal design (14), Trip generation (15), and more (4) in the transportation field). After more experience with Expert Systems, professionals also turned to probabilistic occurrences (16-18).

Although there are only a few results and experiences with these Expert Systems, these could be the basis of the TMS system to be developed.

2.4.3 GIS

Almost all software, designed for transportation purposes, contains graphic routines for visualizing the network and the results of the analysis. Some of these programs were developed before the spreading of GIS packages. The majority of these graphic software packages were written for a specific purpose, others use generally distributed graphic tools, like CAD systems.

Nowadays the competition for the dominance in transportation GIS is getting sharper. The giants of the computer industry developed their own GIS software with the necessary hardware supply. At this moment there are no direct relationships between these products (SICAD [Siemens], GPG [IBM], ArcInfo [ESRI], etc.), although there is an aspiration to standardize the data input. However the result of this cannot be expected in the short term, so the most suitable system has to be chosen very carefully, because this decision has far-reaching consequences and the system must operate over a long period of time (19,20).

2.4.4 Data and knowledge exchange

The development of RSMS (and TMS) needs two types of data exchange.

In the phase of development the data and knowledge communication occurs between independent systems and organizations. The media used can be varied, ranging from the direct discussion through magnetic and optical disks to the on-line connection. Of course to realize this, some harmonization and co-ordination (a committee, a workplan etc.) is required.

In the operational phase there will be two types of communication. On the one hand the system has to be maintained regularly. For this purpose the same data are required just as in the development phase, but no knowledge, because the new rules are derived by the data acquisition subsystem. The data will come from independent sources, outside the user's system, but the communication has to be organised on a higher level than before. It could work with regular monitoring, and later as a remote access distributed database.

On the other hand RSMS or TMS operates inside the user's own system, and it also requires data and knowledge communication.

Comparing the demands to the present possibilities, it is clear that all the requirements cannot be fulfilled at the beginning. There will be some problem with the data and knowledge communication in the development phase, caused by the need of harmonization, and critical parts of the distributed database technology are not yet available. This means that at the beginning the data transfer has to be solved in a traditional way. Later on both the TMS (on the basis of RSMS) and the data communication have to be developed in parallelism, according to the new results in the computing and database-management field.

2.4.5 Networking on a large scale

Data and knowledge (including graphics) can be exchanged by communication on a large scale. Therefore we have to set up rules and formats. In the system to be developed we also have to provide us with inter-process communication possibilities, as follows:

Message passing - Processes communicate by exchanging messages. No additional formal structure on message exchange is imposed by the communication system, but the applications themselves adopt a protocol for understanding the messages.

Remote operations - Adds structure to communication among processes by viewing interchanges as a client invoking (remote) operations on a server.

Remote procedure call - Uses the subroutine or procedure call as the metaphor for exchanges between processes. The metaphor of procedure call can be extended in many different ways to incorporate synchronization and other properties in a single mechanism.

2.5 REALIZATION OF THE PROGRAM

The scope of the necessary activities is very wide. This means that co-operation of experts and institutions is required. In the team there have to be experts (or expert groups) on traffic safety ES, data teleprocessing, GIS, transportation management.

The Research Unit for Traffic Engineering and Infrastructure Planning, KU Leuven, has experience in traffic safety, and is involved in a Transport Management System using GIS. With this background, while looking for co-operation, the start of the project is possible with the problem identification, finding the bottlenecks, defining the detailed schedule of the project. Neither the completion of these, nor the beginning of the subsequent phases are possible without having the team of collaborators. When the team is together, these steps could be completed in a short term.

Having the detailed schedule, it will be possible to determine the exact costs and duration of the project.

It is very important to check, whether the circumstances are really suitable to develop the system, as it is drafted. Examining the different requirements, there are two essential parts, which are not available yet, and have to be developed independently from this project:

distributed database technology, and the complete, high-capacity international communication network. Looking at the trend of the development of these, by the operational phase of the Safety Management System both of them will be available.

2.6 WORKING WITH THE SYSTEM, OUTPUTS

Although it is evident from the previous chapters, we try to demonstrate by some examples, how will be the work of the system and what will be the outputs at different stages.

2.6.1 General Transport Management System

The Safety Management System, to be developed in the first step, will be an essential part also of the general management system. It can give answers for wide scale of queries, as e.g. identifying the blackspots in a given area, calculating the safest route between two points of the network, or, due to the ES built in, it can give solution proposals to defined traffic safety problems.

There are many other aspects of transportation besides traffic safety.
On the one hand the evaluation of a network or an investment needs other characteristics. Persisting with the example above, a safety improvement may influence air pollution and noise, mainly in urban areas. In this case the system has to search for the common optimum on subsequent iterative steps, comparing the different modes of solution. The influence of the change of traffic load on the road maintenance cycle could also be taken into account.

There are even more complicated tasks, when e.g. two or more means of transport are involved. Let us suppose that the problem above has to be solved in an urban area, where many kinds of public transport (underground, bus, trolley-bus, tram) compete with car traffic, and in the modal split the parking circumstances also have to be taken into consideration.

These problems could also be solved in the traditional way: using the personal knowledge of the expert, aided by the single-purpose software tools (simulation, calculation, evaluation packages). However this takes much longer and the result depends upon the skill and intuition of the expert.

When only the traffic safety Expert System will be implemented, complex problems, such as those mentioned, could be similarly solved in the traditional way, having the advantage of the comprehensive database, the advanced GIS, and of course the Expert System, created just for safety problems.

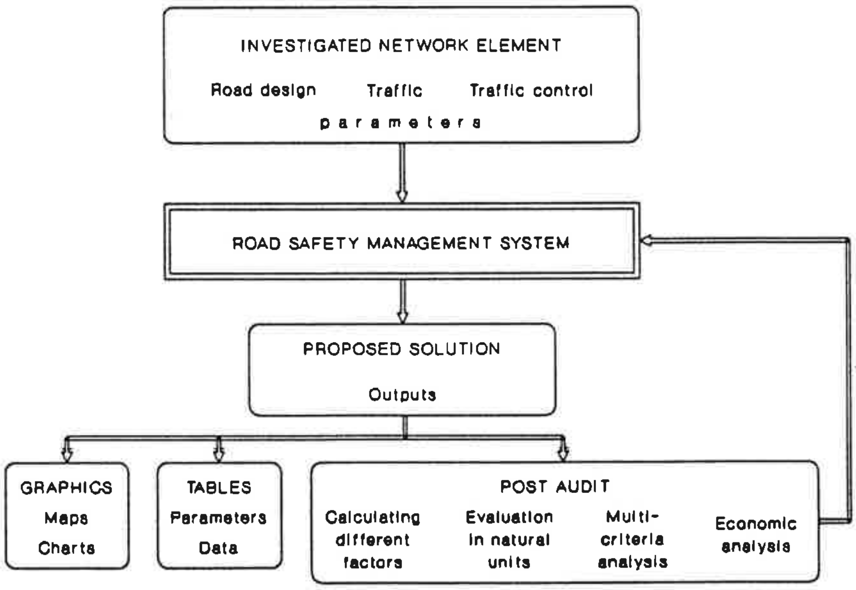
While improving the system and implementing more ESs representing different domains of transportation, the part of the solution which only needs assistance but works independently, is getting bigger. At the same time the duration of the procedure decreasing dramatically in comparison with the traditional solution.

2.6.2 Outputs

The TMS and RSMS must be suitable for solving some simple problems like reporting, mapping, making statistics, etc. The results of these operations are the reports, the maps and the statistics themselves; first on the screen, then in an edited form on a hardcopy device.

The outputs of the more complicated problems depend on the tools implemented. Consider e.g. a safety improvement of a junction, the result could be drafted in text, the changes could be explained in tables, or detailed on a map. The users decide the level of detail required according to their purposes and the type and scale of the problems.

It is certain that on the one hand the system has to provide maximum flexibility to the user in choosing the medium of the result, and on the other hand all the texts, tables and maps are necessary for presenting the results of a complex problem. The outputs have also to be suitable for a 'post audit', with a feedback to update the system itself. (Figure 2)



2.7 CONCLUSIONS

After satisfying the overwhelming majority of the transportation demand, the burning issues in the transportation field are safety and environmental protection. The loss of human life caused by accidents are very high each year. At the present level of technique a solution is necessary:

- where the guidelines and the main tendencies are internationally harmonized,
- which uses all available knowledge,
- which is computerized, and
- easy to use with a basic level of professional skill.

These requirements could be fulfilled by a Road Safety Management System (RSMS) based on a Traffic Safety Expert System. The visualization and the spatial data processing on the one hand, the connection to other spatial models and databases on the other hand require a Geographic Information System.

To solve more comprehensive transportation problems other ESs are also necessary. These have to be integrated into the same Management System. In this regard the first step of the RSMS has to be prepared for this future integration. This general "frame" is the Transport Management System (TMS), and in its future extended form it will be a "global" TMS. Considering both the software (ESs, data teleprocessing, management, GIS) and the hardware circumstances, the situation is suitable for the realization of the system. For the development, international co-operation on data and knowledge exchange on transport safety ESs, GIS and transportation management is required.

Since the system will integrate all available data and knowledge, and will have an iterative control feedback, its use will result in the most effective solutions firstly in road traffic safety, and later for every other transportation problem. Using the same knowledge base to solve similar traffic safety problems in different countries will be an important step for the future standardization.

Taking into account the improvement of the transportation circumstances and the reduction of losses, the efforts of developing the system will be recovered many times over.

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