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ENGINEERING FOUNDATION CONFERENCE 1987

MANAGEMENT AND CONTROL OF URBAN TRAFFIC

PROCEEDINGS

31097775

June 24, 1987

Los Angeles County
Transportation
Commission
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LACTC

MEMO TO: RICK RICHMOND, JIM SIMS, PAUL TAYLOR

FROM: GINGER GHERARDI G.G.

SUBJECT: ENGINEERING FOUNDATION CONFERENCE - MANAGEMENT AND CONTROL OF URBAN TRAFFIC

The Engineering Foundation Conference was most beneficial in many ways. I had the opportunity to meet with experts from the United Kingdom, Germany, Australia, Canada and Japan to learn about other systems and their current status. I also had an opportunity to meet with Conrad Dudek, Texas A&M, who is renowned in the United States for his work on real-time motorist display systems and who is now very interested in our project.

There were three people from California at the conference: Ed Rowe, myself and Wes Lum from Caltrans. It became very clear that the Santa Monica Smart Corridor project is the most ambitious and technologically advanced project proposed thus far, worldwide. The other nations have a great deal of interest in what we are doing, and some good ideas which may benefit us. In the United Kingdom (U.K.), the "Autoguide" project is underway. This project relies on historical traffic information and visual directions in the motorist display -- such as turn right -- rather than a map and hopefully will have a real-time data base in the future. I met with Ken Russum of the Transport Road Research Laboratory (TRRL) to discuss their approach, as well as some rather universal problems such as "turf," voluntary cooperation between agencies, etc.

The communication technology varies throughout the world -- some countries relying on microwave; others, radio signals, infra-red, loops (predominant in the U.S. and Canada), and the Japanese with sonar. Very little information is available about the benefits of the Japanese system, however, their approach on the Hanshin Expressway is perhaps the most similar to the Smart Corridor, except that, for political and jurisdictional reasons, they cannot connect to the street system. They do not have ramp meters, but use their toll booths like ramp meters to control the flow of traffic. Professor Toshiharo Hasegawa, Kyoto University will be in the United States in October. He had a video tape (in English) at the Conference which was very informative. Right now the Japanese are making technical improvements to the project. Professor Hasengawa indicated that he would be most willing to stop in Los Angeles on his way home to discuss the status of the project and bring the video tape with him. I indicated that I would get a group of people involved in our project together to meet with him.

Peter Phillips, Germany, discussed the various German systems. He is involved in the Prometheus project which is being developed by the European Automotive Manufacturers, and a bus and light rail (BON) pre-empt system that uses IBIS technology. Up until now, the European governments have been excluded from the Prometheus project but of necessity are becoming involved. There is also some work being done in France and Italy that was not presented at the conference. Peter will be in Los Angeles on Friday, and he is very interested in our road system and demonstration project. He will be at our office and I will be taking him over to see the City's system. He may have an interest in talking with some of our light rail people.

As a note, the Australian system, SCAT, is only for streets, not corridors. There is also a video tape available on this. Light rail system interface with the streets is perhaps the most interesting aspect of the project. They have an unusual approach of predicting arrival time at the light to the transit vehicle operator to "make the green". If there is any interest, I'll try to get a copy of the presentation.

GENERAL OBSERVATIONS

None of the systems planned for the near-term are as comprehensive as our project. There, however, is much to be learned about the technology being evaluated and/or used by other nations. There is a technical conference scheduled at Bath University, England between September 9th - 11th which will have additional information on the Autoguide and Prometheus projects, and information on developments in France and Italy (brochure attached).

We have been asked to make information on the Smart Corridor project available to many people of the conference attendees from other nations and FHWA in Washington. I was also asked to make a presentation on the Smart Corridor project at TRB in January as a part of the session on new technology. I believe we should prepare a promotion piece on the project, including a printed fact sheet and a video tape of the various elements. Lou Schmidt, from Arizona DOT, plans to do a similar project in Phoenix. He had a video tape prepared for $1,200 to assist him in lining up support for the project. The Arizona project will require several years of feasibility studies before any sort of demonstration gets on the ground. It is apparent to me that California has quickly assumed a leadership position in the field and that the eyes of the transportation community in the U.S. and the world are upon us.

Many controversial issues will begin to emerge as technology proceeds with in-vehicle motorist communication and vehicle identification. One of those issues is private versus public financing. In England they are taking a private funding approach with the

Autoguide project. Prometheus is a private venture which has found that it must deal with public agencies. Data on the status of Prometheus is expected to be available in the early fall and will be discussed at the Conference in Bath.

It appears to me that the Europeans have, and will continue to take a much more "big brother" approach to motorists information systems, while in the U.S. concerns about privacy will probably prohibit that approach. It is also very clear to me that Changeable Message Signs are necessary now, but that they will have a limited life cycle (10 to 15 years at most), and, therefore, we should be cautious about investing large sums of money into them. Right now, CMS will provide the necessary transition between driving as we commonly know it today, and driving with verbal or visual in-vehicle navigation and information systems.

Future research will determine what the actual benefit of these type systems will be and what will happen in the future when 80% of the population has these devices in their cars.

I have not attempted to explain any of the foreign systems. I am attaching copies of the following information that I was able to get at the conference:

- Conference Agenda and Attendance List
- Conference Abstracts
- Autoguide - TRRL (United Kingdom)
- Control in Transportation System [1986] (Japan)
- Computerized Operating Control System for Urban Public Transport [Bon-IBIS] (West Germany)

The actual conference papers will be available and mailed to us in about six months.

I also have available "Commuting in America", a National Report on Commuting Patterns and Trends by the ENO Foundation for Transportation, Inc. and "Urban Traffic Congestion: What Does The Future Hold?" by ITE. Both documents are lengthy, but I will be glad to duplicate them on request.

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GGD7

Abstract

TRAFFIC CONGESTION PROBLEMS AND SOLUTIONS
RECOMMENDATIONS FROM THE ITE ANNUAL CONFERENCES

by

Mark R. Norman

Professional Programs Director

Institute of Transportation Engineers

Traffic congestion, only a few years ago almost the exclusive "privilege" of the center cities, has become a major concern in every part of the United States. Traffic congestion has gone from being merely a nuisance to being a critical liability affecting the country's economic health.

Many areas are being stagnated with congestion at the same time that transportation professionals lack the budgets and trained manpower to implement the needed improvements. With limited highway funding programs, a growing economy, stable fuel prices, and continued growth in most urbanized areas, traffic congestion will increase in the future and must be dealt with.

There are techniques available to hold off gridlock, however. Cost effective transportation actions can and are being used to help relieve congestion, reduce delay, and maintain mobility. But certain institutional and funding frameworks need to be put into place if these measures are to be applied on a broad enough scale to make a real difference. The ITE annual conferences on traffic congestion have generated issue papers, statistics, reports, and recommendations. The recommendations include the need for cooperation among all players, public/private partnerships, assessing future needs, revising the structure of conventional funding programs at all government levels, streamlining the project development and approval process, providing competent professional transportation staff, and a call to action for transportation professionals.

TRRL's TRAFFIC RESEARCH PROBLEMS AND PLANS

K Russam

TRRL's Traffic Group carries out research which seeks to help all classes of road traffic, including pedestrians, make efficient and safe use of existing roads. The case for allocating resources to such research, now and in the future, rests on the scale of the problem and on the opportunities for effective action.

The waste from traffic movement in Britain is conservatively estimated to total £5000M annually. This is the target for traffic research and the major components are:

- Congestion at junctions £2000M
- Accidents at junctions £1000M
- Inefficient route choice £1600M

Problems of congestion and accidents already occur on a very large scale in urban areas and are sensitive to pedestrian flow patterns and to the growth in vehicular traffic. Overall, it is concluded that the DTp and the traffic engineering community at large will be under increasingly severe pressure to find ways of making better and safer use of existing roads. However, we do not expect road traffic to 'grind to a halt'. Drivers will not tolerate such extreme conditions and will adapt their trip time, route, destination and even their general lifestyle to avoid the worst effects of congestion.

Many new opportunities are being created by the rapid improvement in the performance/price ratio of micro-electronic systems.

These opportunities, which must be applied with circumspection, range from providing the traffic engineer with micro-computer based design aids to giving drivers in-vehicle route guidance and hazard warning. The techniques make it possible to solve old but intractable problems as well as to pursue new applications. Specific research topics and key tasks which cover a period up to the mid 1990's are:

a) Junction design and control
b) Urban traffic control systems
c) Network and accident risk
d) Parking, pedestrians and restraint
e) Speeds, flows and data collection
f) Motorway control systems
g) Roadworks and signs
h) Driver information systems

Beyond the mid 1990's, it is probable that the pressures on roadspace will reach such a level that road pricing becomes acceptable. Other impacts on road traffic may occur through the development of 'expert systems' that can 'learn' and make decisions about, for example, the identification of a traffic incident and the actions to be taken. Exploratory research has been undertaken on these topics but major breakthroughs also seem to be some years away.

UPDATING AND UPGRADING A SMALL COMPUTERIZED TRAFFIC CONTROL SYSTEM IN THE CITY OF BELLEVUE, WASHINGTON

BY: Dirk S. Mitchell P.E.
Traffic Signal Engineer
City of Bellevue, Washington

ABSTRACT

The City of Bellevue, a city of 80,000 population with 100 traffic signals entered the computerized traffic control era in 1975. At that time Bellevue was given federal funding to install a traffic control system to coordinate fully actuated traffic signals utilizing one of the first versions of the UTCS software that was written in Fortran. This system took nearly three years to become operational, never truly functioned in a user friendly manor, and soon became outdated.

In 1982 the City of Bellevue knew it had to upgrade its existing system to handle increased traffic demands as it transitioned from a Seattle bedroom community to an urban center in its right. This paper describes the process of updating the computerized traffic signal control system.

It documents how Bellevue went about evaluating its systems inadequacies and reviewing the capabilities of existing systems throughout the US and Canada. It describes the features that Bellevue selected as important from centralized and decentralized state of the art, fully operational systems and what would be done differently. It also describes how the city used two different consultants in this process. One to evaluate the existing system and one to develop plans and specifications for hardware purchase and installation, to review equipment submittals and to integrate a 1986, upgraded version of UTCS software.

In addition the paper describes a software application developed by the city to use a spreadsheet format to automate data reduction of field travel time and delay study information. This program can be used to evaluate one time studies or before and after studies along an arterial. It will be used to measure the new systems performance.

Peter Philipps
Heusch/Boesefeldt GmbH
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Transit Companies Sharing in Computerized Traffic Control for Bus Priority

Priority for Busses and Streetcars

The facility of signal preemptions can improve the operating conditions for transit vehicles in street space. Above all, the travel times of busses and streetcars can be reduced and punctuality can be ensured. Besides, there is a possibility to operate more economically in same service quality, but with less vehicles.

Public Transport in the Federal Republic of Germany still has an important part in mastering the traffic volume in cities. In average, about 20 - 25 % of the total transport volume is done by means of public transport. In Hamburg and Munich, for example, where a very good rapid transit system is in existence, it is even more than 50 %. The importance of the public transport system as an energy saving system which is also compatible with environmental aspects - because of the partial substitution of the motorized individual transportation - is well recognized so that public transport is sponsored by the government of the FR Germany. Thus, there are a lot of measures to improve the driveways, the transit vehicles themselves and the operating as well as the organizational conditions.

Here, it is aimed to describe one aspect, that is preemptions at traffic lights realized by special detection techniques. Because of the fact that transit vehicles represent a spot event in traffic under local as well as temporal aspects, they are usually served by a special preemption when approaching a signal. This can be provided either by special signal phases for transit vehicles or by green time modifications in the signal plan. For that purpose, detection systems must be installed to select transit vehicles in the total traffic flow. The information gathered by them is transmitted to intersection controllers or a traffic control computer where special control strategies/methods are implemented to compute the signalization and control the traffic lights in favour of transit vehicles.

For all of the three components, which are

- detection and transmission system,
- control system,
- control strategies,

new possibilities in the economical and technical utilization have been brought about by the development of vehicle location and operational control systems for public transport companies. In the following, it will be especially reported about these systems.

(Abstract)

A Fire Preferential Route System for White Plains, New York

By Bernard Adler, P.E., Commissioner of Traffic and
Thomas J. Soyk, E.I.T., Traffic Systems Engineer

The City of White Plains, New York presently has seventy (70) downtown signals which are controlled by a central traffic system computer. While the City has a relatively modest residential population of 50,000, the traffic control system has become essential in effectively handling the traffic impacts of approximately 250,000 vehicles in that White Plains is a major business and retail center.

One of the recently developed features of the traffic control system allows for the use of the ten (10) fire priority routes which can be called by using simple instructions on a computer terminal. The system works by advancing the phases (without violating minimums) of the traffic signals along a preselected route to turn green in sequence and holding that phase while fire trucks and emergency vehicles travel the route. The signals remain green for a pre-determined amount of time and then return to normal operation automatically. While the preferential route is in effect, all intersecting streets along the route display red signal indications. The duration of the route can be manually increased or decreased by a dispatcher as determined by the circumstances.

The system was implemented in November of 1986 amidst favorable media coverage in local newspapers. In the six (6) months that followed, use was monitored and a preliminary evaluation made. Thus far, the results indicate close to the anticipated level of benefits from the use of system. Overall, the system has been used for eighty-five (85) percent of the actual calls with some of the non-use attributed to equipment problems and system crashes. Fire Department personnel response has been encouraging, as general observations have indicated definite benefits in terms of both a reduction in the potential for accidents and reliability or travel time improvements. Future evaluations are planned as well as expansion of the routes as the traffic control system is extended along radial arterials.

MODERN VEHICLE ACTUATED TRAFFIC SIGNAL CONTROLLERS FOR PUBLIC TRANSPORT PRIORITY

Ken W Huddart
Traffic Engineering Consultant and The MVA Consultancy

ABSTRACT

Microprocessors are now commonplace in individual traffic signal controllers. Hence the equipment logic no longer constrains the facilities which can be provided. Moreover the controllers are able to change programmes, thus providing different degrees of sophistication or vehicle actuation as circumstances change. Urban Traffic Control, cableless linking and dial-up facilities are available.

The paper outlines the features which are now available and indicates some of the international variants.

Priority for public transport can be provided on a network basis or by response to individual vehicles. The paper reviews such alternatives.

For the Light Rail Transit system now being built in Tune Mun (Hong Kong) a vehicle actuated system of road traffic control has been chosen. The novelty of the application arises from the high flows of up to 100 light rail vehicles per hour entering a junction, the complex route pattern, the size (20 or 40 metre long) and speed (up to 80 kph) of the vehicles, and the requirement to provide priority and ensure a specified journey time.

An initial proposal based on fixed cycle times with flexible green waves for the light rail vehicles proved insufficiently flexible; unacceptable delays might occur as vehicles waited to join their progressions.

The chosen solution emphasises vehicle actuation so as to minimise delays at the more trivial junctions; transponders identify light rail vehicles which can then receive priority. To evaluate the implications of very frequent mode changing several situations have been assessed using the FLEXSYT simulation developed by the Dutch government; these are described in the paper. It describes that the signal control requirements can readily be met with microprocessor controllers to British specifications slightly modified for local conditions.

ABSTRACT

This paper presents an approach to two interrelated problems in traffic control; the difficulty of applying multivariate optimization techniques and the lack of simulation models to support such optimizations. The design of fully actuated traffic signals under volume density control is a problem that typifies these difficulties. The EVIPAS program developed at the University of Pittsburgh under contract to the Pennsylvania Department of Transportation is a package for the analysis of a fully actuated signalized intersection which addresses these deficiencies. It provides a constrained multi-variate optimization algorithm using Quasi-Newton methods that can deal with a non analytic cost surface of discrete functional values that is irregular and rough. The package also has a detailed microsimulation to provide the functional values for the optimization that is more efficient and more representative of traffic behavior than has traditionally been available. EVIPAS will handle a wide range of intersection geometries, detector layouts, and associated control protocols. Any standard signal configuration available in North America can be modeled. The input traffic characteristics can be for a single time period or for up to ten time periods weighted to represent a typical day or week.

Optimization of Left-Turn Phase Sequence in Closed Grid Networks

- by Stephen L. Cohen and C. Liu

ABSTRACT

The traffic engineer has four variables available which can be adjusted to provide signal timing plans for signalized urban/suburban closed grid networks. These are green phase time, offset, cycle length, and left-turn phase sequence. Up until recently, there has existed no capability of optimizing the last of these variables in closed multi-arterial networks. This is to be contrasted with the situation on single arterials for which MAXBAND (1) and PASSER-II (2), have been developed which can explicitly consider the impact of changing left-turn phase sequence so as to maximize the amount of green bandwidth on a two-way signalized arterial with left-turn phases at some or all of the intersections. However, recently, the MAXBAND program has been extended so that it is now capable of developing signal timing plans for multi-arterial closed networks as well as single arterials, using the sum of all bands on all arterials as the objective function (3).

Our objective in this study was to examine the effect of optimizing left-turn phase sequence in multi-arterial closed networks. Data from seven real-world networks was available. The networks had a sufficient number of intersection approaches with left-turn bays so that left-turn phases for these approaches could be added. The result of the study was

PAPER SUBMITTED FOR PRESENTATION AND PUBLICATION AT THE TRAFFIC CONTROL SYSTEM CONFERENCE OF THE ENGINEERING FOUNDATION AT THE NEW ENGLAND COLLEGE IN HENNIKER, NEW HAMPSHIRE ON JUNE 14-19, 1987.

"AN EXPERT SYSTEMS APPLICATION ON SIGNALIZED INTERSECTION CONTROL"

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ABSTRACT

Currently, most metropolitan areas in the United States are encountering growing traffic management problems, such as providing intersection signal control and traffic congestion management in oversaturated highway networks. These problems result from general traffic increases as well as the reconstruction of major urban freeways. Since more than half of all vehicular trips take place in urban areas, there is an immediate need to improve existing arterial operation to alleviate growing urban freeway corridor congestion. Urban traffic control strategies can be effectively obtained through efficient traffic signal timing for alternative traffic control analysis. Spontaneous response and decision-making support assistance on selecting control strategies can assist transportation engineers in evaluating the effects of alternative traffic signal control strategies.

This paper describes research in progress to implement a Traffic Engineer Knowledge-Based Expert System for simulating signal intersection control in an IBM PC/XT/AT microcomputer environment. Prototype traffic signal control analysis systems are being developed using Knowledge Engineering tools. The system is designed to assist end users in selecting traffic signal timing plans for an isolated intersection by emulating the reasoning process of an experienced traffic engineer. Control strategies can then be determined as if a group of experienced traffic engineers were constantly available to assist the individual engineer or control operator in searching for alternative signalized intersection management strategies. This prototype expert system may later be expanded to optimize the signal system operation in both linear-type arterials and open-type arterial networks. This system demonstrates a feasible Expert Systems Design application to assist traffic engineers in solving the growing traffic management problems, especially in overcongested urban areas.

Stephen L. Cohen

Application of Traffic Simulation to Analysis of Freeway Reconstruction Alternatives - A Case Study

ABSTRACT

A discussion is given of methods for evaluating traffic operations improvements which might be expected from freeway reconstruction alternatives which include capacity improvements. It is asserted that traffic simulation provides a better approach to such analyses than use of the traditional Highway Capacity Manual (HCM). Several traffic simulation models are described. An application involving proposed geometric changes on the Kennedy Expressway in Chicago, Illinois, as part of a reconstruction project is described. Required modifications to the INTRAS model and calibration/validation activities are described. The paper concludes with a description of the simulation experiment of the existing in-bound condition and an alternative. The most interesting finding from this analysis was that the State's proposal to relocate the access point to two express lanes in the median would increase throughput on the Kennedy mainline by 900 vehicles per hour <u>without</u> adding new lanes.

REAL-TIME MOTORIST INFORMATION DISPLAYS FOR URBAN FREEWAY CORRIDOR TRAFFIC MANAGEMENT

by
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INTRODUCTION

Real-time motorist information displays are playing increasingly important roles in urban freeway corridor traffic management. They play critical rolls by furnishing motorists with up-to-date information that advises them of problems and the best courses of action.

This paper 1) reviews the role and applications of these devices in urban freeway corridor traffic management, 2) summarizes some of the systems in the United States, 3) reviews the types of hardware, and 4) illustrates the positive results that can be accomplished with these tools. The paper focuses on changeable message signs (CMSs) and Highway Advisory Radio (HAR).

The message that I want to leave with you concerning real-time displays is as follows:

1. Tools are available to use in managing traffic;
2. Motorists are looking for help;
3. Motorists will respond to accurate, timely and helpful information; and
4. Traffic management will result in considerable benefits in terms of reduced congestion, delay, etc.

N. Inoue

TRAFFIC CONTROL SYSTEM ON THE HANSHIN EXPRESSWAY

- FURTHER DEVELOPMENTS -

Noriyuki INOUE, Toshiharu HASEGAWA and Takeshi MATSUO

ABSTRACT

The Hanshin Expressway Public Corporation, Osaka, Japan has been constructing, operating and managing a system of urban expressways covering the areas of Osaka and Kobe with the present total length of about 140 km. Its traffic control system was intially introduced in the fiscal year of 1969 and has been improved ever since.

The Corporation is now planning a new system to be implemented from 1988. The new system is going not only to adopt new hardware sub-systems, but also to start new services to the drivers along the expressway. One of the most promissing services is the installation of an estimated travel time advisory system.

The Corporation has many monitors among its expressway users and there is a regular meeting of the monitors with the representatives of the Corporation. With many other channels connecting the users and the Corporation, the Corporation has realized that the users' need for estimated travel time between certain points of the expressway is quite keen.

This paper deals with a simulation model for travel time estimation on the Hanshin Expressway and some methods of travel time estimation with this simulation model and others. The simulation model has been tested by comparison with the observed traffic data, and the results obtained from the proposed estimation method show that the errors of the estimated vlues are less than 5 minutes for an average travel time of real trip of about 30 to 40 minutes. Although some procedures to make this estimation method understood and relied upon by the users are left untouched yet, this advisory system is expected to be a powerful tool for raffic control on the Hanshin Expressway.

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Toshiharu HASEGAWA: Professor, Dept. of Appl. Math. & Phys., Kyoto Univ.
Takeshi MATSUO: Chief, Div. of Traffic Control, The Hanshin Expressway Public Corpoation, Osaka, Japan.

CORQ 2- AN OPERATIONAL PROCEDURE FOR CORRIDOR EVALUATION

by

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ABSTRACT

CORQ has been used to test freeway control schemes. It predicts flows and queues in a corridor with sufficient precision to be used for operational modelling. However the original version was not very user-friendly. It required the services of a person with a high degree of knowledge of the model, and a full set of time-varying O-D matrices, which had to be developed along with the calibration of CORQ to each individual corridor.

During the last 2 years CORQ has been overhauled to greatly reduce its input data requirements and improve its output. The major savings in user effort provided by the current CORQ2 version are as follows:

(i) Link-flow characteristics are specified in terms of the following simply obtained factors: free speed, capacity and link type.

(ii) O-D Matrices are created internally by the model from counts of flows and queues, and from responses from O-D survey questionnaires which may be handed out at any strategic locations selected by the user. This allows the user to feed in high quality O-D information for critical locations and simple counts for other, less critical, locations. CORQ2's preprocessor merges these sets of information for the user.

It has also added an efficient look-ahead feature. This allows it to model a regular driver's pre-knowledge of the travel time characteristics that a selection of road will have when he gets there, rather than a knowledge of the present characteristics of the link, which are out of phase with the time of his own interaction with that section of road.

REVIEWING THE BASICS OF SIGNAL COORDINATION:

THROUGHBANDS, GREENBANDS AND CYCLIC FLOW PROFILES

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ABSTRACT

When traffic volumes are well below saturation levels, it is desirable to coordinate offsets of green intervals at neighbouring traffic signals so that it is possible for vehicles to travel through several signals with a minimum of stops and delays. Traditionally, this type of coordination of signals has been designed using "throughbands" or "greenbands" on time-space diagrams. Since the development of the TRANSYT computer program in 1968, the use of "cyclic flow profiles" has become popular for complex problems. These different coordination design procedures represent alternative perspectives with varying strengths and weaknesses.

In this paper, these three coordination design procedures are examined and their strengths and weaknesses discussed. Vehicle trajectories and flow patterns on time-space diagrams are used to compare these procedures and to illustrate their differences. The main conclusions presented as the results of these examinations and comparisons are as follows:

(1) an excessive reliance on the use of throughbands may lead to misleading results because the influences of both queued vehicles and true flow patterns may be overlooked;

(2) the use of greenbands is appropriate in some situations because a relatively simple yet reasonably accurate representation of traffic behaviour is employed; and

(3) the use of cyclic flow profiles in combination with greenband based time-space diagrams provides the most complete information for the design and evaluation of coordination alternatives. The use of cyclic flow profiles is especially appropriate for very complex situations.

ABSTRACT

A phase-based calculation method for settings at a signal-controlled junction

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Transport Studies Group

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Modern microprocessor controllers offer greater scope for choice of stage sequence and the structure of the interstage period because their operation is defined in terms of phases rather than stages. Previous methods of calculating signal timings have been stage-based; it is evident that new phase-based techniques are required to assist traffic engineers to make full use of the capabilities of the new controllers.

A method of phase-based optimisation of signal settings for a single junction is described which uses variables related to the start times and durations of the green periods for phases rather than a pre-determined stage structure. The method is embodied in a program written in Fortran 77 which uses data relating to traffic streams, phases, stages and stage sequences at a junction to give the most efficient stage sequence and interstage periods in terms of capacity. The stage sequence and the interstage period are thus included in the optimisation of the signal settings.

The program uses a simplex linear programing method to maximise capacity for the diferent stage sequences that can be considered for a given junction configuration. The results from the examples illustrated give the optimum green durations, interstage structures and stage sequence for the junction in addition to information on reserve capacity, degree of saturation and delay for each traffic stream.

Improved Signal Timing Selection

by

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ABSTRACT

In recognition of the potential for employment of the advanced digital computer and other electronic equipment, the Federal Highway Administration, U.S. Department of Transportation has sponsored the development of Urban Traffic Control Systems (UTCS). UTCS are computerized urban network signal control systems with sufficient flexibility and capability to implement virtually any conceivable control strategy. Among UTCS, First Generation Control systems (1GC) are the most widely used systems.

UTCS 1GC utilize pre-determined, fixed-time traffic signal plans and implement these timing plans either in time-of-day (TOD) mode or traffic responsive (TRPS) mode. In TRPS mode, the traffic pattern recognition algorithm selects the best available timing plan based on the computed deviations of the signatures of corresponding pre-determined signal plans from the field volume and occupancy information. Operational experience has show that there is a need for improvement in the traffic pattern recognition algorithm used. Some theoretical considerations of the signal timing plan selection algorithm are discussed.

The compromise of the current practice of applying a constant weight of 20 to all occupancy data in the deviation computation is discussed. Different weighting schemes using the free-flow speed or combination of jam density and its corresponding speed are proposed. These new occupancy weighting schemes in the deviation computation are based on different quantitative speed-density relationships. The proposed weighting schemes provide the same results under the non-congested flow condition as compared to the current weighting scheme. However, the proposed schemes provide better results for heavily congested networks.

This paper also examines the deviation computation within the traffic pattern recognition algorithm. The deficiency of the current computation formulation is discussed. A new formulation based on volume and occupancy data separately is proposed. The new formulation fully utilizes congested flow characteristics embodied within the occupancy data and thus is more sensitive than the current deviation computation under a congested network flow condition.

The traffic surveillance data collected by the computerized control system in the City of Clearwater, Florida is used to demonstrate conclusions reached based on theoretical considerations as well as the advantage provided by the proposed methodologies.

Development of a Pseudo-Count Generator and Detector Placement Algorithm for a 1.5 Generation System
- by Para Jayasinghe

ABSTRACT

This paper describes the results of a Research and Development effort undertaken by the Ontario Ministry of Transportation and Communications to develop a software package that improves the current methodology used in updating traffic signal timing plans by the typical user of Traffic Control Systems (TCS). Regular development of optimum signal timing plans results in improved progression and reduced fuel consumption, delays, stops, travel time, pollution and accidents to the travelling public.

Existing First Generation TCS's generally do not offer simple and cost effective means to maintain optimum timing plans. Second and Third Generation systems automatically maintain optimum timing plans, but at a high initial cost to provide the extensive levels of detectorization that is required.

1.5 Generation Systems have been proposed and developed that use limited levels of detectorization and off-line optimization. The key element of such a system is an ability to predict volumes at un-detectorized lications.

The Ministry has developed a computer package/model that successfully and with a minimum of data input determines the following:

a) Number of detectors required for a particular degree of volume error
b) Detector placement locations
c) Volumes at non-detectorized locations

Development of an Intelligent Adaptive Signal Control Logic

ABSTRACT

Adaptive signal control utilizes very short-term advance information for real-time optimization of signal operations. It has the potential to significantly improve the existing level of signal control efficiency. This paper describes the development and the characteristics of an adaptive control logic referred to as Stepwise Adjustment of Signal Timing (SAST). At the present time this logic is intended for applications at individual intersections. SAST logic divides time into discrete intervals or steps. In each step a decision is made to either terminate the current green phase at the end of that step or extend the green beyond it. This timing adjustment procedure allows the use of a limited amount of information to achieve a high level of control efficiency. SAST logic relies on a four-level decision-making process. The first three levels are based on simple decision rules and the last level requires signal optimization. The information needed to reach a timing decision in each step includes queue lengths at the beginning of a step and the expected numbers of vehicle arrivals at the stop lines in each of several steps in the future. Queue lengths are estimated from a traffic model. The expected numbers of arrivals at the stop lines are derived from data provided by detectors which are located several hundred feet upstream of the intersection. SAST logic avoids the use of predicted data to supplement detector data. Simulation analyses reveal that SAST based control can bring about much needed improvements in signal operations, particularly when the flow rates at an intersection are heavy. This logic may be enhanced to increase its effectiveness and flexibility for signal control.

ABSTRACT

THE USE OF COAXIAL CABLE FOR TRAFFIC CONTROL COMMUNICATIONS IN CANADA

By: Syd Bowcott, NET Corporation

Currently, there are 2 municipalities in Canada using coaxial cable for traffic signal control. Both systems utilize a portion of a bandwidth on a cable used for entertainment purposes by Rogers Cable TV. In addition, both systems are hybrid, utilizing RF and leased telephone lines, dependent on the location of a particular intersection.

The London RF system operates at 19.2 kbd and was supplied by Canadian General Electric who supplied the system software and all communications hardware including the RF modem. There is a capacity of 128 intersections per 80 khz channel. In lieu of a data translator at the head end, a dedicated cable was supplied between the head end and the control centre.

The Brampton RF system operates at 9600 bd and was supplied by Guild Electric. Computran provided the system software with Winkomatic supplying all communications hardware including the RF modem. The system utilizes 2-80 khz channels into the control centre and 1-80 khz channel out. Data translation is done at the head end.

The operational characteristics of these RF systems were compared to a leased telephone line signal system in Mississauga. Preliminary indications are that the RF system lease rate is considerably less expensive than leased telephone lines and that the CATV Company, in this case, Rogers, was willing to guarantee response time, mean time to repair, the rate of lease increase, etc., which Bell was not.

Additionally, preliminary data indicates that the RF and leased telephone line signal systems have comparable operational reliability, with the average daily downtime due to transmission errors being under one percent.

TWO-WAY DATA COMMUNICATIONS USING MICROWAVE TECHNOLOGY

by Philip Blythe

ABSTRACT

In recent years it has been recognised that a form of robust, cheap and reliable data-communication between a roadside unit and a moving vehicle is desirable. Considerable development has taken place in the fields of information technology, data processing and communication systems which has resulted in a number of prototype automatic data-communication systems being developed using infrared beam, satellite, radio and inductive-loop technologies. A low energy microwave system currently under development on an SERC-financed project at Newcastle offers improved performance over the above systems due to the small size, low cost and high data-transfer rates achieved.

Following a brief review of the background and applications of the system, the proposed paper will discuss the design and development of a low profile microwave receiver. The low profile structure is realised using microstrip technology which uses photo-etching techniques as used in the manufacture of printed circuit boards.

The associated digital sub-system consisting of a microprocessor and support devices will be implemented using VLSI to achieve a low profile design compatible with the microstrip receiver. Experimental results relating to the overall performance of the system obtained from field trials will be given in the paper.

The receiver system will be developed finally in a form similar in size to the conventional tax-disc and approximately 5 mm thick, which will make it suitable for mounting on the windscreen of a vehicle. The system could have numerous applications, such as: collection of data on traffic parameters, automatic vehicle identification, fleet control, automatic toll-collection at bridges, tunnels and car parks and route guidance/traffic information systems.

Paper prepared for the
Engineering Foundation Conference on
Management and Control of Urban Traffic
Henniker, New Hampshire, June 14-19, 1987

IMPROVEMENT OF URBAN TRAFFIC CONDITIONS BY VEHICULAR NAVIGATION AND ROUTE GUIDANCE

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ABSTRACT

Automobile navigation and route guidance systems will provide unprecedented convenience and benefits to drivers of equipped vehicles in the 1990's and beyond. Drivers of non-equipped vehicles will also benefit from reduction of urban traffic congestion because, according to independent studies performed in England and in the United States, equipped vehicles will spend ten to twelve percent less time on the streets and roads. Most automobile route guidance projects, starting with ERGS (Electronic Route Guidance System) in the United States in the late 1960s, followed by the Japanese CACS (Comprehensive Automobile Traffic Control System) and the West German ALI (Guidance and Information System or Drivers) projects of the 1970s, and including the current West German ALI-SCOUT and U.K. Autoguide projects, have been motivated by escalating traffic management requirements. Many systems approaches include provision for considering real-time traffic conditions in determining optimum routes. Automobile navigation technologies currently being developed include short-range proximity beacons at strategic locations, dead-reckoning augmented by artificial-intelligence map matching, and radio trilateration using satellites or earth stations. Advanced integrated systems typically include on-board computers, digital-map data bases, and mobile data communications for receiving real-time traffic information required for computing optimum route guidance instructions to the driver's specified destination. Practical technologies and systems approaches are becoming available at acceptable costs, and the traffic management benefits alone provide sufficient market incentives. However, extensive deployment of such systems will depend upon demonstrating benefits, establishing standards, and developing public sector involvement.

EUROPEAN RESEARCH INTO ROUTE GUIDANCE

K Russam

Reliable information of most concern to drivers in Europe is still largely about the state of the road and weather conditions, the level of traffic (which would affect journey time), and details of bottlenecks. This paper considers some developments in Europe which will help drivers meet basic needs and some advanced systems which will provide new services.

The EUCO-COST 30 project on electronic traffic aids on major roads reported that the quantifiable benefits which might be achieved by real time route guidance and hazard warning systems are estimated at around £900M per year for each of France, Germany, Italy, and the UK. Corresponding figures for Belgium and the Netherlands are £100M and £200M per year respectively. These benefits are mostly derived from saved distance and time, ie, the generalised costs of motoring, which would flow from improved route guidance, but they include significant contributions from saved congestion, delays, accidents, and road maintenance costs.

Traffic data collection systems and computerised databases currently being widely implemented across Europe will ensure that much of the information needed for guidance purposes will be readily available. Automatic incident detection has already been shown to work satisfactorily and expert systems are being developed

Recent advances in microcomputers and data storage techniques have enab in-vehicle navigational and route guidance aids to be produced. Systems which distribute most of their intelligence outside the vehicle will have cheaper in-vehicle equipment.

Two major route guidance projects are now moving to the implementation phase in Europe, the 'Leit-und Informationssystem Berlin', or LISB, and 'AUTOGUIDE' in London.

The road to vehicle link will be based on infra-red technology and a joint West German and British working party is close to agreement on a draft standard for this purpose which it is hoped may well be adopted elsewhere. The aim is to allow differences in features and circumstances between national systems whilst allowing any equipped vehicle to get route guidance whatever the country.

Links have also been forged with the European PROMETHEUS project. The 'Programme for European Traffic with Highest Efficiency and Safety', is the brainchild of the European automotive industry. Leading car and truck manufacturers have got together to pool research resources in a coordinated eight-year programme.

EXTENDING URBAN TRAFFIC SIGNAL CONTROL

TO PROVIDE SYSTEM MANAGEMENT

K. F. DALEY, Dip. C.E., M. Eng. Sci., M.I.E. Aust., M.I.T.E.
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Victoria, Australia

ABSTRACT

Melbourne is the capital of Victoria, the second most populous of the eight States and Territories which comprise the Commonwealth of Australia. Melbourne, like other major Australian cities has invested heavily in a sophisticated traffic signal control system which has the ability to dynamically alter signal cycle times, splits and offsets in accordance with traffic demand. Experience in the use and operation of the SCAT signal system and most notably the communication capabilities has helped traffic managers adapt this technology so that it can be used for much wider traffic management applications.

Melbourne is serviced by an extensive street based tram network comprising of over 280 route kilometres. As part of a Government initiative to improve public transport facilities and services there has been major emphasis on the provision of active tram priority. The extension of the SCAT system of traffic control to provide site specific and route based tram priority has been successful, indicating the benefits of a flexible, adaptive traffic signal strategy.

The Road Traffic Authority is currently investigating opportunities for the technological expansion of the traffic signal system to enable :

- vehicle fleet monitoring
- automatic collection of traffic statistics such as speed, travel times, vehicle classification and O-D movements
- demand management
- road pricing
- enforcement of traffic regulations.

At a time when funds for new roads are declining due to smaller tax bases and competition for funds from other public sectors, the attractiveness of high technology to provide information and improved traffic management is increasing. This paper reports on the public transport/selective vehicle priority capabilities of the SCAT Traffic Signal Linking System and explores the technological issues related to the development of a vehicle monitoring system based on the integration of in-vehicle intelligence and sensory equipment in the road bed.

It is concluded that recent developments in technology now provide realistic opportunities to extend the classical functions of urban traffic signal systems to assist the community and traffic manager.

ROAD TRANSPORT INFORMATICS EVOLUTION

Ove Svidén

ABSTRACT

Modern information and microelectronic technology can be used to improve road traffic. The aim of this study is to create scenarios on how new information systems for improved road traffic can evolve. What are the driving forces? Who can act? Who can benefit? What are the social impacts?

Through the use of a Delphi panel of professionals, researchers and informed generalists, we have gathered impulses for the scenarios on how information technology, communication means and control systems can reshape future road traffic. The issue studied is how this "Road Transport Informatics" (RTI) will evolve.

Autoguide

A better way to go?

A discussion document

Issued by the Department of Transport

CONTENTS

The cover of this document is intended to serve as a summary.

AUTOGUIDE – A BETTER WAY TO GO?

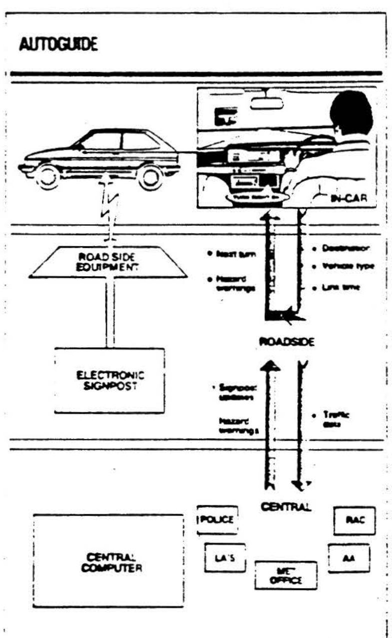
It is to everyone's advantage if cars, vans and lorries use the most efficient routes. That saves time and cost to drivers, and beyond that to their employers.

New ideas for helping people to get about are being looked at in many cities around the world. If Britain is to have the capacity to develop the best systems and to contribute to international discussions, now is the time for the options and issues to be examined and discussed.

The rapid development in technology in the past few years, especially in microelectronics and computers as part of information technology, offers new opportunities to help people find their way around. This discussion document is about the opportunities for the 1990s to develop the best possible systems.

It looks in particular at the Autoguide concept. This is a system that helps drivers find the best routes to their destinations, using up-to-the-minute information on traffic conditions. The Transport and Road Research Laboratory (TRRL) has estimated that Autoguide could help drivers reduce their average journey times by about 10 per cent.

The purposes of this discussion document are to look at what sort of systems could be developed for the 1990s, and to seek the views of a wide range of people. Because the main gains would be likely to flow from the application of route guidance over a large urban area the document looks in particular at the possible application to London, where it is estimated that an Autoguide system could provide savings of well over £100 million each year.

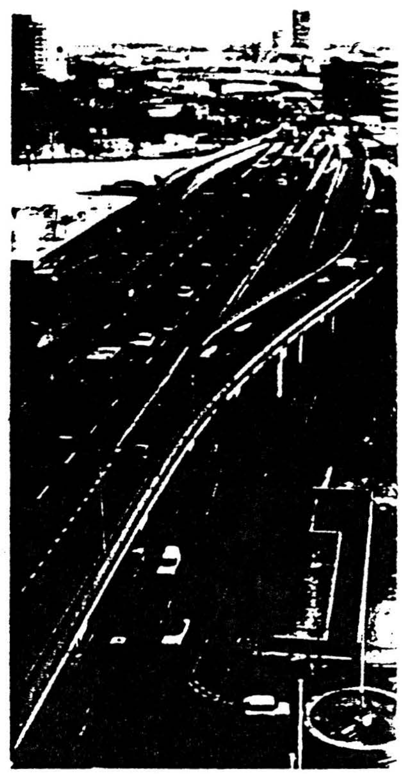


WHAT IS AUTOGUIDE?

Autoguide is a system for helping drivers find their way through the complex road network. A route computer is mounted in the vehicle and the driver gives it the destination. Either visually or using synthesised speech, the computer then gives easy-to-follow instructions during the journey.

The route computer communicates with beacons, near main junctions, which act as 'electronic signposts'. As an equipped vehicle passes a beacon, it transmits its destination, type and, possibly, preferences for the type of route – the driver might want the quickest, or the shortest (the two are quite often not the same), or have some other requirement such as 'no motorways'. The beacon immediately transmits back to the vehicle details of the directions to be taken at the junction, and the route computer translates these into the simple instruction for the driver.

The beacons are themselves small computers which store the electronic signpost information as a form of list, which is frequently updated by a larger computer in a control centre. The control centre continuously re-calculates routes on the basis of current traffic conditions. Drivers can therefore be given guidance based on up-to-date information about the whole of an urban area.



The proposed system fits well with the Government's intention to pursue improved driver information on London's roads. It offers the opportunity to bring direct to drivers the information they need on road-works, accidents and other causes of delay so that they can make the best possible use of the capital's road system.

WHAT THIS DOCUMENT IS FOR

The purposes of this document are:

- to describe the thinking behind electronic route guidance systems
- to present the issues which arise when looking at this possible tool for traffic management and guidance
- to invite comments on what is the best way forward.

A SYSTEM FOR LONDON

How it would work

The map (right) shows the locations of about 700 junctions which cover the main road network out to and including the M25. (There are a few outside the motorway so that all alternative routes are included.)

The system would build up its own expected travel times between each pair of junctions, based upon the data it collected from users. So, for example, if a van was leaving Heathrow at 7.45 am on a weekday to make a delivery in Islington, the system would 'know' that there was likely to be a build-up of traffic by the time it reached the West End – even though there was no congestion at 7.45 – and would take this into account in recommending a route.

As the journey progressed, the system would be collecting real data on actual journey times in the West End, and would be able to modify the route if there were any unexpected traffic delays – or if rush-hour conditions were more free-flowing than usual.

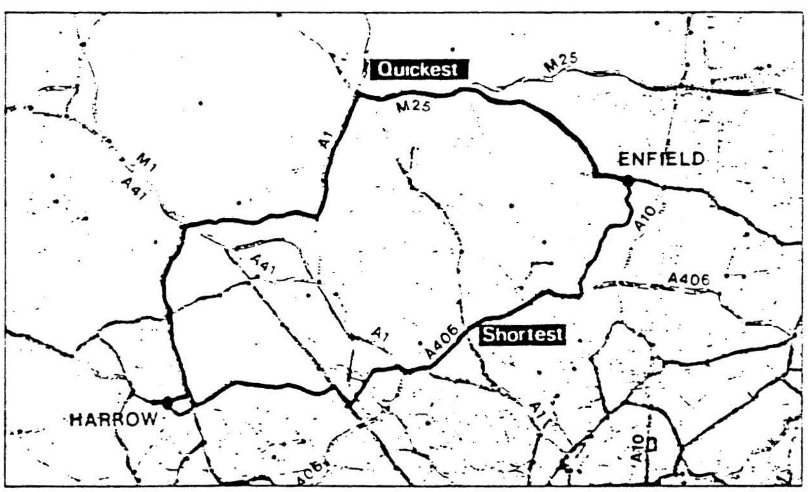
and the roads which might therefore be used by the system in generating recommended routes. All main roads are included, but it would not extend to 'rat runs' in purely residential streets.

A system for expansion

The system shown on the map would give the geographic basis for expanding the coverage to other urban areas in the South East. But the user base it would establish could also make it worthwhile to install Autoguide systems in other major conurbations in the country. Inter-urban roads could eventually be covered, and international coverage could be achieved by co-operating with our partners in Europe.

WHAT IT WOULD MEAN FOR THE DRIVER

- No need to worry about the route, either at the start of the journey, or during it – the driver just 'tells' the set in the vehicle the destination
- The route computer gives simple directions to follow as the vehicle approaches major junctions

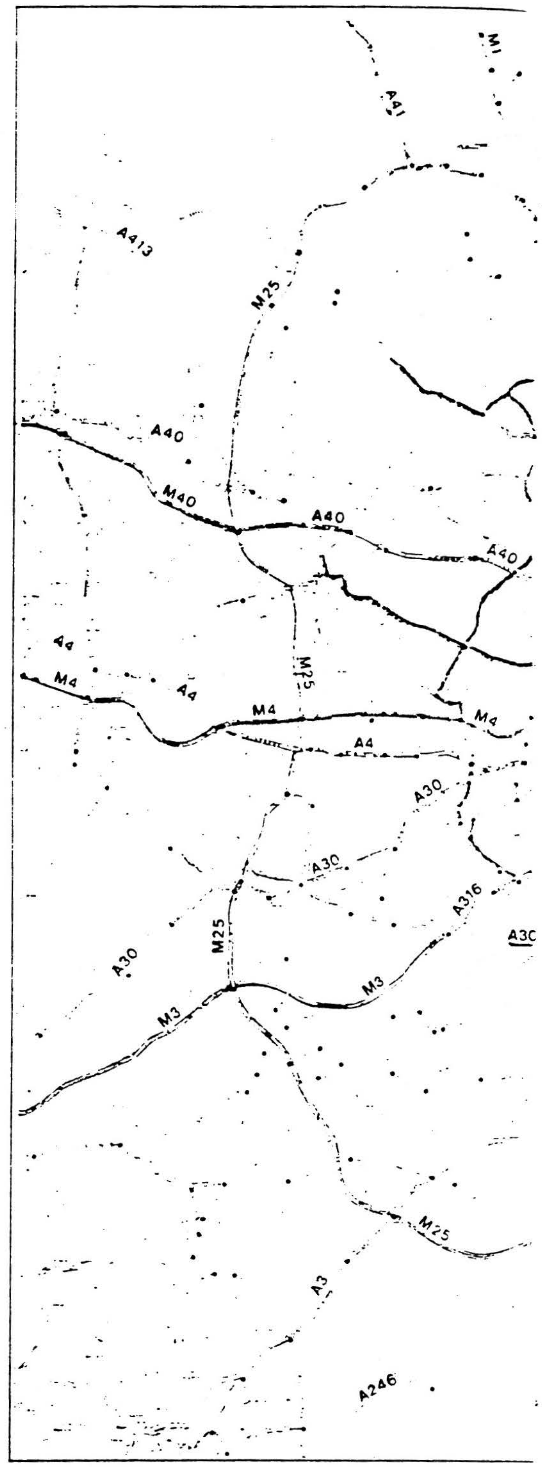


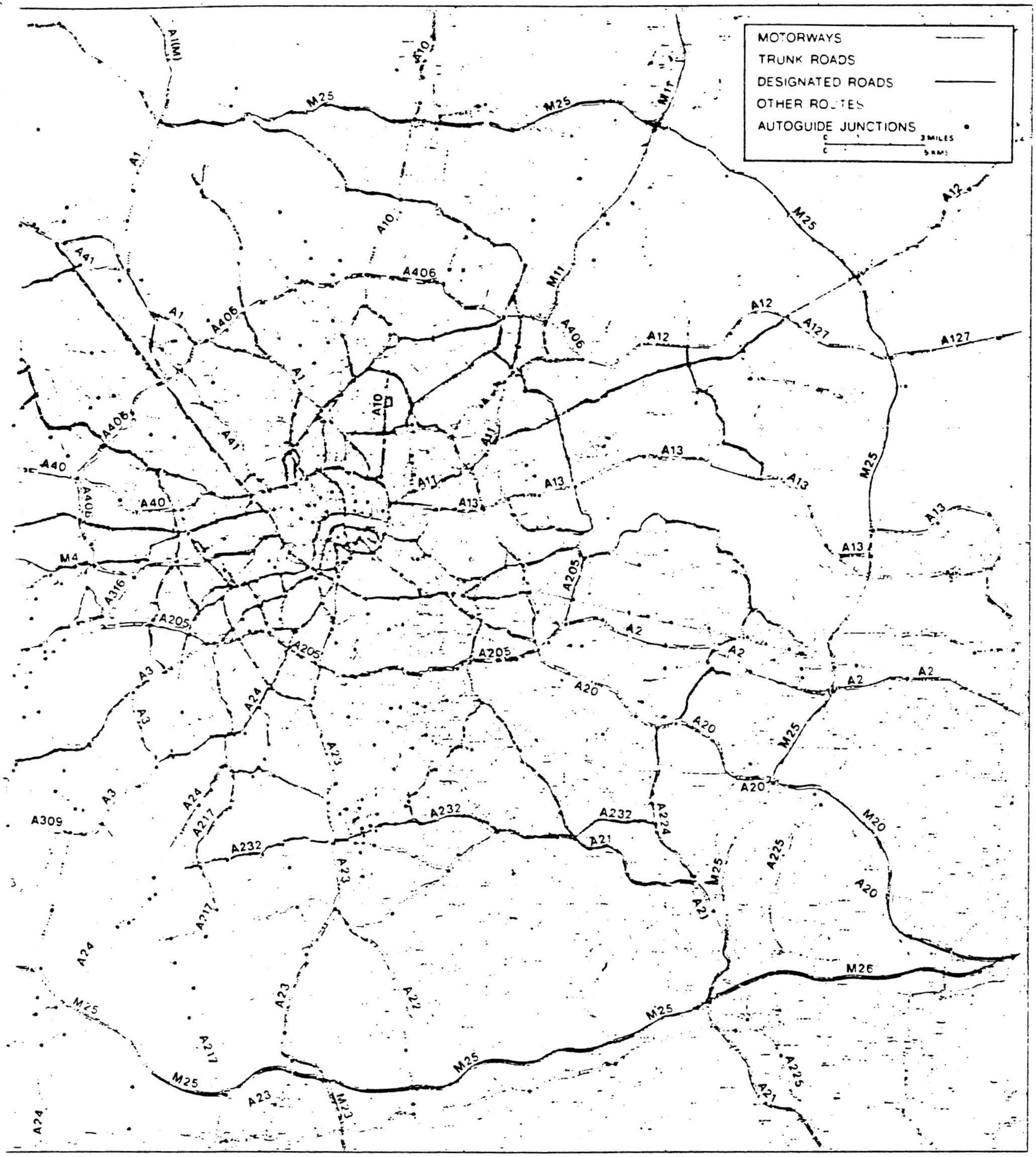
An example of the choice of routes is the journey from Harrow to Enfield. The shortest route is via Hendon, but during normal daytime traffic conditions the quickest way is to go via Elstree, Bignells Corner and a short section of the M25. An Autoguide system would advise on the choice taking into account the prevailing traffic conditions.

Coverage of the road network

The map (above right) shows the junctions which could be equipped in the system proposed by the TRRL,

- Even the regular traveller will gain from the route advice because it is based on actual traffic conditions
- Journeys in the area covered by the system will on average be around 10 per cent quicker, and will cost less in fuel, operating costs and time
- Autoguide removes one of the many stress factors facing a driver in London today
- The system keeps drivers informed of the traffic conditions which directly affect their journeys.





n of Geographers A-Z Map Co Ltd

Department of Transport: RPHP3 Drawing Office 86 323

The map shows the 700 or so junctions which might be equipped as an Autoguide system for London, and the roads which might typically be used by the system in its recommended routes.

WHO WOULD BENEFIT

- Car drivers – particularly when making unfamiliar trips
- Business trips – when time is expensive
- Delivery vehicles – even when the driver knows the best route, time can be saved by using the system's up-to-date traffic information
- Lorries – the movement of goods is expensive, and the system would help to keep costs down
- Coaches – especially if not on fixed routes
- Buses – passengers benefit from lower journey times because of reduced congestion.

MAIN FEATURES OF AUTOGUIDE

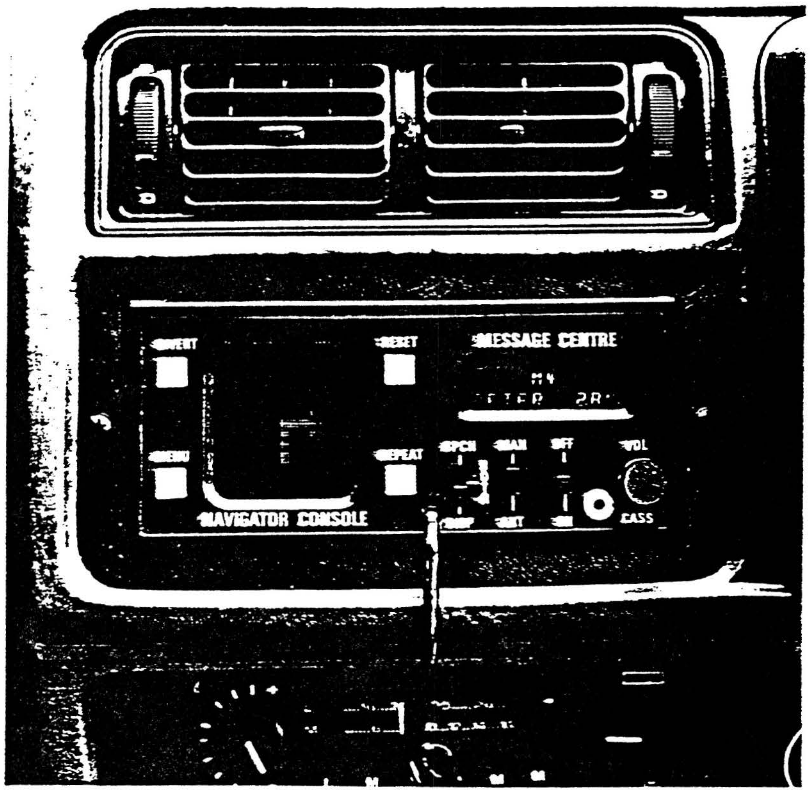
An Autoguide system could reduce average journey times in London for fitted vehicles by around 10 per cent. These are the key points of the system, and the estimated benefits:

- typical savings of time and vehicle operating costs for each fitted vehicle of several hundred pounds per year
- total cost savings for fitted vehicles of between £100 million and £150 million per year
- less congestion for other vehicles – worth around £25 million per year
- fewer accidents – about 500 casualties, including some deaths, avoided each year
- improved information on traffic conditions for the driver
- voluntary membership of the system and no need to follow the advice given
- highly cost effective, particularly for working travel
- based on the main road system – does not encourage 'rat-runs'
- guidance based on up-to-the-minute traffic information
- guidance tailored to individual's requirements.

NEXT STEPS

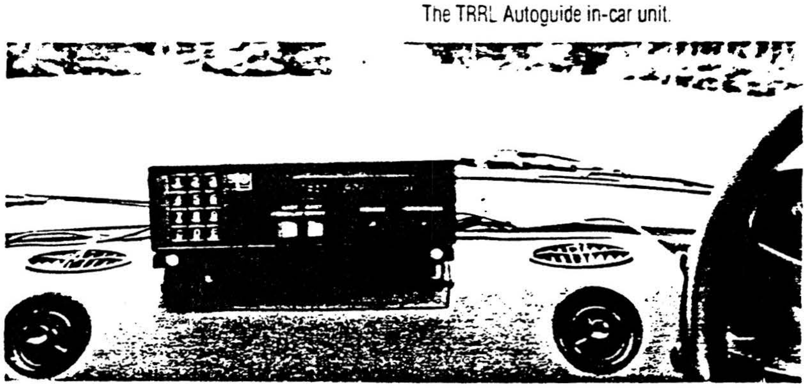
The Government would like to receive from those interested views on this document and the issues presented in it by the end of the year. In the meantime, work will continue on the technical aspects of the project and discussions will be held with industry, local authorities, the police and those working on similar projects overseas.

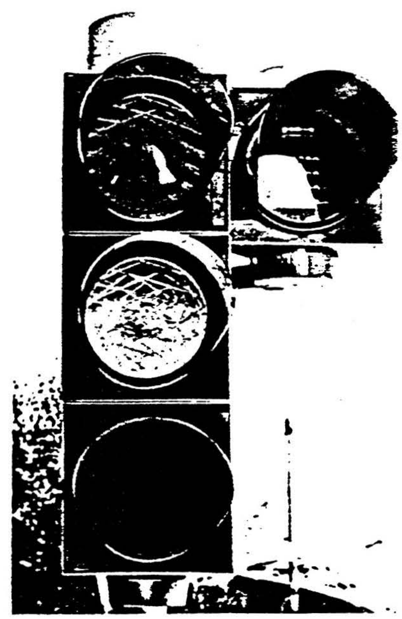
After views have been received, and with more information to hand, the Government will be better able to take a decision on whether or not to proceed with the concept. If there is a decision to go ahead, the most likely next stage would be an on-street demonstration project.



The NAVIGATOR unit fitted to a car at the TRRL.

The TRRL Autoguide in-car unit.





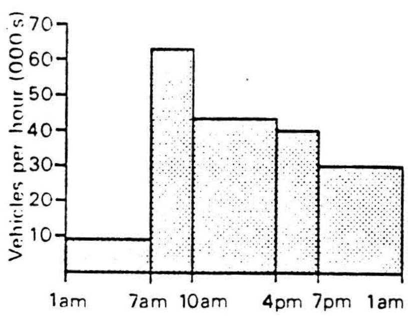
The ALI-SCOUT infra-red beacon.

1 INTRODUCTION AND BACKGROUND

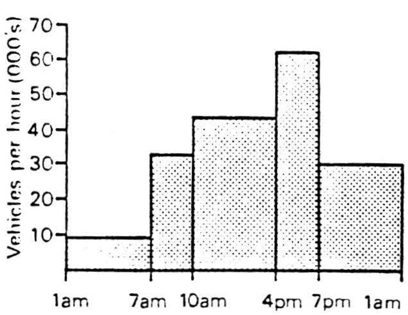
Each year cars, vans and lorries using the nation's roads travel over 170 billion miles. A substantial part of this mileage, and the time spent by vehicles and drivers, is wasted in traffic jams, taking longer routes than are needed, or getting lost.

The Transport and Road Research Laboratory (TRRL) has estimated that wastage due to poor routeing in Britain is 6 per cent of all vehicle mileage, and costs the nation £2,400 million per year. Though some of this wastage cannot be eliminated the TRRL estimates that average journey times could be reduced by as much as 8 to 12 per cent by helping drivers find better routes. In London alone, there could be potential savings of well over £100 million each year from better route guidance.

Traffic entering central London during a normal working day



Traffic leaving central London during a normal working day



People have a variety of ways of finding their way around: maps, signposts, previous knowledge or advice from friends, sometimes specific information about congestion from radio broadcasts. Motoring organisations play a significant part in map production and providing traffic information. Road signs and traffic lights are provided by highway authorities. The police play an active role in traffic broadcasting, in particular about trouble-spots. The Government has fostered and encouraged the development of effective information systems through the many bodies, public and private, that are involved.

But all of these can give only partial information on which is the best route for an individual driver and sometimes drivers are unsure how up-to-date and accurate the information is. One aspect of the Government's fresh look at the quality of information being given to the driver in London is therefore the potential for electronic route guidance – Autoguide.

Advances in microelectronics and the use of computers in information technology have already brought about many improvements in the efficiency with which we use our roads. The TRRL has led many developments in the application of technology to traffic systems. The pioneering work on traffic control systems in the 1970s and the innovative SCOOT system, which adjusts traffic signal timings in 'real time' in response to the actual traffic conditions on a network, are examples. The TRRL's control strategies are now adopted world-wide from the United States to the People's Republic of China. The effectiveness of today's computerised traffic control is likely to be recognised only on the rare occasions when it is disconnected. For example, one survey in London saw average journey times go up by 30 per cent, and double in key areas, when traffic signals were operated conventionally without central co-ordination.

Electronic route guidance is one exciting new application of technology which has scope for reaping benefits.

Navigation aids are already becoming available. These can help drivers to keep track of exactly where they are, and so decide on their routes forward. But the potential for true electronic route guidance is much greater. Through information transmitted to the vehicle from equipment at the roadside, the driver can be given route guidance based upon detailed and up-to-the-minute information on the traffic conditions which affect that particular journey. To realise the full potential requires the installation of roadside equipment and central computers and the development of in-vehicle units.

A viable electronic route guidance system is now attainable. The TRRL have demonstrated one potential system, and experiments have taken place in Japan and West Germany – all indicating that the technology will work and that the benefits could be significant. Because the main gains would be likely to flow from the application of route guidance over a large urban area where there were hundreds of thousands if not millions of vehicles, London would be the natural starting-point in Britain. It would be possible to install a system in the area out to and including the M25 by the early 1990s. It would provide the basis for expansion to other urban areas, to major inter-urban routes and, in co-operation with other countries, to international coverage.

The purposes of this document are:

- to describe the thinking behind electronic route guidance, including a brief summary of the types of guidance systems currently available or which have been the subject of research
- to present for discussion some of the procedural, organisational, technical and general issues that will need to be resolved if such a major development affecting traffic movement is to be pursued
- to invite comments from interested parties – including, but not confined to, highway authorities, the police, motoring organisations, the motor industry, equipment manufacturers, marketing organisations, industry and the general motorist – to help decide the best way forward.

Issue for discussion: Is there sufficient interest in route guidance, both from potential users and suppliers, to justify seeking to set up a system in Britain?

2 EVOLUTION OF ROUTE GUIDANCE SYSTEMS

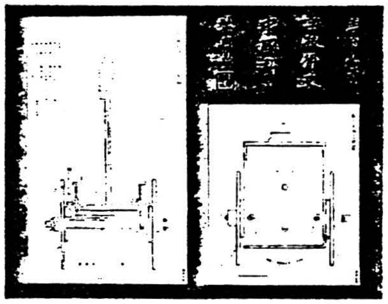
'Electronic route guidance' describes a variety of systems aimed at helping the driver find a good route for each journey.

Trip planning

Traditionally, route guidance has been available from maps and signposts. What looks like the best route from a map, however, can turn out to be much slower than alternatives. In a dense network like London there can be dozens of possible routes for a journey of just a few miles. For many years motoring organisations have offered route guidance services to members and this has been followed by similar services from some large car rental firms to their customers. Recently this has been computerised. A computer chooses the quickest (or the shortest) route for a particular journey, based upon its stored information on average journey times for each stretch of road. Computer-generated route maps for trip planning have become increasingly sophisticated and widespread during the last three years. The TRRL has developed a prototype system – ROUTE-TEL – which uses the Department of Transport's database of information on main roads in England and Wales.

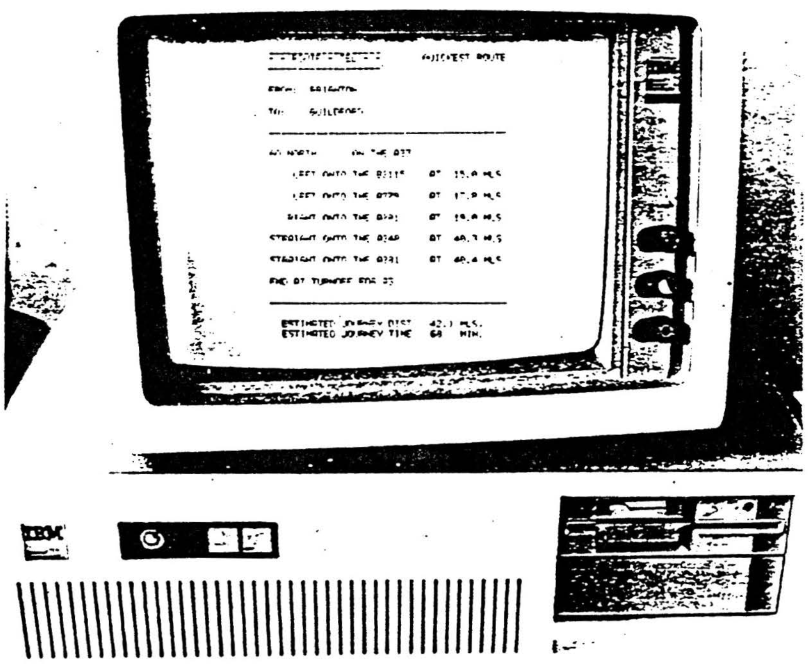
Drivers may also obtain trip planning information over the telephone from services which can give them details of weather and traffic conditions. They can use the teletext services CEEFAX and ORACLE, or the PRESTEL service.

The police provide advance warning notices of foreseeable congestion due to road closures, demonstrations and so on, which enable drivers to plan changes to their normal routes.

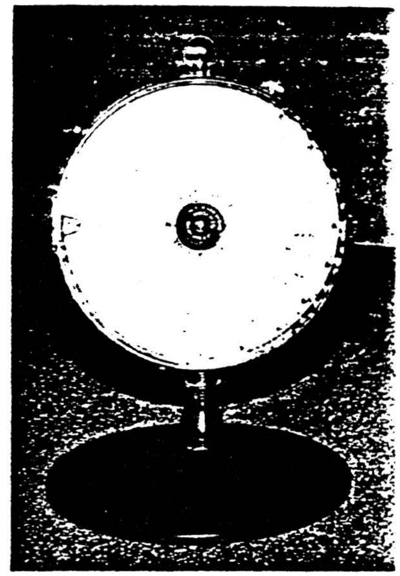


The ancient Chinese 'south pointing carriage' was a device for maintaining a constant direction, pre-dating the discovery of the magnetic compass (although a little less reliable!).

These route-finding aids and information systems can help a driver to plan a suitable route before setting off, in the light of expected road conditions. But apart from any radio broadcasts that might be picked up, there is no further information to help during the journey, for instance if the driver gets lost, or traffic conditions turn out badly.



The ROUTE-TEL system developed by the TRRL is an example of trip planning services which produce clear instructions for a recommended route.



Before the First World War the 'Jones Live-Map' was proclaimed as 'the phonograph of the road'. The advertisement continued: 'When you tour with a Jones Live-Map you leave all the guide books, maps and folders behind. You take all the puzzling corners and forks with never a pause. You fly past sign boards with never a thought. You never stop to enquire your way.'

Navigation aids

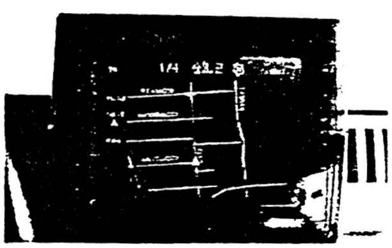
Aids to navigation do not necessarily provide direct route guidance but help drivers to keep track of where they are. The odometer, the simplest navigation aid, is the only one universally fitted to motor vehicles, although there have been many attempts to supplement the information it provides. In the early days of motoring, the confusion caused by inadequate road signs – or the absence of signs – led to the development of the first route guidance systems. These were mechanical devices which kept track of a vehicle's location using dead-reckoning, in which a record is kept of the vehicle's movements from the distance travelled and, ideally, the compass directions followed at each stage of the journey.

These systems were the forerunners of sophisticated systems such as LANDFALL and PACE, developed by British firms. The recently launched PACE, for example, works out and displays a vehicle's position on an electronic map based on data received from complex magnetic compass and odometer devices.

Working out routes, and telling them to the driver, has been taken a step further with in-vehicle units which combine dead-reckoning navigation with route finding. The NAVIGATOR system, developed jointly by the

The Plessey Adaptive Compass Equipment – PACE – is a sophisticated navigation aid which keeps track of a vehicle's location and displays it on an electronic map.

TRRL and a British firm, is one example of such a device, which displays (and 'speaks') to the driver the distance remaining to the next junction and the directions to be followed. Similar systems are being developed in other European countries and in the USA – the Dutch CARIN system makes innovative use of compact discs for storage, and the ETAK system has been marketed in California for over a year.



The ETAK electronic map display.

Traffic information

Information can be presented to a driver during a journey in a number of ways. The most familiar is radio broadcasting. The BBC's motoring unit feeds the national network, and many local stations rely heavily on the AA's Roadwatch, as well as drawing on bulletins from the Department of Transport's Road Information Unit about major roadworks, closures and other activities which may affect journey times. In London, Austin Rover has recently sponsored Capital Radio's Flying Eye traffic-spotter plane. Experiments with special broadcasting services, in which specific frequencies are allocated for local traffic information, have been made in a number of countries including Britain. Work is currently in progress on the specification of a European standard for traffic information broadcasting using the new Radio Data System (RDS), in which digital information is superimposed on the normal broadcast from a VHF (FM) radio station. In-vehicle equipment could then convert the data into messages presented visually or aurally to the driver. All these systems tend to be 'snapshots' and often rely on somewhat impressionistic data.

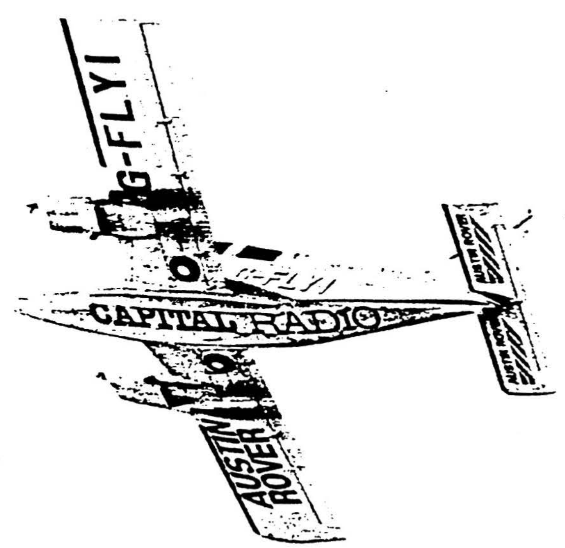
Variable message signs are used in Britain for a number of purposes including route control, for example on the approaches to the Dartford Tunnel and the Severn Bridge. They warn drivers of adverse traffic conditions ahead and offer a limited form of alternative route guidance. Further studies on the potential for variable signs are being launched by the Department of Transport on the M25, within London generally and, jointly with the British Airport Authority, around Heathrow.

Cellular radio has been looked at as one way of getting up-to-date traffic information to individual drivers. The vehicle units might cost around £1000 and this affects the potential market. The main limitation, however, is that a cellular radio system could not accept more than a proportion of the motorists who might want to use a low-cost route guidance device.

All these forms of information can help the driver decide on a route, either before or during the journey. But they all lack real time information on traffic conditions as they actually exist. They are therefore somewhat limited in their capacity to inform drivers of the best way to go, taking account of traffic conditions as they change during the day.

Autoguide

What is likely to be most useful to drivers is an Autoguide system that works out the best routes in the light of actual traffic conditions, then tells drivers in a simple and easy-to-follow form as they go. Roadside equipment acting as electronic 'beacons' transmits location and route guidance information to passing vehicles. The beacons, or 'electronic signposts', are connected to a central computer



Capital Radio uses information from the Flying Eye to give London motorists up-to-date news on traffic conditions.

which sifts the data coming in about traffic as a whole and turns that into advice for drivers. This system requires relatively low-cost units in the vehicle.

Its disadvantage is that it depends upon the provision of a system of roadside equipment before it can be operational. The extent and cost of getting such equipment installed on the street would have to be addressed.

There are choices, in a system which combines in-vehicle units with beacons, between the amount of 'intelligence' in the roadside equipment and on board the vehicle. Different countries have been exploring different approaches. The type of Autoguide system being developed at the TRRL places virtually all the system intelligence at the roadside. This means that the vehicle units can be relatively inexpensive, and so more people can afford them, but that the beacons are needed at fairly close spacing throughout the network.

The German experimental system ALI-SCOUT combines a beacon-based system with on-board dead-reckoning equipment. The in-vehicle equipment is likely to cost a little more, but an initial system can be provided with fewer beacons because the intelligence on board the vehicle will provide the route guidance instructions to reach the next beacon. It is also easier with on-board intelligence to guide drivers more closely to their exact destinations.


Variable message signs on the M25 warn motorists of unexpected hold-ups.

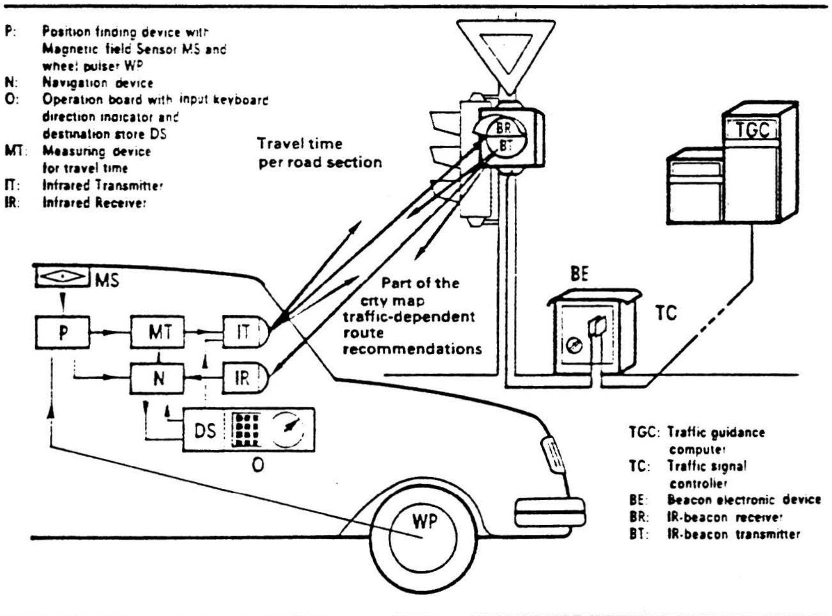
This trade-off is one of the issues for discussion. But it does seem clear from work to date that whatever system is adopted, if the latest developments in computer technology are to be fully exploited to help motorists with sophisticated traffic information, there will need to be investment in roadside beacons.

Road/vehicle communication

A technical issue in a beacon-based system is the method of communication used between vehicles and the roadside. British Telecom have recently announced a vehicle location and navigation system – PINPOINT – which combines dead-reckoning equipment with a system of radio beacons in London. The beacons transmit their location to the in-vehicle equipment, but there will be no direct route guidance. Ordinary radio broadcasting, and even cellular radio, is unlikely to be responsive enough to provide information tailored to an individual's requirements.

Satellite systems have been suggested for vehicle navigation – as in the marine world – but in a road environment there are problems of signal reflection and masking, and the vehicle equipment would be expensive. Again, the information could not be tailored to the individual.

Most of the work in recent years has used inductive loops buried in the road surface, similar to those commonly used for detecting vehicles on the approaches to traffic signals. On-street projects in London, Japan, Germany and Hong Kong have indicated that this would work well for electronic route guidance. Another approach being developed is a German system using infra-red transmission from beacons which are usually mounted on traffic signal posts. This could be cheaper to install and allow greater information transfer. But until recently the necessary equipment has not been readily available and so there is not the same body of experience as there is with the loop-based techniques. But if the German work proves to have solved these problems infra-red could offer a way ahead.



The ALI-SCOUT system being developed for trials in Berlin.

Issue for discussion: Should the Government encourage the development of Autoguide systems requiring 'electronic signposts', or are self-contained navigation aids the way forward?

3 BENEFITS FROM AUTOGUIDE

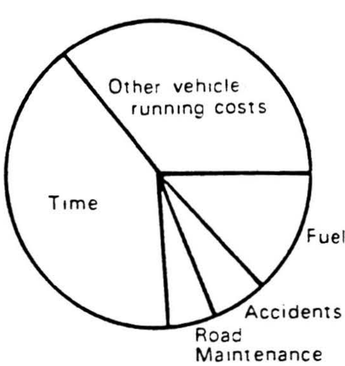
The usefulness of a guidance system depends on the quality of the traffic information it uses. For example, its calculations will produce better routes if it allows for the different times it takes to cover a given stretch of road at different times of the day or week. It will also be more useful if it can allow for roadworks, accidents and other temporary disruptions.

An Autoguide system, which all the time builds its advice on traffic data as it is collected, can approach the most efficient guidance that is possible. This is doubly important since a system which gives poor guidance may quickly fall into disrepute and be abandoned.

Many people could benefit from a system of this sort. They include system-users themselves, other drivers, the police and other traffic information providers. It could also more generally benefit the country as a whole because using existing roads more effectively reduces the need for costly new construction.

Benefits to Autoguide users

An Autoguide system would be likely to pay off best in a congested urban area such as London. Research by the TRRL, and the results of overseas experiments, suggest that the most likely time savings in London from a route guidance system operating in real time would average about 10 per cent for each vehicle fitted with the necessary equipment. Drivers overall would not only save a tenth of the time they spend on the road, but also fuel and other vehicle operating costs. For a heavy goods vehicle covering 10,000 miles per year on London's roads these savings could be in the order of £600, which in the first year would comfortably cover the cost of the unit and any service charges. The larger the mileage the bigger the savings in relation to the outlay. This would apply to all sorts of business users.



The break-down of the benefits from an Autoguide system estimated by the TRRL.

As a guide, the TRRL has attempted to quantify the annual benefits to system users from a system installed in the London area. The estimates are substantial – over £100 million and perhaps as much as £150 million.

Benefits to other vehicles

Other drivers without the Autoguide kit would also get some benefit though not as much. Reduced congestion would ease their journeys, particularly through traffic bottlenecks.

Safety

Given the relation between vehicle miles travelled, congestion and accidents, the number of people injured or killed should be reduced. It would be particularly important though to ensure that visual displays did not reduce concentration and lead to reduced safety standards. Voice synthesis methods are continually improving and might be one way to avoid this. The reduction in levels of stress and the effective removal of the need to follow maps while on the move should have a beneficial effect which, as yet, cannot be quantified.

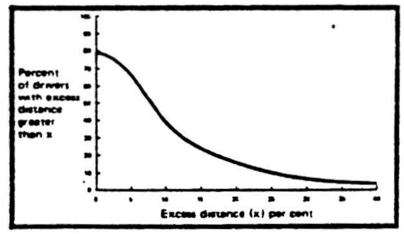
Other benefits

The roadside-to-vehicle system proposed for Autoguide would make it practical and inexpensive to convey hazard warnings and advice to drivers. Roadworks, accidents and adverse weather conditions such as fog could all be included in messages passed to equipped vehicles from a control centre. Indeed, the system itself could function as an efficient incident detection system and could be linked to conventional variable message signs and to broadcasting units to provide information to all road users.

For drivers unfamiliar with a route, Autoguide would give the opportunity to help choose the correct lane ahead of a junction.

Lower vehicle mileage would result in less wear and tear to the roads, producing savings in road maintenance costs.

The implementation of an Autoguide system in London would provide a means of collecting better, more up-to-date and more reliable traffic data than has been possible before. There would be savings in carrying out current traffic census work – which can be expensive. Moreover the better quality of data should yield additional benefits to road users as the design of traffic management measures and road improvement schemes can be more closely tailored to actual traffic conditions.



The graph shows the results of experiments conducted by the TRRL in which most drivers travelled further (and took more time) than they needed to on unfamiliar journeys.

> **Issue for discussion:** To what extent should the economic benefits identified by the TRRL affect decisions about the system?

4 THE TRRL AUTOGUIDE SYSTEM

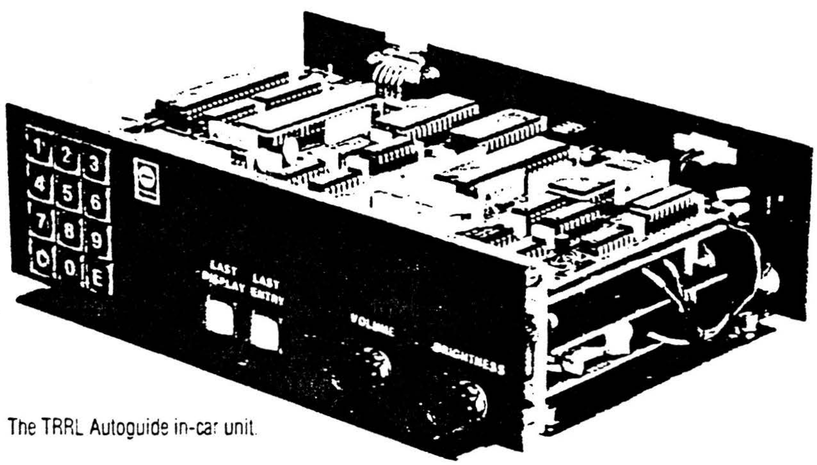
The prototype system for route guidance that the TRRL has developed together with industry could be particularly usefully installed in the London area. Its information and recommendations could be tailored to up-to-the-minute knowledge of conditions throughout the London area out to, and including, the M25.

A network of beacons – 'electronic signposts' – would be installed on the approaches to all major junctions, to pass information to and from passing vehicles. The beacons would be connected over telephone lines to a control centre in which a central computer would continuously monitor traffic conditions and update the 'signpost' information accordingly.

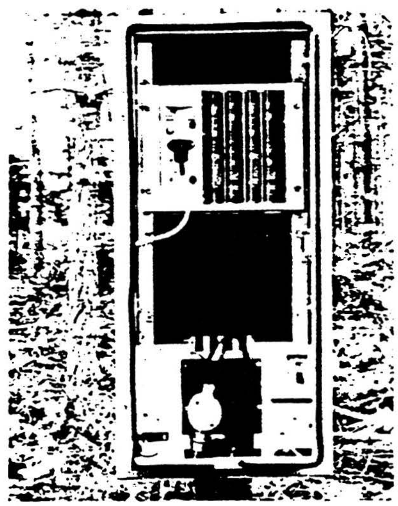
The route computer

The in-vehicle route computer comprises a calculator-style key pad and display, a microcomputer, a receiver/transmitter and a means of conveying guidance information to the driver. This may be a special visual display, synthetic speech, or both. At the start of a journey, or at any time during it, the driver enters the destination on the key pad, and as the vehicle approaches each equipped junction guidance is given (e.g. 'Turn *left* onto the A4') appropriate to the destination and vehicle type.

The set can also be designed to give messages on, for example, speed limits, weather, accidents, roadworks and other special traffic conditions. The unit does not transmit a number that identifies the particular vehicle, so there are no 'big brother' implications of a central computer keeping track of individual movements.



The TRRL Autoguide in-car unit.


The roadside beacon in the TRRL Autoguide system.

The roadside unit

The roadside unit consists of a receiver/transmitter, a micro-computer, a connection to the control centre, and a memory unit which contains the 'signpost' information for the junction. This is effectively a list of detailed place-names. In practice it is useful to have more than one list in each roadside unit so that different vehicles can be given different routes – recognising lorry traffic restrictions for example, or giving routes selected by different criteria (e.g. quickest route, or cheapest route which, rather like a taxi meter, takes into account the time and distance travelled).

The demonstration system developed at the TRRL links the route computer and the beacon through small aerials fitted underneath vehicles and inductive loops buried in the road surface. As well as carrying information, the loops can also detect, and count, all unequipped vehicles, giving extra information on traffic conditions. The major source of useful data, however, would be the information on the time journeys were taking, transmitted by route computers. Each unit transmits the number of the last beacon passed, and the elapsed time since doing so, as well as the destination code.

The control centre

The central computer collects data from the roadside units and continually updates a database recording traffic conditions throughout the network by time of day and day of week. These data, together with the latest information concerning abnormal events, are used to calculate the 'signposts' for each beacon. New directions are then transmitted at frequent intervals to the beacons themselves, so that drivers throughout the network are given information based on the latest traffic conditions.

If a driver does not follow the guidance at a junction – or if the equipment at a junction fails – new directions will be given at the next equipped junction passed.

Costs

The TRRL estimates that vehicle owners should be able to obtain their route computers for about £150, through normal channels. As the system expanded and gained wider acceptance, it could become worthwhile for vehicle manufacturers to install the sets as original equipment, and the unit price of the set would probably come down to below £100. These estimates are based on preliminary work. A market research exercise would be needed to establish costings and take-up rates more clearly.

Although further work is necessary to assess the cost of providing the roadside beacons and the control centre, one illustrative estimate by the TRRL for equipping the whole area bounded by the M25 showed the cost to be in the order of £15 million–£20 million. Annual running costs might be of the order of £2 million–£3 million.

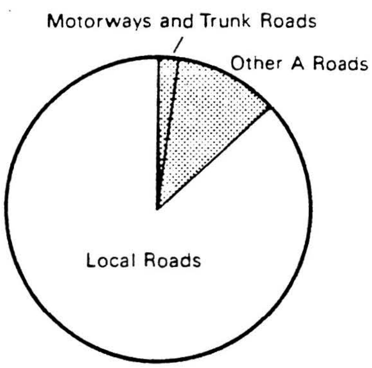
Issue for discussion: How should the trade-off between the amount of intelligence in vehicles and at the roadside be resolved?

5 AUTOGUIDE IN LONDON

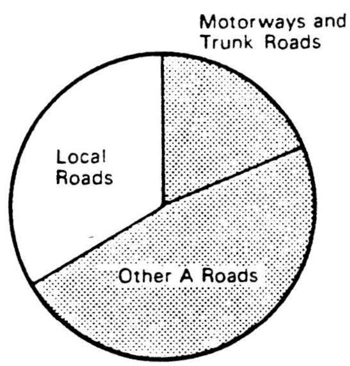
London would be the natural starting-point for a system in Britain because of its major traffic problems, complex routeing and the number of vehicle owners who could benefit. Spending patterns in London and the South East are also favourable to the development of a commercially viable system.

As the M25 nears completion, the route choices in the London area are changing. Many trips can now be made more quickly and/or cheaply, and with less stress, by following routes which at first sight on a map look unattractive. The area out to and including the M25 would be a practical one to equip with the necessary infrastructure for a traffic-responsive route guidance system, and as the largest urban area in Britain could offer significant benefits in routeing traffic more efficiently.

About a quarter of all the traffic within the M25 ring runs on the Department of Transport's trunk roads. The remainder is carried on roads administered by local authorities – the six Home Counties and 33 London Boroughs. As with liaison over conventional signing, the different highway authorities and police forces would need to contribute their local knowledge to help to set up the best possible system.



Lengths of road in London – total 12,980 km.



Estimated mileage travelled on each type of road in London – total 23,200 m vehicle-km per year.

Two thirds of the mileage travelled in London is on the main roads which account for 13 per cent of the total road length.

The inside back cover shows a possible 'beacon map' for London. About 700 junctions might be fitted with roadside equipment, and the roads which could be covered by the route guidance instructions are indicated. On this layout all the major roads are included, and a good deal of the normally heavily trafficked minor ones. Residential roads currently used as 'rat-runs' would not in general be made known to the computers calculating the recommended routes, so the system would not cause undesirable increases of traffic on unsuitable roads.

Issue for discussion: Is London the natural choice to be the first British city in which to install a viable Autoguide system?

6 DEVELOPMENTS IN OTHER COUNTRIES AND THE ADVANTAGES OF STANDARDISATION

Working with other countries can lead to a number of advantages. Development costs can be shared and experience pooled. A common standard means that companies can produce for a larger market at lower cost and so equipment becomes cheaper and more people can afford to take advantage of it. For many years the TRRL has kept in touch with developments overseas to assess their relevance to our own research programme.

The CACS system in Tokyo included variable direction signing as well as in-car guidance units.

The earliest demonstration of true route guidance equipment was in Japan in the late 1970s. The CACS system was originally demonstrated in Tokyo and has formed the basis for continued developments on route guidance systems in Japan.

The pilot ALI-SCOUT system being developed in Berlin by a consortium of German companies combines the use of roadside beacons – which transmit guidance information in a similar way to the TRRL system – with vehicle units which 'know' their position at all times. This is achieved by including a dead-reckoning device in the unit, so that the unit itself is capable of giving at least directional guidance even when no information is available from the infrastructure.

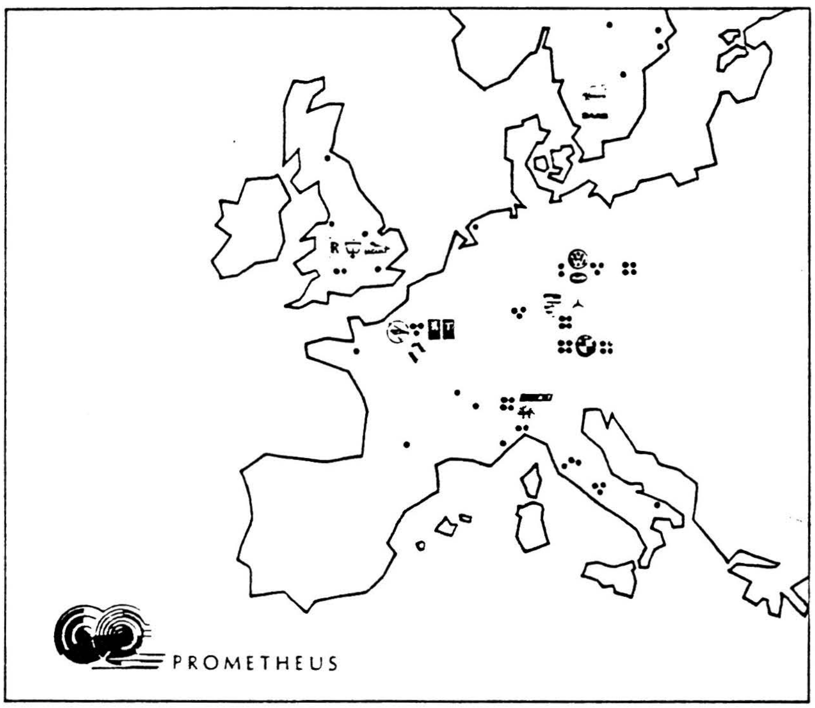
ALI-SCOUT therefore potentially offers the advantages of the TRRL system, because information on real time traffic conditions can be collected in a similar way, but has the advantage that it does not need so large an initial outlay on beacons to make it operate effectively. The disadvantage may be that the vehicle units could be slightly more expensive. The German pilot system is planned to be operational in 1989, and although the design is well advanced it is planned to make use of some technological features, particularly the infra-red data link, which are not as well tried and tested as those in the TRRL system.

A number of other countries have also carried out more limited work on route guidance and information technology. The European Community's DRIVE project, which is specifically concerned with safety, is worthy of note. There is also the joint initiative by the major European motor manufacturers to co-ordinate research in new technology in vehicles: the project, PROMETHEUS, has been accepted within the general EUREKA framework for co-ordinating research in Europe. Further work in Britain on Autoguide could be integrated within this international framework.

There are clear advantages in seeking to achieve an international standard for route guidance. Users of the system – particularly in mainland Europe – would certainly gain from being able to use in one country equipment bought in another. The definition of standards would help to smooth progress towards vehicles being fitted with route guidance devices as standard original equipment by manufacturers.

The Government is keen to encourage the opportunities opened up by initiatives such as PROMETHEUS. Sharing research and development across national boundaries avoids duplicated effort, reduces costs and gets results more quickly. The more countries adopt the same standard the cheaper the system is likely to be for users as a result of manufacturers enjoying economies of scale. Lower prices in turn could mean more units will be sold and it then becomes economic to provide more beacons over more of Europe.

On the other hand, the achievement of agreed standards can itself be a lengthy process which can hinder the very developments it is seeking to help. The technology proposed for the TRRL Autoguide system is largely tried and tested, and British manufacturers of traffic control equipment have particular expertise in much of it. Attempts to achieve standards sometimes founder on differences of view or can lead to unsatisfactory compromises.



PROMETHEUS is a collaborative research programme being undertaken by 14 European motor manufacturers.

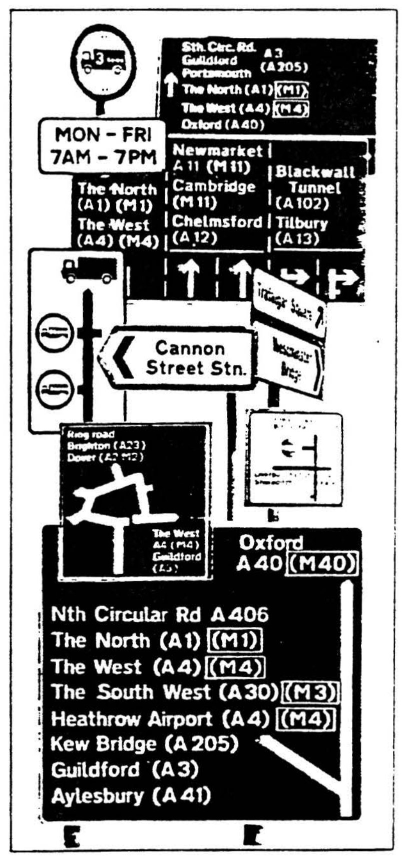
Issue for discussion: Which features of route guidance systems should the Government seek to pursue in an international framework?

7 ROUTEING CRITERIA

Choosing a recommended route can be complex. There are a number of differing viewpoints from which the best routeing criteria could be selected. There is no clear-cut 'best' route for all drivers, and when other factors such as traffic management, environmental considerations and road network efficiency are taken into account, the result may be a number of possibilities.

Even given identical trips and traffic conditions some drivers will prefer different routes to others. Many drivers might prefer a slightly longer, but less stressful, trip using dual-carriageway roads to one involving the frequent stopping and starting which is typical of traffic on many roads in the London area during the working day.

Routes advised by the system must of course be within the law. They cannot direct through traffic past 'access only' restrictions, and vehicle size or weight restrictions must be recognised.



Drivers, or subscribers, would not all necessarily want to be given the quickest route. Goods vehicle operators for example might be more concerned with vehicle operating costs and prefer a slightly shorter but slower journey to a faster route incurring high fuel costs. Many drivers prefer to avoid sitting in traffic jams, even if there is a slight time penalty, and some do not like driving on motorways and prefer to avoid them. In order to make a system a viable commercial proposition, it would clearly be important to be able to assure potential users that the routes being recommended will be close to those most preferred. It would be technically possible to offer drivers a choice of criteria – perhaps 'quickest' or 'cheapest' – for each journey as well as routes which exclude certain types of road which the driver may wish to avoid.

There are other wider issues beyond offering drivers their optimum legal routes. There are traffic management considerations about which highway authorities and the police would rightly be concerned. For example, the system might identify a quick route which involved a particular right turn, which if it were recommended to too many drivers would become overloaded and start to cause congestion on other approaches. It should, however, be possible to anticipate such situations, given a sufficiently high input of local knowledge and a suitable design of the computer software which would have to take such factors into account.

Another important consideration is the environment. It would be undesirable, both from the residents' point of view and possibly on safety grounds, if a guidance system were to route large amounts of extra traffic through residential streets or local shopping areas. The TRRL Autoguide system, however, (as can be seen from the map inside the back cover) would not do this to any significant extent because its coverage does not extend to minor residential roads. This potential problem – and its organisational implications – will need to be considered in further detail.

These are only some of the issues that will arise in deciding the principles on which the range of recommended route choices should be derived. Exactly how the balance should be struck between all the elements and interests is one of the issues for discussion on the way ahead for Autoguide.

Issue for discussion: On what criteria should routes be calculated and offered to users?

8 ORGANISATION

If Autoguide is to be introduced, there are a variety of interests to be brought together so that the system can be installed. When it is up and running, a single organisation will be needed to operate the roadside beacons and central computer back-up. In planning and running the system, the organisation promoting Autoguide will need to co-operate closely with the traffic authorities and police and take account of the patterns of responsibilities in London and the Home Counties.

A key element in handling traffic in London is the Urban Traffic Control (UTC) system. At present, under reserve powers in the Local Government Act 1985, this is the responsibility of the Secretary of State for Transport. London's Traffic Control Systems Unit provides and maintains for him central computers and traffic signal equipment throughout London with a view to getting efficient and safe movement of vehicles and people on the road network. Day-to-day operations are carried out at Scotland Yard, where the police monitor traffic conditions across the capital and take action through the system's central computers to cope with local trouble-spots, road closures, special events and so forth. This overall monitoring also forms the basis of traffic broadcasts for motorists and advice for motoring organisations.

An Autoguide system would need to work closely with these traffic control arrangements. A basic question will be the extent to which the system once in operation is to be regarded solely in terms of the special service it provides to vehicle owners who have 'bought it in' and how far it also has a subsidiary role in the general traffic management of London. The system would share the need for up-to-date knowledge of changes in the road network (e.g. new banned turns, temporary road closures). Not only would it need to be able to take account of any emergency re-routeing that on-the-spot traffic management might require to handle a temporary situation, but the effect of the systems on each other would also need to be catered for. Thus if Autoguide proves popular with significant numbers of vehicles responding to the system's advice, then it will be important to ensure that UTC systems 'know' about current advice so that they in turn can act and respond effectively. In designing new traffic systems it will become important to take into account the routine advice which will be given by the system.

Another feature the two systems will have in common is the need to keep equipment in first-rate working order.

London's Urban Traffic Control centre at Scotland Yard.

A programme is in hand to improve the reliability of London's traffic signals and timings in relation to traffic flows. The systems will share the need for reliability and a speedy tracing and repair of faults.

For all these reasons, the organisation to promote and run a system of this sort will need to fit closely with highway authorities, the Traffic Control Systems Unit and the police. There are various forms this relationship might take. One option would be for one of the existing organisations to take a lead. Another would be for a new organisation to be established specifically to do so. Early decisions on this organisation issue will enable the planning stages to be handled in the best way.

Issue for discussion: How should an Autoguide system best be installed, operated and maintained?

9 LEGISLATION AND FUNDING

The choice of organisation will depend in part on what powers might be needed to install and operate a system and the basis on which its costs are to be met.

The existing legislation in the fields of telecommunications, traffic control, data protection, highways, public street works, competition and monopoly is all relevant in some way to the installation and use of Autoguide. This list is not comprehensive. Preliminary consideration indicates that Autoguide in its suggested form could not be satisfactorily introduced and operated without either changes in the legislation or the introduction of new specific legislation. It would be for consideration who might appropriately promote such legislation in the light of a decision to press ahead.

A system of this sort will have 'up front' costs. Considerable investment will have to be made in development and on the streets before the benefits are felt.

An essential feature of the system proposed is that drivers should be able to buy its services. It follows from this that the roadside beacons and central computers should be funded by the private sector and the running costs of the system met commercially. This in itself will provide an important test of the case for setting it up. Commercial judgement will be needed about how quickly or slowly vehicle owners might choose to have their vehicles fitted with route computers and what the proportion of such vehicles will be. The Government believes that decisions involving trade-offs between risk and reward are in general best made by the private sector. It is preferable for different private sector groupings, which might for example include equipment manufacturers, systems suppliers or road user organisations, to make independent detailed assessments of the risks and rewards from investing in and providing the system. They could then take their own views in making proposals as to, for example, the scale of implementation of an initial system. Such assessments and subsequent proposals would be on the basis of broad guidelines issued by Government specifying the general requirements of the system. A factor which private sector concerns will bear in mind is that the development costs of such an information technology system are likely to be eligible for some support under the usual programmes.

If the system is to be funded commercially, then there must be a means whereby payment for use of the system is made. Users could pay for the system in a number of ways depending on the details of the technology employed. The options include the use of personal identification numbers (PINs) that are

entered into the route computer each year on payment of the standing charge, a levy added to each route computer sold, or the payment of a licence fee. Alternatively charges might possibly be levied, as with in-car telephones, bearing in mind how often the system is used. This would spread charges more fairly among users and cater better in particular for occasional users from outside the capital.

The costs of the system will depend very much on the details of the design and the way forward chosen. For illustration, the system investigated by the TRRL might cost £15 million–£20 million with annual running costs of £2 million–£3 million and each in-car set adding the same cost to a new vehicle as a good in-car radio/cassette player. From this, illustrative calculations also indicate an individual's annual payment for use of the system would be around £20–£30 with 400,000 sets in use.

> **Issues for discussion:** What powers are needed to enable the system to proceed?
> What role should the private sector play in the development of Autoguide?

FURTHER READING

This discussion document has been aimed at providing a concise overview of what route guidance is, what its benefits are, and the major issues arising in pursuing a system for London. The document cannot provide much of the detail which will be of interest to some professionals. Indeed, some of the material used in the preparation of the document has yet to be published. However, the following list includes recent major seminars and conferences at which route guidance has been discussed.

Commission of the European Communities: EUCO COST 30, European Project on Electronic Traffic Aids on Major Roads, Final Report, December 1981. EUR 7154

Institution of Electrical Engineers: International Conference on Road Traffic Signalling, London, March–April 1982

OECD: Seminar on Traffic Control and Driver Communication, Aachen, Germany, 1982

Institution of Transportation Engineers: 53rd Annual Meeting, London, August 1983

OECD: Seminar on Microelectronics for Roads and Traffic Management, Tokyo, October–November 1984

Institution of Electrical Engineers: International Conference on Road Traffic Data Collection, London, December 1984

OECD: International Seminar on Electronics and Traffic on Major Roads, Paris, June 1985

Commission of the European Communities: EUCO COST 30 *bis*, European Project on Electronic Traffic Aids on Major Roads, Final Report, 1985. EUR 9835

Institution of Electrical Engineers: International Conference on Road Traffic Control, London, April 1986

GLOSSARY OF TERMS

ALI-SCOUT The name of the pilot route guidance system being installed in West Berlin by Siemens, Blaupunkt and the West German Government.

Autoguide An electronic route guidance system which both gives drivers positive routing advice and bases the advice on information about actual traffic conditions.

Beacon A device at the roadside capable of communicating with equipment in a vehicle.

CACS The Comprehensive Automobile Traffic Control System developed and installed in demonstration form in Tokyo in the late 1970s, which included electronic route guidance. A limited development of the system was demonstrated at EXPO '85.

CARIN An in-car information system under development by Philips in The Netherlands. It uses compact disc technology to store electronic maps, and can give route guidance to the driver.

CEEFAX The BBC's teletext service, which includes information on road works, road closures and other causes of delay.

Cellular radio The recently-introduced mobile telephone systems provided by CELLNET and VODAPHONE in Britain. The technique can be used for broadcasting over short ranges, in 'cells', so that location-specific information can be transmitted.

Dead-reckoning Calculating a vehicle's position by keeping track of the distances and directions travelled from a known starting-point.

DRIVE A project established by the European Commission to investigate the use of technology for improving the safety of road transport in the future.

Electronic map The details of a conventional map stored electronically.

Electronic map display A map shown on a screen. In navigation aids such as CARIN, ETAK and PACE (qv) the equipment includes a compass and connections to the odometer so that the vehicle's position, as well as the destination, can be shown on the display.

Electronic route guidance The use of electronic equipment to give a driver advice on the best routes to follow for individual journeys.

ETAK An in-car navigation device produced in the United States by ETAK Corporation, featuring an electronic map display which is orientated according to the vehicle's movements.

EUREKA A programme for establishing collaborative technology-based projects in Europe, agreed and funded by the governments of 19 countries.

Flying Eye The traffic information service run by Capital Radio in London, using a spotter plane sponsored by Austin Rover.

Inductive loop A coil of wire, usually buried in the road surface, which carries a reference electric current. Changes in the signal occur when vehicles or special transmitter/receivers pass over the loop, so it can be used both for detecting the presence of a vehicle (as happens at traffic signals) and for communicating with it.

Infra-red The part of the electro-magnetic spectrum between visible light and microwaves, often used for short-range control or communication purposes. Remote control units for televisions, for example, frequently use infra-red.

LANDFALL A dead-reckoning navigation system developed by GEC in the late 1970s. Radio speech channels were used to transmit vehicles' locations to a control centre where managers could keep track of their fleets.

Navigation The process of keeping track of a vehicle's location during a journey, and of finding a route to the destination.

Navigation aid Any instrument or device which helps the process of navigation.

NAVIGATOR A navigation aid developed by Lucas Ltd under contract to the TRRL. It has its own electronic map representation and gives route directions to the driver based on the distance travelled from the last junction.

Odometer The mileage recorder fitted universally to motor vehicles. Most vehicles also have a trip meter which can be reset to measure the length of an individual journey.

ORACLE The teletext service offered by the Independent Broadcasting Authority which includes road traffic information such as roadworks, closures and other delays.

PACE A navigation aid produced by Plessey. It consists of an electronic map display and microcomputer in the vehicle which is connected to a sophisticated compass so that the vehicle's location can be dead-reckoned.

PINPOINT A system developed by BT for fleet managers to keep track of the location of their vehicles. A network of short-range radio beacons will enable fitted vehicles to transmit their locations and identities back to a control centre.

PRESTEL The videotex system offered for use with suitably equipped television sets by BT. Users communicate with a central computer over the standard telephone network, and are able to get information on, inter alia, traffic conditions.

PROMETHEUS A major EUREKA (qv) project established by 14 European motor manufacturers to develop advanced vehicle-based systems for improved safety, efficiency and economy. Route guidance systems are included in the programme.

Radio Data System (RDS) A system for adding data to standard VHF radio transmissions so that specially modified receivers can extract information without affecting the normal radio reception. A European standard has recently been defined.

Real time A computer term used to describe processes which depend upon reaction to events as they happen – for example a real time traffic control system continuously adjusts signal settings according to actual traffic conditions.

Road Information Unit The Department of Transport's team who collect details of roadworks, closures and special events likely to cause traffic delays, and inform the broadcasting companies and the press.

Roadwatch The Automobile Association's service which uses its patrols on the roads to monitor traffic conditions and report back on accidents and other causes of delay.

Route computer The device in an Autoguide system which is in the vehicle and gives the driver details of the recommended route.

Route guidance Any method of giving advice to drivers on which routes to take to get to particular destinations.

Route maps Maps produced to highlight recommended routes. The motoring organisations produce standard route maps showing routes from particular towns, and will prepare route maps for individual journeys in response to members' requests.

ROUTE-TEL A route-planning system developed by the TRRL which produces displays and print-outs of recommended routes for journeys in England.

SCOOT The traffic control system developed by the TRRL which automatically adjusts traffic signal settings according to actual conditions. SCOOT stands for Split Cycle and Off-set Optimisation Technique.

Speed maps Road maps which show roads colour-coded according to average speeds rather than the conventional road class – these can help a driver to plan the quickest route.

Traffic Control Systems Unit The section of the London Residuary Body which runs London's traffic control systems under contract to the Department of Transport.

TRRL The Transport and Road Research Laboratory – the Government's centre for research in all matters affecting roads and transport which has been responsible for many developments in route guidance.

Urban Traffic Control (UTC) The use of central computers to control a network of traffic signals in order to make the most efficient use of a dense urban road network.

BON - a computerized Urban Public Transport Control system /1/

by Dipl. Ing. Gregor Wessels, Dipl. Ing. Hartmut Dowideit and Dipl. Math. Günter Stöhr

1. Introduction

A computerized urban public transport control system simulates aspects of reality in software for realtime data processing - with BON this is the sequence of events in urban public transport. These aspects take place in the external world, the simulation is the system's internal world. Within this every external event is reproduced to create a process replica at one central point.

To compute a realistic replica three conditions must be fulfilled with BON:

1. A 'model' for example a computerized circuit network and the corresponding time-table must exist. This 'model' contains the setpoint data, the replica is based on the comparison between the 'model' and up to date information called from the external process.

2. The algorithms for the simulation of external events must be as complete as to allow the processing of any relevant information from the external world in the internal world so that they don't miss in the replica.

3. The internal world must be able to request any relevant process data from the external world via an interface.

If a realistic replica exists in BON mistakes perceived in the simulation can lead to an intervention in the external world. In this case the replica serves as process control and a control loop is installed between both worlds.

2. Description

The interface between the system's internal and external world has to be differentiated into five connectors; these are the connections between internal world and

1. the network of routes and lines,

2. the time-table and duty plans,

3. the vehicles,

4. the control center and

5. the passenger.

Here point 1 and 2 describe the 'model' based on which an internal replica is drawn by comparison with actual vehicle data (state of the distance counter, traffic beacons). The replica can be displayed at the control center and at the same time parts of information in the replica can be offered to the passengers.

In the internal world a vehicle is represented by a number of attributes; the vehicle virtually moves on the model network of routes and lines by changes in the value of some attributes. Current values of other attributes are compared with the model time-table. Deviations are classified and if necessary worked on either by autonomous internal decisions (e.g. simple cases of connection ensurent) or by consultation of the system supervisor at the control center, i.e. the external world (e.g. difficult cases of connection ensurent). Reports to the control center and consultations of the system supervisor only take place with disturbances, for which no plain treatment for the automized removal of model deviations could have been defined. Then necessary manual intervention is aided by indices and diagrams, which provide a complete replica sight - including undisturbed "surroundings" such as lines, which work on plan.

3. BON control loops for operating control

BON realizes three control loops, which operate partly automized, partly computer aided. These three control loops are based on the comparison between setpoint and actual state, they aim at influencing the system's external world to such an extend as to create a correspondance between replica and model. Fig.1 shows the control loops and indicates the components of BON concerned: radio communication to vehicles, location definition, setpoint and actual state comparison, disposition and statistics. These denotations comprehend extensive software packages, which partly contain algorithms to compute and test replica (location definition computes the vehicles' location within the network of routes and lines; setpoint and actual state comparison tests the replica in its accordance with the time-table of the model; disposition takes maesures for correction, if model and replica do not accord), partly offer service programs (the radio communication to vehicle secures the data transmission to the vehicles) or programs for the subsequent analysis of runs (statistics).

The control loops perform in particular:

1. acceleration-control loop: request of priority at traffic lights for vehicles of the urban public transport.
   The priority request is ordered, when a vehicle is located approaching traffic light with influencable signal program, if this vehicle is behind schedule. The vehicle receives the priority index and its radio transmitter sends this to the receiver of the intersection controller as soon as the vehicle has reached the point of request (fig. 2).
   The control loop operates between radio communication to vehicle -> location definition -> radio communication and takes into consideration the current time-table deviations present at the replica.
   The acceleration-control loop aids to the acceleration of travelling times by the reduction of stops at traffic lights and aids to a raise in the punctuality of the vehicles of urban public transport by the balancing of time-table devitations.

2. accuracy-control loop : assurence of connection

In simple cases the connection assurent is an automized process, e.g. in cases, when the order for a stop time elongation at a connection bus stop does not cause a fresh disturbance in the secondary course of the corresponding connection.
In other cases the cooperation of the system supervisor at the control center cannot be missed.
Thus this control loop operates online and (partly) automized between radio communication to the vehicle -> location definition -> setpoint and actual state comparison -> disposition (system supervisor) -> radio communication.
By assureing connections this control loop gains a raise in the operating quality of urban public transport.

3. service control loop : optimization of a model

This control loop is not yet automized; replica flaws are rather judged by the planer's expertise and systematic mistakes are eliminated by a modification of the model.This does not imply, that modifications should be carried out such as to push the model towards the replica and avoid mistakes in the replica by assimilation of the model; it rather means that measures have to be taken, which allow to avoid mistakes in the replica by a processing adequate to the model, that means an operating which meets the model's demands : increase of bus frequency, establishing of autonomous buslanes, etc. The planning of improvements in the service for passengers is to be facilitated.
Thus this control loop operates without a direct connection to the vehicles and takes into consideration offline statistics and eventual editors for alteration of the model data.

In the security-control loop a retreat from the BON internal world sometimes can be necessary (system supervisor), with the offers-control loop in its present from an external decision is absolutly necessary.

4. Operational measures for the standarization of BON

In several aspects the development of BON served as an impulse to undertake standarization measures. The development of the IBIS-vehicle device /2/ may serve as an example just as the almost-normization of the telegram-sizes in data transmission between the control center and the vehicles. Both developments were coordinated by VÖV-departments (VÖV = association of public transport authorities in the Federal Republic of Germany), who guaranteed for a meaningful operational application. The results reached were published in a series of VÖV-terms of references. /3,4,5,6,7,8/.

The operational requests for BON's display surfaces meant for the passengers and the control center were defined by the VÖV-member ÜSTRA, Hannover. This definition took into consideration ergonomic requests to exclude an overstraining of the control center's staff by e.g. a too high density of information in each displayed graphic. On the other hand the reverse aspect of too little information was considered also, as the quality, i.e. the rapidity and correctness of the operation does in the long term not only suffer by stimulus overkill but by stimulus abstinence too.

This led to a user-oriented setting up of supervision limits, which can be defined individualy by each urban public transport company in a way as to make sure that neither unnecessary many and operationaly meaningless nor too little reports of disturbances are put out. Display surfaces realized to meet the above mentioned operational demands are just one of a number of possible realizations. Variations can be carried out and are already under development. For example line graphs for the representation of routes of busses which were until now only route scale based are completed by a time scale based alternative. This development is undertaken for the installation of a computerized operating control system for the "Stadtwerke Wiesbaden"; this is the second implementation of the BON software besides the pilot and development application at the ÜSTRA.

The extension of BON's software sortiment in the scope of the implementation for the town of Wiesbaden is not only limited to fitting the display surface to meet the user's demands, but also additionel components are programmed, which are to be added to the already existing software. At the moment for example the module "supervision of drivers minimal breaktimes" is being realized, which discernes and indicates inadmissable undercuttings of breaktimes.

By this BON-implementation - and in decreasing extent by others to follow - additional operational demands are formulated and in consequence are realized. Therefore the application practice itself cares for the completion of standarized measures, which have been developed for the pilot application. By this iteration the software package BON will continuously more meet all demands of urban public transport companies. This gradual extension of the top set of free to choose software components leads to the realisation of a state-of-the-art which makes it possible to configurate a user-oriented BON incarnation by subset generation.

5. Software technical measure for the standarization of BON

Demands on the software, which rise with the standarization of BON can be derived from the above mentioned:

1. development of a program topset as a central software for any kind and size of urban public transport company.

2. easy reduction of this program topset to the elements which are required in special cases of application.

3. easy maintenance and good adaption of the software to special operational functions to guarantee the degrees of freedom of each urban plublic transport company.

To reach these aims seperate software packages, which each comprehend several programs with co-operational functions were built during the eleboration of the system's concept (fig. 3). These packages defined by function were cut into modules, determined by software technics, which process subtasks of the operational functions.

For example the function "informing the passengers on the up to date service "is executed by a program package called "passenger information system", the subtask " switch on a specific disruption message to the output media of the passenger information system by the system supervisor" in this program package is taken over by the modul "system supervisor-dialogue". This may serve as an example to indicate up to which differentiation of tasks the software functions have been seperated and arranged.

Any subsequent rearrangement of seperate algorithms within the software moduls has no influence on the BON software as a whole, as long as no interface to the surrounding software is touched. This allows a great flexibility in meeting the special demands of each urban public transport company, often even without varying a great number of moduls. In case that several moduls or even program packages were touched by special operational functions, the unequivocal and standarized interface-definition allows to fit in software expansions lucidly into the existing net of interfaces by the introduction of additional nodes and edges (software functions and interfaces).

The easy facility to reduce the program topset has been secured by the development of the BON software generator.

The BON software generator is a program, which turns to use a technic, that already has been used in the scope of operating systems for a long time : the user - oriented configurability of software functions.

This programm is mainly employed for two tasks:

1. Definition of parameters of the BON system

   Characteristic examples for parameters which can be generized are the numbers of vehicles, of workstations and the number of sections within the route network as well as the above mentioned user-oriented adjustable supervision limits.
   With an urban public transport company which operates 800 vehicles number of vehicles (NV) = 800) the BON software generator on declaring the structur "vehicle list", which the PEARL-source program states as
   DECLARE VEHICLE-LIST (%VAL NV;) STRUCT .....
   generates an object, which allows exactly 800 entries of the type STRUCT.

2. Configuration of the BON system

   With this not parameters are generated, but software functions which are part of the BON program topset and on whose adaption has to be decided for each concrete application.
   The generatable function of"build tram-units" may serve as an example, which is only needed by urban public transport companies that run trams.

```
%IF TRAM = "YES";
BUILD_TRAM-UNITS: PROCEDURE (...
 "
 "
 "
RETURN;
END;
%FIN;
```

If the object TRAM has been assigned the value "yes" for a specific system configuration, the BON software generator takes over the program "BUILD TRAM-UNITS" into the program subset for this case of application, not so with any other value.

The BON software generator in connection with a standarized programming language offers valuable premises for the portability of the BON software. The portation job done for the implementation in Wiesbaden confirms this at the moment; software which was developed with the effort of about 60 man years can be transferred from a Krupp Atlas computer onto a VAX-11/750 by DEC and can be implemented to run there within 6 man months only.

6. Future plans

The gradual perfection of the BON software sortiment in the scope of further implementation work today is seen as a process, which evidently will take place by iterative steps.

Besides these quantitative expansions of the program topset the main emphasis must be laid on such measures that raise the quality of the interfaces between BON's internal and external world.

Besides this an introductory step of BON is described, which refers to a local system to influence traffic lights to give priority to the vehicles of the urban public transport.

6.1 Measures for the improvement of interfaces between the system's internal and external world

An improvement of the quality is mainly desirable in four cases. These are the interfaces between

1. passenger,

2. driver,

3. time-table and

4. garage.

Even now BON realizes a passenger information system at the bus stop, which informs with actual data on the services and supplies information in case of a disturbance partly automatically partly following a dispositive intervention of the system supervisor. This passenger information system works with visuell display units, e.g. colour monitors are used as output devices.

Based on this, an advanced passenger information system is under development at the moment. In place of the plain display units - monitors, LCD displays etc. - intelligent output stations which provide a decentral image management are planned to serve as terminals at bus stops. This contains the possibility to provide besides the information on departure times, which take into consideration actual time-table deviations the representation of routes of busses. The decentral intelligence in the terminal will automatically decide, whether such geographic information can be displayed or whether they have to be temporarily superseded by information on the departure time or a disturbance annoucement.

Between the BON central computer and the terminals for the passenger information system a switch will be installed, which takes over the distribution of information to the seperate terminals. This switch will be realized as an autonomous computer, which is linked to BON by a rapid data coupling. As this will serve as a buffer at the same time, a cheaper coupling with a lower data transfer rate can be chosen for the second data link from switch to terminal, as a disturbing feedback of the slower data transfer procedure to the central BON software cannot occur from this point onward.

Supplementary to the optical display it is considered to establish a digital speech output. Besides this there are plans to test in how far the decentral intelligence of the terminals allows to introduce out-house information in situations acceptable to the operation, e.g. advertisment. This probably can open up sources of income, that could reduce the costs of a passenger information system.

While the passenger information system already is at the point of realisation, only designs have been made for the development of system for the supervision of drivers' exchange. Terminals are planned at bus terminal, rest rooms and bus depots at which drivers can signal their readiness for going on duty. Disturbances in drivers' exchange can already be recognized when they are to be expected because of missing drivers' readiness and not only after they have already occured.

Further more many urban public transport companies employ a system to generate time-tables and driver-duty-plans besides a computerized urban public transport control system. To prevent double effort in the setpoint supply and a possible data inconsistence between the two systems, a coupling for the take over of time-tables and driver-duty-plans by BON will be installed. Between BON and the EPON /9/ program system these interfaces are almost realized.

The operational test for EPON is finished and its employment with the ÜSTRA in Hanover has proved that EPON truly meets the demands of German urban public transport companies on time-table and driver-duty-plan generation.

The component time-table may serve as an example. Based on the data of the network of routes and lines EPON generates a time-table pattern with a given bus-succesion as a time-distance diagram (see fig. 4). Within this pattern for example connections can be defined. Finally with this time-table pattern so called "notice board time-tables" for the passenger information at bus stops or pocket time-tables are computed.

Finally an interface to a garage-information system can be realized, which can make use of data existing in BON on technical disturbances of vehicles and stationary installations (traffic beacons) for work-planning at garages.

6.2 Influencing traffic lights by a local system

Such a system can serve as an 'initial step' instead of the immediate complete implementation, as any component needed here can be fully integrated, if a BON installation is added later on. The concept of the local influencing of traffic lights for priority to the vehicles of the urban public transport works on the same principle as the central influencing by BON. In both cases a vehicle on passing a defined place within the route network receives the instruction to send out an influencing telegram to the receiver of an intersection controller. Besides this the vehicle is informed on the distance to be passed beween receiving the instruction and telegraphing. The difference between a local and a central solution is that in the first case a stationary infrared beacon must be installed at the point of instruction to instruct the vehicle while passing it (fig. 5) and in the second case the point of instruction must only be defined as an interaction in the route network. Furthermore the central solution allows to check the necessity of bus priority by the criterium of requirement, as only late vehicles should profit of bus priority and by no means vehicles, which are already fast (see above: acceleration - control loop). On the long term a central solution is the operationaly more sensible form of influencing traffic lights.

When thus the installation of BON is started with the installation of a local system for priority request at traffic lights, the stationary traffic beacons later on can be removed and placed at such points, where they can function as location support for the radio location of vehicles, e.g. at U-turns. At the moment the process of local influencing is for the first time tested in practice by the urban public transport company of the town of Wuppertal in the scope of a BMFT /10/ sponsored research program. The subsequent expansion into a computer - controlled operating control system is planned.

With the research program at Wuppertal, on the route of bus line 622, 15 of altogether 22 traffic lights have been equipped with intersection controllers with influencable signal plans. 7 out of these 15 are pure pedestrian traffic lights (see fig. 6).

Up to now no detailed test results are available which could name the decrease of waiting times at traffic lights. Therefore the possible circle-times reduction can not be given. But already the tendency can be made out that a significant raise of the average travelling speed of the buses can be reached.

7. Summary

Not only in function with the ÜSTRA-Hanover does BON prove its efficiency as a control loop-oriented operating control system, but first experiences with adaption during the implementation of BON in Wiesbaden already indicate that efforts undertaken for a standarization have been effective. The modular software concept and the employment of a software generator maintaine the possibility to fit in new moduls into the content of the standard BON program package without fractures. Because of this every new implementation lets grow the number of free to choose functions and operation facilities of BON. Additional improvments of BON have already been initiated - passenger information system, connection to EPON - or are already planed - as e.g. the supervision system for drivers' exchange. The installation of a local system to influence traffic lights can serve as an initial step to introduce BON.

/1/ "Betriebsleitsystem für den Oeffentlichen Nahverkehr" is the German expression for "computerized urban public transport control system" from which the acronym "BON" derives.

/2/ IBIS (Integrated Board Information System) is the standarized, microprocessor-based vehicle device for all buses and trams in public transport in Germany.

/3/ VÖV-term of reference 70.61.1

/4/ VÖV-term of reference 04.05.1

/5/ VÖV-term of reference 04.05.2

/6/ VÖV-term of reference 04.05.3

/7/ VÖV-term of reference 04.05.4

/8/ VÖV-term of reference 04.05.5

/9/ "Einsatz-Planungssystem für den Oeffentlichen Nahverkehr" is the German expression for "Time-table Calculation System for Public Transport" from which the acronym EPON derives.

/10/ Minister for Research and Technology of the Federal Republic of Germany

BON - Control Loops

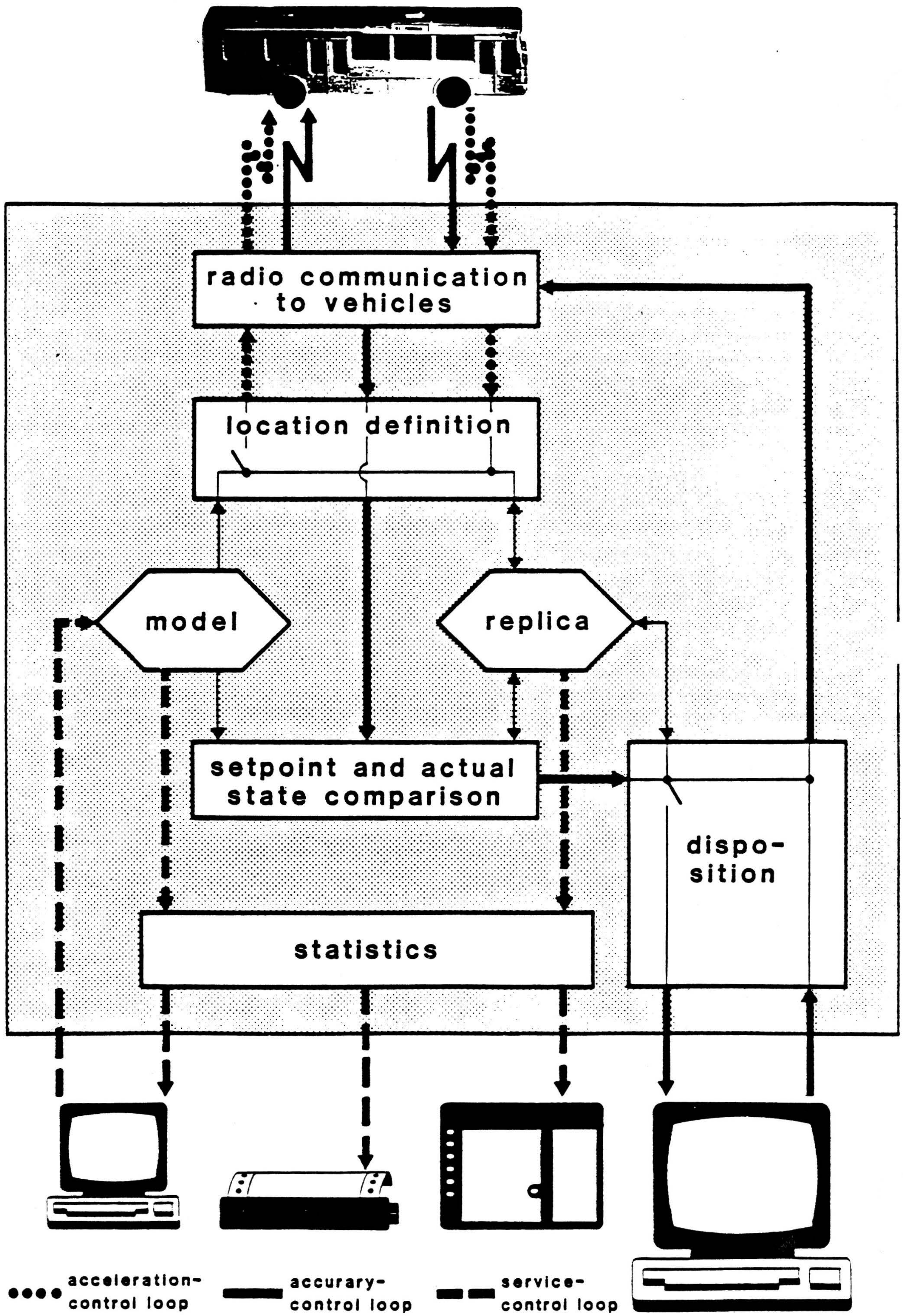


fig. 1

Central Priority System for Vehicles of Public Transport at Traffic Lights

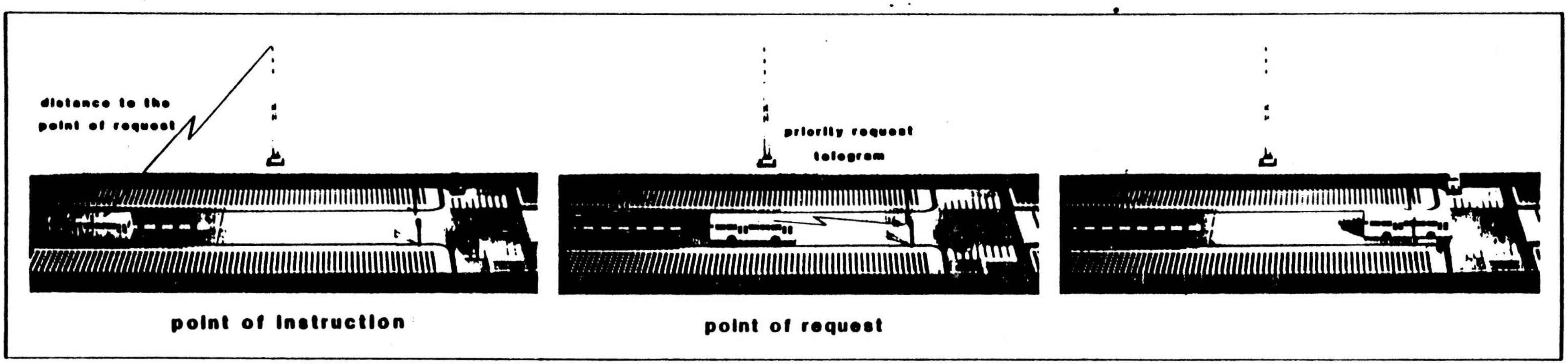


fig. 2

BON-Software-Packages

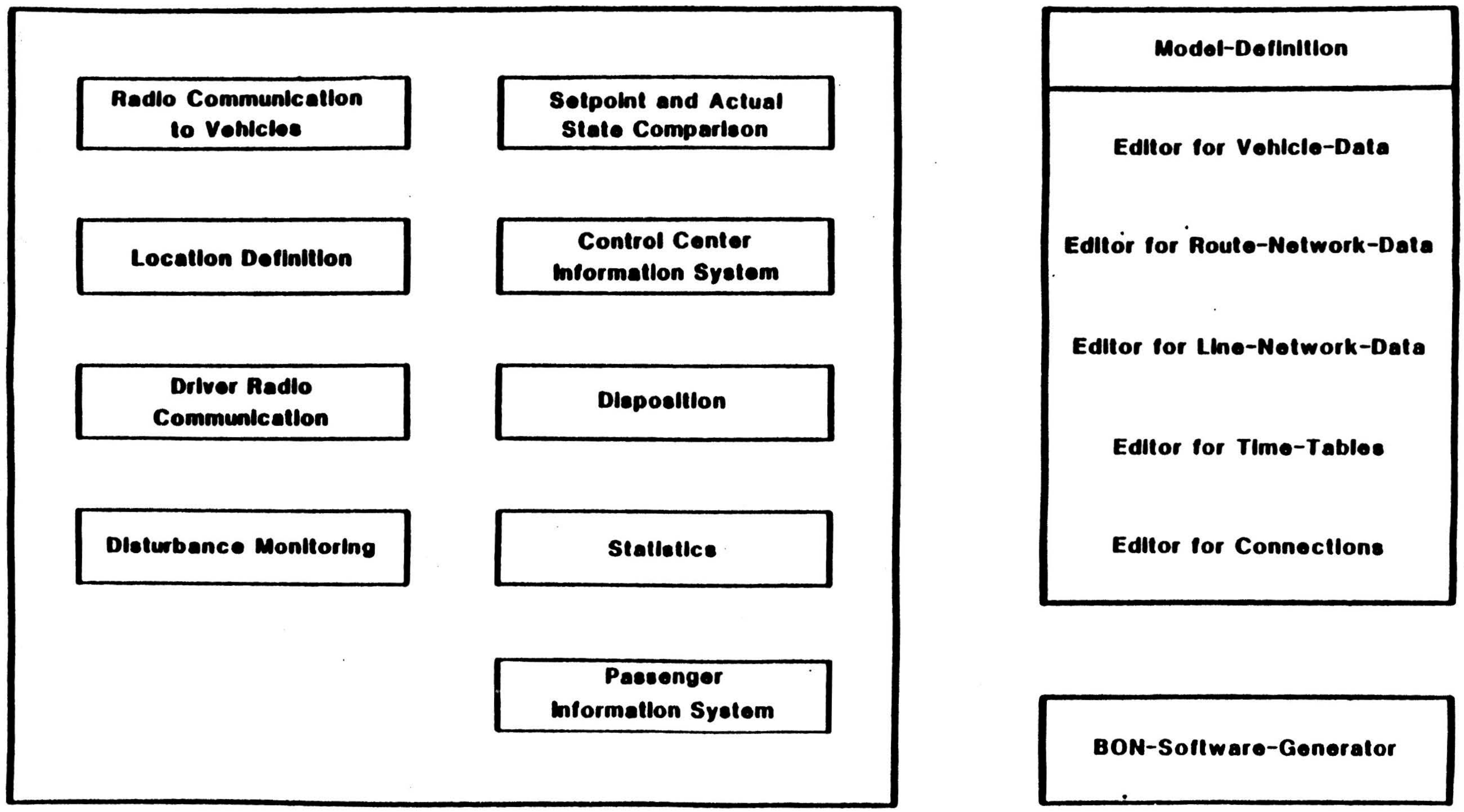


fig. 3

Time-Table Pattern as Time-Distance Diagram

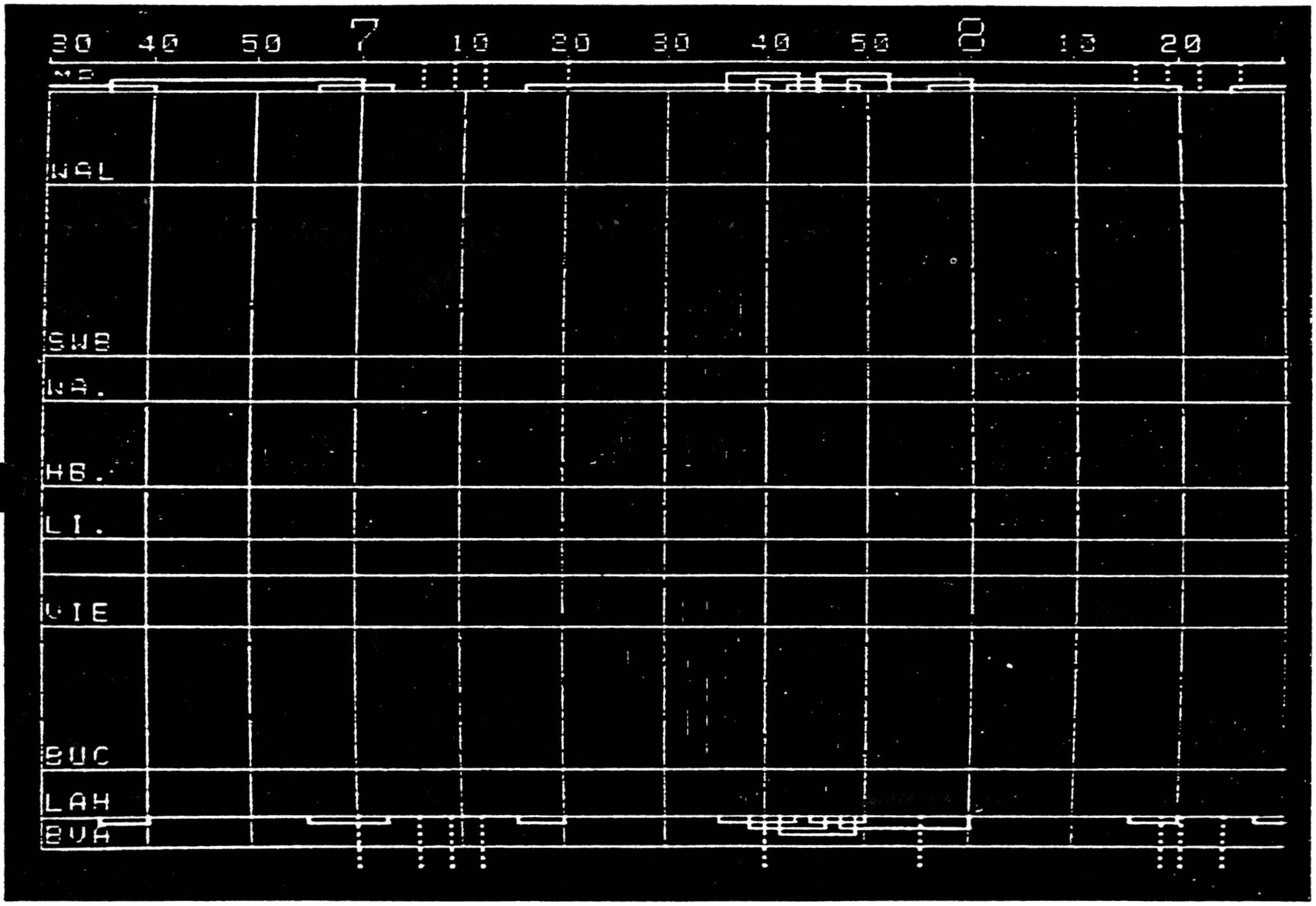


fig. 4

Local Priority System for Vehicles of Public Transport at Traffic Lights

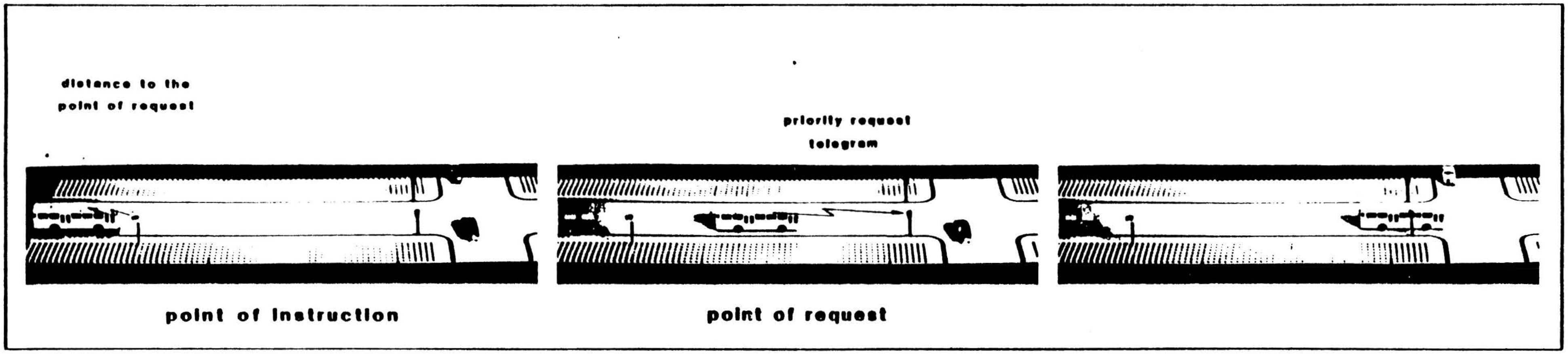


fig. 5

SITEPLAN

Line 622 - Wichlinghausen Market - Elberfeld Station

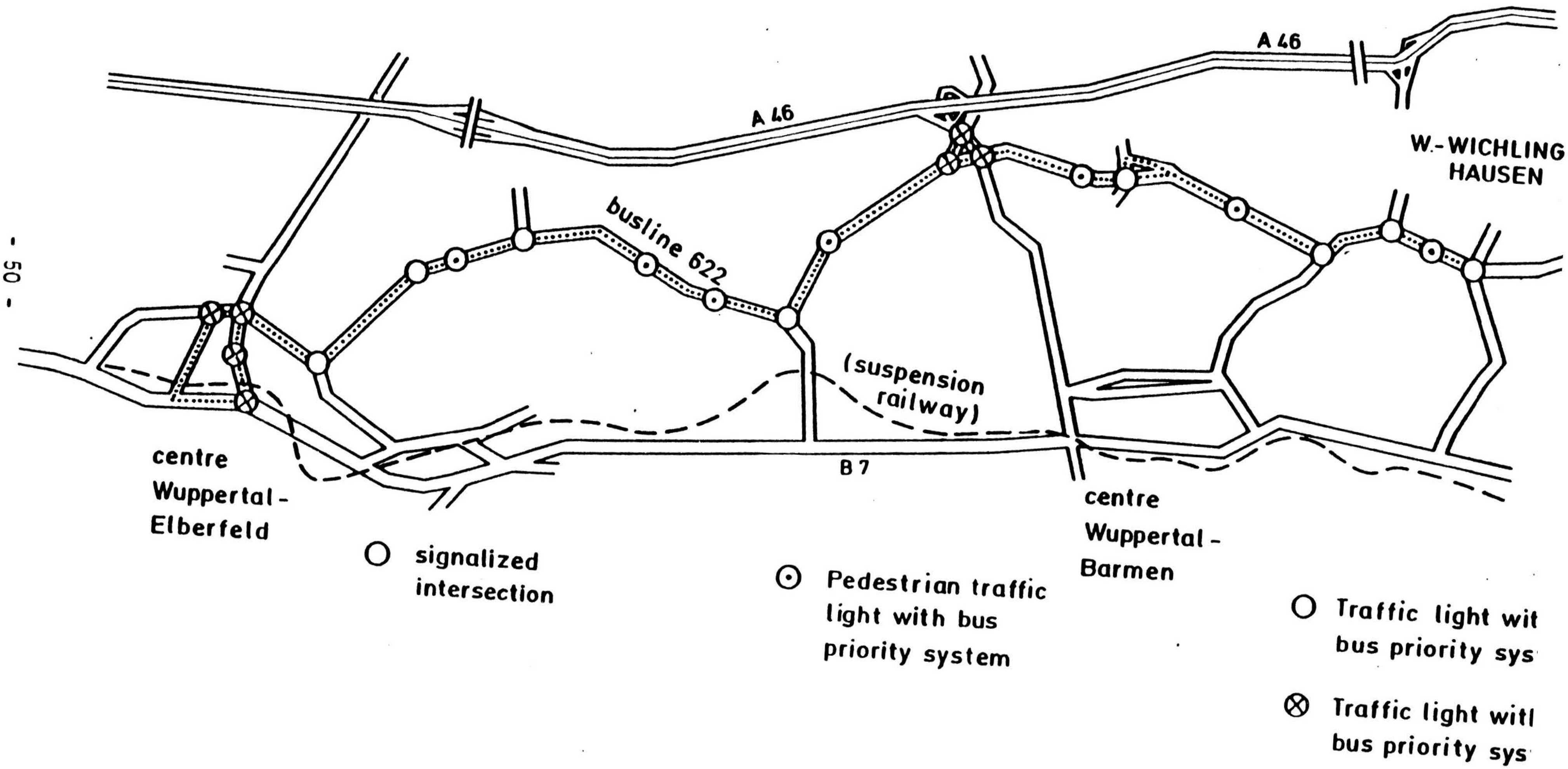


fig. 6

Computerized Operating Control Systems

Computerized operating control systems (COCS) are information and disposal systems which are implemented with the purpose to optimize the realization and preparation of operating processes within the field of urban public transport. They are not prepared to care for safety functions so that they can definitely be distinguished from, for example, tramway safety systems. Under the name BON ("Betriebsleitsystem für den Oeffentlichen Nahverkehr" which means "Operating Control System For Urban Public Transport") a standardized COCS has been developed and tested which should satisfy all the demands on an advanced operating control system.

System Concept

The conception is derived from the main purposes for such a system (fig. 1, see frontpage):

- information about the current operating conditions
- recognition and elimination of disturbances and irregularities.

Depending on the characteristics of the different demands of system-users, it has been the goal to develop different standards of the BON - system to make specific configurations available. Therefore, BON has been constructed as a modular system.

Basis for all functions is the permanent surveillance and control of the position of all vehicles within the urban traffic network. By the aid of wireless data transmission, the computer center is in constant contact with all vehicles. It is required to actualize the positions every 15 seconds on the average. Above all, within urban traffic networks - where driving times from 30 seconds up to 1 minute between two bus or tram stops are needed on the average and where the passenger fluctuation at bus or tram stops need about 20 seconds - such frequency is absolutely necessary to assure a sufficiently current surveillance of the vehicle positions (for example at or between bus and tram stops; before or after branch-lines). For special functions as, for example, driving time analyses, the cycle can be shortened.

This all leads to a comprehensive information interchange which requires a center-controlled and synchronized wireless data transmission.

Furthermore, the location of the vehicles' positions is required to be very precise that means within a 10 meters tolerance at a maximum which corresponds to the dimension of the average vehicle's length. The high precision is necessary, for example, in cases where an optimal management of a public transport priority system at intersections with traffic lights should be realized.

The BON - system provides three types of vehicle location:

- radio location supported by signals which are sent out when passing defined places (e.g. traffic beacons)

- location at bus-stops supported by contacts which signalize the opening of doors (the so-called logical location)

- a "mixed" location where both is used, the information as it is given at defined places as well as during breaks at bus-stops.

Based on comparisons between the constant locations (position and time) and the time-table which is stored in the central computer, prematurity and delay can be determined and then indicated to the drivers (via "Integrated Board-Information System " IBIS).
Beside those indications concerning time-table deviations, direct indications of disturbances and irregularities within running operations are pointed out by the operating control system. Those are determined by control functions on the basis of comparisons between the "debit" and the actual state and in accord to specific statements given by the driver.
Furthermore, services for automatic and supervisor-handeled disposal measures in case of disturbances are also supplied. Disposal measures can be supported by a priority management at technical systems such as traffic lights and signal-boxes.
Within the range of "off-line-evaluations", all the collected data concerning the operations can be used for routine statistics, for traffic management and control plans and measures.

Structure

The installation of BON is possible in three different standards of the equipment as the whole system consists of independent components (fig. 2).

Standard 1 can be called the "basic system". It provides all the basic elements of the total system and includes functions as

- information interchange between center and vehicle via radio-telephony and wireless data transmission

- radio location of the vehicles

- simple indications in the operating control center.

Already this first standard construction is very effective and provides more than any simple radio communication system because of the provision of radio location.

Standard 2 completes BON as an "information system". It includes additionally:

- the comparison between "debit" and actual state

- the control functions for indications of irregularities

- the comprehensive representation of the operating conditions by tabular and graphical illustrations on monitors in the operating control center.

Standard 3 represents the total system as a "disposal and control system"; the installation of only one of the additional components which are represented in fig. 2 is possible as well as the setting-to-work of all.

In addition to the provisions of the other standards , standard 3 provides:

- a passenger information system which indicates the current operating service including current disposal measures
- the assurance of bus-connections which is the most important measure of the correction / elimination of disturbances
- the ability of statistical evaluations.
- the traffic light management and control for priority systems for the urban public transport
- a computerized and automatic management of disposal measures
- the connection to signal-boxes and their coordination for priority settings within the field of tramway distribution.

In the following, all those fields of the BON - system which directly concern the driver (as the system-user) as well as the passengers (fig. 3) will be described more in detail. These are:

- the driver's terminal of the Integrated Vehicle Information System IBIS
- the provision of the "debit" - operational data
- the information in the operating control center
- the statistics
- the current information for passengers.

Integrated Vehicle Information System IBIS

The core of this system is the central device equipped with a microprocessor, a display and a keyboard for the driver. The keyboard consists of 22 keys arranged according to the demands of the ergonomics; the two lines display offers 16 characters per line. This brings about a lot of comfort for the data input. When the IBIS-device is switched on, the required data input is already indicated to the driver. In a totally equipped vehicle for the urban public transport, those are the following inputs:

- the line-number and the route-number on this line (so called line-route-number) for the operating control system, for the external display on the vehicle, for the cancellation device and for radio recognition

- additional features for the cancellation device

- the destination for the external display on the vehicle and for the operating control system.

All the indications can be changed at any time by the driver as well as by the operator of the control system; input faults can be corrected.

Provision Of The "Debit" - Operational Data

The first step to set every computerized operational system in operation is to feed in a comprehensive illustration of the "debit" operational conditions. The archives are subdivided into the following components:

- vehicle archives

- route network archives

- line archives with the description of the routes in the network

- time-table archives for the provision of the daily time-tables

- connection archives which make the data needed for the "debit-actual-state comparison" available to assure connections in case of disturbances.

The data input is done via input masks.
The dialogue via monitor is mainly controlled by the computer so that exactly defined inputs are required. The generated data are filed in the archives marked as being valid so that from that moment on, for example, time-tables as well as derivation routes can be made available in advance.

The data which the user has put in are checked concerning their plausibility respectively their consistence compared to those data which are already stored, because ambiguities respectively contradictions lead to mistakes within the whole system. It is necessary to check and compare the data of a single subject, the consistence of all the subjects of one of the archives as well as the subjects of all the archives mutually.

Operation Management And Control In The Operating Control Center

To put a computerized operating system to work it is necessary to install an operating control center where information can be collected and if necessary be worked on.
The possibilities of a COCS can only be used to the full extent if the indications which are available to the system supervisor are tuned in as best as possible to the operations in the management center. The dialogues between system supervisor an computer have to be constructed in a logical and simple way. I_ is the principle mode of operation in the BON-management center that the computer takes over the automatic surveillance and control so that the system supervisor only has to act on direct indications on the monitor (eventually supported acoustically). A

constant visual surveillance of the operations is not necessary.

Workstation-oriented monitors have been chosen as indication devices to provide comfortable working conditions to every system supervisor in the management center. An analysis of running operations has proved that every workstation needs at least two monitors. To optimize the management of the dialogues especially in cases of disposal measures against disturbances, even a third monitor should be set into operation.
All the inputs are to be done via a keyboard. Monitors and keyboard are integrated in the whole concept for the management workstation under consideration of the ergonomics.
The communication with the vehicles (radio communication, transmission of orders) works via the so-called standard mask. All the displayed messages provide the most important information about the vehicles (line-route-number, vehicle number, position, deviation from the time-table). Without a COCS, all this information has to be asked via radio telephony.
All further information about the current operation conditions are represented tabulary or semigraphically.

The semigraphical representation of the network (fig. 4) reproduces the whole network of the transport company in a sketched out form. The positions of the vehicles in the network are marked and each vehicle is described by its line-route-number, by its irregularities according to the time-table and by an approximate description of the number of passengers.
The line-representation gives a survey over all courses of one line.

As soon as a disturbance is recognized (it will be automatically recognized by the BON-system and indicated on the standard mask) the computer-supported disposal measures will come into effect at once.
Concerning the disposal measure one has to distinguish between automatic and manual but computer aided dispositions. If there is a disturbance within already defined conditions, the computer system will automatically compute the disposal measures. The driver, then, can execute the disposition according to the orders which are indicated to him by the IBIS-device. The effect is a considerable relief for the system supervisor. In cases in which the presuppositions for an automatic disposal measure are not provided the measure has to be figured out in a computer aided dialogue between BON and the system supervisor. Even here, you can expect that the more efficient treatment of disturbances and irregularities will cause

- a considerable relief for the system supervisor and

- that the measures which are started will be more successful because of better information and a faster treatment.

Statistics

The statistics are subdivided in

- protocol of daily events, disturbances, irregularities
- regular operation statistics
- planning statistics.

The records of the daily irregularities contain a documentation of the operating. Each case of disturbance is registered in a general list which gives a survey of all disturbances of a day and in a special list which sums up all the disturbances of a certain type. Some data are automatically registered (e.g. announcement of an accident), others only after using the record key, during the radio-communication. The information about those events will later be completed by the supervisor in a dialogue with the computer.

The regular operation statistics are a first analysis of running operations. They provide data for other statistics (e.g. the annual statistics) and beside they give a wider survey of time-table deviations and disturbances on the different lines.

The planning statistics are subdivided into driving time analyses and evaluations of passenger countings.
Driving time analyses are worked out when they are necessary for time-table corrections and for plans within the field of route optimization. The basic data are determined by the operating control system or by a mobile data recording device (e.g. MODS system) which lists up those events as stops with opene_ respectively closed doors and other data describing the traffic flow.
The number of passengers as a basis for the service supply is counted by passenger counting devices and transmitted via wireless data transmission to the central computer.
It is by means of detectors in the doors respectively of contacts in the doorsteps that the passenger counting device can determine the number of people getting in or out of the vehicle at stops.
For driving time analyses and passengers' countings one can select the output of standard programs as well as of detail representations. The evaluations can be represented as tabulars or as graphics, they can be route-, course-, or stop-oriented. The spot-check can be related to a defined interval, a weekday, or to groups of days. The planning statistics can be represented as speed-space-diagrams or as cumulative frequency of travel times, time-table deviations and speed rates, of passenger numbers at bus and tram stops, and so on.

Information For Passengers About The Current Operations

In connection with the application of computerized operating control systems which are informed at any time about the current state of all the operations because of the continuous dat interchange between operating vehicles and operating contrc center a direct and specified information for the passengers about service, connections, and departures has become possible and useful.
Information systems which have been put into action for the

public transport until now have only been able to provide "static" information about kind and extent of the scheduled vehicle operations. The implementation of computerized operating control systems provides additionally "dynamic" information, that means information about the current operation service.

Especially in case of disturbances which lead to greater irregularities compared to the given time-tables, such an information system for passengers can prevent informational deficiencies .

Fig. 5 represents the indication at bus or tram stops. It provides the following information:

- current day time
- line-number
- route-direction
- expected departure
- position for departure at the bus or tram stop.

Summary

In this article the main functions of BON as the most advanced example of a computerized operating control system for urban public transport should be explained.
The main emphasis has been given to those aspects of BON which concern the system users: the bus- or tram drivers, the system supervisors and first of all: the passengers.
And it should be remembered that systems like BON are to be installed to better the quality of urban public transport and to invite the people to go by tram or bus instead of private cars. Everybody is able to recognize that private transport needs much more and bigger streets than the public transport and becomes therefore very expensive. And everybody is able to recognize too that the increasing of private transport is responsible for a lot of the air pollution in the modern cities all over the world.

Operating Control System For Public Transport
BON

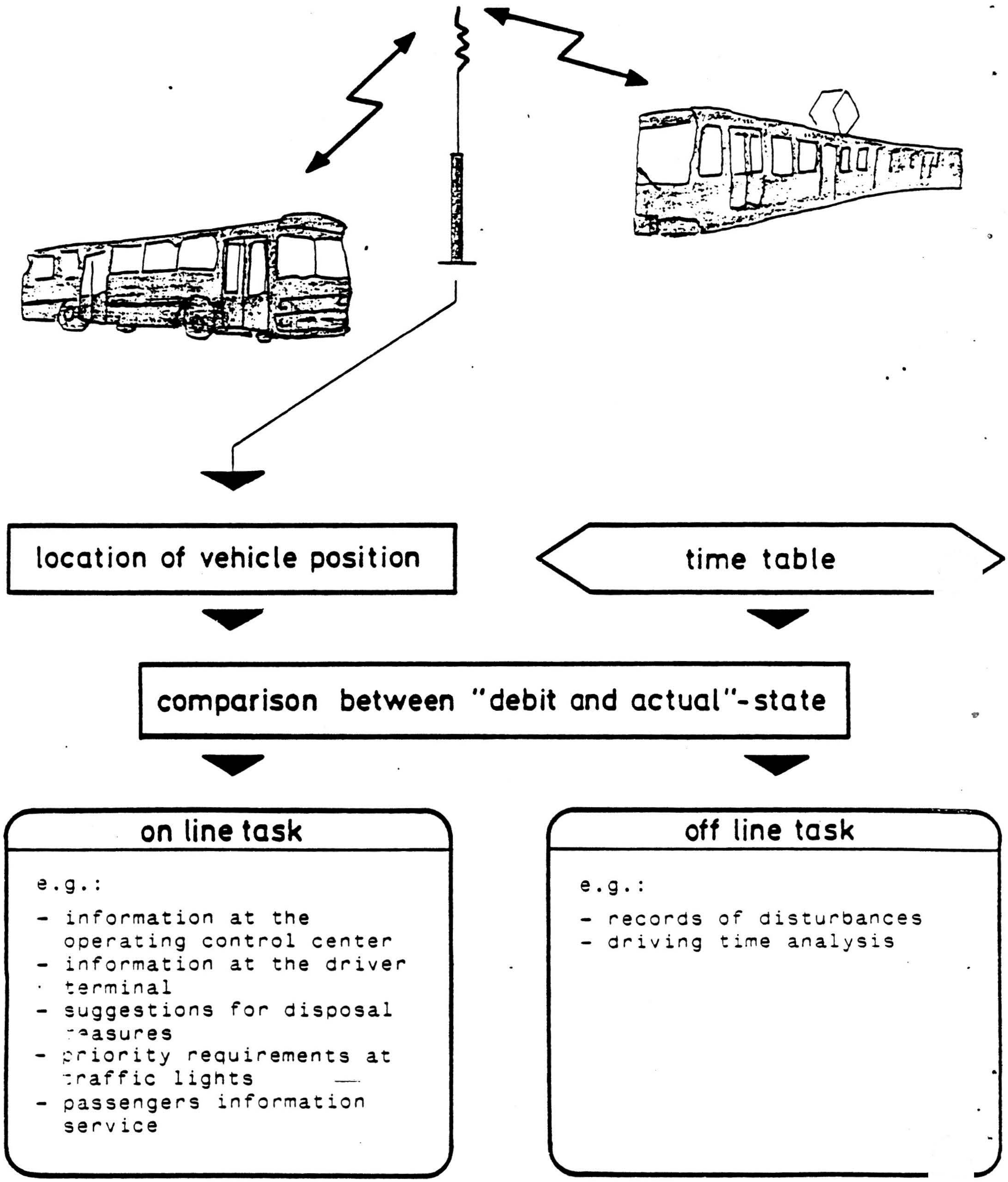


fig. 1

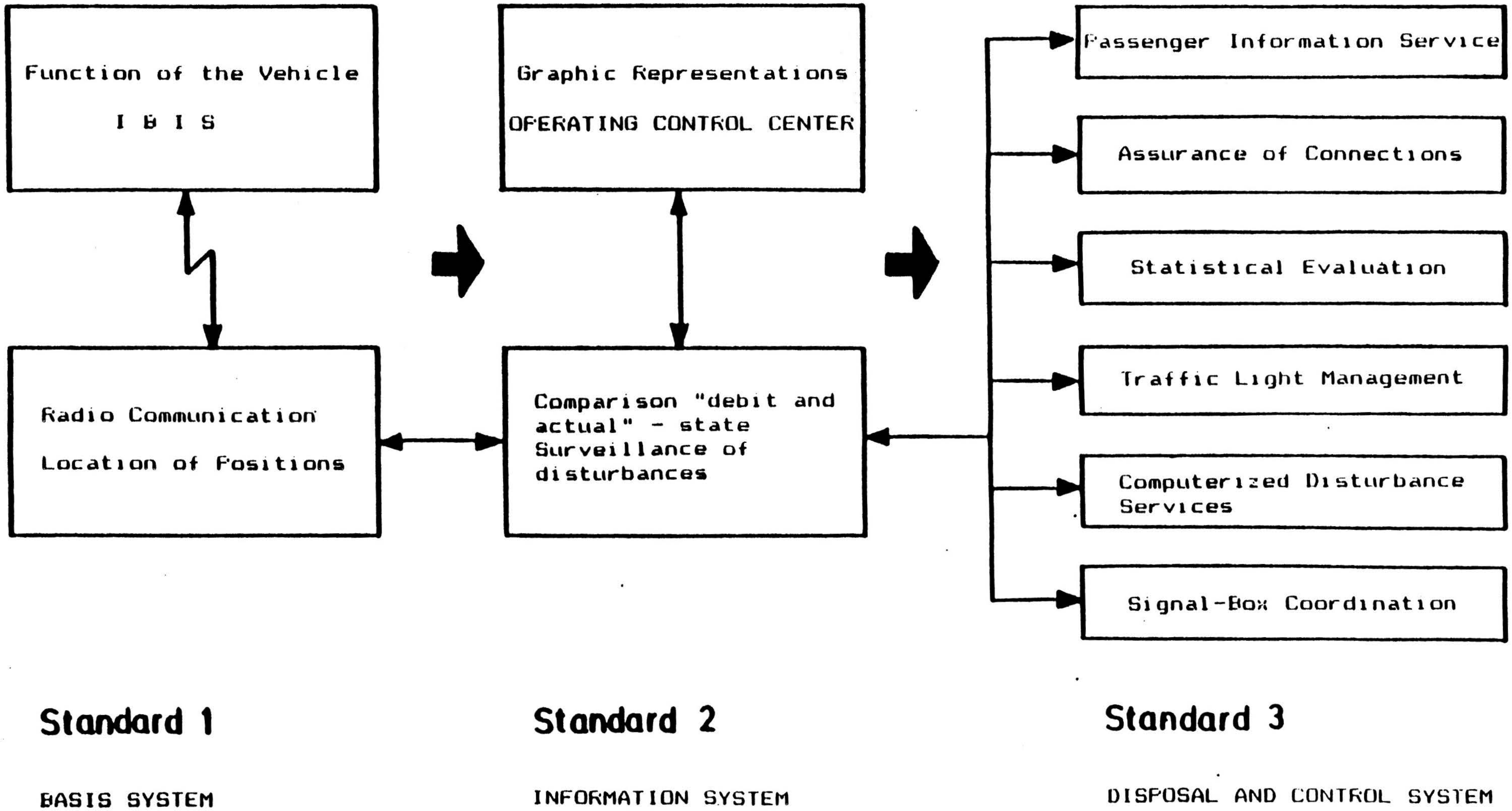


FIG. 2.: Development Standards Of BON

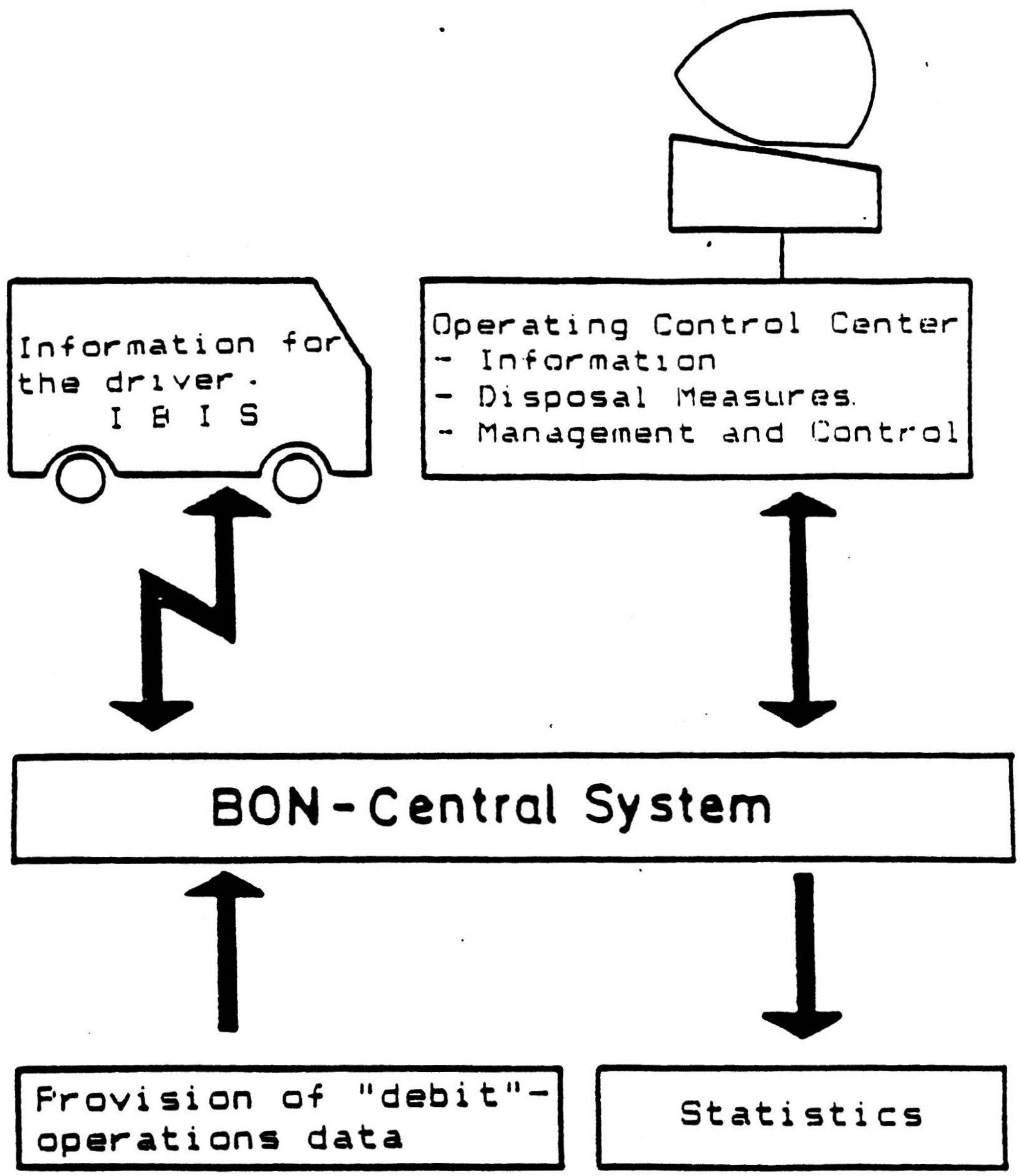


FIG 3.: User Interface Of BON

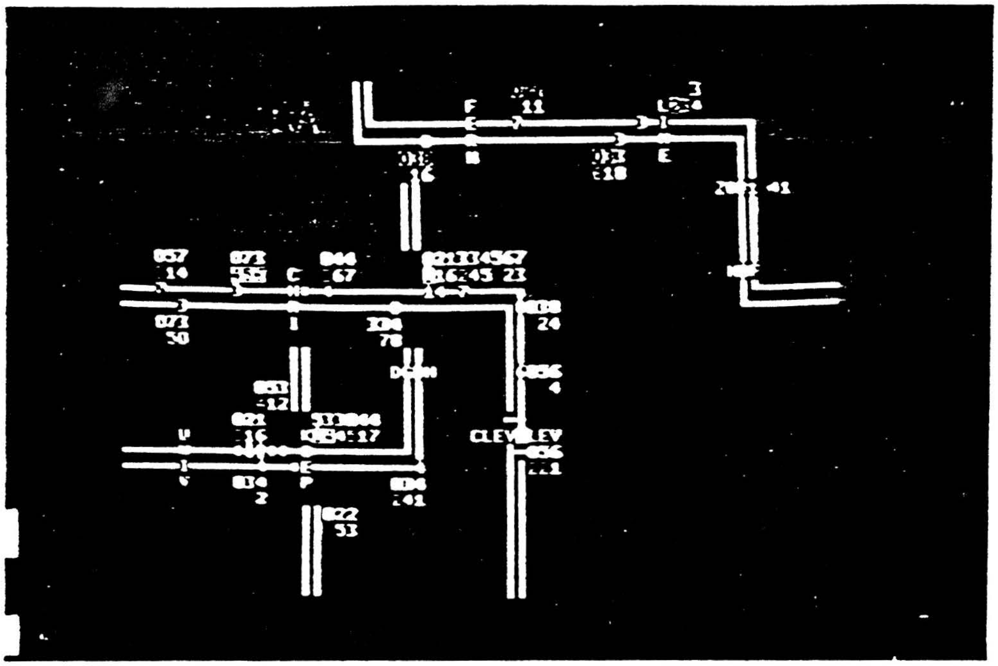


FIG. 4: Network Representation

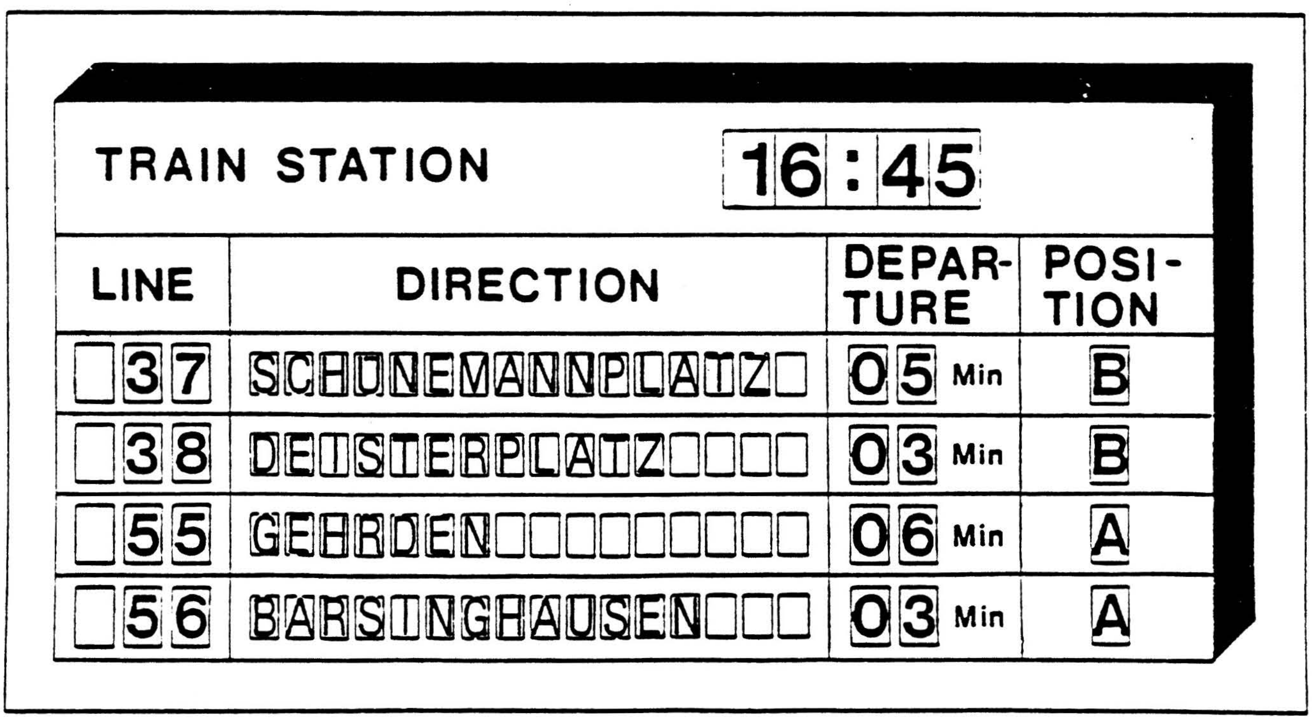


FIG. 5: Computerized Passenger Information Service

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THE TRAFFIC CONTROL SYSTEM ON THE HANSHIN EXPRESSWAY — FURTHER DEVELOPMENTS

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***Hansin Expressway Public Corporation, Osaka, Japan*

Abstract. Road traffic control systems have become indispensable to the modern society. The Hanshin Expressway Public Corporation, Osaka, Japan started its first traffic control system in 1970 and has been developping it ever since. This paper presents the recent control concept and system configuration of the system together with the expected developments in near future.

Keywords. Traffic control; computer control; man-machine systems; urban systems; social and behavioral sciences.

INTRODUCTION

Twenty years ago, the Hanshin Expressway Public Corporation, Osaka, Japan, decided to implement fully automated computerized traffic control system in order to cope with the expected traffic congestions along the Hanshin Expressway. Then the corporation started the Special Committee on Traffic Control of the Hanshin Expressway under the chairmanship of Professor Eiji Kometani of Kyoto University in 1962. This committee has been running since then, now under the chairmanship of Professor Tsuna Sasaki of Kyoto University, and this report explaines the results of efforts by the above committee and the Hanshin Expressway Public Corporation.

The Hanshin Expressway, which is an urban expressway covering parts of Osaka area and Kobe area, started its first service to the public in 1964 with the expressway length of 3.1 km in Osaka City.

As a matter of course, when the corporation started planning its traffic control system, the total length was only 14.5 km and there was no traffic congestion there. It means that people who have been involved with this planning should have had profound and wide foresight towards the future.

The first phase of the first traffic control system started its operation on 15th of March, 1970 to be in time for the begining of Expo 70 in Osaka. Although there is no major change of the control concept and strategy ever since, its hardware systems have been improved continuously and then tremendously according to the developments of new hardware systems and elements together with the development of the communication systems utilizing optical fibers.

The first system in the last phase was reported several times, already (for instance, (1) - (3)) and it has been removed entirely after many steps of improvements, then, it may be better to explain it only briefly, here.

The first system might be classfied as one of the world's first distributed processing systems. The central computer system consisted of one computer for real time control, FACOM 270-30 of Fujitsu Ltd., Tokyo, Japan. Many front end processors with dedicated hardware systems were installed along the expressway. This distributed hierarchical system enabled us to design and implement a very efficient and compact system with rather low cost. These characteristics of the system met, as a matter of course, the requirements by the Hanshin Expressway Public Corporation in designing the system. In addition, the Hanshin Expressway Public Corporation required us that the hardware system including computer itself should not become obsolete for at least ten years after the final designing. This was the most difficult requirement to meet. We investigated various computer systems including imported one and adopted the above computer system. Fortunately, the first system worked very well and did not become obsolete for more than ten years after the fundamental system decision.

In these twenty years, we have been experiencing incredible developments in the field of computer and communication systems, such as evolutions of VLSI,

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microprocessors, optical fiber communication systems and image aquisition and processing systems, etc. Therefore, the present traffic control system has become entirely different and advanced compared with the first one. The major points of difference are;

(i) Adoptation of minicomputer complexes at the computer center with the distributed control functions,

(ii) Full utilization of optical fiber communication system throughout the expressway in transmitting image signal,voice signal and data,

(iii) full automatic road side radio system broadcasting on 21 sites along the expressway.

These 21 radio stations broadcast different items according to the relevance between the information content and the site.

The first system gained very high reputation, as far as we understand, in the world, and at the same time, the present system has been also achieving very high evaluation not only in the world but also in Japan.

TRAFFIC CONTROL SYSTEM ON THE HANSHIN EXPRESSWAY

Table 1 shows the breif and condensed history of the Hanshin Expressway from the view point of data concerning the traffic flow and situation of the expressway. This shows that this urban expressway system has been struggling against the traffic congestions and casualities under the limited physical and social resources. The traffic control system is one of the tools to keep this struggle, which is impossible for us to win but is not allowed to loose, going. Traffic congestion on the expressway is a serious social and economical problem. As it is impossible for us to have enough capacity of the road due to the scarcity of land, the importance of the traffic control has never decreased in spite of the fact that the traffic control can not be an ultimate solution.

The fundamental strategy of this traffic control is to maximize the number of inflow cars. This means that any type of traffic congestion along the expressway should be avoided by all means. Figure 1 shows an typical computer output of the relation between traffic volue and time occupancy** by an X-Y plotter. This figure illustrates that congestion decreases the traffic volume tremendously. Figure 2 is also a typical data showing the relation between average velocity and time occupancy of a certain point.

These figures lead the basic idea how to recognize automatically congestion on the expressway by the data derived from the detectors along the expressway.

The system collects data of traffic volume, time occupancy and average speed in each section of the expressway and inflow and outgoing traffic volume of on- and off-ramps with the time unit of five minutes. The maximum inflow is expected to be achieved by maximizing the number of inflow cars from each on-ramps under the condition that no traffic jam is caused at any section of the expressway by solving Linear Programming problems in every five minutes.

The above method utilizing LP model is not suitable when the traffic situation varies severely. Then, LP model is used only when the traffic is stable.

When the traffic is unstable due to, for instance, an accidents, sequential ramp closure control is adopted. This is to close the toll gates of on-ramps which are

**Time occupanncy refers to the time percentage of vehicles' presence in the area of a vehicle detector for a uit time interval.

Fiscal Year	Expressway Length(km)	Congestion Frequency	Accidents (cases)	Breakdowns (cases)*	Number of Vehicles in millions
1964	3.1	0	7	234	1.4
1965	7.3	0	21	455	2.9
1966	14.5	0	52	1,082	6.8
1967	25.6	69	327	4,128	22.8
1968	38.6	440	1,097	11,482	47.9
1969	74.1	1,004	1,491	15,710	64.7
1970	74.1	913	2,121	20,011	92.8
1971	79.7	1,718	2,578	21,255	107.8
1972	81.0	2,673	2,520	20,083	124.7
1973	83.3	4,428	2,323	17,636	134.4
1974	90.5	5,113	2,138	15,004	140.6
1975	90.9	5,936	2,114	14,977	146.9
1976	90.9	7,254	2,271	16,813	154.7
1977	92.1	8,782	2,143	17,131	162.3
1978	92.1	8,097	2,400	15,907	174.8
1979	103.3	9,474	3,215	14,108	180.0
1980	103.3	10,509	2,819	14,922	193.3
1981	117.6	10,526	2,879	15,104	213.7
1982	123.6	11,241	3,592	15,792	227.2
1983	124.1	11,131	5,085	16,747	239.4
1984	124.1	12,530	5,468	17,274	248.1
1985	129.3	14,006	5,463	17,678	254.4

Table 1. Annual progress of the expressway length, congestion frequency, number of accidents, breakdowns* and number of vehicles.
*Breakdowns mean a number of cases of breakdowns among the inflow cars.

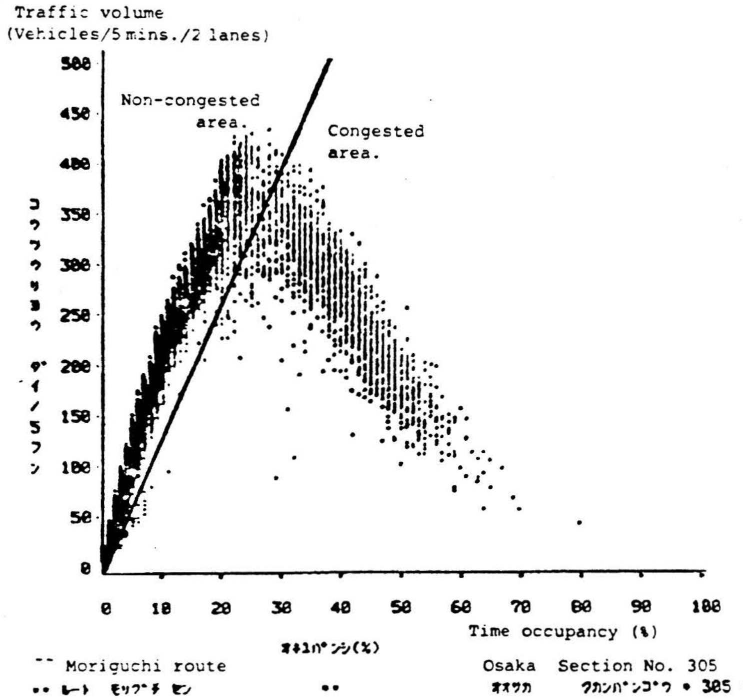

Figure 1 ｵｷｭﾊﾟﾝｼｰｺｳﾂｳﾘｮｳ ｿｳｶﾝｽﾞ
Occupancy vs. traffic volume.

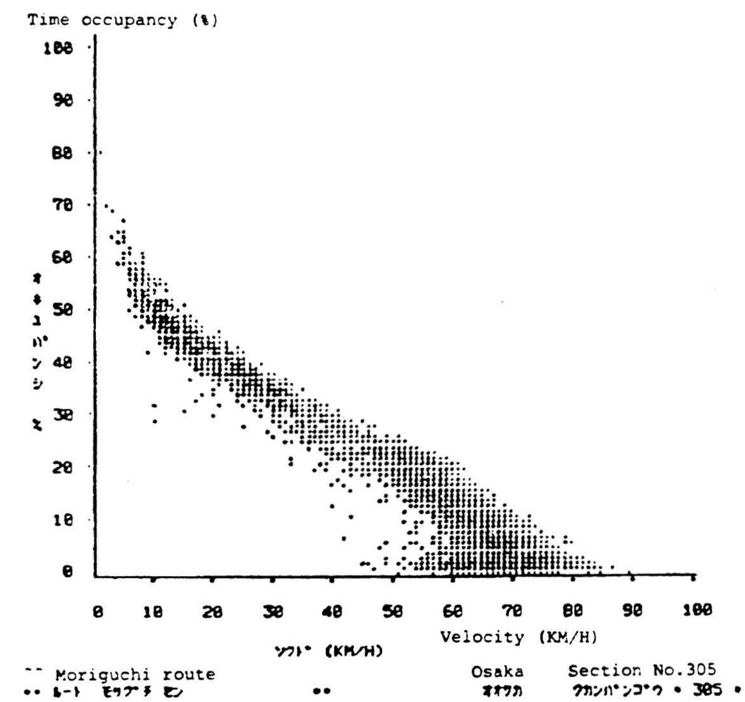

Figure 2 ｿｸﾄﾞｰｵｷｭﾊﾟﾝｼｰ ｿｳｶﾝｽﾞ
Average Velocity vs. Occupancy

most effective to avoid deadly traffic jam at the congested section. Off line simulation models are devised in order to perform this closure control corresponding to the expected jammimg sections and on-ramps to be controlled.

As is understood from the characteristics shown on Figure 1, this has been quite effective to ease the rush hour natural congestions, also.

As mentioned before, when the traffic flow on the expressway is stable, LP control is performed by controlling the inflow traffic volue at certain on-ramps. Though the traffic control system itself has a control strategy of precise and fine control of inflow traffic, the actual control up to now is done by controlling the number of open toll booths at each on-ramps. As a matter of course, this is insufficient, but it will take some more time to utilize the full traffic control strategies equipped, not by the technical or engineering reason.

The other control method is a kind of indirect one by supplying various information concerning the traffic situations of the expressway and near-by roads. There are two ways of supplying information. One is by the varable information boads (VIB) installed on the expressway and on the other roads than Hanshin Expressway near the on-ramps. A VIB shows the following information; (i) Original point of congestion and length and the cause of the congestion. (ii) Closed on-ramp or number of controlled toll booths at the corresponding on-ramp and the reason of the control. (iii) Mainline and off-ramp closures and the reason. (iv) Warning of maintenance work, accidents, breakdowns, etc., ahead.

Due to the size of VIB, the items shown on a VIB is quite limited. According to the capacity of a VIB, one or two items which are most appripriate to the VIB are automatically selected following the predetermined method of selection.

Another way of supplying information is by the road side radio stations. At 21 sections along the expressway, each has more than 2 km of length, road sid radio stations are operated. These radio stations can give much more information than VIB's. The broadcasting frequency is same 1,620KHz for all stations. Each anouncement lasts 40 seconds. As explained before, the unit time of control in this traffic control system is five minutes. Every information to the drivers given by VIB's and road side radios are refreshed in every five minutes. For a time duration of five minutes, all information collecting devices collect information and the central computer system processes the information within 50 seconds at the longest. Then, the information provided by these two ways will be refreshed with the maximum delay of 50 seconds, which is much shorter usually.

According to the surveys, more than 80% of the users of the expressway are relying on the information suppled by the expressway in deciding the routes they take to fullfill their traffic demands.

CONFIGURATION OF THE TRACCIC CONTROL SYSTEM

A rough configuration of the traffic control system of the Hanshin Expressway is shown on Figure 3.

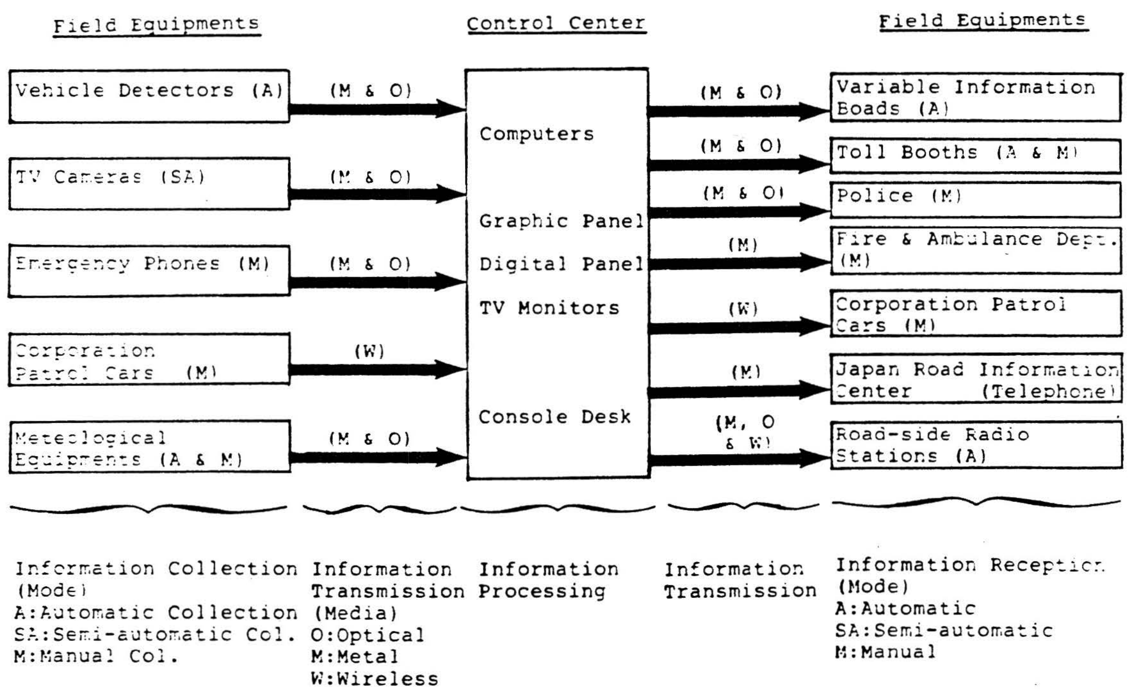

Figure 3 Traffic Control Configuration

The Hanshin Expressway is divided into four sections according to the toll areas and traffic control. In each sections, drivers are supposed pay toll charges separately. These sections are Osaka Section, Kobe Section, Kita-Kobe Section and Bay Section. The control computer systems are installed in one place but these sections have their own traffic control rooms along the expressway of each section except Kita-Kobe Section which has just opened recently. The centralization of computer systems with distributed control makes the system quite cost effective and yet powerful. This has become possible by the adoption of optical fiber communication system.

The Computer system consists of four PFU-1500 minicomputers made by Fujitsu, Ltd. with the cycle time of 500ns/4B, main IC memory of 512KB each and with disks, and three PFU-400 of Fujitsu with 750ns/B cycle time, main core memory of 256KB each and with disks. One of the four PFU-1500 is for road side radio system with automatic sentence synthesizing with predigitized voice fragments.

Sets of three PFU-1500's and three PFU-400's compose two to one stand by systems for reliable operation of the system. In addition, there are many peripheral devices to achieve high performance.

A rough explanation of the field equipment system scale is shown on Table 2. The effect of road side radio is limited, yet, because all of the broadcast stations are on the expressway and the service area of each station is limited to the expressway users, as much as possible. It is earnestly desired to serve out side the expressway, too. There is only one frequency alloted to the road side radios through out Japan. This is another problem to be solved in future.

Figure 4 shows a picture of the graphic panel, digital panel and TV monitor panel in the control center of Osaka Section. In this building, the computer system of the traffic control covering all sections are installed. In front of these panels, the console desks are installed with graphic displays and communication desks.

Units / Section	Vehicle Detector	Variable Informtion Boad	TV Camera	Road Side Radio	Expressway Length
Osaka	702	177	45	16	83 km
Kobe	266	54	16	5	33 km
Bay	75	15	8	0	8 km
Kita-Kobe	14	7	6	0	5 km
Total	1,057	253	75	21	129 km

(As of June 28, 1986)

Table 2 System Scale of Field Equipments

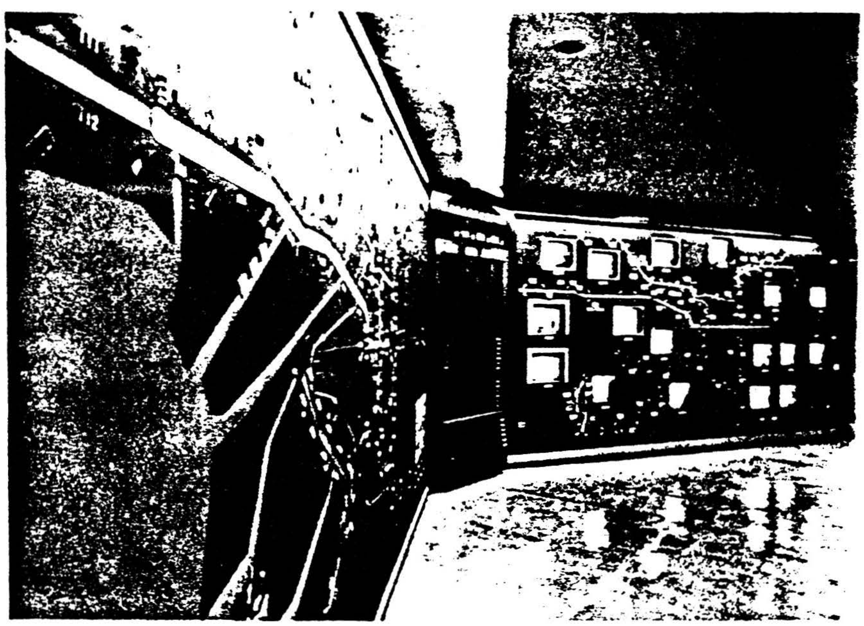

Figure 4 Graphic Panel, Digital Panel and TV Monitor Panel in the Osaka Control Center

FUTURE DEVELOPMENTS AND CONCLUSION

As a future development, it is planned to supply graphic information as shown in Figure 4 to the potential users of the expressway before they leave their origin in order to help their decision making through a public communication system.

On the opening of the Kita-Kobe Section, the Hanshin Expressway has rather long tunnels and the number and length of tunnels are expected to increase. In order to cope with the traffic control and incident detection in the tunnel, the Hanshin Expressway has started to study on the new surveilance TV cameras for the tunnel with the automatic image sensing of cars. It seems to be quite promissing.

The corporation is also developing a system to assit toll booth attendants with automatic recognition of vehicle classifications according to the toll fee to be collected. However, any no attendant toll booth is not considered.

The main object of the traffic control system is to be relied by the citizen. There still exist many problems yet to be solved. For instance, efforts should be made to minimize the traffic accidents on the expressway. Any complete traffic control system can not exist.

The authors would like to express their sincere appreciations to Dr. Eiji Koetani, Professor Emeritus of Kyoto University, Professor T. Sasaki of Kyoto University, Professor T. Fujisawa of Osaka University and members of the Hanshin Expressway Public Corporation for their kind and extensive guidance. They also thank members of the prime contractor of the system, Tateishi Electronics Co. Ltd, Kyoto for their kind help.

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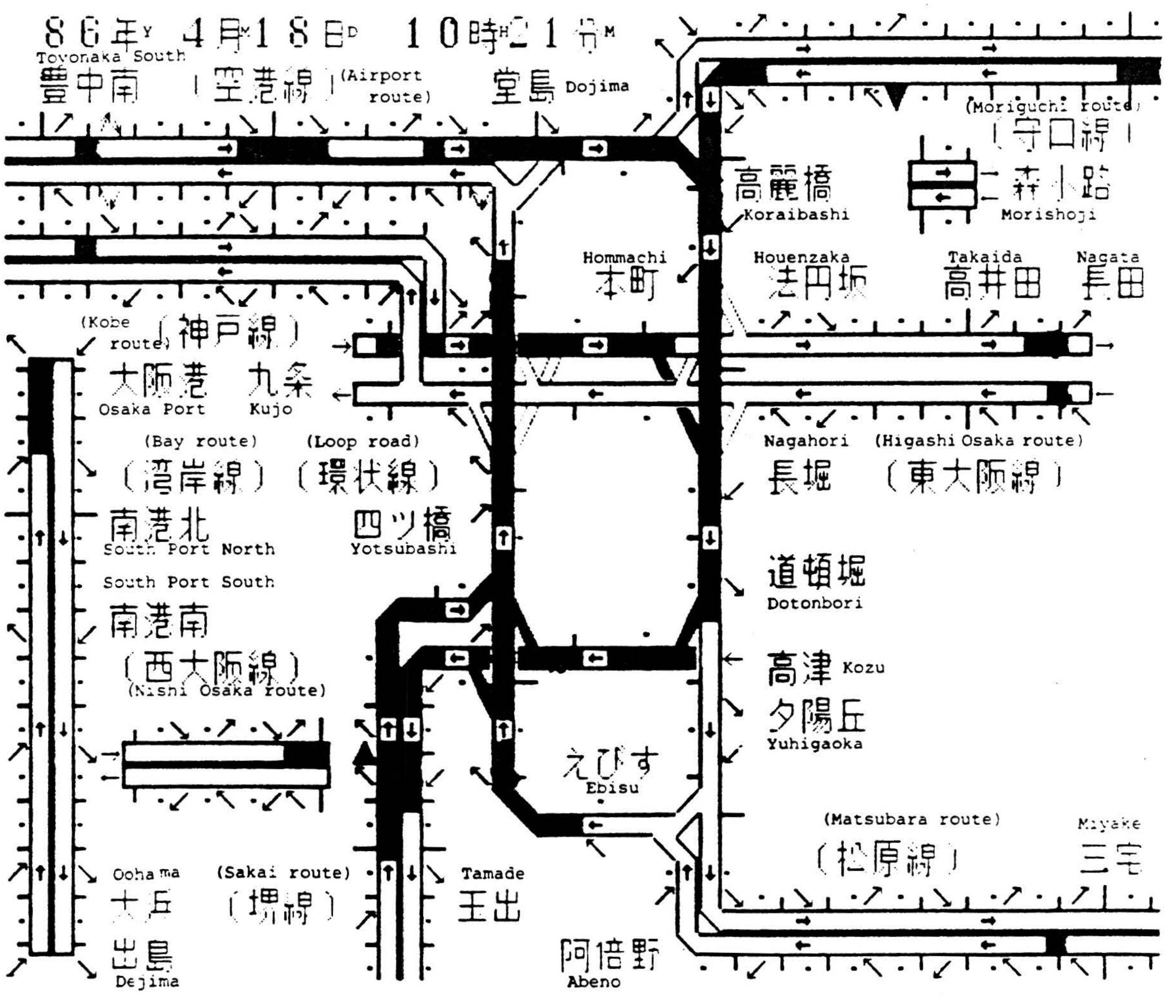


Figure 5 Hard Copy of a Graphic Display Image Reporting Congested sections in Osaka Area

HEUSCH
BOESEFELDT

Zukunftsweisende
Verkehrstechnik und
Datenverarbeitung

The Aims

The development of the Computer Aided Planning device - CAP (Computer Aided Planning of signal plans and green waves) - aims at facilitating the traffic engineer's tasks and increasing its qualitiy.

The field of work is marked by the following activities:

- planning and design,
- operation and optimisation,
- analyses and evaluation as well as
- documentation and filing.

All of these activities can be traced in the range of tasks of the traffic engineer, for example in signal plan control, sign posting or illumination.

```
        C C C      A A A A A A     P P P P
      C            A         A     P       P
    C              A         A     P       P
    C              A A A A A A     P P P P
    C              A         A     P
      C            A         A     P
        C C C      A         A     P


          Computer Aided Planing of Signal Plans

                    and Green Waves


       Workstation :

       Operator    :

       Password    :
                       Date                : Time


   Heusch/Boesefeldt Micro Computer Systems, Aachen-Hamburg ,

                     West - Germany
```

Obviously not every one of these activities can be computerized. But some of them almost offer themselves to being computerized. This is true in the first place for drawing- and documentation work as well as for the ever returning calculations and tests. Once the traffic engineer is relieved of such routine work he can turn the better to his true tasks and raise the quality and reliability of his results considerably. Moreover does the employment of a computer distinctively reduce the time needed in administrative procedures. Extensive files can be diminished by the optimised data storage, and the results of operations can be immediately transfered to the control level of the traffic computer.

The development of CAP was started on these conditions. For the signal plan control the following results have been reached:

- operation and tests of signal plans and

- operation and tests of time-distance-diagrams.

For these tasks the system permits the application to a computer aided supply, data storage, operation, output and filing of all the data relevant in the management of the signal plan control of intersections and of the time-distance-diagrams.

The Technical Concept

For a modern convenient computer system the easy operation and the output and the plotting, which have to be as close as possible to original, of any required document are an absolute must. Specially in traffic control working without graphic documents is unthinkable.

Because of this in CAP only full graphic terminals will be employed. By this there are practically no limits to the possibilities of displaying. Site planes, signal plans and time-distance-diagrams even when using special symbols for the signal or the signal time can be plotted true to original on the display and or paper, too.

An user friendly interface is provided for by the traffic engineer's keyboard, which was specially designed for the traffic engineer's tasks. It permits him to work with forms in the same way as if he worked at his desk, only pencil and rubber are being replaced by the keyboard.

Under these conditions the basic hardware configuration consists at least of the following components:

- computer system with a suitable main- and peripheric storage capacity and the operating system CP/M, MS-DOS or UNIX,

- peripheric storage for data securing and data filing,

- full graphical, eventually coloured display with a minimum dispersion of 1024*784 pixells with the minimum screen's size of 15",

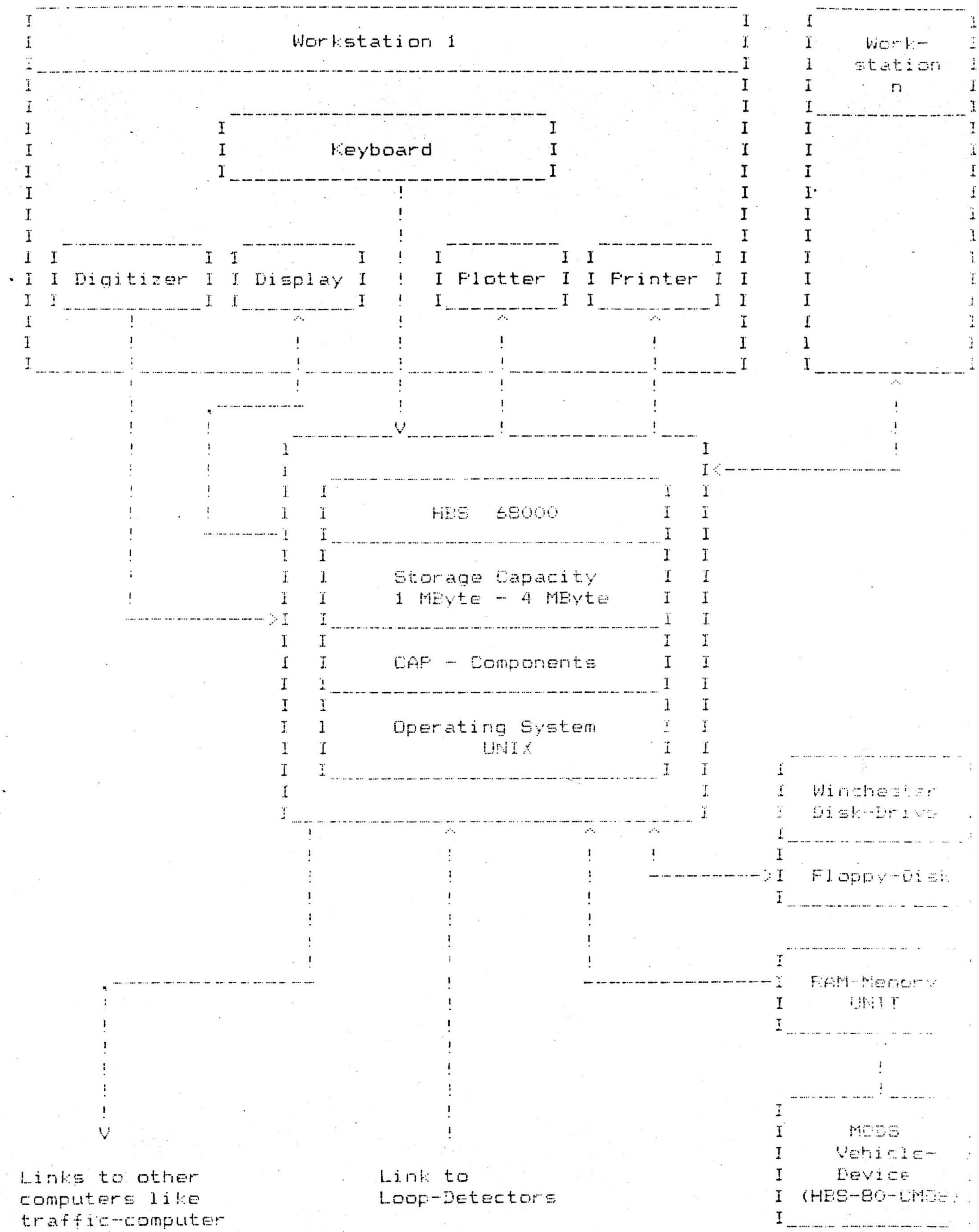
- traffic engineer's keyboard with a seperate set of keys for word processing and the operation of signal times,

- a plotter for the plotting of graphic diagrams,

- a printer for the printing of diagrams and lists.

The system's hardware configuration can be composed manifold out of the above mentioned components. The software was designed in such a way as to make its implementation on computers by different producers possible. Single user and multi user systems can be installed. Each workstation can be equipped with the periphery, which is required for every task at hand. For each individual case the system can be configurated to the demands of the operator.

CAP - Multi User System



The Operation Concept

CAP works as a 'turn-key-system'. On switching the workstation the program is started automatically, communication with data files is produced and the CAP initial form is shown on the display.

Immediately afterwards the operator can choose and handle any form by the form-choice-key. To do so the traffic engineer's keyboard has an integrated word processing key-set with special cursor-control-keys and keys to set to work any function usual with modern word-processing systems. For a particulary fast and adequate operation of signal times an additional seperate set of keys has been integrated into the keyboard.

A rather high operating safety is reached by the three-leveled operation concept, which is tolerant to errors made by the operator. As if he was working at his desk the operator can move within the form as he likes and fill in the gaps with his input. Just that input is admitted, which has been defined on installing the system. Thus on a first level of diagnosis every input is tested on its keeping with formal terms as "symbol permitted" or "value within range of valuation" and in case of error it is rejected immediately. A signal tone informs the operator of this. This test is generally effective to each field of input. A second test on keeping with logic terms is done on leaving any field of input, for which such a restriction has been defined. For example the permission of access to certain data or the admissibility of the data input are tested. In case of error a corresponding hint is given immediately on input. On the third level of error-diagnosis the coherence of the measure taken for traffic control is tested. For example a test diagram can be used to analyse a signal plan. By this the consistence of traffic data can be ensured.

In summary the operation concept consits of:

- form oriented operation
  * true to original display of common forms
  * operation within the forms as if at a desk
  * replacement of pencil and rubber by the keyboard
- easy and selfexplanatory operation
  * convenient traffic engineer's keyboard
  * symbols based on graphic signs
  * hints on non-selfexplanatory reactions of the system
- tolerance to errors by three-leveled concept of error diagnosis
  * test of the input on keeping with formal terms
  * test of the input on keeping with logic terms

* test of the coherence of the measure taken for traffic control

Each of the CAP-components works with the same common data basis. Thus data only have to be put in once and every other component can dispose of it. By this the green times of signal plans can immediately be transferred to time-distance-diagrams. When green times have been worked on in the time-distance-diagram they do change simultaneously in the signal plans.

In order not to modify or destroy any data unvoluntarily, the data basis of CAP works as a 'version-concept'. Of each data file a copy can be drawn and in this free operating and design is possible without modification of the original. Because of this the traffic-engineer can experiment until he has reached a valid version, which can be taken over into the files.

The Range of Application

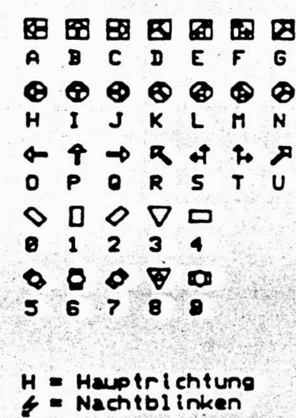
Within the field of signal plan control CAP offers every possibility of complete operation on intersections and arterials with coordinated signal control.

The form 'intersection file' gives a summary of all the intersections taken into the data files. Additionally to giving the number of intersections and the code-name of the traffic light the forms gives information on the previous operator and the date of operation.

The form 'intersection data' gives the data, which have been collected on the intersection. It cannot only be perceived whether or not an intergreentime matrix or a greentime-shift-matrix are already existing, but also which versions of the data have already been stored and how many signal plans are already existing.

The 'intersection's basic plan' defines the main basic data of each intersection. They are valid for every other form. The intersection's basic plan contains on the one hand administrative data as the number of the intersection, the code-name of the traffic light, the date of operations and the name of the operator as well as data concerning the hardware equipment as e.g. the type of control device, the local traffic computer and at least the signal groups, which the intersection is part of. On the other hand the intersection's signal structure is obligatory fixed here: the signal groups are named, the kind of traffic light, the minimum green time and the length of the fixed yellow-and red-yellow-time are defined here.

Signalgruppe	Symb	min t_{gn}	t_{rg}	t_{g}
1	H	10	2	3
2	H	10	2	3
4		5	2	3
6		5	2	3
51	←	5		
8		5	2	3
9		5	2	3
11		5		
12		5		
14		5		
16		5		
17		5		
18		5		
19		5		
44		5		
39		5		



H = Hauptrichtung
ϟ = Nachtblinken

Bemerkungen: Entwurfsstand 1983

LSA Kurhausstr./Grosskölnstr./Hotmannspief

GrundgerÜst Blatt: 1	Gerät: M	Bearb.: Ph	Anl. z. Schr.
	Rechner :	Vers.: 1	vom
	Anwahl-Nr.:	Entwurf	Abzeichnung
Z-V-Diagr. : Hir - Sel	Stammkabel :		12.6.85
Knotennummer : 39 85 14	Gruppen :		

Based on the intersection's basic plan the intergreentime matrix, the greentime-shift matrix and signal plans can be designed.

While the intergreentime matrix gives the relations between signal groups relevant to safety, the greentime-shift matrix takes into consideration the relations between signal groups relevant to traffic control. Such relations can turn up e.g. between two signal groups following one on another at short time distance in the traffic flow to secure an advantage of time for one signal group to the other, at seperate direction signals at one arm of an intersection or at auxiliary or speed signals.

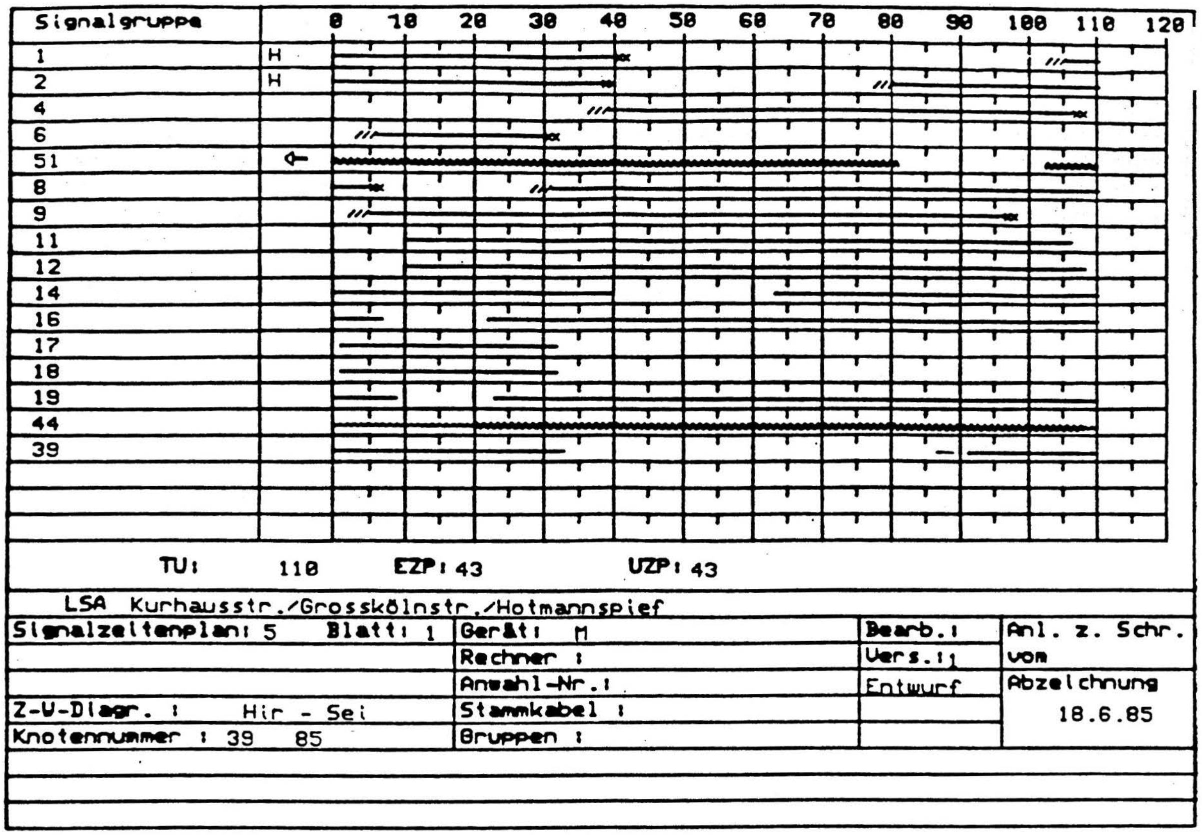
Räumen \ Einfahren	1	2	4	6	51	8	9	11	12	14	16	17	18	19	44	39	
1			6					4	6								
2			4		4			5	4								
4	4	4			4					4							
6						4					4			6			
51		5	5							6							
8				4			4					4	4			5	
9						5					5			4		4	
11	13	11															
12	10	11															
14			12		10												
16				10			9										
17						6											
18						4											
19				9			12										
44						5	7										
39																	

LSA Kurhausstr./Grosskölnstr./Hotmannspief

Zwischenzeitenmatrix 5		Bearb.Phi	Anl. z. Schr.
		Vers.: 1	vom
		Entwurf	Abzeichnung
			10.6.85
Knotennummer : 39 85 14		gepr.:	Alb

The form 'signal plan' was prepared for the design and operation of signal plans. The intersection's basic plan containes the signal groups. Aided by a special set of keys for the modification of signal times, signal plans can be designed entirely new or if necessary modified. Besides the operation with signal times the automatic work on complete signal plans is made possible by specially designed algorithms.

Because of this seperate green times can be modified with automatic regard to any consequences, under maintenance of intergreentimes and the shift of the start of greentime. Even entire phases can be abridged or extended, while it is left open whether a new cycletime is to be reached or whether a change is planned in favour or to the debit of another phase. Furthermore a shifting of the time axis to any direction wanted is possible. By this the fast adaptation of each signal time in a signal plan is possible in both directions: when the operation of a time-distance-diagram requires this or when a signal plan is to be fitted into a time-distance-diagram.



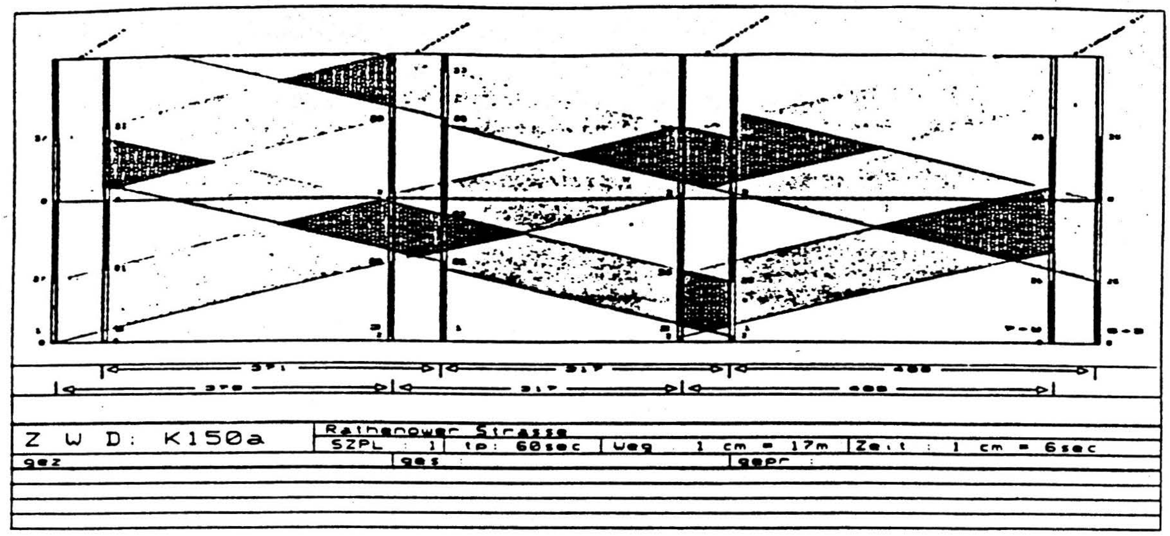
The examination of a signal plan is done by setting up a test diagram. The keeping with intergreentimes is examined by the calculation of the difference between exsisting and minimum intergreentimes as well as the keeping up of minimum greentimes and maximum redtimes.

The work on time-distance-diagrams is thightly connected to the work on intersections. Both components fall back on one common data file. This implies, that with regard to the work on time-distance-diagrams only those data must be put in additionally, which are specially needed for this task. This on the other hand requires the previous input of a number of intersection data via the form 'work on intersection' before the corresponding time-distance-diagrams can be designed. Any change which is undertaken while working on one component shows its immediate influence on the others. The operator must keep this in mind if he wants to secure consistant results.

Exactly as with work on intersections the work on time-distance-diagrams is laid out like a version - concept. For each coordination any alternative wanted can be provided for.

The display of time-distance-functions requires the design of a basic plan of a time-distance-diagram, where the geometry of the route which is to be coordinated is fixed. Here instead of the input form an input procedure is used, which is similar to a graphic construction. The total length of the route is of no relevance for the design work. If the route is too long, only a part of it will be displayed to maintain a sufficient legibility.

Any part wanted can be displayed by a zoom realised in the software. Up to a length of 2000 metres routes with no more than 5 or 6 intersections can be displayed completely. Independent of this time-distance-diagrams can be plotted in any length wanted, if the equipment used allows a sufficiently long plotting in the needed propotion.



Once the basic plan of the time-distance-diagram is put in the diagram itself. can be constructed when the flowspeed is given and use can be made of formerly worked on signal plans. They can be displayed together with the graphic representations of green-waves. After that the beginning and end of a green time at each stopline can be changed by signal time operation using the keyboard. The operation ensues in steps of seconds, which means that after any change of a second's time the corresponding graphic representation of the time-distance-diagram will be plotted anew on the display. By this the effect of any change is visible.

Aided by CAP once designed and displayed coordinations can be subjected to the comparison of debit and actual state. The vehicle device MODS, which was specially designed for measuring the courses of test drives, allows to take these measured data into the coordinations. Test drives, which have been made for the coordination can immediately been plotted in the displayed time-distance-diagrams. Compared with those driving profiles the time-distance-diagrams can be tested on their realism. MODS also can be used in precise measurement of route distance if the corresponding planning data are not at hand or inprecise.

Future Plans

The present standard of development of CAP is only the start of a whole line of consequent developments. As a start it was important to design the overlapping and complete concept with regard to traffic control, to the technical structure and above all to the operation of the system. By now a capable realisation of these concepts can be presented. It can prove its convenience to the operator and its applicability to the daily tasks of the traffic engineer. On this basis the development of further elements of CAP has already started. Even in 1985 the following components will be ready for application:

- digitalisation and operation of site plans,
- design of a week's program and
- the development of data for the traffic control (paper tape, floppy disks, direct linkage to a traffic computer).

For further development are planned:

- automized design of signal plans,
- digitalisation and operation of signal plan networks,
- criticism of traffic quality and valuation of signal plans,
- criticism of traffic quality and valuation of time-distance-diagrams.

At present parallel to this the concepts for other fields of application of CAP are being under design. Most important of all are sign posting and the management of sign-registers.

PROMETHEUS

P R O M E T H E U S

The European Research Program

by

Tage Karlsson

Member of the PROMETHEUS International Steering Committee

A Presentation for the Transport Research Board
of the National Research Council
in Washington D.C., January 12, 1988

PROMETHEUS, THE EUROPEAN RESEARCH PROGRAM

PROMETHEUS is an acronym composed of PROM for program and the initial letters of the important words in the condensed project description expressed as the ambition to be the:"Program for European Traffic with Highest Efficiency and Unprecedented Safety". There are good reasons for every word in that program description.Really, there should have been the word Western inserted before European but then there had not been the very proper reference to the semigod that brought the fire from heaven to mankind. To deal with the problems of Western Europe is quite a task in itself and therefor that is where PROMETHEUS is starting.Take a look on the following table:

COMPARISON OF USA AND WESTERN EUROPE

ITEM		USA	WESTERN EUROPE 4	17	28
POPULATION	millions	234.2	228.9	351.7	353.1
AREA x 1000	sq.kms	9373	1331	3552	3774
DENSITY OF POPULATION	inh./sq.km	25	172	99	91
GROSS DOM. PROD. PER CAPITA	pps	15700	9700	9700	9700
EXPRESSWAYS	kms	69000	23000	30000	30000
MOTORVEHICLES	millions	164	88	128	128.5
FATALITIES	/ million population	210	175	171	170
FATALITIES	/ million vehicles.	300	455	469	467
MAJOR LANGUAGES		1	4	14	14
GOVERNMENTS		1	4	17	28
BLOCKS		1	1	2	>3

Including Andorra, Malta, San Remo, Lichtenstein, Monaco and a number of other small nations together with United Kingdom, France, West Germany and Italy there are some 28 countries in Western Europe having a population of 353 million people living on an area that is 40 % of the area of the USA. That makes for a density of populat[illegible] that is some four times higher than the one in the states.

The average income per capita is hardly 2/3 of the US one but behind that figure is hiding a wide spread from the Swiss which today have a higher income than the citizens of United States to Portugal which is only on a level corresponding to some 16% of the average American income.

The Europeans like the cars and there are 128 millions of motor vehicles on European roads.This means that there are 364 vehicles per 1000 inhabitants which however is only a little more than half the ratio of 700 in the US.

In Europe there are a few percent more express roads per sq.km than in the US but since the area is smaller the total length is only 40% of the American Interstate Highway System. Europe has 45% less expressroads per vehicle and that may be part of the reason why there are 55% more fatalities_ per vehicle than in the US.It is a small consolation that the lower number of vehicles make Europe look 20% better as far as fatalities per population are concerned.

60,000 people killed on West European roads every year are far too many and all the 28 governments worry about that as many international organizations and bodies do as well.The safest roads are the expressroads and therefore you could assume that there are ambitious investment programs for more such roads under way but that is not the case and there are some more or less acceptable reasons for that.

2/3 of the West European population live in the four countries of Great Britain, France, West Germany and Italy but the accumulated area of those countries is only 1/3 of the total of Western Europe resulting in a density of the population seven times the US one or almost double the average West European one. Those four countries have 3/4 of the expressroads in Europe and the density of expressroads per land area is considerably more than double the US one.

The next picture is a map of Europe with a blue line surrounding what is called Western Europe. The blue figures indicate the density of population in the different countries. There is a red line circumscribing England, Northern France, the Benelux countries and the northwestern part of West Germany . Some 125 miljon people live within the 350,000 sq.kms of the enclosed area which means that the density of the population is 350 per sq.km. A look on a road map shows that there are numerous expressroads connecting the many big cities; Paris, Amsterdam, the"European Capital" Brussels, the Ruhr area etc.. There are already now congestions, delays, accidents and a heavy load on the environment. The European Conference of Ministers of Transport concluded furthermore in a study made in 1986 that with the existing plans for investments in infrastructure there will be considerable bottlenecks for transport in this area at the turn of the century.

The environmentalists are no longer alone in believing that more expressroads won't solve the congestional problems of central Europe. There is also agreement to the need of reducing the accidents, the pollution and the delays and that has of course to be done without restricting neither the business nor the private travelling.

The PROMETHEUS idea is to employ the progress in information technology in order to use the roads more efficiently,to avoid accidents and to have less detrimental effects on the environment.This is easily said but how to realize it?

The border crossing international traffic is rapidly increasing in Europe. Using more electronics but having different systems in neighbouring countries would be the opposite of improving the safety in traffic as there are existing examples of already today because of different traffic rules and road building principles.

A merger of the information revolution with the road traffic therefore has to be on a Pan European level. But there is no Pan European authority that could possibly coordinate such a gigant[illegible] task of technical development and infrastructure adaptation. In table above was shown three different compositions of Europe. One consists of the four big countries, the next group is the sum of the two big blocks of Europe, the Common Market and the EFTA, in all 17 countries. The last group includes also all the lileputian states and the total of governmènts that have to agree on Pan European policies then come to 28. The small countries are important as tourist places and therefore they cannot be forgotten in this connection. At least 14 different languages are spoken in the Western Europe and the risk for babylonian confusion is not to be neglected in cooperation efforts.

One thing is clear.Despite the difficulties Europe cannot afford to do nothing because then the congestional problems of traffic will get ever worse and in the end there will be some kind of crisis or breakdown. One solution is of course that US or Japanese companies will develop systems for a more efficient and safe traffic and that they come to Europe and sell their methods. It will be a commercial, gradual proposition taking one country at a time and the opportunity for an all encompassing Pan European solution will be lost.

Facing the choices of either a traffic situation getting into caos, which will severely hurt the automotive industry of Europe, or having to adapt to non ideal step by step overseas solutions, the European automotive industry has taken the initiative to research the possibilities of a Pan European solution. That initiative is th[illegible] PROMETHEUS project.

Behind PROMETHEUS are the fourteen major European automotive companies. Daimler-Benz, Volkswagen, BMW and Porsche from West Germany, Renault, Peugeot and Matra from France, Gaydon Technologies representing Rover, Rolls-Royce and Jaguar from Great Britain , Fiat representing Alfa-Romeo as well from Italy and finally Saab-Scania and Volvo from Sweden.

The project is managed by an International Steering Committee composed of eleven representatives from the participating automotive companies. The Steering Committee has a small secretariat placed in Stuttgart, Germany.

Efficient working relations with the authorities are essential if PROMETHEUS shall be the basis for a Pan European traffic system. A bridge to such relations is the PROMETHEUS Council which is made up of representatives indicated by the governments of the host countries of the automotive companies taking part in PROMETHEUS. The organization on a national level differs from country to country.

The automotive companies have reserved to lead the industrial research of PROMETHEUS themselves. This type of research is split in three subprojects; PRO-CAR, PRO-NET and PRO-ROAD.

PRO-CAR is to look into driver assistence by electronic systems like sensing and actuating systems, structures, man-machine relations as well as safety and dependability.

PRO-NET is working with vehicle to vehicle communications studying the interactions between vehicles in different situations like overtaking, merging and computer assisted vehicle trains.

PRO-ROAD studies the communications between the vehicles and the environment. Route guidance, navigation, local electronic yellow pages and traffic management including traffic signs, electronic or regular type, fall under PRO-ROAD as do more or less advanced mobile telephone systems sometimes developed into Fleet Management Systems.

The aim of PROMETHEUS is to increase the efficiency and safety of traffic by utilizing computer assisted driving and traffic management without going for the automatic highway. The electronic equipment needed to realize these goals has to have high capacity, be compact enough to be installed in vehicles, be very reliable not to say fail safe but still the cost has to be low in order to fit into the automotive price pattern. To get such equipment developed the automotive industry is calling upon the electronic industry. There was a symposium in beginning of December 1987 in Brussels at which were presented the results of PROMETHEUS this far and what the automotive industry is expecting from the electronics industry.

All the methods, systems and hardware to realize the PROMETHEUS objectives are not yet developed or conceived and therefore basic research has to be done in addition to the industrial research that the automotive and electronic industries are undertaking. The best research institutions in Europe have been mustered for this purpose.

The basic research is divided in four subprojects; PRO-ART, PRO-CHIP, PRO-COM and PRO-GEN.

PRO-ART which is coordinated by one French and one Swedish professor, deals with methods and systems of artificial intelligence like defining algorithms for solving actual or simulated traffic situations.

PRO-CHIP, coordinated by a German professor, is to look beyond what is available today as far as hardware for intelligent processing in vehicles is concerned.

PRO-COM, jointly coordinated by one Italian and one Swedish professor, investigates methods and standards for communications, long and short distance.

PRO-GEN is crucial to the success of PROMETHEUS. It is coordinated by a specialist from the British Department of Transpo PRO-GEN is making scenarios for assessment and introduction of new systems. The researchers participating are from or working on account of the Road Authorities in the host countries of PROMETHEUS and because of the decisive role these bodies are supposed to play in the realization of PROMETHEUS these researchers must believe in the concepts of PROMETHEUS if there ever is to be a coordination on a Pan European level.

Recently the PROMETHEUS Steering Committee has formed a new subcommittee called the Impact Analysis Committee whose task it is to study both the expected impact and later the realized impact of PROMETHEUS from a traffic point of view on the Safety, Efficiency, Environment and on the Society in general. True to it's name this committee has started to look into how PROMETHEUS may cause the greatest impact in the shortest time and the ideas point towards converting PROMETHEUS from an intended pure research program into an action program by defining quantified PROMETHEUS objectives for the areas of Safety, Efficiency and Environment. No doubt the automotive industry in cooperation with the authorities and other industries would be assuming a far greater challenge if PROMETHEUS would be turned into an ambitious realization program but on the other hand it might be what is needed to blow a spirit of achievement and even more cooperation into the project. This matter is for the moment an open question but may be decided within a few months.

PROMETHEUS was suggested in the end of 1985 and after s preparatory discussions the first so called definition year was launched in October 1986. During the definition year some 175 researchers and engineers were working together in 32 international groups to determine the state of the art and describe what research was needed to be done later in the areas of industrial research. A similar number of scientists were working in the basic research subprojects. The industrial research definition year culminated in the symposium held in Brussels in beginning of December 1987 and there will be a similar symposium for the basic research definition year early in 1988.

The research and development phase has now started and is planned to last for seven more years i.e. the research work of PROMETHEUS will go on until the end of 1994. The implementation of the results of the research may take decades because there will be included new laws and standards as well as the gradual transformation of the road and communication infrastructures. With the life of vehicles approaching twenty years it will take considerable time until all are equipped according to the latest PROMETHEUS findings.

There is a cooperation agreement between the companies participating in the project. In this agreement all research work is defined to be precompetitive and that is fundamental for the good cooperation between these otherwise highly rivalling automotive companies. Of course each participating company will encounter difficulties in determining what is regular development and what is precompetitive research for PROMETHEUS. The result of the research is to be shared but not necessary the methods how the results were achieved. If some partner to the agreement as a result of the work in PROMETHEUS will make an invention and register a patent he is obliged to sell the right to use this patent at a reasonable price to his partners.

The cooperation rests on an understanding of common interest and in this spirit every participant has the right to withdraw from the project within a short time of notice.

The total cost of the PROMETHEUS project is difficult to determine but the latest estimates point towards some 700 million USD for the remaining seven years with 37 % for the automotive industry, 32 % for the electronic and supplier industries and 31 % for the basic research made by the institutions. The financing of the project was managed for the definition year but is not yet solved for the seven years just started. The proposal from the automotive industry is that the host governments should pay for all institutional research and for half of the industrial research based on the idea that even the industrial research is more for the common good than for industrial interests only. The equal treatment of the industries from the different governments may be more important than the contribution with a certain percentage of the total cost of research.

There are other European projects dealing with or touching the same areas as PROMETHEUS like the the DRIVE and the EUROPOLIS for instance. The position from the partners of PROMETHEUS in this relation is that cooperation that will contribute to more safety, better efficiency and less pollution in Europe is welcome from whatever corner it may come. For the moment the policy is not to accept offers of cooperation from non European companies however. This policy is not an expression of any kind of protectionism but depends on the fact that PROMETHEUS intends to solve the problems of European traffic in European countries with the help of European financing. For the moment only the governments of the host countries are to some extent involved but in order to arrive to Pan European solutions the other 23 European governments have to be involved as well beside the ones from Great Britain, France, Germany, Italy and Sweden. It is a complicated project and this europeanization of the project has for the moment a higher priority than to engage non European companies in it. In the long run all industries and governments involved can only welcome a similar approach worldwide but it is necessary to walk before running.

PROMETHEUS is an ambitious attempt to use the latest advances in electronics and information technology in order to shape compu aided driving and through this is expected that despite high.. concentration of vehicles on the road the safety will be improved and the average travelling speed will be higher. With PROMETHEUS great strides will be taken and they are steps that have to be taken even if no one is expecting them to be the only nor the ultimate stages of progress.

The information revolution brings mumerous other possibilities to use the road investments more efficiently. In some metropolitan areas it might get worse before it gets better and it may temporarily be necessary to resort to such less popular measures as limited access, variable pricing of the use of the road or to give priority to cars occupied by more passengers than the driver. Better communications, stationary and mobile, facilitate the use of flextime and staggered working hours as well as working at home part of the time. It is difficult to understand the common downgrading of this latter item with reference to the need of people coming together for coordination and stimulation. After having been coordinated and stimulated work should be performed and that is best done in loneliness. Already a fifty-fifty relation between the time spent working at home and at the office would both lessen and spread the traffic on the roads and such a relation would not do away with the appreciated contact possibilities.

Driving in a big European city during a hectic working day among all misparked cars makes you wonder if such a city is viable. Is freedom of mobility so valuable that it also involves the freedom to break the parking regulations at will. In the same breath it could be questioned whether the freedom of mobility really should make us look benignly on those drivers that travel at speeds below or above the general speed pattern. Most accidents and near accidents on the highway are caused by the speed deviators. With new beacon short range communication and simple electronic devices it would be easy to make a flashing light on top of the cars to clearly brand both the parking and the speed violators.Most likely such easily visible markings would make the transgressors to comply, in the speed cases by adapting their rate of motion but something extra would have to be done for those who need the cars to go to and from the city in order for them to have a place to put the cars. The solution seems to be more highrise automatic car parkings because then the areas available for parking would be multiplied by a factor of ten or higher and the streets could be free for the traffic as originally was the intention.

A lot of the congestions in the metropolitan areas are because of the radial lay out of the cities which has its origin in the gradual growth from simple centers of trade into a central city with business and work, surrounded by dormitory suburbs. With improved communications you don't have to be in the center of the city to work or do business. The concept of multicentered metropolitan areas with a smaller center surrounded by satellites which offer both work and living, like here in Washington, alleviates a lot of the big city congestions.

The development in the electronic field helps to reduce the concentration of goods transport vehicles on the roads as well. Instant reliable communication makes it possible to run a precision production process with spread out suppliers but without any stocks by refining the Just in Time concept. It is not even necessary to have the assembly factories or the distribution centers within the metropolitan areas.

Combining the above mentioned trends and possibilities for less density of traffic by improved communications and decentralization with the creation of the true common market in Europe by the end of 1992 there are reasons to expect a gradual levelling out of the tremendous differences in population density which will lessen the congestional problems of traffic as well. Such a development will take a long time however and it is a matter of conjecture whether that trend will ever overcome the natural growth of the road transport.

Seen in this perspective the PROMETHEUS time schedule is short range and very necessary to realize in order to have a good start of the road traffic in Europe in the third millenium.

USA-WESTERN EUROPE COMPARISONS

	USA	WESTERN EUROPE		
		4	17	28
POPULATION MILJ	234.2	226.9	351.7	353
AREA x 1000 KM²	9373	1331	3552	3774
DENSITY INH./KM²	25	172	99	94
GDP/CAP PPS	15700	9700	9700	9700
EXPRESSWAYS KM	69000	23000	30000	30000
MOTORVEH. MILJ	154	88	128	1[illegible]
MOT.VEH.REL. FAT:S	49000	40000	60000	60000
FAT:S/MILJ POP.	210	175	171	170
FAT:S/MILJ VEH.	300	455	469	467
MAJOR LANGUAGES	1	4	14	14
GOVERNMENTS	1	4	17	28
BLOCKS	1	1	2	>3

Norwegian Sea
ATLANTIC OCEAN
NORWAY
North Sea
UNITED KINGDOM
REPUBLIC OF IRELAND
English Channel
POLAND
FRANCE
PORTUGAL
Corsica
Tyrrhenian Sea
Ionian Sea
Black Sea
Sea of Azov
UNION OF SOVIET SOCIALIST REPUBLICS
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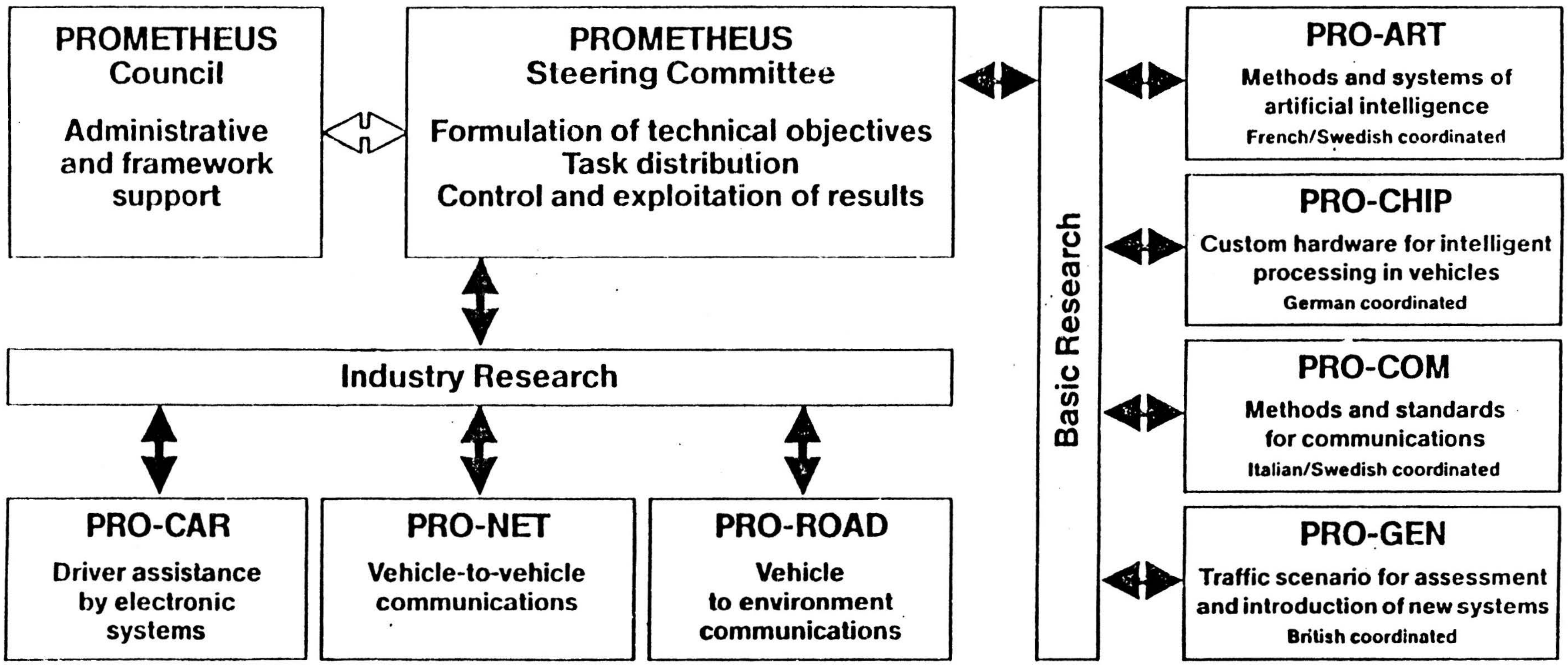
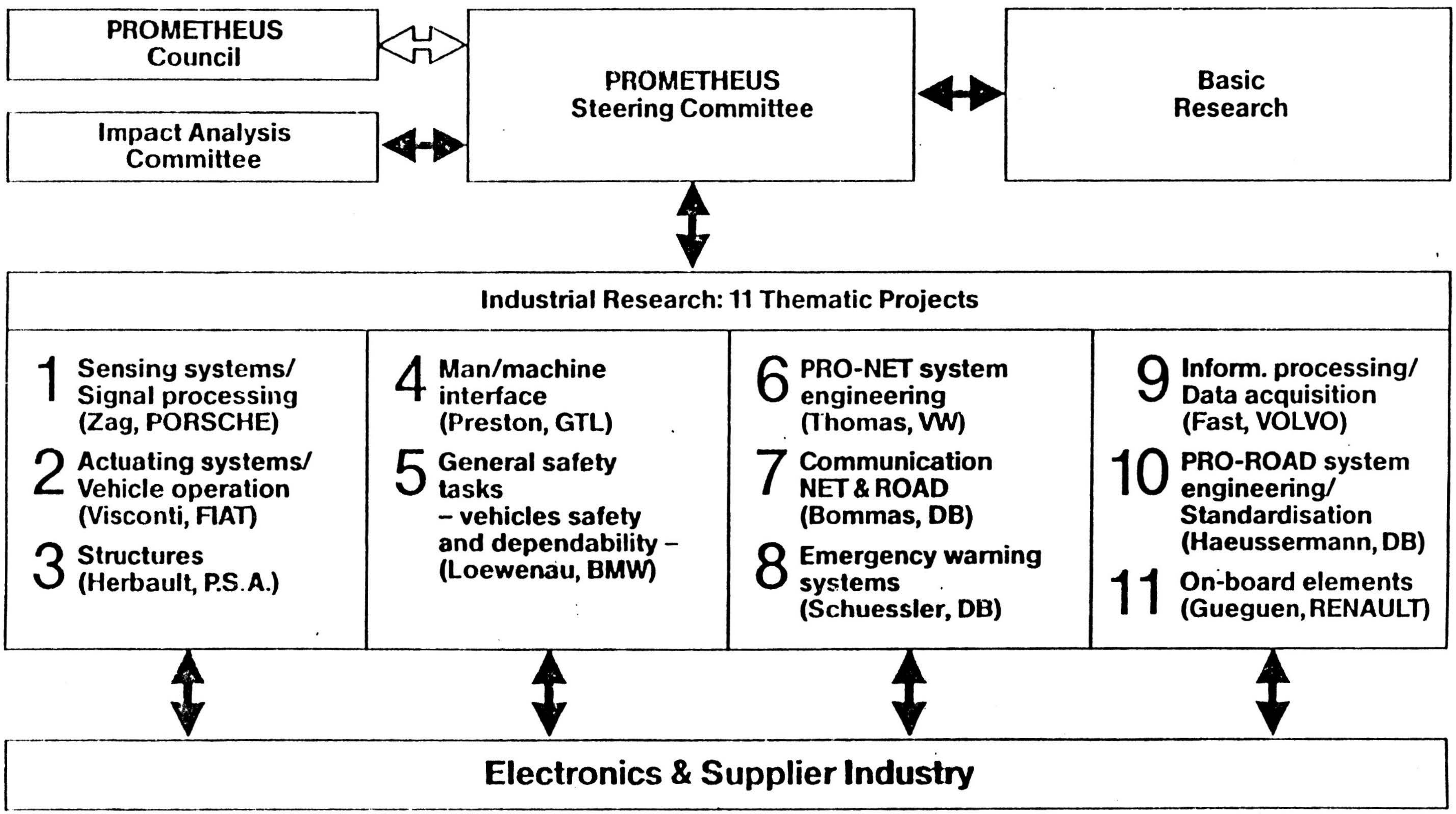
PROMETHEUS Organisation



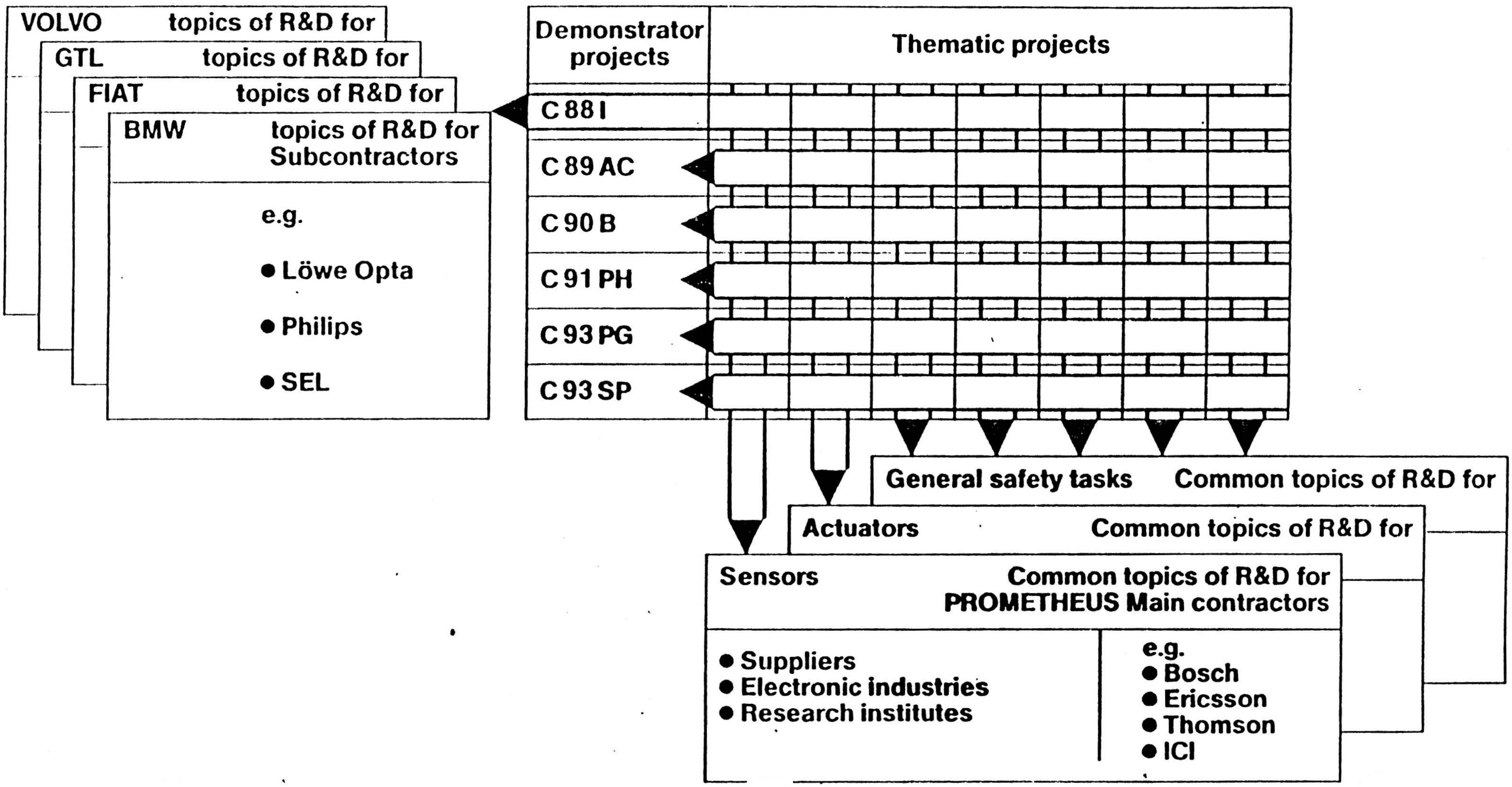
Organisational Structure of the R&D starting phase 1988

PROMETHEUS



Structure for links with the E&S Industry

PROMETHEUS



"INTELLIGENT" VEHICLE/HIGHWAY SYSTEMS: A SUMMARY OF ACTIVITIES UNDERWAY, WORLDWIDE

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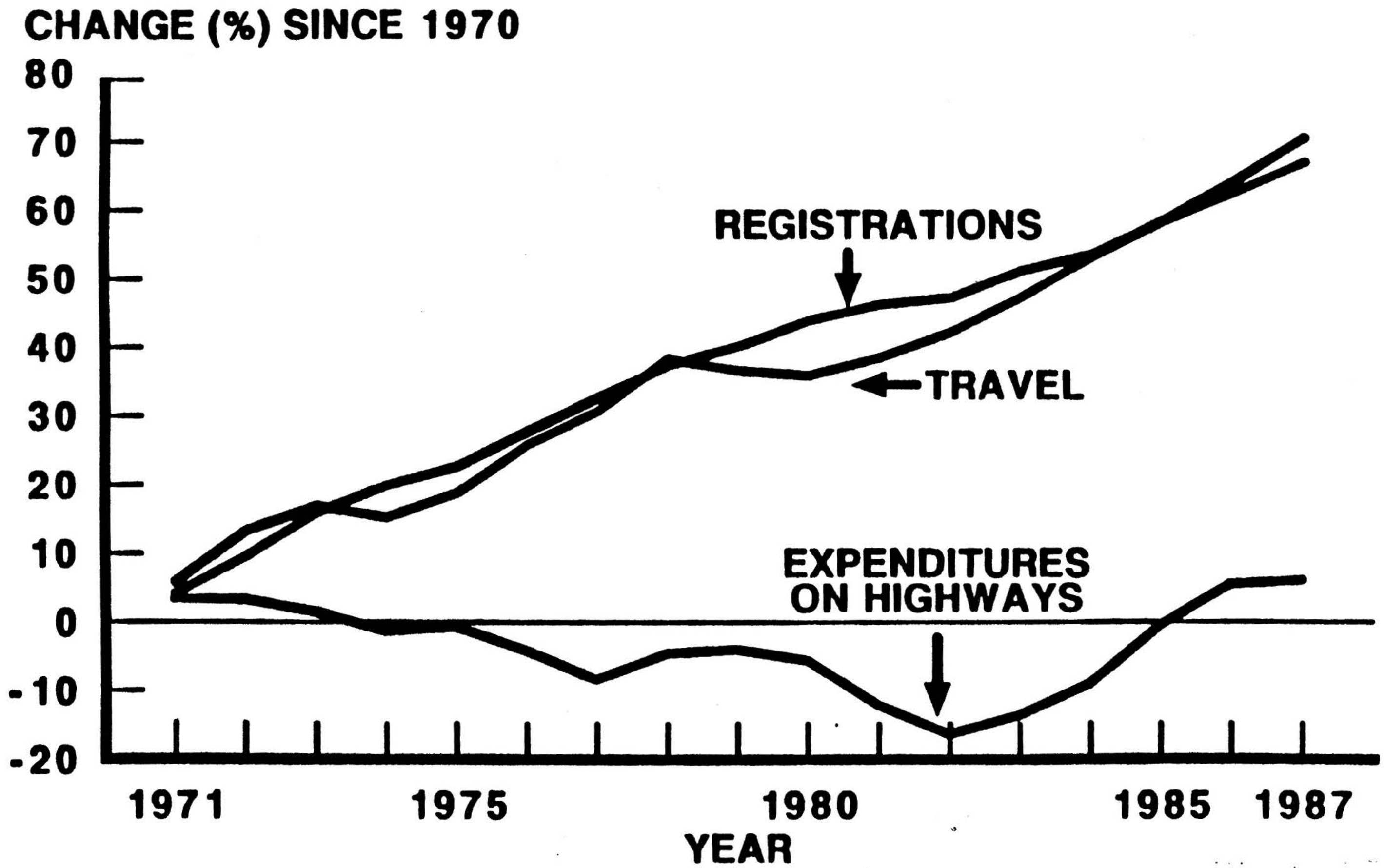
WHAT ARE "INTELLIGENT" VEHICLE / HIGHWAY SYSTEMS?

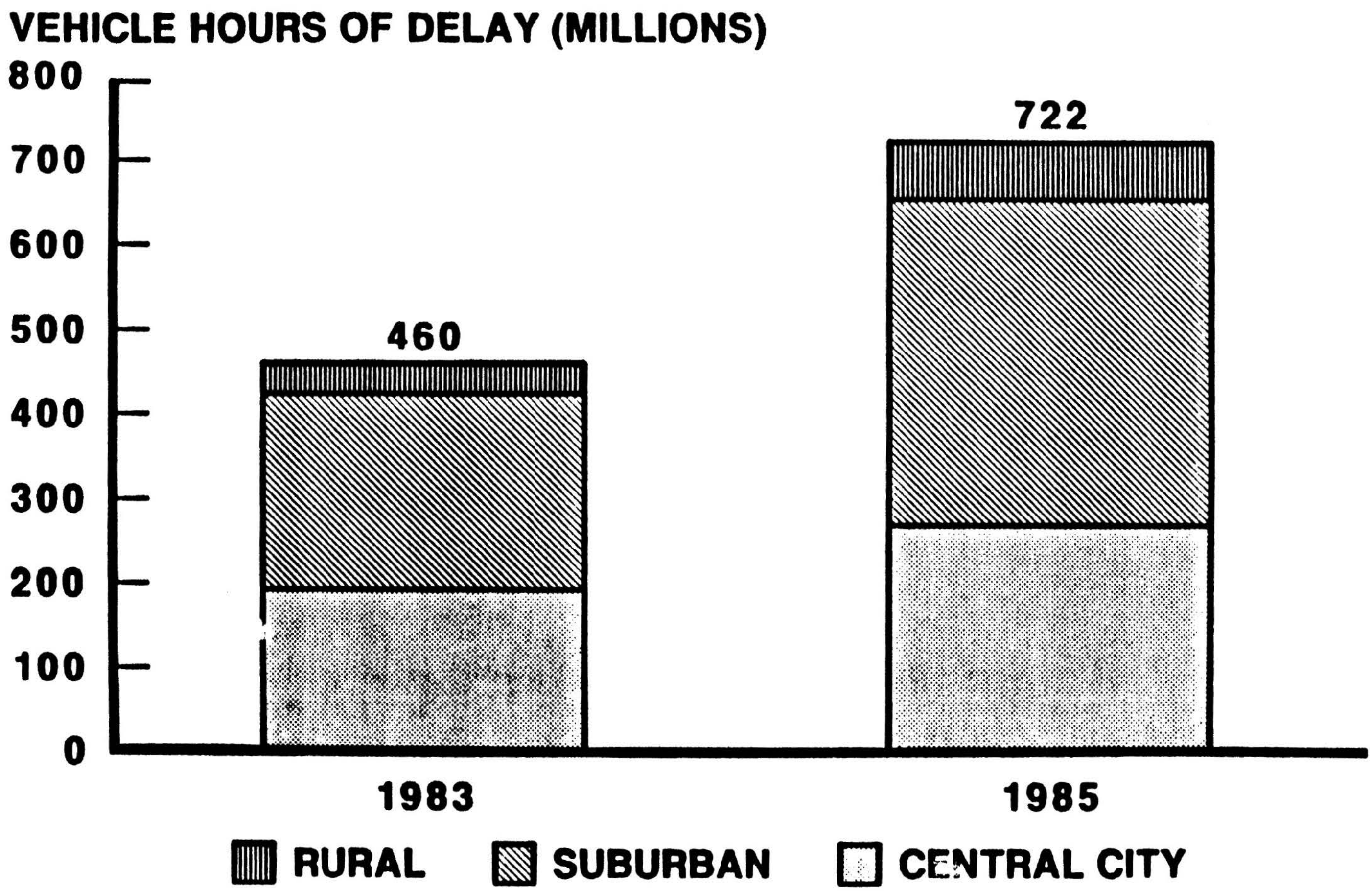
- TECHNOLOGIES WHICH CAN LEAD TO MORE EFFICIENT USE OF EXISTING OR FUTURE ROADS, THEREBY REDUCING TRAFFIC CONGESTION
  - TECHNOLOGIES ON-BOARD THE VEHICLE
  - TECHNOLOGIES EXTERNAL TO THE VEHICLE
  - COMBINATIONS OF ON-BOARD AND EXTERNAL

TRAFFIC CONGESTION

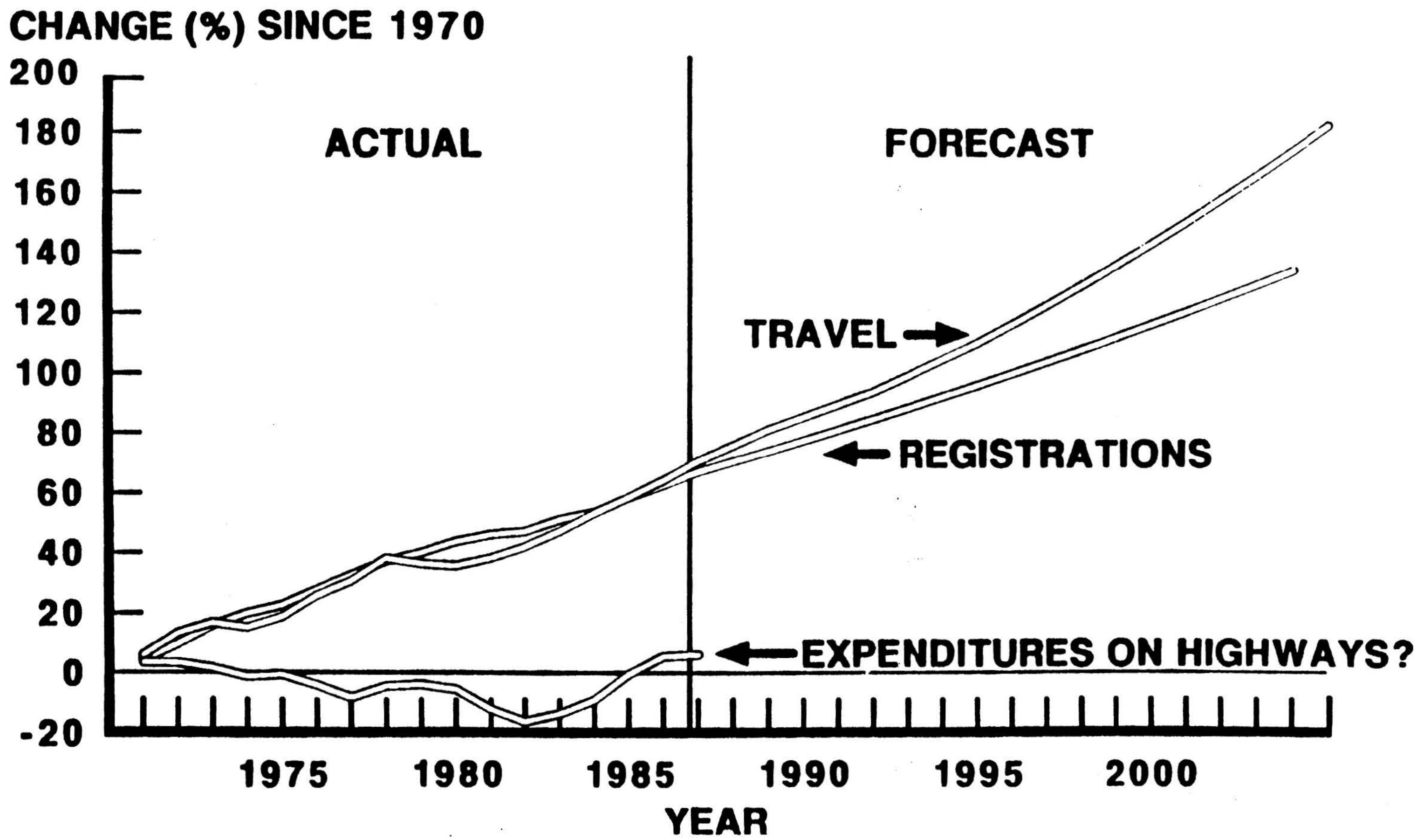
VEHICLE REGISTRATIONS AND MILES OF TRAVEL VERSUS REAL DOLLAR EXPENDITURES ON HIGHWAYS



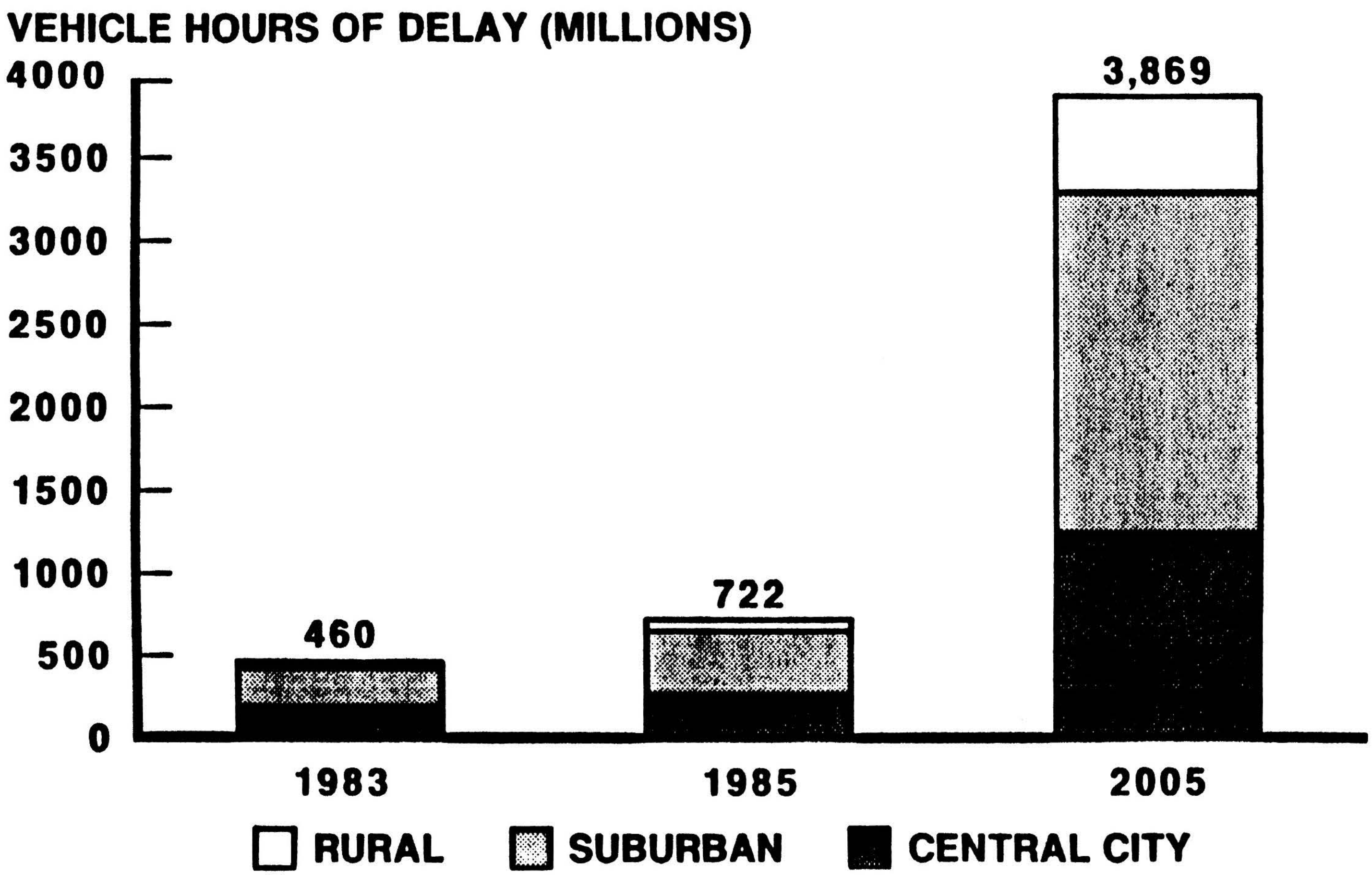
A RESULT: GROWING LEVELS OF TRAFFIC CONGESTION



VEHICLE REGISTRATIONS AND MILES OF TRAVEL WILL CONTINUE TO GROW INTO THE 21ST CENTURY - BUT WHAT ABOUT EXPENDITURES ON HIGHWAYS?



... OR CONGESTION?



TRAFFIC CONGESTION ALTERNATIVES

- LEARN TO LIVE WITH IT?
- OR MANAGE IT, BY:
  - ADDING SOME ROAD CAPACITY?
  - RESTRICTING USE?
  - MAKING MORE EFFICIENT USE OF OUR ROADS?

"INTELLIGENT" VEHICLE/HIGHWAY TECHNOLOGIES

- DRIVER INFORMATION
- TRAFFIC CONTROL
- VEHICLE CONTROL

DRIVER INFORMATION TECHNOLOGIES

- ELECTRONIC ROUTE PLANNING
- RADIO BROADCASTS
- ON-BOARD ROUTING ADVICE
- ON-BOARD NAVIGATION

ELECTRONIC ROUTE PLANNING

- NOW AVAILABLE USING VIDEOTEXT / TELETEXT
  - TELETEL-ROUTE (FRANCE)
  - ANTIOPE (FRANCE)
  - ROADWATCH (UNITED KINGDOM)
  - ROUTEFINDER (UNITED KINGDOM)

SIA ROUTEFINDER - ENGLAND AND WALES - JULY 1987

From TRRL

to HYDE PARK CORNER

Quickest route	Car speeds			36 miles	52 mins
	GO NORTH on	UNNUMBERED	for	.2 miles	(0:01)
	TURN RIGHT onto	B3430	for	2.6 miles	(0:04)
	TURN RIGHT onto	A 322	for	3.5 miles	(0:08)
At M3 J3	TURN LEFT onto	M 3	for	7.1 miles	(0:15)
At M3 J2/M25 J12	TURN LEFT onto	M 25	for	7.0 miles	(0:22)
At M25 J15	TURN RIGHT onto	M 4	for	9.7 miles	(0:32)
At M4 J1	FORWARD onto	A 4	for	5.9 miles	- END

ELECTRONIC ROUTE PLANNING

- UNDER DEVELOPMENT
  - VIDEOTRANS (BELGIUM)
  - ERTIS (EUROPE-WIDE, A EUREKA PROJECT)
  - ATIS (EUROPE-WIDE, A EUREKA PROJECT)

EUREKA

OBJECTIVE:

- ENHANCE THE COMPETITIVENESS OF EUROPEAN ENTERPRISES, WORLDWIDE
- AID THESE ENTERPRISES IN COMMERCIALIZING HIGH-TECHNOLOGY-INTENSIVE PRODUCTS AND SERVICES

EUREKA

SCOPE AND BUDGET:

- INITIATED IN 1985
- 19 EUROPEAN COUNTRIES
- 400 EUROPEAN FIRMS OR OTHER ORGANIZATIONS
- 165 PROJECTS
- ECU 4 BILLION BUDGET (ABOUT $4.9 BILLION)
- PARTICIPATION BY NON-EUROPEAN COUNTRIES OR ENTERPRISES GENERALLY PROHIBITED

EUREKA

PROJECTS ON INTELLIGENT VEHICLES / HIGHWAYS:

■ PROMETHEUS	ECU 327 MILLION
■ EUROPOLIS	128 MILLION
■ CARMINAT	52 MILLION
■ ATIS	7 MILLION
■ ERTIS	2 MILLION

EUREKA

SUPPORTING PROJECTS:

■ DAB	38 MILLION
■ DEMETER	5 MILLION
TOTAL	ECU 559 MILLION (ABOUT $680 MILLION)

ERTIS

- EUROPEAN ROAD TRANSPORT INFORMATION SYSTEM
- OBJECTIVE: DEVELOP ROAD INFORMATION AND COMMUNICATIONS SYSTEMS FOR MOTOR CARRIERS
- PARTICIPANTS: TRUCKING FIRMS AND ASSOCIATIONS IN BELGIUM, DENMARK, THE NETHERLANDS, AND THE UNITED KINGDOM
- DURATION: 3 YEARS
- BUDGET: ECU 2.2 MILLION (ABOUT $2.7 MILLION)

ATIS

- ALLIANCE INTERNATIONALE DE TOURISME INFORMATION SYSTEM
- OBJECTIVE: PROVIDE PRE-TRIP INFORMATION ON ROAD TRAFFIC CONDITIONS AND OTHER SUBJECTS IMPORTANT TO TOURISTS
- PARTICIPANTS: SWISS, DUTCH, AND AUSTRIAN MOTORIST/TRAVEL ORGANIZATIONS

  DURATION: 5 YEARS

  BUDGET: ECU 7 MILLION (ABOUT $8.5 MILLION)

DAB

- DIGITAL AUDIO BROADCASTING SYSTEM
- OBJECTIVE: DEVELOP COMMON STANDARDS FOR DIGITAL RADIO BROADCASTING
- PARTICIPANTS: PHILIPS, BOSCH-BLAUPUNKT, AND 7 OTHER FIRMS
- DURATION: 5 YEARS
- BUDGET: ECU 38 MILLION (ABOUT $46 MILLION)

DEMETER

- DIGITAL ELECTRONIC MAPPING OF EUROPEAN TERRITORY
- OBJECTIVE: ADVANCE COMPUTER-AIDED CARTOGRAPHY AND DEVELOP COMMON STANDARDS
- PARTICIPANTS: PHILIPS, BOSCH-BLAUPUNKT
- DURATION: 4 YEARS
- BUDGET: ECU 5 MILLION (ABOUT $6 MILLION)

RADIO BROADCASTS

- HIGHWAY ADVISORY RADIO (HAR) (U.S.)
- AUTOFAHRER RUNDFUNK INFORMATION (ARI) (WEST GERMANY)
- ARIAM (WEST GERMANY)
- RADIO DATA SYSTEM (RDS) (EUROPE-WIDE)

ON-BOARD ROUTING ADVICE

- ROUTEN-RECHNER (DAIMLER-BENZ, WEST GERMANY)
- EVA (BOSCH-BLAUPUNKT, WEST GERMANY)
- TRRL NAVIGATOR (UNITED KINGDOM)
- CARIN (PHILIPS, NETHERLANDS; NOW PART OF EUREKA CARMINAT PROJECT)
- PACE (PLESSEY, UNITED KINGDOM)

ON-BOARD NAVIGATION

- SELF-CONTAINED
  - ETAK NAVIGATOR (U.S.)
  - CARIN (PHILIPS, NETHERLANDS; NOW PART OF CARMINAT)

ON BOARD NAVIGATION

■ SELF-CONTAINED WITH COMMUNICATIONS

- ALI-SCOUT (BOSCH/BLAUPUNKT & SIEMENS, WEST GERMANY)
- AUTOMOBILE ROAD INFORMATION SYSTEM EVOLUTION (ARISE) (SWEDEN)
- DEDICATED ROAD INFRASTRUCTURE FOR VEHICLE SAFETY IN EUROPE (DRIVE) (EUROPEAN ECONOMIC COMMUNITY)

ON BOARD NAVIGATION

- **SELF-CONTAINED WITH COMMUNICATIONS**
  - PROGRAM FOR EUROPEAN TRAFFIC WITH HIGHEST EFFICIENCY AND UNPRECEDENTED SAFETY (PROMETHEUS) (EUROPE-WIDE)
  - ADVANCED MOBILE TRAFFIC INFORMATION AND COMMUNICATION SYSTEM (AMTICS) (JAPAN)
  - PATHFINDER (U.S.)

PROMETHEUS

- PROGRAM FOR EUROPEAN TRAFFIC WITH HIGHEST EFFICIENCY AND UNPRECEDENTED SAFETY
- OBJECTIVE: REDUCE TRAFFIC CONGESTION AND INCREASE TRAFFIC SAFETY THROUGH COMPUTER ASSISTED DRIVING AND TRAFFIC MANAGEMENT

PROMETHEUS

- PARTICIPANTS: DAIMLER-BENZ, VOLKSWAGEN, BMW, PORSCHE, RENAULT, PEUGEOT, MATRA, JAGUAR, ROLLS ROYCE, FIAT, ALFA ROMEO, VOLVO, AND SAAB-SCANIA
- DURATION: 8 YEARS; BEGAN IN OCTOBER, 1986
- BUDGET: ECU 327 MILLION (ABOUT $400 MILLION)

PROMETHEUS

- INDUSTRIAL RESEARCH PROJECTS:
  - PRO-CAR (VEHICLE ELECTRONICS TO ASSIST THE DRIVER)
  - PRO-NET (VEHICLE TO VEHICLE COMMUNICATIONS)
  - PRO-ROAD (EXTERNALLY-LINKED VEHICLE NAVIGATION)

PROMETHEUS

- **BASIC RESEARCH PROJECTS:**
  - PRO-ART (RESEARCH ON ARTIFICIAL INTELLIGENCE)
  - PRO-CHIP (ON-BOARD VEHICLE MICROPROCESSING RESEARCH)
  - PRO-COM (COMMUNICATIONS RESEARCH)
  - PRO-GEN (TRAFFIC ENGINEERING RESEARCH)

CARMINAT

- **OBJECTIVE:** DEVELOP IN-VEHICLE ELECTRONIC NAVIGATION AND COMMUNICATIONS SYSTEMS
- **PARTICIPANTS:** PHILIPS (CARIN) AND RENAULT (ATLAS)
- **DURATION:** 4 YEARS
- **BUDGET:** ECU 52 MILLION (ABOUT $63 MILLION)

ON BOARD NAVIGATION

- **SELF-CONTAINED WITH COMMUNICATIONS**
  - ATLAS (RENAULT, FRANCE; NOW PART OF CARMINAT)
  - CARIN
  - BERLIN NAVIGATION AND INFORMATION SYSTEM (LISB) (WEST GERMANY; NOW PART OF EUREKA PROMETHEUS PROJECT)
  - AUTOGUIDE (UNITED KINGDOM; NOW PART OF PROMETHEUS)

AMTICS

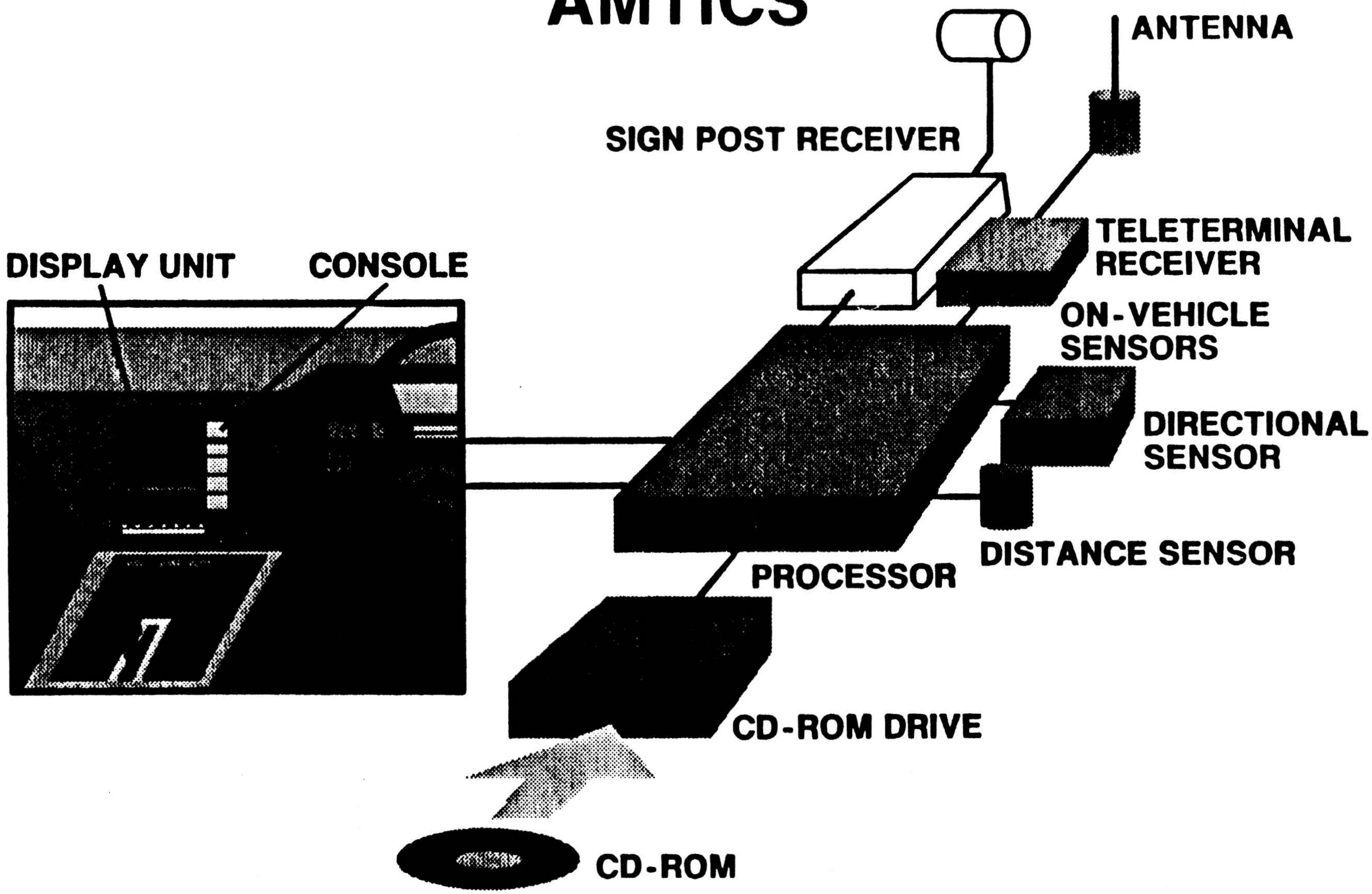
- ADVANCED MOBILE TRAFFIC INFORMATION AND COMMUNICATION SYSTEM
- OBJECTIVE: INTEGRATE ON-BOARD ELECTRONIC VEHICLE NAVIGATION WITH COMMUNICATED TRAFFIC INFORMATION IN 74 CITIES THROUGHOUT JAPAN

AMTICS

■ **PARTICIPANTS:**

- MINISTRY OF POSTS AND TELECOMMUNICATIONS
- NATIONAL POLICE AGENCY
- JAPAN TRAFFIC MANAGEMENT AND TECHNOLOGY ASSOCIATION
- 59 PRIVATE CORPORATIONS

AMTICS



ANTENNA
SIGN POST RECEIVER
TELETERMINAL RECEIVER
DISPLAY UNIT
CONSOLE
ON-VEHICLE SENSORS
DIRECTIONAL SENSOR
DISTANCE SENSOR
PROCESSOR
CD-ROM DRIVE
CD-ROM

AMTICS

- **DURATION:**
  - PROJECT BEGUN IN 1987
  - BUILDS ON EXTENSIVE EXISTING TRAFFIC MANAGEMENT SYSTEMS
  - PILOT TESTING IN TOKYO BEGAN IN APRIL 1988
  - FIRST COMMERCIAL SYSTEM SCHEDULED FOR OSAKA IN 1990
- **BUDGET:** UNKNOWN

PATHFINDER

- **OBJECTIVE:** TEST VEHICLE NAVIGATION SYSTEM WITH TWO-WAY COMMUNICATIONS
- **PARTICIPANTS:** CALTRANS, FHWA, GENERAL MOTORS
- **DURATION:** 3 YEARS, BEGINNING SEPTEMBER, 1988
- **BUDGET:** $1.65 MILLION

TRAFFIC CONTROL TECHNOLOGIES

- TRAFFIC SIGNALS
- FREEWAY AND CORRIDOR CONTROL

TRAFFIC SIGNALS

■ UNSYNCHRONIZED

TRAFFIC SIGNALS

- FIXED-TIME SYNCHRONIZATION
  - SINGLE FIXED PLAN
  - MULTIPLE FIXED PLANS
  - TRAFFIC ADAPTIVE PLANS (e.g., SCATS IN AUSTRALIA)

TRAFFIC SIGNALS

- ■ TRAFFIC-RESPONSIVE SYNCHRONIZATION
  - SPLIT, CYCLE AND OFFSET OPTIMIZATION TECHNIQUE (SCOOT) (UNITED KINGDOM)

FREEWAY AND CORRIDOR CONTROL

- RAMP METERING
- VARIABLE MESSAGE SIGNS
- LANE CONTROLS
- INCIDENT DETECTION SYSTEMS

FREEWAY AND CORRIDOR CONTROL

■ INTEGRATED MANAGEMENT SYSTEMS

- SANTA MONICA FREEWAY "SMART CORRIDOR" PROJECT (U.S.)

VEHICLE CONTROL TECHNOLOGIES

- ELECTRONIC VEHICLE IDENTIFICATION
- ELECTRONIC VEHICLE LOCATION
- AUTOMATIC VEHICLE CONTROL

ELECTRONIC VEHICLE IDENTIFICATION

- AUTOMATIC TOLL COLLECTION
  - SAN DIEGO-CORONADO BRIDGE EXPERIMENTS (U.S.)

ELECTRONIC VEHICLE IDENTIFICATION

- HELP (HEAVY VEHICLE ELECTRONIC LICENSE PLATE) (ALSO KNOWN AS THE CRESCENT PROJECT) (U.S.)
  - WEIGH IN MOTION
  - COLLECT PERMIT FEES AND TOLLS IN MOTION
  - MONITOR ROUTING OF HAZARDOUS MATERIALS
  - MONITOR DRIVER PERFORMANCE

ELECTRONIC VEHICLE IDENTIFICATION

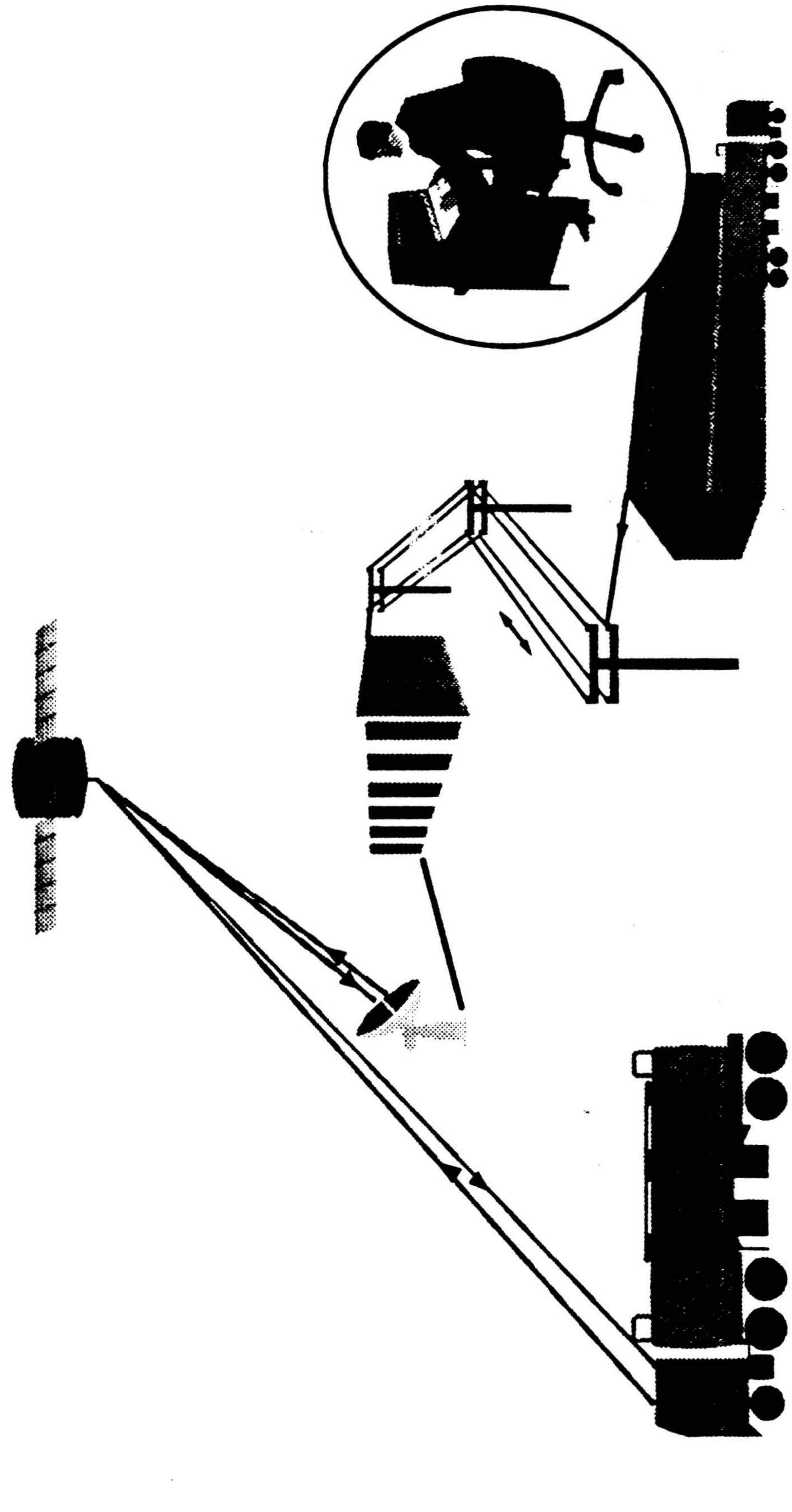
- ROAD OR CONGESTION PRICING
  - SINGAPORE AREA-LICENSING SYSTEM (SINGAPORE)
  - HONG KONG ROAD PRICING EXPERIMENTS (HONG KONG)

ELECTRONIC VEHICLE LOCATION

- **LORAN-C BASED SYSTEMS**
  - TRACKNET AVL-200 (MOTOROLA, U.S.)
  - VEHICLE TRACKING SYSTEM (VTS) (II MORROW, U.S.)
  - METS TRACKER (METS, U.S.)
  - AUTOTRAC (SPECTRUM CELLULAR, U.S.)

ELECTRONIC VEHICLE LOCATION

- SATELLITE BASED SYSTEMS
  - NAVSTAR GPS (U.S.)
  - RADIO DETERMINATION SATELLITE SERVICES (RDSS)
    - GEOSTAR (SYSTEMS 1.0, 3.0 AND 4.0) (GEOSTAR, U.S.)



ELECTRONIC VEHICLE LOCATION

- ■ COMBINED SYSTEMS (LORAN-C AND RDSS)
  - GEOSTAR (SYSTEM 2.0)
    (GEOSTAR, U.S.)
  - OMNITRACS (OMNINET, U.S.)

ELECTRONIC VEHICLE LOCATION

- SYSTEMS USING DEAD-RECKONING WITH COMMUNICATIONS
  - ETAK FLEET MANAGEMENT SYSTEM (ETAK, U.S.)
  - GEC TRACKER (GEC TRAFFIC AUTOMATION, UNITED KINGDOM)
  - PINPOINT (BRITISH TELECOM, UNITED KINGDOM)

AUTOMATIC VEHICLE CONTROL

- TECHNOLOGIES TO ASSIST THE DRIVER
  - PROMETHEUS (EUROPE-WIDE; A EUREKA PROJECT)
    - RADAR BRAKING
    - AUTOMATIC HEADWAY CONTROL
    - MACHINE VISION

AUTOMATIC VEHICLE CONTROL

- TECHNOLOGIES TO REPLACE THE DRIVER
  - AUTOMATED HIGHWAYS
    - EUROPOLIS (EUROPE-WIDE; A EUREKA PROJECT)
    - PROGRAM ON ADVANCED TECHNOLOGY FOR THE HIGHWAY (PATH) (U.S.)

EUROPOLIS

- **OBJECTIVE:** AUTOMATED ROADS AFTER THE YEAR 2000
- **PARTICIPANTS:** FRENCH, SPANISH, AND DANISH RESEARCH GROUPS
- **DURATION:** 7 YEARS
- **BUDGET:** ECU 128 MILLION (ABOUT $156 MILLION)

AUTOMATIC VEHICLE CONTROL

- **TECHNOLOGIES TO REPLACE THE DRIVER**
  - AUTOMATED VEHICLES
    - AUTONOMOUS LAND VEHICLE (ALV) PROGRAM (MARTIN MARIETTA, U.S.)

TRAFFIC CONGESTION ALTERNATIVES

- LEARN TO LIVE WITH IT?
- OR MANAGE IT, BY:
  - ADDING SOME ROAD CAPACITY?
  - RESTRICTING USE?
  - MAKING MORE EFFICIENT USE OF OUR ROADS?

Advanced Mobile Traffic Information and Communication System (AMTICS)

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Tomokazu Kawabata [2)]

1) National Police Agency, Traffic Bureau, Traffic Planning Division

2) Japan Traffic Management and Technology Association

Abstract

The chronic traffic jams which occur in and around cities in Japan have become a major problem. In an attempt to ease traffic congestion, traffic information is now being relayed at fixed intervals by means of television, radio and traffic information signboards on major highways. However, this is not always sufficient, as drivers require more detailed information, and there is a limit to the ability of the present media to meet this need.

For this reason, the Japan Traffic Management and Technology Association, by the suggestion of the National Police Agency, set up a group to study proposals for the Advanced Mobile Traffic Information & Communication System (AMTICS) at the beginning of this year in cooperation with the Ministry of Posts and Telecommunications (MPT) and private corporations.

AMTICS is an integrated traffic information and navigation system. The system will display on screens in each car traffic information gathered by the police at Traffic control and Surveillance Centers in 74 cities. The information will be reprocessed by computer at the AMTICS data-processing center and broadcast to cars. The broadcasting system being promoted by the MPT is a new radio data communication system which will also be able to carry voice signals and users radio broadcasting stations called teleterminals. The equipment in the cars will consist of a display, a compact disk-read only memory (CD-ROM) reader for retrieving for retrieving map information stored on CDs, and a microcomputer to calculate the car's position and to superimpose it on the display.

The major benefit of this system will be its ability to display in real time, not only the car's current position and route, but also information on traffic congestion, regulations, road works and parking. The system is also being considered for application to business vehicle management systems.

On April 27, 1987, after the AMTICS research group issued its report, a Conference on the Practicability of AMTICS was established with the participation of 50 private corporations. An experimental pilot system may be started in Tokyo in 198~~9~~8 and the first commercial system may also be started in Osaka in 1990 in time for the International Garden and Greenery Exposition.

1. Background and History of Development

Furnishing traffic information to moving automobiles and other vehicles has become an increasingly important subject along with traffic congestion and expansion progress of areas.

According to the "Survey on the Actual Condition of Road Traffic Information Demand" conducted by the Japan Road Traffic Information Center in 1985, the leading situation in which the need for information develops is "when having been trapped in a traffic jam" (65% of responses). The types of information needed then are: "the length of the traffic jam" (58.7%), "the cause of the traffic jam" (36.1%), "the probability that the traffic congestion will clear" (53.7%), and "a detour route" (35.6%). On the other hand, many drivers complain that they "cannot obtain information they want" (88.1%). The furnishing of traffic information by radio, which is the most frequently used method, has elicited strong requests from drivers for an expansion of furnished information, such as: "want broadcasts at times other than the current times" (49.7%), "want an increase in the number of broadcasts" (55.8%), and "want an extension of the broadcast time per broadcast" (39.1%).

Japan Traffic Management and Technology Association (hereinafter referred to as "T.M.T.") has long been conducting research on sophisticated traffic information service under the supervision of the National Police Agency. Last year, T.M.T. started to study new ideas for developing a system to respond to such needs of drivers in both quantitative and qualitative aspects.

Based on the car navigation system, the technical development of which has been recently conducted in each field (It may be more appropriate to call the currently realized one the car location system. Therefore, it shall be referred to as the location system, hereinafter.), one idea is to add to the location system traffic jam information that drivers desire the most, and to show this information on a display inside the car. This system has been named the Advanced Mobile Traffic Information and Communication System (AMTICS). A fundamental idea is to supply various types of traffic information, centered around traffic congestion information, from the police traffic control centers (currently established in 74 cities nationwide), and to use the planned teleterminal system of the Ministry of Posts and Telecommunications as the communication media to send the information to each automobile.

With this background, the AMTICS research group (Chairman: Fumio Minozuma) was established at the beginning in 1987 to study the possibility of realizing this system. This study was conducted from the perspective of the technical aspects as well as the business aspects. The study results were reported at the final study session, held on April 27th. The conclusion was that there is sufficient possibility of its practical use.

Based on the study results of the AMTICS research group, the organization promotor to establish the Conference on the Practicability of AMTICS was held by 27 companies on April 13th. On April 27th, an organization meeting was held with 45 companies participating, and the Conference on the Practicability of AMTICS (Chairman: Fumio Minozuma) was officially inaugurated. This conference appointed Professor Iguchi, each person concerned of the National Police Agency, the Ministry of Posts and Telecommunications, and the Metropolitan Police Department and a Special Assistant for Traffic Control from the National Police Agency Traffic Bureau as advisors.

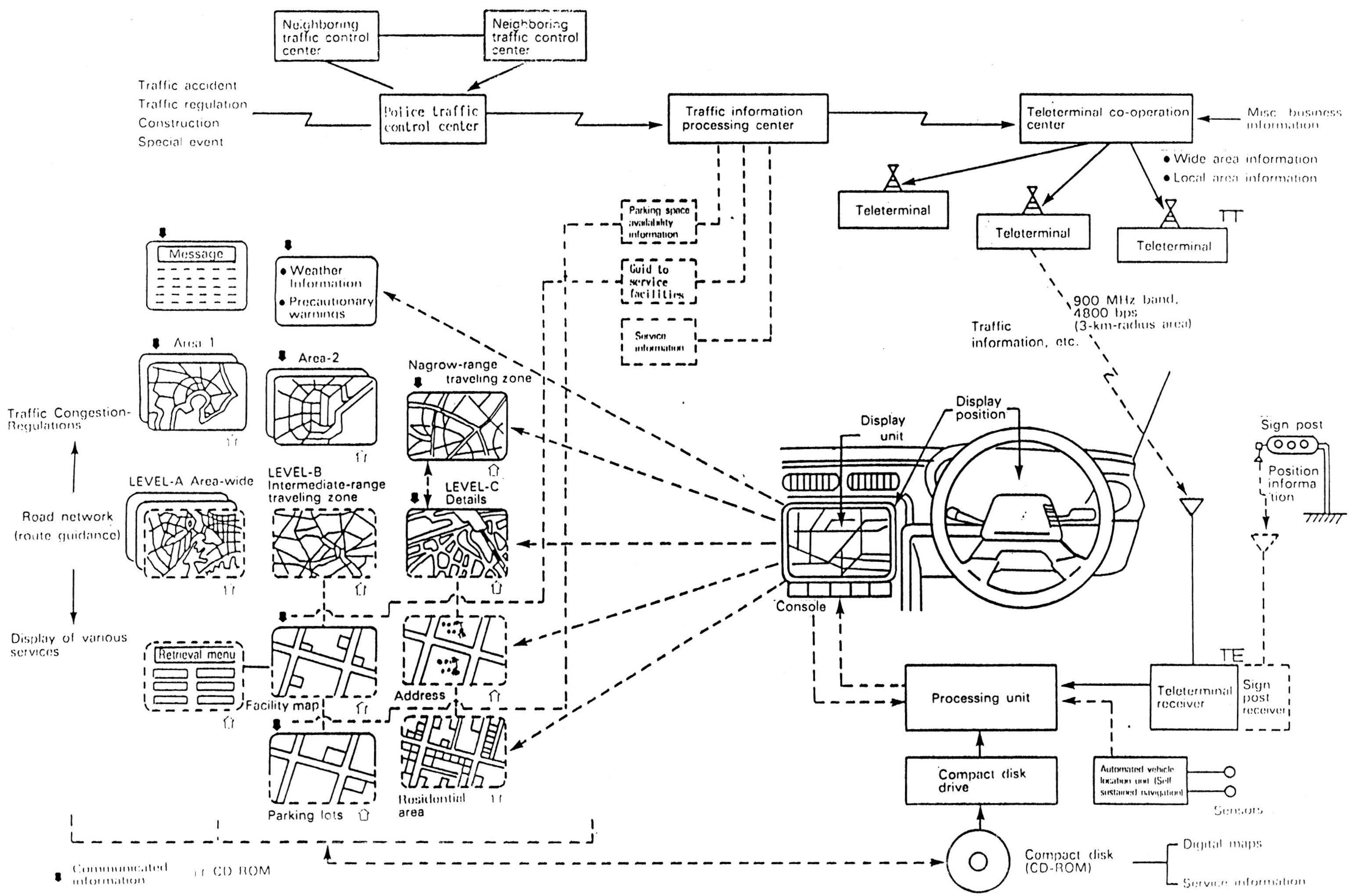
Further, this conference consigned study on the practical use of this system to T.M.T. again on June 1st, and T.M.T., responding to this, inaugurated the AMTICS Development Committee (Chairman: Hiroyuki Okamoto). It is presently proceeding with the work toward practical utilization of this system in cooperation with the National Police Agency, the Ministry of Posts and Telecommunications, the Metropolitan Police Department, and private companies (59 companies as of October 31st) as its members.

2. Outline of the System

(1) Configuration of the System

This system will provide the car location system (system to display a road map and the location of the car on the display mounted in the car) that is currently being developed in each field with traffic information collected at the traffic control centers online/real-time through the teleterminal system. Figure 1 is a system schematic diagram.

Figure 1 System Schematic Diagram



The main functions of this system are as follows:

1 Car location:

Displaying road map and car location

2 Traffic information:

Supplying of traffic jam, traffic regulations, and weather information, etc.

3 Related information:

Supplying of information such as location and availability of parking lots, and locations of tourist resorts

4 Application for business communication:

Application for locating cars possessed by the company and for business communication

(2) Information Supplied by AMTICS

The two types of information supplied by this system are:

1 Dynamic information supplied through teleterminal system

2 Static information recorded on a compact disk recording medium (hereinafter referred to as "CD-ROM")

Table 1 lists each type of information.

Table 1 Types of Information Supplied by AMTICS

Dynamic information	Traffic congestion information Temporary traffic regulation information (construction, accidents, events, freezing conditions in mountain areas, etc.) Urgent information, such as precautionary warnings Weather information Parking space availability information Other (route guidance information, etc.)	Basic information	Supplied through tele-terminal system
Static information	Road network data General traffic regulations (one-way, no right turn, etc.) Location of parking lots Background data (railroads, rivers, coasts, Administrative boundaries, etc.) Locations of major facilities (schools, hospitals, etc.) Locations of gas stations and service facilities Tourist information Residential maps Other	Service information	Supplied by recording medium

The coverage of information service shown on the display mounted in the car depends on the type of information. For example, for traffic jam information there are two types, local area information and wide area information, and the driver can select either type and view it. The former regards as one unit a circle of a radius of 8 km with a teleterminal at its center. The latter is an area whose size is as wide as the prefecture. (In some cases parts of the neighboring prefectures are included.) Naturally the former will be partial and dense information, and the latter will be general information about main sections. Figure 2 shows the relationship between the service area of a teleterminal (described later) and the coverage of this information service.

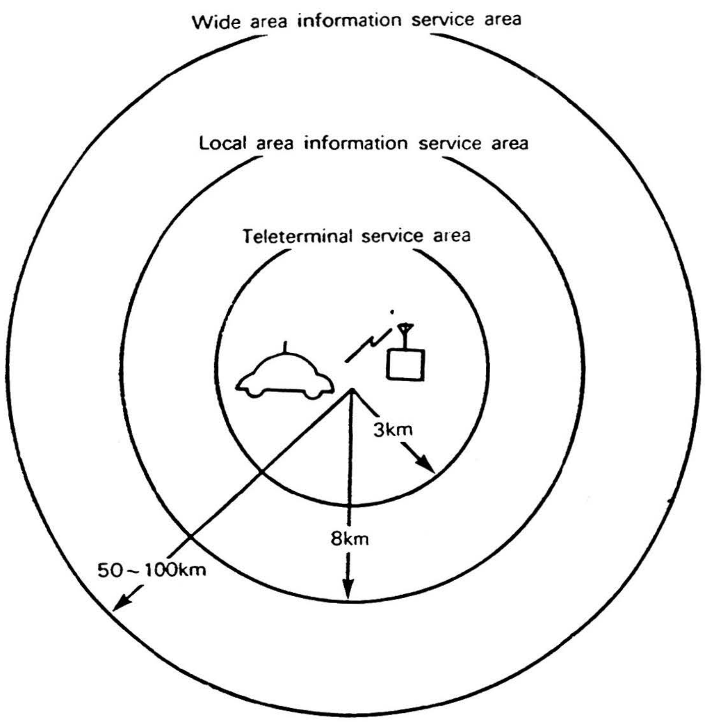


Figure 2 Coverage of Information Diagram

3. Function of Each Part of the System

The outline of the functions of the main parts shown in Figure 1, System Schematic Diagram, is as follows:

(1) Traffic Control Center of Police

The traffic control center calculates the lengths of traffic jam lines, the degree of congestion, etc., from information on the traffic volume, speed, etc., collected from the vehicle detectors set up on roads. It controls the traffic signals online so that the traffic flows in the most appropriate manner. In addition, it displays the collected traffic congestion information on the wall map display panel established in the center. (The traffic jam condition is displayed in three colors depending on the degree of congestion on a simplified map panel of a road network.) It performs general traffic management by the operator, broadcasts radio traffic information, provides information service, etc., for the general public and provides the driver with information through changeable message signs and roadside re-broadcasting equipment. Figure 3 shows a concept of the traffic control system.

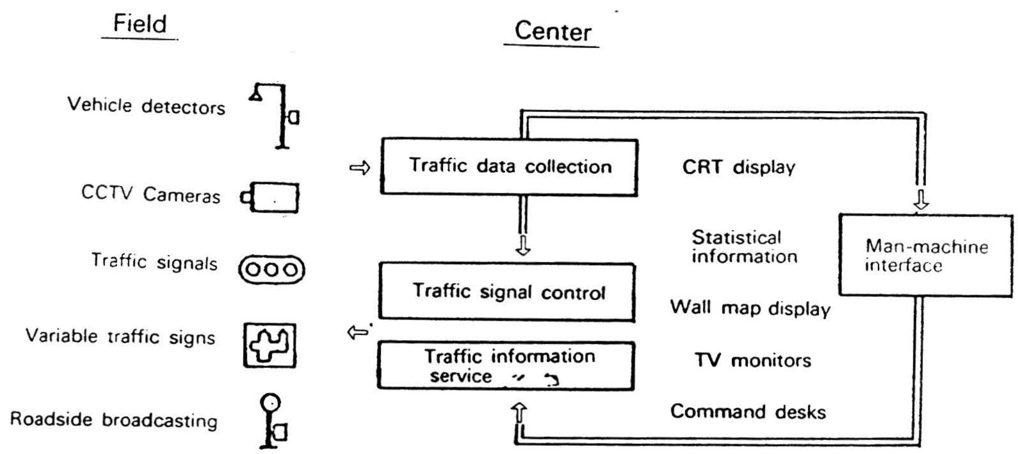


Figure 3 Concept of Traffic Control System

This system is currently installed in 74 major cities nationwide. For example, traffic signals are installed at approximately 12,000 intersections in Tokyo, approximately 6,000 of which are controlled by the traffic control center.

Further, information about accidents, construction and temporary traffic regulations etc., is manually entered into the computer at the traffic control center. At the same time, it is displayed on the wall map display panel.

As one example, Figure 4 and Table 2 show a configuration chart indicating the condition of the equipment arrangement and the size of the system of the traffic control center of the Metropolitan Police Department.

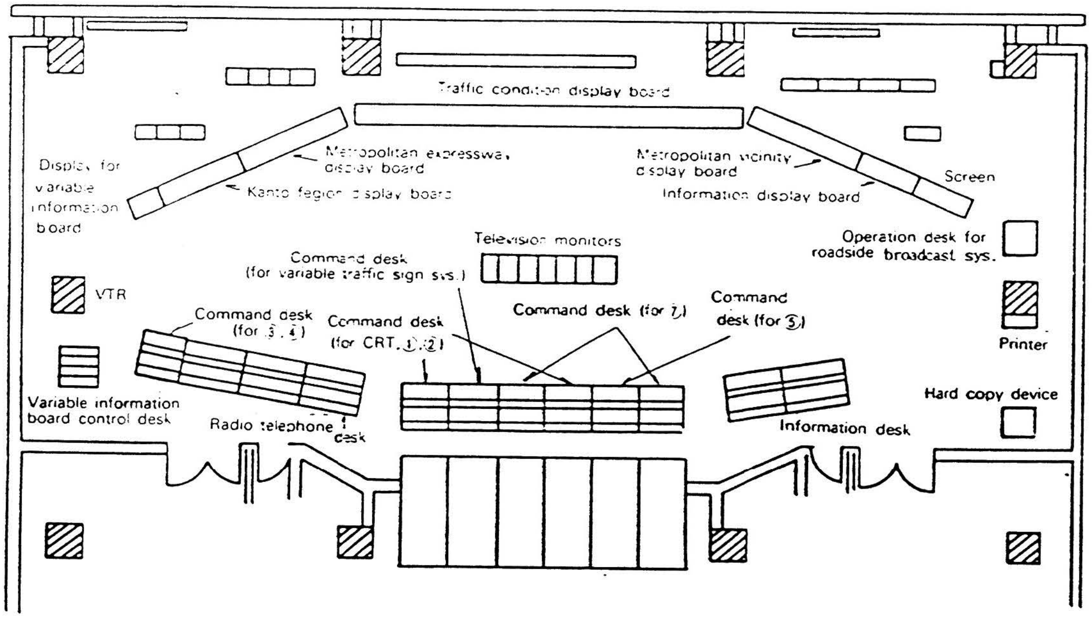


Figure 4 Arrangement Diagram of Equipment of the Tokyo Traffic Control and Surveillance Center

Table 2 Size of the Metropolitan Police Department Traffic Control System (As of July, 1987)

Component	Size
Controlled traffic signals	6,023 intersections (Total number of traffic signals: 12,315)
Vehicle detectors	5,691 units
Intersections displayed on wall map	462 intersections
CCTV cameras	81 units
TV monitors	20 units
Large computer	1 system:
Medium computers	22 systems:
Small computers	22 systems:
Area of machine rooms, etc.	1,380 m^2
First machine room	430 m^2
Second machine room	330 m^2
Traffic control center	320 m^2 (excluding broadcasting rooms, office)
Broadcasting rooms	8 rooms (6 rooms used)

(2) Traffic Information Processing Center of AMTICS

To display information, such as traffic information received online from the traffic control center and information on parking space availability sent from other organizations to be overlapped on a road map, the traffic information processing center rearranges the contents of the information and adds necessary information. Further, it converts the information so that it matches the transmission format of the teleterminal system, and then sends it out to the teleterminal co-operation center.

Moreover, this center is defined as one of the user centers of the teleterminal system.

(3) Teleterminal System

This system is planned by the Ministry of Posts and Telecommunications and is developed by the Research and Development for Radio Systems. It is a communication system to perform data communication between a vehicle and the user center as well as between vehicles. The system configuration is as follows. Teleterminals (tele-communication terminal) that have a service area of approximately 3 km are established in many places in the city, and each of these is connected with the co-operation center by a communication line. As a whole, it constitutes a system to cover the entire city. The co-operation center is further connected with each user center by a communication line, and the vehicle is connected with each teleterminal by radio. The teleterminal system plays a role of transmitting traffic information sent from the traffic information processing center to the driver.

Although preliminary calculations have shown that approximately 40 teleterminals are necessary to cover the entire Tokyo metropolitan area, pilot experiments are now being conducted with three teleterminals in the central part of Tokyo. The pilot experiments are scheduled to continue until March of this year.

(4) On-vehicle Equipment

Figure 5 shows an example of the configuration of the units related to the on-vehicle display.

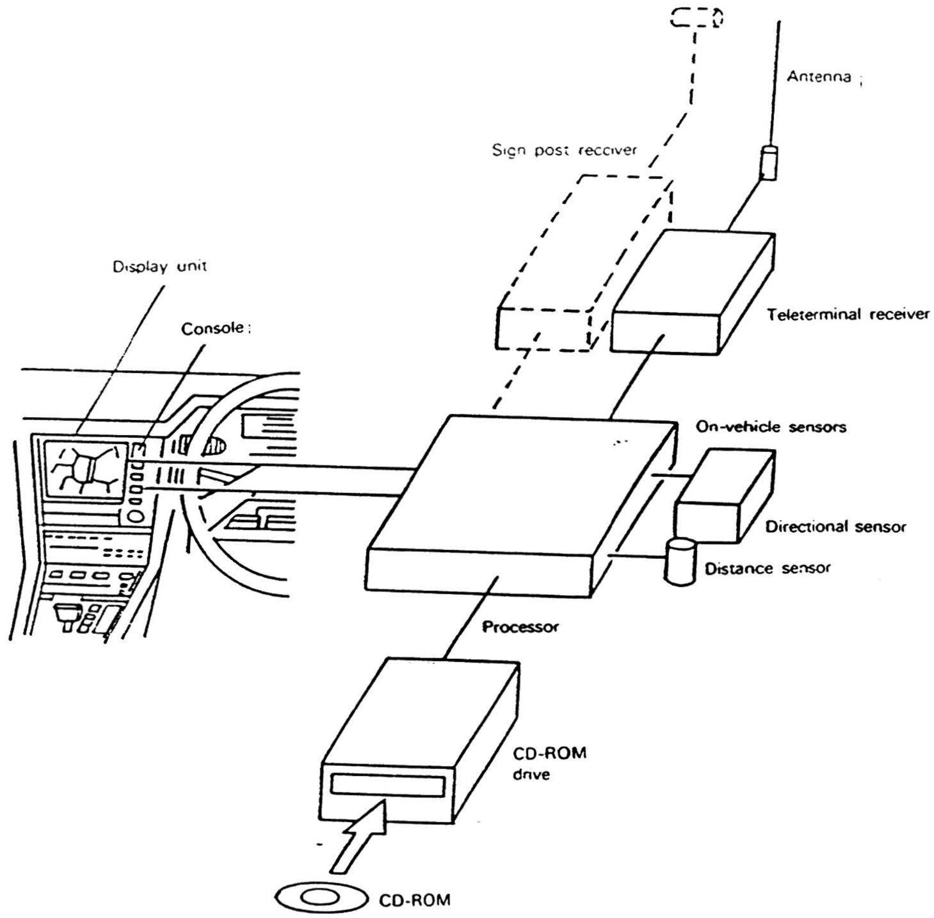


Figure 5 Sample Configuration of On-vehicle Unit

The on-vehicle equipment detects the position of the vehicle itself by the distance (distance traveled) sensor and the directional sensor, and it displays the position of the vehicle on the road map shown on the display by the output from CD-ROM.

It also displays various information sent through the teleterminal overlapped on the same screen. In addition, various service information recorded on CD-ROM is also displayed.

It has also been considered in this system to use voice as a means to communicate information to the driver rather than displaying on the screen as mentioned above.

Manufacture of the on-vehicle units is now at a stage to make trial models; specific introduction cannot be made at the moment. However, the fundamental idea is moving in the direction to limit the standard trial model specifications to minimum fundamental specifications so that the creativity of the manufacturing company in charge of the trial models can be sufficiently expressed. For reference, Figure 6 shows an image illustration of the on-vehicle display.

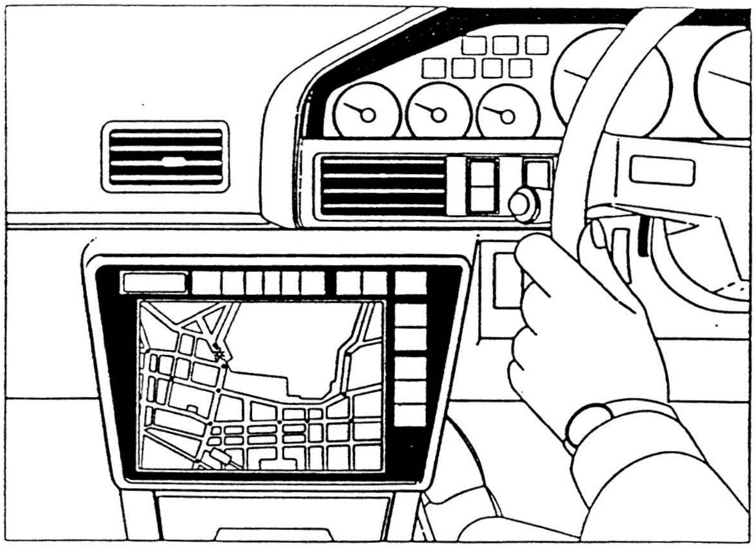


Figure 6 Image Illustration of On-vehicle Unit

(5) Map storage (CD-ROM)

Although many types of media can be used to record road maps, etc., CD-ROM is the most practical at present due to its capacity, accessibility, cost, etc. The main specifications of CD-ROM are as follows:

1 Capacity: 540 MB

2 Transfer speed: 150 KB/sec

3 Access method: Random access

4 Other: Read only

Various static information is stored in this CD-ROM. As an example, if only maps are stored in one CD-ROM, almost all the roads in the Kanto Area (roads with a width of 2.5 m or greater including background data) can be stored.

(6) Sign Post

The sign post is used to correct of detection errors in the vehicle position caused by errors of the distance and directional sensors and for initialization of the vehicle position. However, it will be unnecessary if the detection accuracy of the car position improves.

4. Results of Demand Survey

The results of the demand survey conducted by the AMTICS study group are as follows:

A questionnaire survey on demand tendency of this system was conducted for 2,503 general drivers and 814 transport operation companies in five cities: Tokyo, Osaka, Sendai, Hiroshima, and Kanazawa. As a result, 91.9% of the general drivers and 85.5% of the transport operators answered that they "think it would be convenient to have a device like this". For the price of the on-vehicle equipment, the purchasing tendencies are as shown in Figures 7 and 8.

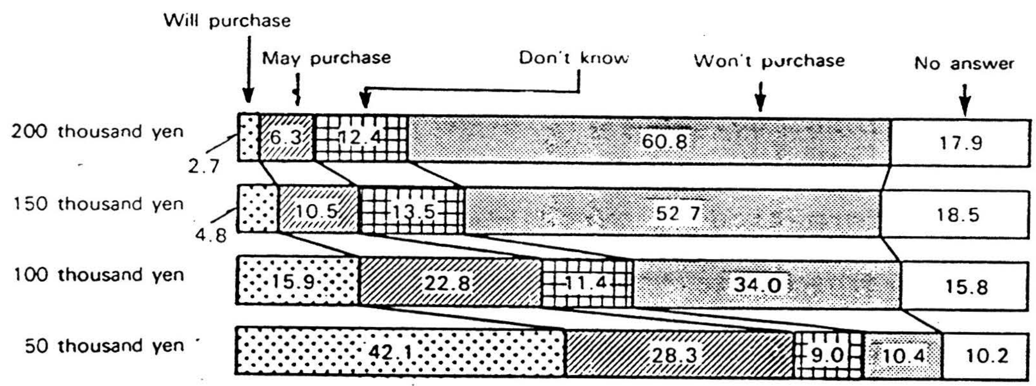


Figure 7 Purchasing Intentions of General Drivers

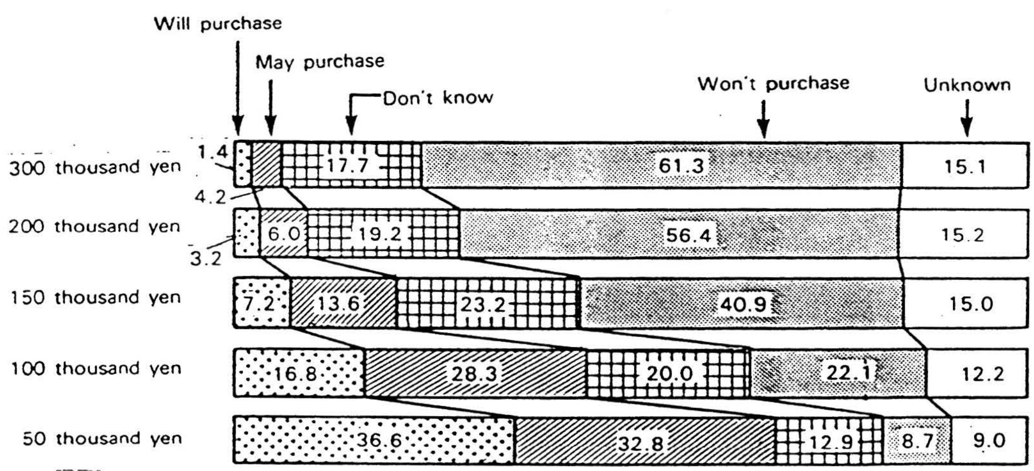


Figure 8 Purchasing Intentions of Transportaiton Operators

Preliminary calculation compiled to determine the demand -- for the on-vehicle unit based on these questionnaire surveys, etc., shows that demand for 12 million to 21 million units nationwide and demand for 870 thousand to 1,430 thousand units in Tokyo can be expected in ten years.

5. Current Schedule and its Prospect

As mentioned earlier, the AMTICS Development Committee is at present studying the matter from various aspects and preparing for pilot experiments. Preliminary manufacturing of the on-vehicle unit started in October, and a preliminary manufacturing period of approximately 6 months is expected.

Pilot experiment for the teleterminal system has started in the central part of Tokyo since last summer.

If the situation permits, the target is to conduct AMTICS pilot experiments, using the teleterminal, from April to June, 1988.

Based on the results of these experiments, the persons concerned expect to see possible practical use by the end of fiscal year 1988 and to operate the practical system at the International Garden and Greenery Exposition to be held in Osaka in 1990.

Since the information gathering network for traffic information to be provided is already completed on a relatively large scale the reality of completion is very possible. It is also possible to constitute a system of higher utilization value which includes various business systems and the mutual communication function between drivers, etc. if the bidirectional communication function of the teleterminal system, etc. are utilized. Further, CD-ROM, which has a very large memory capacity, can be used for furnishing a variety of attractive information in the vehicle. Considering all this, expectations are that this system may be a first step to producing multi-functional information space based on AMTICS inside the vehicle.