INFORMATION, COMMUNICATION AND CONTROL SYSTEMS FOR VEHICLE, ROAD AND TRAFFIC MANAGEMENT

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1. INTRODUCTION

The application of micro-electronics for vehicle, road and traffic management has increased rapidly in the past 10 to 15 years. The approach, however, is very often rather isolated, resulting in problems regarding consistency, continuity, uniformity and compatibility.
The whole field of possible applications and needs regarding micro-electronics for road traffic, is mapped in a functional and consistent way, using relevant interrelated structuring principles. Subareas and subsystems can thus be placed in total context. A framework for integration is given.

Selection of a system for a chosen problem area can be done as follows:
- problem identification and analysis;
- dependent on type and complexibility of the problem, the level of management and control is selected;
- functional requirements are formulated;
- from the hierarchy of information needs and the local situation is decided, when, where, and in what form the information should be presented;
- a total system is composed of the available system components and software;
- an evaluation of the system as regards effects on behaviour of drivers and traffic as well as safety is necessary;
- eventual adaptation of the system.

It would be even better if a masterplan was to be designed (in time and space) for the application of micro-electronic systems, that can be introduced step by step. Every step along with eventual preceding step(s) has to function autonomously. With every step an increase in functionality is achieved. Even when the process of introducing the systems is stopped, because of e.g. economical reasons, the steps that have already been realised still fulfill their meaningful functions.

The following interrelated approaches are being dealt with and the main needs indicated:
- structuring the road network according to function and design;

- informational needs regarding changes in road, traffic and environmental characteristics;
- informational needs approached from the driving tasks;
- needs from the point of view of management and control;
- needs from the system and system component approach.

Finally general functional requirements are formulated.

2. ROAD NETWORK

Government policy is designed to ensure that our roads and the way they are used are ordered in such a way that traffic is directed along the most appropriate routes according to the season and time of day and the nature, origin and destination of that traffic. Efforts are being made to manage road traffic on the basis of a functional classification of the road network. The way in which roads are designed and equipped must be attuned to their function and to the traffic flow commensurate with that function.

Problems relating to road safety and the flow of traffic may be attributed, in this context, to a discrepancy between function and equipment and the actual use of the road. Route-information systems which are attuned to the function of the road network can help to ensure that traffic actually takes the routes intended for it.

The needs in this field are to identify the above mentioned discrepancies and to compensate them by influencing traffic circulation and vehicle speeds.

3. ROAD, TRAFFIC AND ENVIRONMENTAL CHARACTERISTICS

Unexpected changes in time or space of these characteristics give rise to safety problems and therefore to information needs.

Road characteristics. Temporary changes such as road works pose a hazard as these changes are often unexpected even for the habitué.

Need for an accurate prediction model regarding the effects on traffic flow of these discontinuities and for a mobile warning and control system.

Traffic flow characteristics. Instability, encounters, incidents, accidents, and overloading very often result in a safety hazard and congestion. Timely detection of these disturbances is needed to take preventive measures or to warn oncoming traffic.

Vehicle characteristics. Need for monitoring vital vehicle functions such as tyre integrity and pressure, brake pressure and lining brake pads, lighting, and signalling systems.
Need for optimization of signalling systems such as information to rear vehicles regarding the speed (-changes) of the vehicle.

Environmental conditions. The most important are the weather conditions, such as ice and fog. Accurate prediction in time, location, severity and duration, is needed so preventive measures can be taken.
Coordination and integration of information gathered from satellites, weather radar, regional and local (road-side) weather stations is needed.

4. DRIVER'S TASKS

The driver's tasks can be subdivided according to the following hierarchy:

- lateral and longitudinal control
- vehicle manoeuvering: overtaking, car following;
- route selection and route following.

Connected hereto is a hierarchy in informational needs: respectively continual, frequent and intermittent.

Each of these tasks encompasses:

- perception
- judgment and decision
- action.

Discrepancies between driver expectancy and the real situation can create critical situations.

Lateral and longitudinal control. Adverse environmental conditions create problems in perception and judgement regarding the lateral and longitudinal position of the vehicle on the road.

Vehicle manoeuvering. This is also influenced by adverse weather and heavy traffic conditions. Needs to perceive and judge the relative position of the vehicle in relation to other vehicles and obstacles.

Route selection and following. With route planning and following the needs are for current information of road conditions and consistency and attunement of the different information sources. Visual presentation of a planned route with orientation points to be memorized, on request presented at home. En-route information presentation in the car by radio or along the road by dynamic signposts.
The need is to simplify and minimize the route-planning and route-following task through electronic means (automatic route-guidance systems) for urban and rural areas.
Further needs are an even distribution of the information given to the driver according to primacy of the information: the right information on the right moment and the right location.
An optimal distribution of information presentation via the auditory and visual channels is also needed.

5. LEVELS OF MANAGEMENT OF THE TRAFFIC SYSTEM

Through information, communication and control systems, road and traffic management can be done on several levels:

* selection of travel destination, mode of transport, and route and time table;
* road-traffic circulation in the road network related to the environment;
* driving behaviour
  . under conditions leading to encounters
  . under conditions leading to incidents
  . under conditions leading to accidents;
* the crash phase
* the post-crash phase.

This structuring principle is compatible with a phase model of the accident process.

5.1. Management regarding the selection of travel destination, mode of transport and route and time table

Information given to travellers before the start of a trip regarding expected or actual adverse road, weather, or traffic conditions, can influence drivers to cancel or postpone their journey, to choose another (recreation) destination, another mode of transport or another route. Needs: a reliable, accurate and up-to-date information system. Upon request relevant information regarding the route, the main orientation points, route length, and travel time, by car or rail can be given on a TV monitor at home (view-data).
Electronic pricing systems can have a great influence on the mode of transport and route and time table.

5.2. Management of road traffic circulation in the road network

Problems regarding safety and flow can be ascribed to a discrepancy in respectively function, design and actual use of roads, and to overloading of routes.
Given a certain amount of traffic at a certain moment, management can be done by a selective distribution of the traffic in the road network along functional routes resp. by bypassing congested routes. This can be promoted by changeable signs, limiting the accessibility for certain periods and/or for certain vehicle categories, or by alternate route indicators. To prevent instability of this last system a calculation model is needed that gives a reliable prediction of a pending saturation. Preventive measures can then be taken. If the routes are not equivalent, the accident rates of these routes can be taken into account in the calculation model.
More sophisticated route-guidance systems are being developed in several countries, fulfilling the need of the driver for a simpler system. Before starting, origin and destination are being fed in the system installed in the car. At every junction direction indication is displayed on a panel eventually complemented with a synthetic voice. The experimental systems differ greatly: almost complete autonomous vehicle bound systems relying on navigation through the magnetic Northpole or satellites and a geographic map memorized in digital form, or navigation relying on road beacons.

5.3. Influencing the driving behaviour

On this level, traffic-safety problems can be ascribed to unadjusted speed selection in combination with unadjusted lane positioning and car-following behaviour.

Preventing encounters. This can be done by automatic lateral and longitudinal control. Many experiments have been carried out, but has not been put into practice as yet in the road system, because of the many implications of this system. Systems that give a warning to the driver instead of acting on behalf of the driver, have a better chance of application.

Preventing incidents. These occur easily when the traffic flow exceeds certain values. Stabilizing the flow can be done through prevention of the flow to approach the capacity (by access control) and through speed signalling. The height of the indicated speeds should depend on environmental conditions. This can be combined with systems aimed at controlling headways. Further research is still needed.

Preventing accidents. Discontinuities in the traffic flow are potentially dangerous. Warning oncoming traffic and introducing speed funnels as well as lane control are the means to prevent rear-end collisions: automatic incident detection and queue-warning systems. Further development to increase the reliability, accuracy and reaction time is still needed. Until now most of the systems have been applied on motorways. As the road-safety problems on secondary roads are relatively bigger than those on motorways, application of the know how on these kind of roads seems justified. Local speed limits near accident prone areas or spots, being triggered only when speeding vehicles approach, coupled to a photocamera can decrease the speeds drastically. Can also be applied in urban areas.

5.4. The crash phase

Passenger restraint systems such as airbags and seatbelts, being automatically put into operation, have been developed. Flashers being automatically switched on after a crash can prevent secondary collisions.

5.5. The post-crash phase

An alarm system to be switched on by the occupants of the car being involved in an accident has been developed. Automatically a SOS message plus the identity of the car is being sent to a rescue centre, and after voice communication the appropriate help is being dispatched. This system requires rather extensive position finding antennas to be installed spread over the country. Research is needed for cheaper systems e.g. with the use of satellites.

6. SYSTEM COMPOSITION

A system generally is composed of the following subfunctions:
- detection;
- transmission of the information;
- processing the information;
- decision and switching;
- transmission;
- presentation of the information.

Detection. Many detection sytems have been developed and applied. There still is a need for a detector which is reliable accurate, easy to install (and remove) and cheap to operate. Development of sophisticated TV detection systems, using microprocessors to process the images, enables the measurement of speed, vehicle length, density, occupancy, lane-changing movements. Slow moving or stopping vehicles can be detected. Needed is a comparison with conventional detection systems as regards reliability, accuracy and costs.

Transmission. Can be done by wire or wireless. Wireless systems are more susceptible to interferences: decreasing the vulnerability to this kind of disturbances is needed.

Information presentation. First things first. Information having the highest priority should be given first. Ordering the information to primacy is needed. Information distributed via the eye and the ear interact. Research on this field is needed as more and more synthetic speech is being applied.

Also needed is a strategy for application of visual information such as speed. A speed indication can have many meanings: speed limit, recommended mean speed, recommended maximum speed. To stabilize traffic flow recommended mean speed should be indicated, whereas a queue-warning system should show a speed limit.

7. SOME FUNCTIONAL REQUIREMENTS FOR INFORMATION SYSTEMS

The following requirements are not in all cases compatible with each other. Compromises are then necessary.

1. Spreading of the information according to priority in information needs. Information with the highest priority shall be given first. Criteria: safety and immediacy.
Balanced spreading in time, space and via the different sensory channels, prevents over- and underloading of the driver.
2. The information presented should be relevant to the driver.
Drivers for whom the information is relevant, should be given this information.
3. The different information sources should be attuned to each other (consistency, compatibility and complementarity).
4. The information presented should be understandable and unamibiguous and be perceptible under various conditions.
5. The information system has to fulfill requirements regarding reliability and accuracy for reason of effectivity, credibility and safety.
6. Education of the driver with respect to the information systems is necessary for correct interpretation and behaviour.
7. The system should be failsafe. This can be achieved through duplication or redundancy, or in the least by giving an indication when the system is failing.
8. The opinion of the user should also be reckoned with in the design stage of the system, for user affinity reasons.
9. An evaluation on the effectivity of the information system is necessary (driver behaviour, traffic flow and safety).
10. The greatest possible account should be taken of future developments. Care must be taken to ensure that the introduction of a new system does not hamper the later introduction of foreseeably better systems.

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