invent
Intelligent traffic and user-oriented technology

Traffic Network Equalization NIV

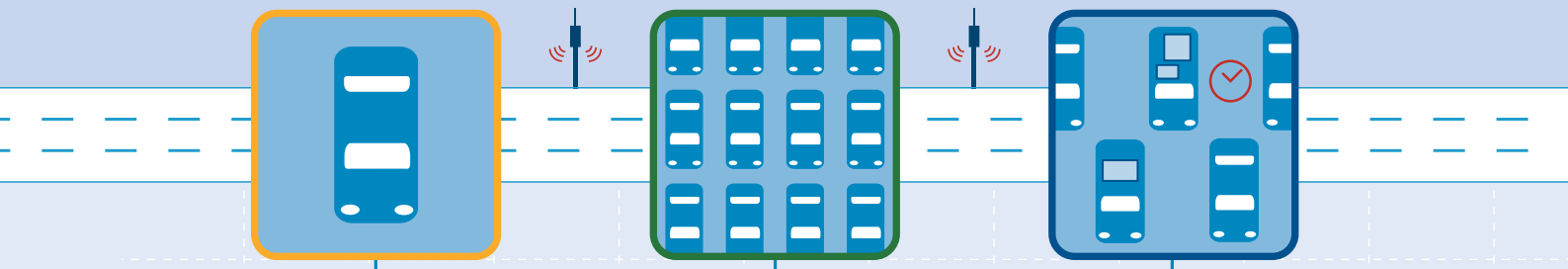
A brief supplement to the INVENT brochure
describing the component project
Traffic Network Equalization NIV

INVENT

Driver Assistance Active Safety

Traffic Management 2010

Traffic Management in Transport and Logistics



- Detection and Interpretation of the Driving Environment
- Anticipatory Active Safety
- Congestion Assistant
- Driver Behavior and Human-Machine Interaction
- Traffic Impact, Legal Issues, and Acceptance

- Traffic Performance Assistance
- Traffic Network Equalization

- Traffic Management in Transport and Logistics

Traffic Network Equalization in the Context of INVENT

Traffic and transport continue to be key economic factors. They provide the basis for prosperity and progress and ensure our competitive ability. Mobility is also an important ingredient of quality of life, self-fulfillment, and personal freedom. However, in recent decades the increase in traffic has been accompanied by negative consequences such as accidents and congestion.

Only by using innovative technologies can we find sustainable solutions to these problems and, in the face of ever expanding demands, make traffic safer and more efficient in the future.

The research initiative INVENT (intelligent traffic and user-oriented technology) is designed to bring this goal closer. To this end, 23 companies and institutions are cooperating in the three projects Driver Assistance Active Safety, Traffic Management 2010, and Traffic Management in Transport and Logistics.

Traffic Network Equalization, a component project of Traffic Management 2010, has the objective of improving the performance of the roadway network. The idea is to utilize existing traffic infrastructure more efficiently by combining strategic management of traffic streams with individualized driver information and route guidance.

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Traffic management

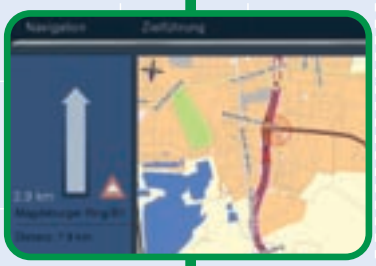
Collective

Public traffic management

Traffic management centers

Freeway management centers

Route guidance systems



Individual

Commercial services

Motivation

Traffic demand has been growing steadily for decades, and this growth is projected to continue in the future. For many years, the main way of adapting to this increasing demand has been to increase the capacity of the roadway network by building new roads or adding new lanes to existing ones. However, financial and ecological considerations are posing increasingly severe constraints on this process. Hence, there is a need for additional intelligent approaches designed to meet the demand while more efficiently utilizing the existing infrastructure and resources.

Public authorities have taken one step in this direction through the installation of traffic management systems intended to equalize traffic demand both temporally (by spreading out trips in time) and spatially (by redistributing demand). However, such collective systems for traffic management suffer from several inherent limitations: For one thing, they are unable to provide continuous, up-to-the-minute information to drivers. For another, it is impossible to restrict advice to a targeted sub-group of drivers, say those with a particular destination area; the options in collective route guidance are essentially "all or nothing".

On the other hand, in the future private service operators will provide a rising level of traffic information services targeted to the user's need for the fastest or shortest route. Modern navigation systems are designed to take delays due to incidents or congestion into account dynamically, provided that these delays have been previously reported and transmitted by some means to the device, e.g., by broadcast media such as TMC in Europe. The reaction of present route guidance systems to delays and incidents is a short-term and/or small-scale strategy. Comprehensive optimization of dynamic routing strategies is not provided. Moreover, current systems are incapable of including the influence of public traffic management strategies, such as traffic signal coordination.

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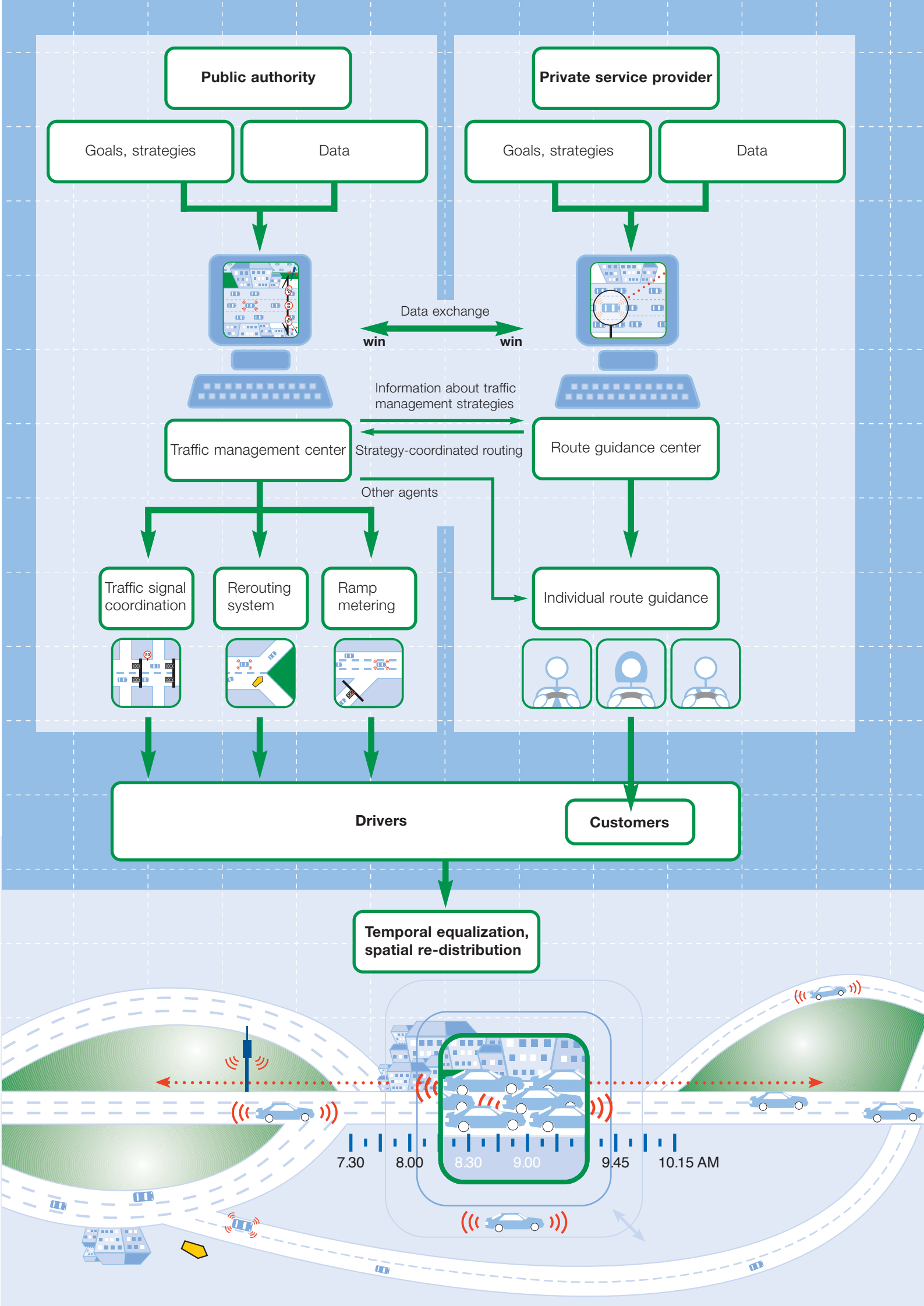
Public authority
Private service provider
Goals, strategies
Data
Goals, strategies
Data
Data exchange
win
win
Information about traffic management strategies
Traffic management center
Strategy-coordinated routing
Route guidance center
Other agents
Traffic signal coordination
Rerouting system
Ramp metering
Individual route guidance
Drivers
Customers
Temporal equalization, spatial re-distribution
7.30
8.00
8.30
9.00
9.45
10.15 AM

Goals and Benefits of NIV

Goals

Reconciling and synthesizing commercial route guidance recommendations with public policy and collective interests, as well as stimulating further development of vehicle navigation, are the main goals of the INVENT component project Traffic Network Equalization.

By development and demonstration of intelligent, traffic - responsive navigation solutions, the project partners seek to contribute to improved organization and management of traffic demand. To this end, they will develop and test new algorithms for dynamically incorporating diverse available sources of traffic data and information as well as public traffic management and control strategies and priorities into integrated comprehensive systems.

These integrated route guidance systems are also known as "third-generation navigation devices." They are designed to enable services targeted to drivers' needs such as recommendation of routes with coordinated traffic signals in urban areas or congestion-free alternative routes on motorways.

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- The first generation of navigation systems is based entirely on static digital maps. Hence, these devices are unable to include current conditions in computation of a route.
- The second generation of navigation systems consist of systems that receive and process current traffic reports. However, forecasts and boundary conditions from traffic management strategies etc. are not included.
- Routing systems of the third generation will be implemented as prototypes in test sites located in Munich and Magdeburg, Germany.

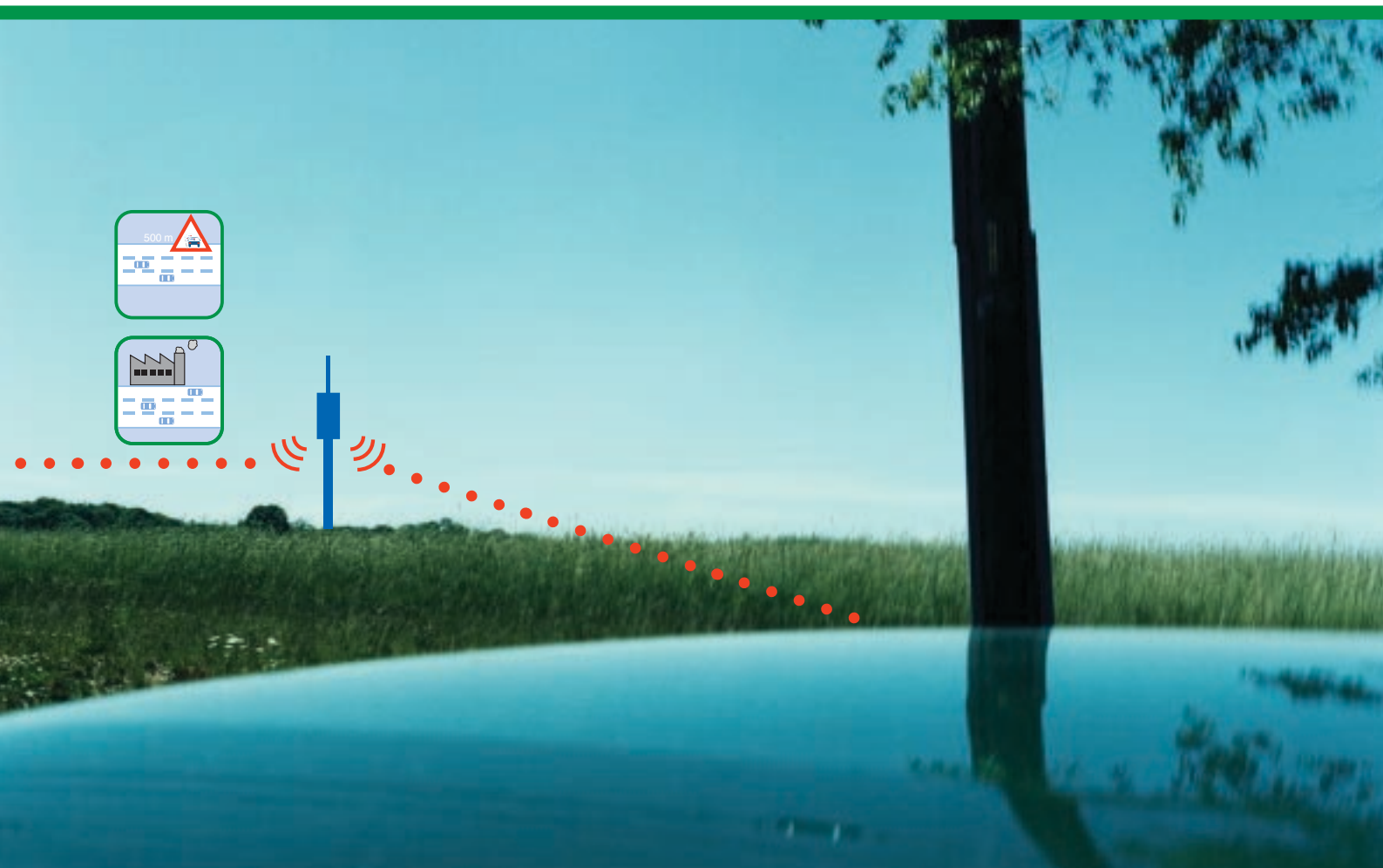
Solution Approaches

An analysis of the present and predicted traffic state in the entire roadway network and identification of reserve capacity comprises the basis for third-generation navigation systems. Mobile and stationary sensors collect the appropriate traffic data and transmit it to a central unit. Similarly to the weather forecast, the diverse and heterogeneous sources of data are combined to obtain a prognosis of the traffic state during a period ranging from minutes to hours or even longer. In this manner, a comprehensive knowledge base is built up to support optimal individual route guidance.

In addition to effective and reliable data fusion and forecasting algorithms, the approach requires modern communication solutions as well as robust and easily operated user interfaces.

Traffic Network Equalization is developing and testing a range of technological components and comprehensive solutions in five work packages.

The organization of these work packages is modeled on the classical information processing chain for traffic information and navigation services: Data collection, data processing, service provision, and the navigation device itself.



Data Collection

In order to obtain a high-resolution picture of the current traffic state as well as of weather conditions and other environmental factors, the project partners are both utilizing existing stationary detection facilities (such as loop detectors) and developing an advanced vehicle-based data source known as XFCD (eXtended Floating Car Data).

Floating cars (also known as "probe vehicles") are so designated in analogy to corks floating with a flowing fluid. Floating cars act as mobile sensors and can collect a range of information including speed and position data. During a trip, XFCD-vehicles perform an analysis using position, speed, and other data that gives important information on the local traffic state as well as the traffic context and surroundings. If there is relevant information, it is transmitted anonymously to a center and combined or "fused" there with other data sources.

The advantage of this distributed data source is that measurements of traffic occurrences are possible in principle within the entire roadway network without the requirement of expensive stationary infrastructure such as sensors on bridges or induction loops.

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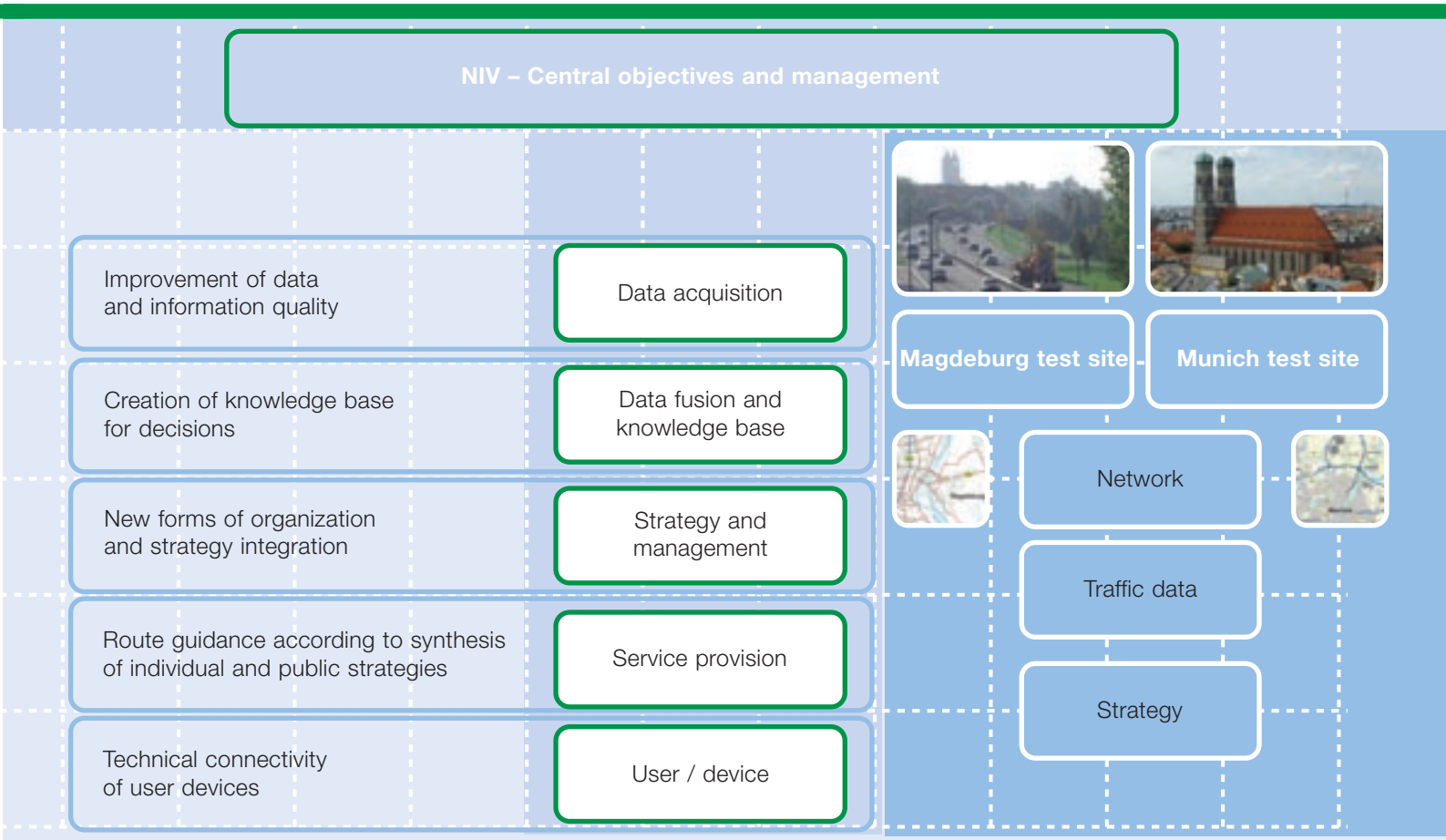

Public authorities

Traffic management center

Traffic and environmental data

Stationary sensors

A broad spectrum of dynamically changing data and information about the various vehicle sub-systems, extending far beyond speed and position, is potentially available from the data busses of a modern vehicle. A number of these information sources can be used to reconstruct details of the local traffic state, the vehicle environment, and the weather situation.

Mobile sensors

Data Fusion and Knowledge Base

The quality of dynamic route guidance depends on the quality of the available dynamic traffic state reconstruction in the roadway network. The higher the quality of the reconstruction, the more reliable the traffic prediction.

An important contribution to this quality could be provided by comprehensive measurement of XFCD. At the same time, innovative technologies are required in order to process and integrate the resulting collection of distributed information bits within a complex, heterogeneous information environment; i.e., each source of information can have a distinct precision, reliability, resolution, etc.

This component project will investigate the application of advanced techniques for the fusion of different data sources and for reconstruction of the traffic state and assess these techniques using an arsenal of methods such as computer simulation of traffic flow.

As a result of these activities, a broad, comprehensive knowledge base with dynamic elements will be created, containing high-level traffic and environmental data/information synthesized from stationary and mobile sensors.

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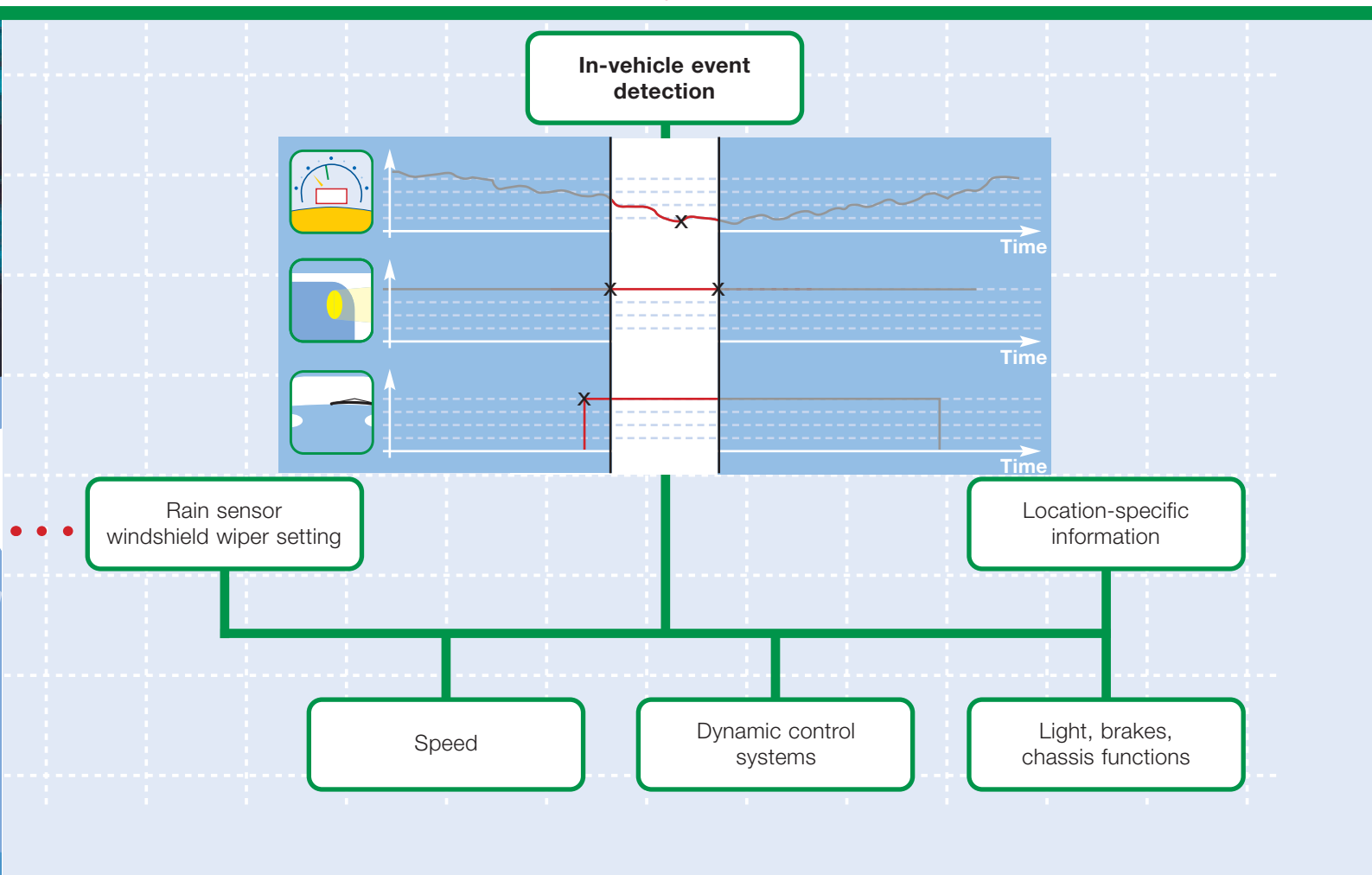
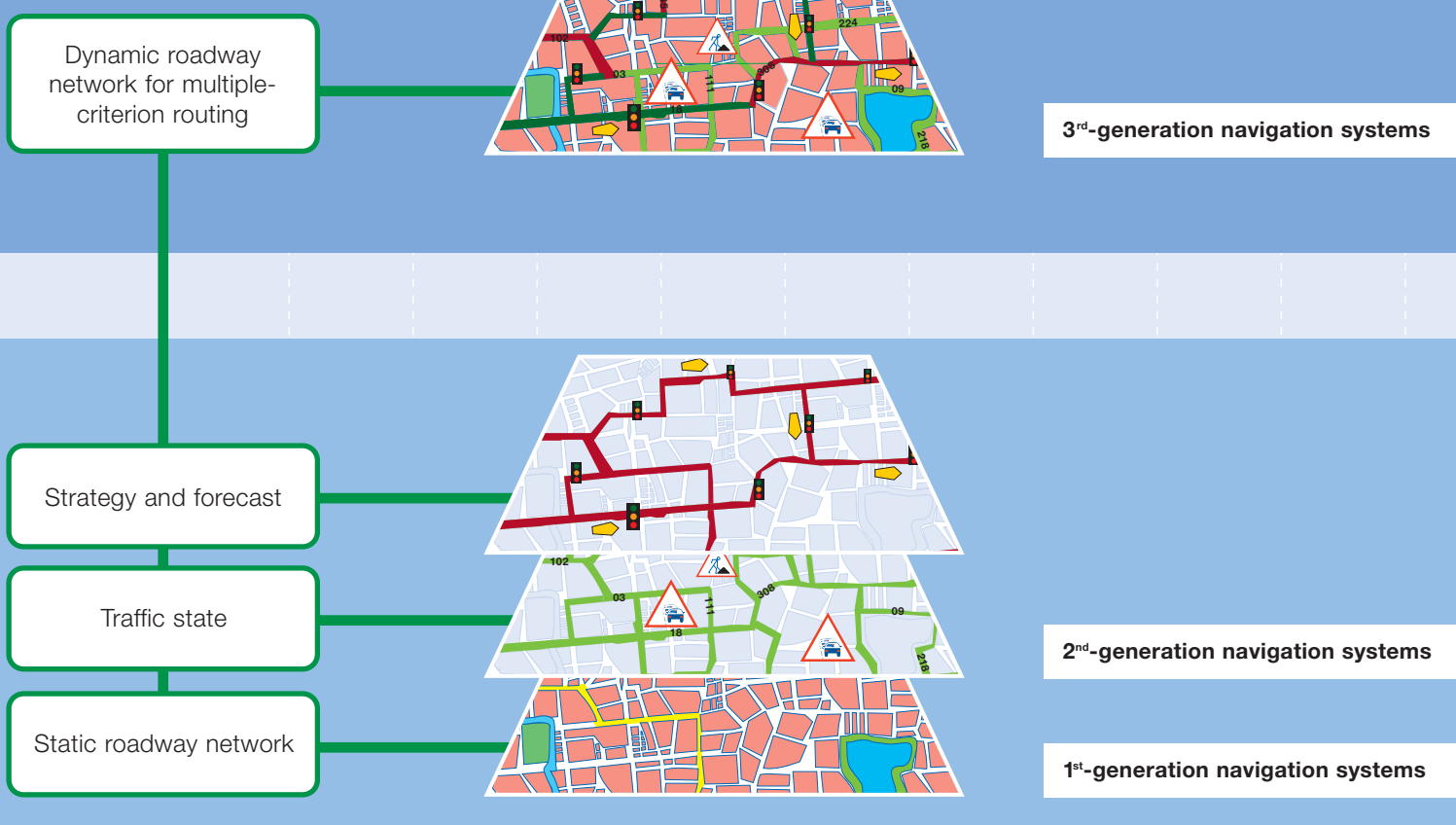


Service Provision

In order to take strategic traffic management requirements into account in route guidance, the component project Traffic Network Equalization is developing new "multiple-criterion" algorithms suitable for implementation in a wide range of navigation devices.

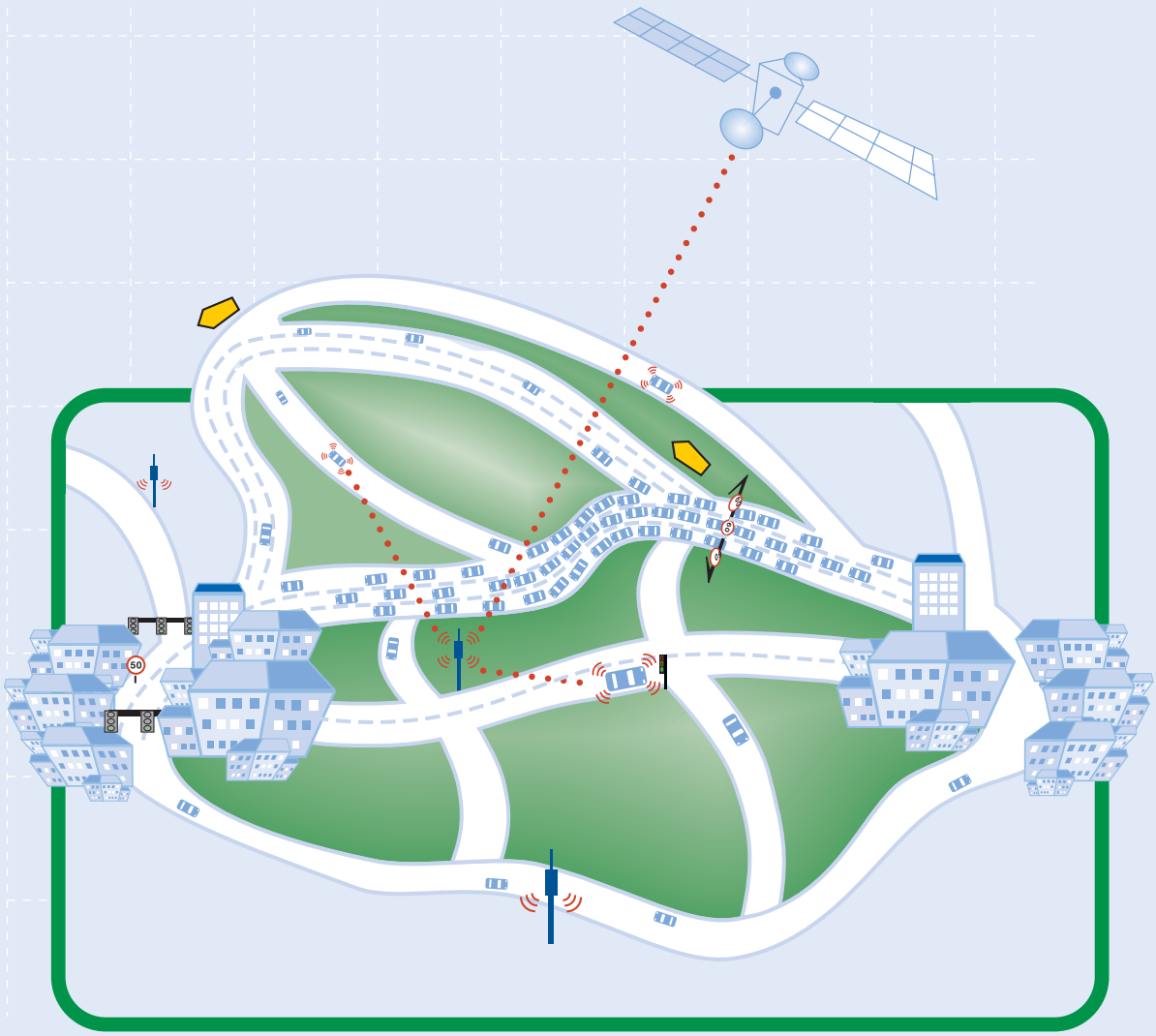
Route planning is performed using a roadway network with dynamic attributes. This network combines criteria from a static digital map with attributes obtained from a reconstruction of the current traffic state, from a forecast of the future traffic state, from a knowledge of traffic management and control strategies.

In the Munich and Magdeburg test sites, two different technologies for computing the route and subsequently transmitting this information into the vehicle will be implemented.



- Waypoint algorithm: The driver transmits his location and destination to a central computer. Taking into account all available traffic information for the roadway network, this computer calculates an individualized route recommendation in the form of a list of waypoints and sends this list back to the navigation device. The vehicle device itself computes the best route between the defined waypoints.

- Sub-net algorithm: The current and future state of the sub-net of the traffic network including relevant traffic control strategies and other attributes are coded and transmitted into the vehicle. The entire route is computed within the vehicle based on this information.



Strategy and Management

In view of the importance of societal consensus in further development of private route guidance systems, an important focus of this component project is to optimize the strategic synthesis of public traffic control policy with individual route guidance. To achieve this goal, private service providers will be given the means to include collective management strategies within the decision support process for route guidance.

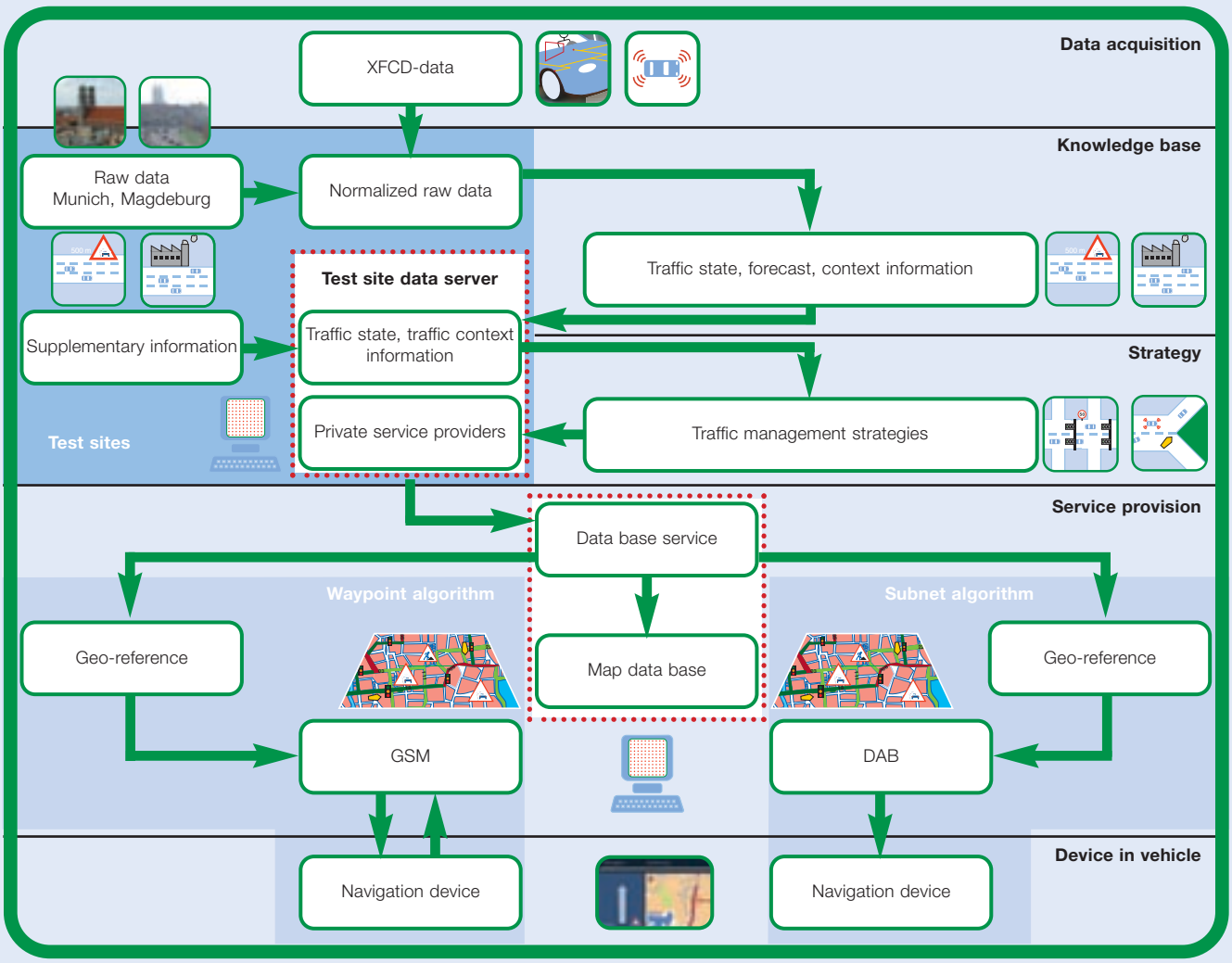
In this way, the component project NIV will prevent undesired potential consequences of unconstrained commercial routing services, such as shortcuts through quiet neighborhood streets. It will also use strategic information on known collective measures to avoid recommendation of routes that the known measures will cause to be slower than otherwise expected. Both the individual and the service will benefit from this aspect of the project. Moreover, the desired effects of public management strategies can actually be enhanced by the ability of route guidance systems to influence a large number of vehicles. Instead of being restricted to collective measures, public traffic control strategies could employ a wider variety of options for influencing traffic flow.

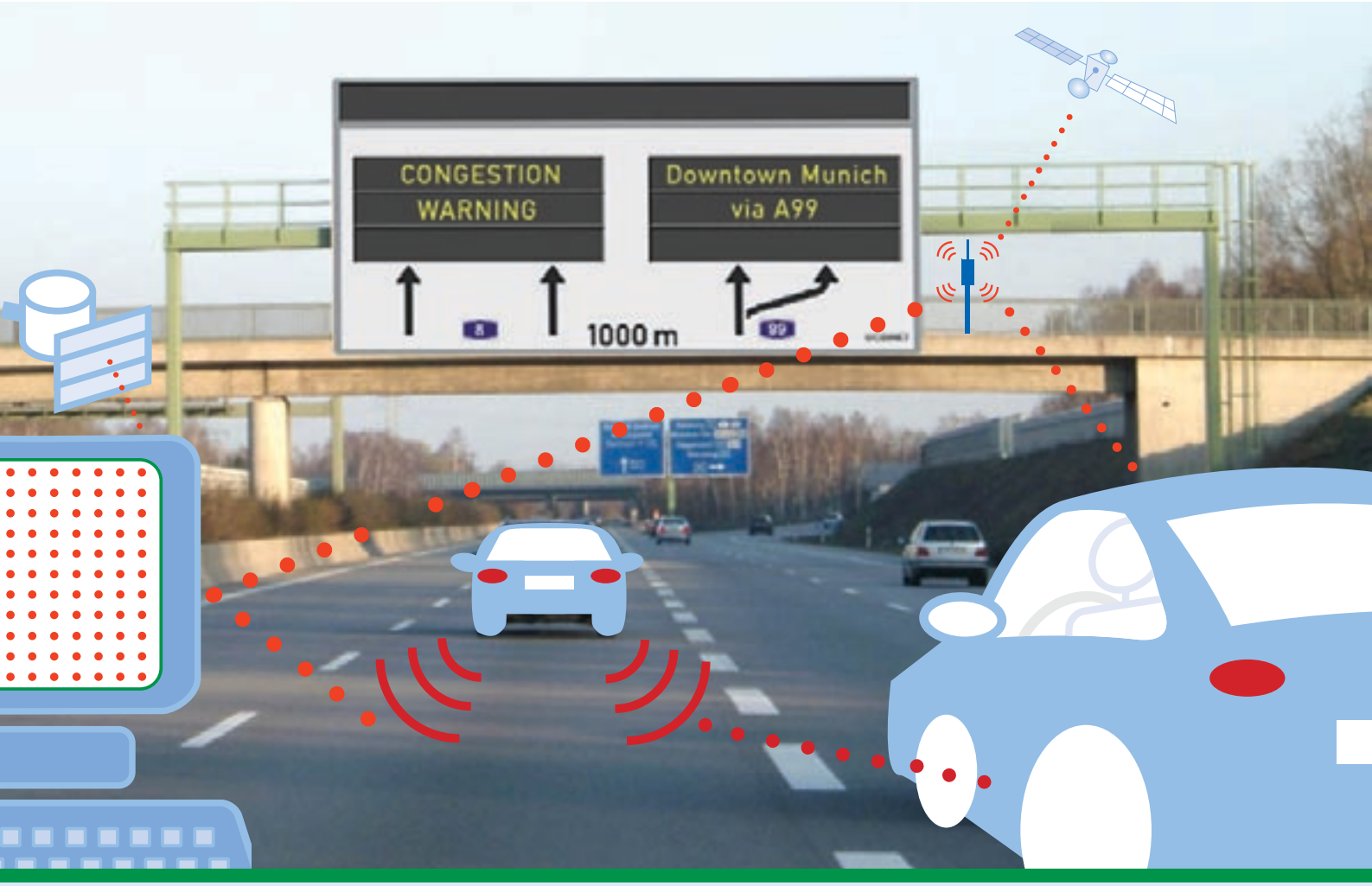
During all project phases, public traffic policy and regulations, principles of traffic management, and technical boundary conditions of the test sites need to be taken into account. In addition, intensive discussion and dialog on organizational and business aspects of strategic traffic management will be promoted throughout the project. Regional strategy forums as well as expert workshops at the national level will be sponsored by the project partners in order to synthesize and reconcile the interests of private and public stakeholders.

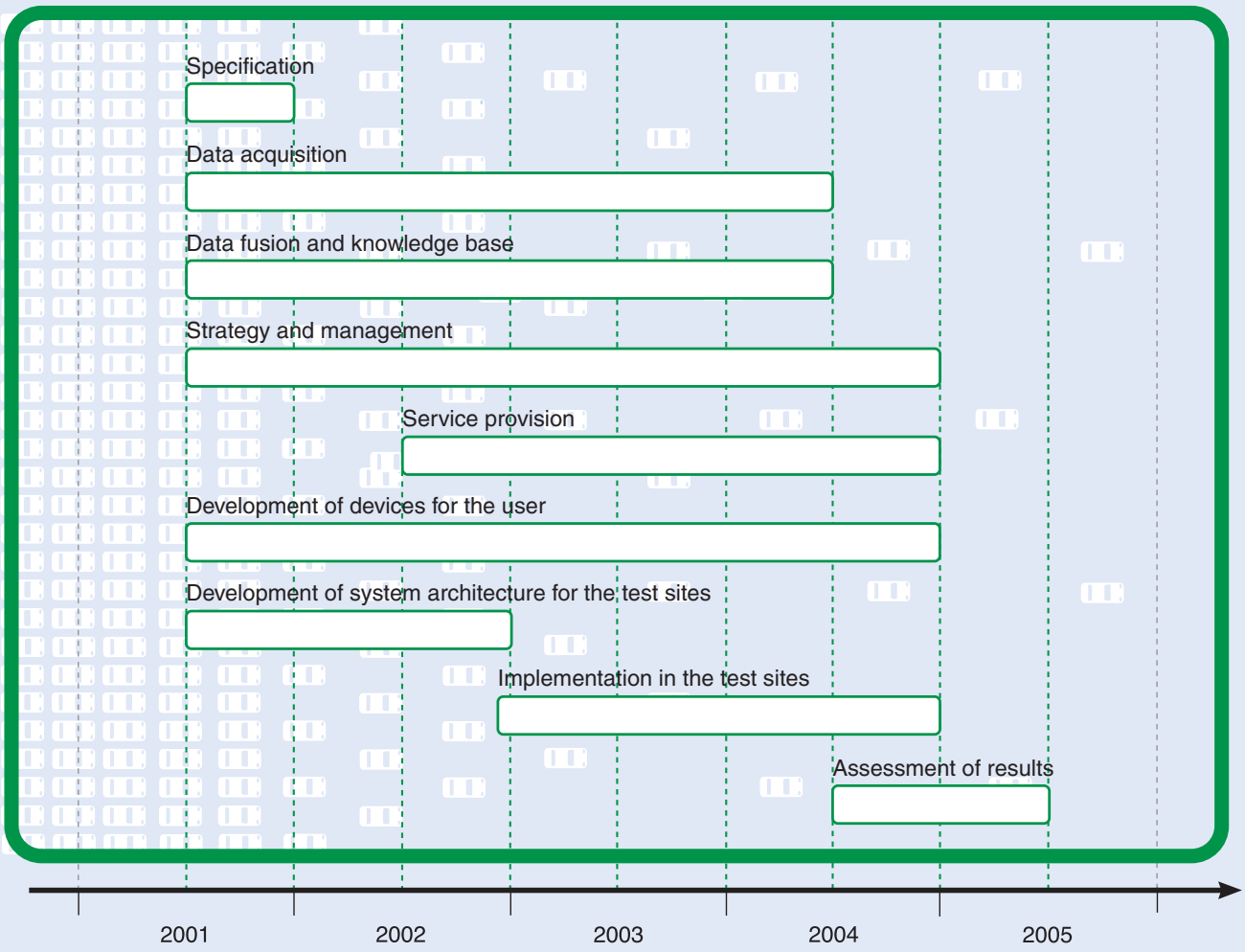
System Architecture

The system architecture of this project will connect the various technological components and integrate them into a coordinated concept.

The information flows and technical interfaces are designed flexibly to allow extensions in response to future requirements in this rapidly evolving field. This flexibility will enable future extension of the knowledge base and a broadening of the spectrum of available services. Anticipated extensions could be of a substantive nature, i.e., improvements in the kinds of services offered, or a geographic extension to new cities and regions.




CONGESTION
WARNING
Downtown Munich
via A99
1000 m


Specification
Data acquisition
Data fusion and knowledge base
Strategy and management
Service provision
Development of devices for the user
Development of system architecture for the test sites
Implementation in the test sites
Assessment of results
2001
2002
2003
2004
2005

User / Device

By weighting the importance of various criteria according to individual preferences in the calculation of an optimal route, it will be feasible to tailor route guidance to the specific needs and preferences of the driver. For example, there could be a difference between the route with the shortest expected travel time to a destination and the most reliable route for arriving at the destination "on time". In the case of the waypoint algorithm, the user requests the service provider to specify a route optimized for his preferences and receives the desired information via an appropriate transmission channel. The reason for a particular route choice should be presented to the user in a plausible way.

For the technical problem of interfacing to a navigation device, the project will use standardized software components providing an exchange of trip-relevant and other required information between the device, vehicle-based information platforms, and stationary information terminals.

Demonstration of Results

The entire strategic approach of Traffic Network Equalization and the prototype solutions are to be demonstrated and assessed within two complementary regional test sites in Munich and Magdeburg, Germany.

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Munich is the capital of the German Federal State of Bavaria with population of about 1.4 million within the city limits. The Munich test area, comprising the northern and northeastern portions of the city's roadway network, was selected because it offers significant technical infrastructure and organizational advantages for traffic management research. The roadway network in the northern area is subject to frequent congestion and incidents due to high traffic demand in this bustling region; in particular, the motorways within the northern area will soon be almost entirely covered by line control systems with variable message signs for speed control and routing advisories. Much of the groundwork involving traffic data acquisition, traffic control, as well as urban and regional management strategies, has already been laid in the project MOBINET, sponsored by the Federal Ministry for Research and Education (BMBF) in Germany. These existing resources will form a foundation for the strategic and methodological approaches in Traffic Network Equalization.

Magdeburg is the capital of the German Federal state of Saxony-Anhalt, located in Eastern Germany. With a population of 230 000, it is a middle-sized urban center. Following a comprehensive renovation of the entire traffic and transport infrastructure during the last decade, a stepwise process of testing and implementation of innovative traffic management components is now being carried out. Considerable support is being provided by agencies in Magdeburg that are associated with this INVENT demonstration as partners, including the City Planning Office, the Civil Engineers Office, the Transport Authority, the Police Department, the Highway Authority, and the Digital Radio Service of Saxony-Anhalt. This test site is intended to demonstrate that, using new methodologies and technologies, traffic management approaches can be implemented at a reasonable cost in middle-sized cities like Magdeburg, and that both private services and public policy can profit from these approaches.

Summary and Perspectives

The INVENT component project Traffic Network Equalization will develop a third-generation route guidance system. This system will be designed to provide each individual user with a recommended route determined according to his personal preferences and at the same time respecting strategic traffic management constraints. The importance of traffic safety and environmental factors will also be included in planning the "optimal" route.

In addition to development and provision of appropriate technologies, an essential element of the project work is the identification and discussion of "win-win" situations for reconciling and synthesizing public and private priorities: First, the new systems have the potential to enhance the effectiveness of public traffic control and management policies and to apply them on a wider scale. Second, by incorporating management strategies in their predictive algorithms, private service providers could obtain more comprehensive information for improved forecasting of travel times and route guidance. Finally, the user will benefit from individually optimized routing.

Viewed in its entirety, this component project is seeking to achieve a benefit for traffic as a whole by use of third-generation navigation devices, because traffic demand will be "equalized", i.e., distributed to utilize the available network more effectively. In this way, the performance of the existing roadway network will be increased; the consequences of rising traffic demand, such as congestion, will be reduced.

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Project partners

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Ford Forschungszentrum Aachen GmbH
Institut für Automation und
Kommunikation e.V. Magdeburg (ifak)
Navigation Technologies NavTech
PTV Planung Transport Verkehr AG
Siemens VDO Automotive AG
Siemens AG
TRANSVER GmbH

supported by the

Federal Ministry
of Education
and Research

In close cooperation with the
Federal Ministry for Transport,
Construction and Housing

Network Traffic Equalization

- will improve modern route guidance systems
- will synthesize individual and public traffic strategies into a single telematic service
- will create a traffic knowledge base for decision support
- will explore new directions for traffic data acquisition
- will demonstrate the implementation in test sites

Traffic Network Equalization NIV

Glossary

GSM	Global System for Mobile Communication: Worldwide leading mobile communication standard of the second generation for voice and data transmission.
DAB	Digital Audio Broadcasting: Terrestrial broadcasting system for digital transmission of radio programs and additional information (data services)
TMC	Traffic Message Channel: TMC is a part of the Radio Data System (RDS), which provides for digital transmission of information parallel to radio programs.
XFCD	eXtended Floating Car Data: Automatic vehicle-based event and traffic state detection supporting detailed, up-to-the-minute data for traffic, environment, and weather information.
MOBINET	Sponsored by the Federal Ministry for Research and Education (BMBF) in Germany, the research project MOBINET is concerned with management of traffic and mobility in the Munich urban area. Comprising 26 partners, the MOBINET project was begun in 1998 and will be completed in 2003.