CONF-960629--1

ISATA Presentation International Symposium on Automotive Technology and Automation

In-Vehicle Signing Functions and Systems Concepts*

by

D. R. Tufano

P. F. Spelt

H. E. Knee

Cognitive Systems and Human Factors Group
Intelligent Systems Section
Computer Science and Mathematics Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee

Florence, ITALY
June 3-6, 1996

---

*Oak Ridge National Laboratory, managed by Lockheed Martin Energy Research Corp. for the U.S. Department of Energy Under contract number DE-AC05-96OR22464.

In-Vehicle Signing Functions and System Concepts

Daniel R. Tufano, Philip F. Spelt, and Helmut E. Knee,
Oak Ridge National Laboratory
United States of America

96ATT049

ABSTRACT

This paper describes functional requirements and system concepts for an In-Vehicle Signing (IVS) system, which will bring information from roadway signs, signals, and pavement markings into the vehicle for presentation to the driver. Information filter functions will assure that the only messages displayed are those which are important to the driver and which apply. Display functions will optimize the presentation of the message to ambient conditions, driver preferences, the number of simultaneous messages, and the urgency of the message. Timing functions will display a sign as soon as it is needed, for the entire time that it applies, and only while it applies. IVS is one of the core components of an integrated In-Vehicle Information System, which will manage and fuse all driving-related information. Two different IVS system concepts have been investigated: one based on a map database, the other on beacon technology. This work is being conducted by the Oak Ridge National Laboratory for the U.S. Federal Highway Administration as part of the Intelligent Transportation System Program.

INTRODUCTION

An IVS system is one which will bring information from roadway signs into the vehicle and present it to the driver, in such a manner that IVS will be an enhancement of the signing technology which is currently on the roads. The functions and system concepts described here represent an initial operating capability to be manifested in a protoype, which will be designed, built, and tested in a follow-on effort. The initial capability will form the basis for future functional and informational enhancements, when IVS is eventually integrated with other driver information systems to become an In-Vehicle Information System (IVIS), which will manage and fuse all driving-related information from many sources. These sources will include all Advanced Traveler Information Systems (ATIS) and related information services developed within the Intelligent Transportation System (ITS) program. The unified system will incorporate the human factors guidelines being developed, under a separate program, by the Battelle Seattle Research Center and its associated team partners (see e.g., 1).

This paper describes the process by which IVS functions were derived. The functions are defined to the system level, since the detailed, subordinate functions are too numerous for the present paper. The system concepts discussion focuses on how the sign information may be brought into the vehicle, since other aspects of IVS (e.g., processor, display) are likely to be the same across concepts. For a more complete accounting of IVS functions and system concepts, the reader is referred to the "Draft In-Vehicle Signing Functional Requirments Specification" (2) and to the "Draft In-Vehicle Information System Analysis: In-Vehicle Signing Concepts" (3), from which substantial portions of this paper were excerpted.

IVS FUNCTIONAL REQUIREMENTS

Flowdown Process

The process of defining the functional requirements of an IVS system began with the stated goal of improving the presentation of roadway sign information to drivers. From this initially stated goal, two high level functional goals were derived: tailor the presentation of sign information to the driver; and tailor the presentation to the operating environment (e.g., the vehicle, the roadway, sign type, weather). Each of the functional goals imply certain classes of information which will be required to fulfill the goals. These classes of information are the supersets of all of the information requirements associated with the lower level functions. Similarly, all of the lower level functional requirements are derived from the functional goals in a hierarchical flowdown

process. This requirements flowdown process provides the audit trail through which all subordinate functions can be traced back to the functional goals and, ultimately, to the top level goal. It also provides the structure for configuration management during the subsequent design phase and supports traceability of all design decisions made in that phase.

The functional goals imply three system objectives to determine: what to display; how to display it; and when to display it. Each objective has information requirements associated with it. These information requirements are varied combinations of the classes of information associated with the two functional goals. In addition, each system objective implies two system level, or primary, functions. The resulting six primary functions comprise varying numbers and levels of subordinate functions. The lower level, subordinate, functions have information requirements which are defined at a much greater level of detail than those associated with the system level functions. The information required by the subordinate functions will be supplied either by other functions, by historical data, or by the driver.

Because of the manner in which functions were derived within the flowdown process, there is necessarily some redundancy in the following narrative descriptions of the different levels of the hierarchy.

IVS Goal

The goal of an IVS system is to enhance roadway sign information and its assimilation by drivers, through the display of sign messages in the vehicle. Two kinds of improvement are sought: signing effectiveness, i.e., the quality of sign information and the ease with which drivers can assimilate it; and safety, i.e., the degree to which signing contributes to, and does not distract from, the driving task. In addition, since such a signing system is likely to be electronic and active, there is the potential legal threat of product and system liability posed by the possibility of system failures. There is, therefore, the associated goal of eliminating or minimizing the legal exposure of private manufacturers of IVS equipment and municipal providers of the IVS infrastructure.

Functional Goals

Two functional goals of the IVS system have been derived from the initially stated goal of improving the presentation of roadway sign information to drivers. These two functional goals state that the type of information presented and the manner in which it is presented, shall be tailored to: the driver; and the operating environment. Tailoring IVS operation to the driver implies information requirements in three classes: the driver's capabilities (e.g., sensory and psychomotor); the driver's goals (e.g., long distance travel along a particular route); and the driver's preferences (e.g., for display modality and sign filtering). Tailoring IVS operation to the operating environment implies requirements for three general classes of information: the sign (e.g., type, message, and location); the driving situation (e.g., vehicle weight and speed, roadway curvature and surface conditions); and the ambient conditions (e.g., light level, glare).

Objectives

Three objectives have been derived from the two functional goals of tailoring the presentation of sign information to the driver and to the operating environment. The first objective, **Detect and Filter**, is to determine which sign messages will be displayed to the driver, and to gather all data which will be required by subsequent functions. The series of information filters, used to determine sign message selection, will involve sign prioritization and sign applicability. The selection criteria applied by the two filters will reflect: driver goals, driver preferences, sign priority, and varying aspects of the driving situation. The second objective, **Display**, is to optimize and adjust the presentation of sign messages to the driver both before and after the activation of a sign display. Display optimization and adjustment shall be in accordance with: ambient conditions, driver capabilities, driver preferences, the number of simultaneous sign messages, and varying aspects of the driving situation contributing to the level of urgency of the sign message. The third objective, **Timing**, is to determine when a sign message display is activated and when it is deactivated. The timing of display activation will provide enough time and distance for the driver and the vehicle to execute an appropriate response. Activation timing will reflect calculations of sight distance requirements, and will take into account: driver capabilities, responses required by each sign, and the driving situation. The timing of display deactivation will mirror the sign applicability information filter. Once a sign message is no longer applicable, it will be deactivated.

System Level Functions

Six system level, or primary functions have been derived from the objectives. These functions represent the initial operating capability of IVS. Each primary function comprises varying numbers and levels of subordinate functions. The six primary functions are:

Sense and Encode Data

The first function which an IVS system will perform is to get information about a roadway sign and the driving situation into the system. This function will be executed first in the sequence of six primary functions performed for each sign detected. This function will perform: detection of the sign's presence, encoding of its type and message, and the determination of the location of the sign and its associated decision point, relative to the vehicle. Sensing and encoding of sign data will be performed continuously for each sign detected. This function will also continuously sense and encode data relevant to the driving situation, which will be required by subsequent functions: spatial conditions, temporal conditions, and operational conditions.

Select Sign Message

The system will select for presentation only sign messages which satisfy both of two information filters. The two information filters will be executed in series. The first filter will apply three sign prioritization criteria: sign type (i.e., regulatory and warning); support of the driver's goals (e.g., route and destination); or meeting the driver's preferences (e.g., for display of other sign categories). A sign message which satisfies any one of the three criteria will pass the first information filter. The second filter will determine whether a sign message is applicable to the relevant conditions: spatial; temporal; and operational. If a sign message does not satisfy all of the appropriate conditions of the second information filter, the system will not select the sign message for presentation to the driver.

Two examples will illustrate how the filtering function will operate. In the first example, a lane restriction sign is detected and passes the first filter because it is a high priority, regulatory sign. If the vehicle is not in the restricted lane, the message will not pass the second filter. If the vehicle is in the restricted lane, but the restriction applies only at a particular time of day which is different from the curent time, the sign message will not be displayed. Finally, if the spatial and temporal conditions are met, but the restriction only applies to a certain class of vehicles (e.g., commercial trucks) different from the vehicle being driven, the sign will be filtered out. In a second example, a driver has entered into the system the intention to follow a specifc numbered route to a specific destination. Even though of relatively low priority, in comparison to regulatory signs, messages related to the route and destination (e.g., mileage distance signs) will be displayed to the driver as long as they meet the conditions of applicability (e.g., vehicle direction of travel). All other guidance and information sign messages will, however, be filtered out. When IVS is eventually integrated with other ITS services and systems, the route selection could be input automatically from (e.g.) a routing and navigation system, an Advanced Traffic Management System (ATMS), or an integration of both.

Optimize Display

The selection of display modality (i.e., audio or visual) and type of display (e.g., head-up display), as well as design of display formats, are decisions which will be made during the design of an IVS system. Display design decisions will determine most of the factors influencing the ease with which sign information is assimilated by the driver, and the degree to which distraction from the driving task is minimized. Once in operation, IVS will optimize and adjust the display of sign information to meet a number of conditions. Drivers will be able to adjust the display to meet their preferences. For example, they will be able to adjust intensity or deselect unwanted display modes (e.g., a voice supplement). Ambient light and noise conditions will be used by the system to adjust, automatically, the intensity and spectral content of visual and auditory displays. When multiple sign messages are selected for display by the filter function, these messages would be either separated over space (i.e., locations) or time (i.e., sequenced) or both, in order to avoid cluttering and driver overload.

Turn Sign Display On

The system will turn on the display of a sign message at a time and distance which will support the execution of an appropriate response by the driver and the vehicle. Estimation of display activation timing will be based on calculation of the time and distance required for the driver and vehicle to execute the required response given current conditions regarding the driver (e.g., reaction time) and the driving situation (e.g., vehicle speed, vehicle weight, roadway coefficient of friction). These calculations will be based on accepted human factors and traffic engineering data and models (4,5).

The rationale for this approach to message timing is as follows. In traffic engineering, the determination of a road sign's size, location, height, etc. is made according to the calculation of the required sight distance. Sight distance requirements (e.g., stopping sight distance) are generally divided into two distances or times: a human component and a physical component (6). The human component comprises the time required by the driver to: detect the sign, recognize its meaning, decide what to do, and respond. The physical component is determined by all of the factors which contribute to how long, in time or distance, it will take for the vehicle to perform the necessary maneuver (e.g., coming to a stop), once the driver has made the proper response (e.g., applying the brakes). The variability of either of these components is quite large. For example, variability in human reaction time is determined by a combination of sensory, perceptual, cognitive, and psychomotor capabilities. Each of these psychological factors varies greatly between individuals, and even within a single individual over time. The physics of a vehicle performing a maneuver are also dependent on a number of factors, e.g.: vehicle weight, vehicle speed, road surface/tire coefficient of friction. The design and placement of current roadway signs generally reflects the selection of one value for each of the many variables which contribute to the determination of required sight distance. For example, 85th percentile vehicle speed on a particular road is used to specify the minimum visibility distance requirements for traffic signals (7). IVS will adjust the time at which a sign display is activated to take into account the variability among: drivers, vehicles, and operating conditions. In this way the driver of a heavy vehicle traveling at a high speed will be alerted of an upcoming requirement to stop well before the driver of a lighter vehicle which is traveling at a lower speed.

Adjust Display

During the presentation of a sign display, the system will adjust the salience of the display in accordance with varying levels of message urgency. The determination of increasing or decreasing urgency will take into account the response required by a sign message and the difference between time and distance required, and time and distance available for the driver and vehicle to execute the required response. Increasing or decreasing display salience will serve two purposes: adjust the conspicuity of a sign message; and convey information to the driver about the changing level of urgency. For example, if a "stop" sign is displayed, and IVS determines that the driver and vehicle are not responding, the visual or auditory salience of the display will increase (e.g., beeping, blinking, addition of a voice supplement, increased intensity).

Turn Sign Display Off

The time at which a sign display is turned off will be determined by a function which mirrors the second selection filter in the filtering function. When a sign message is no longer applicable, it will be deactivated. Offset time will be determined by the same sort of integration of spatial, temporal, and operational conditions described above. This function will accomplish two things. First, a sign message will be displayed for only the amount of time that it is applicable; thus minimizing display clutter and distraction from the driving task. Second, a sign message will be displayed for the entire duration of its applicability (e.g., speed limits, deer crossings); thus eliminating the need for a driver to remember the sign message.

IVS SYSTEM CONCEPTS

This section presents an analysis of two different IVS concepts, one based on a map database stored on CD-ROM disk or a PC-card, containing static sign data. The other technology uses beacons to transmit sign data to the vehicle. An in-vehicle signing system must contain three fundamemtal components to function properly: 1, a data source and storage system; 2, an in-vehicle information processing system which filters and prepares the sign informaiton for display; and 3, an in-vehicle display system which provides the output interface to the driver. These functional components are described more fully in the IVS system analysis report (3). The two system concepts presented here differ only in the first component, the data source and stroage mechanism. It is assumed that a single design of the in-vehicle components (information processing and display) is sufficient for any type of external or internal data source.

Map-based IVS system

A map-based system takes advantage of recent developments in both digital maps on CD ROM, and in map-following routines which run on relatively inexpensive lap-top computers. A system such as that presented by Sweeney et al. (8), contains a digitized map of the region in which the driver wishes to travel, along with a sophisticated map-following algorithm which places the vehicle on the map congruent with its actual location. However, it should be noted that the concept of a map-based system does not necessarily imply that the IVS system will present a visual map to the driver. Rather, the system uses the map and map-following algorithm as a database for obtaining and presenting sign information. In this scheme, weather, traffic, and other variable message sign information is conveyed by the infrastructure, through a wide-area wireless broadcast. Note in Figure 2 that the map-based system lies at the apex represented in the allocation space as the "smart vehicle" point, illustrating that the smart vehicle concept originally developed merely as a design space anchor point is also a practical one.

For any IVS system, three types of data are required, and the sources for each must be specified. Those data types are: sign data, situation data, and driver-related variables.

Sign data comprises three types, information about static (permanent) signs, dynamic information from VMSs, and temporary signs such as those used to designate detours. Static sign data (sign type/message and location) for the map-based system can be stored in the digital database comprising the digital map on the fixed data storage medium (CD-ROM or PC-card). Dynamic sign information must be transmitted to the IVS system from the infrastructure. A precoded set of standard messages used on regional VMSs can be stored in the digital database, reducing the amount of information which must be transmitted.

Situation data is information about the general driving environment which affect driving speed and route selection. Situation data consists of three types, static vehicle information, dynamic vehicle information, and extra-vehicle information about traffic patterns and weather conditions. Vehicle information is obtained from the vehicle. Information about local traffic conditions and weather patterns, as well as other types of information necessary to safe vehicle operation and calculation of appropriate IVS display (such as ambient light and noise) must be either broadcast from the infrastructure or obtained from vehicle sensors, as appropriate.

Driver data include preferences relating to display charcteristics (brightness or loudness) or route to be followed, and personal variables which might affect driving, such as age, visual imparement, etc. Input of driver preferences is accomplished by use of an IVS system input device. Input of trip preferences must be accomplished prior to departure, and safety considerations must determine availability of preference modification during vehicle motion. Should driver preferences for a trip be updated or changed at any point in the trip the system will immediately and automatically adapt to the new preferences. Failure to input trip-specific preferences will result in automatic selection of default preferences selected by the driver at initiation of the system in the vehicle. In turn, failure to specify driver-specific default preferences must result in automatic selection of a default standard set of system preferences. Driver variables comprise relatively long-term (quasi-permanent) characteristics of the driver, such as age and general health conditions which might affect driving. Such data can be entered onto a PC-card for storage, and transferred to the IVS system when the driver enters the vehicle. Such an arrangement permits multiple drivers to operate the vehicle, with the IVS system being simply tailored to each driver by the information contained on the smart card.

For a CD ROM- and/or PC-card-based system, most data can be stored on the memory device, and accessed by the IVS computer as needed. There are problems with data stored in read-only memory (ROM), in that even "permanent" signs such as STOP signs occasionally change location or are removed, and therefore periodic updates to the ROM databases must be made. For CD-ROM this requires a new disk, for the "smart card" system a new card is required. Users who do not update their system present a potential safety risk on the road.

Beacon-based Systems

Beacon-based systems use technology which transmits sign information (static, and possibly dynamic) from the infrastructure to the vehicle. The same kinds of information are required as for a map-based system, only the information sources vary. Similarly, the same information processing and display procedures apply. With beacon-based technology, the information contained in the map database for the previous concept must be transmitted to the vehicle by a number of transmitters or beacons. The number of beacons per area has fixed bounds: the upper limit is one beacon per sign, while the lower limit is one beacon for a large geographical area. Between these two extremes lie an almost unlimited number of options. Factors to be considered with beacon technology include the number of beacons for a given area, the bandwidth of the transmission necessary to carry all the needed data, and the costs of building and installing beacons. The latter two variables are dependent on the number of beacons. The fewer the number of beacons used to cover a given area, the larger the bandwidth must be to transmit all the sign information. On the other hand, the greater the number of beacons, the greater the cost for that area.

One Beacon Per Sign

At one extreme is the model that normally comes to mind when the term "instrumented sign" is mentioned. In this system, each sign transmits its identity (static sign information) to the vehicle as it approaches the sign. Dynamic information, of course, must still be broadcast to the vehicle. This concept has been demonstrated on an experimental basis by the 3-M Corporation (9), in a system in which a STOP sign and a YIELD sign transmit a radio signal causing an appropriate sign icon to appear on an LCD screen inside a vehicle. Another concept uses a passive transceiver built into the sign to modulate and reflect back an energy transmission from the vehicle. These two types of instrumented sign, each with its own set of liabilities and assets, represent the two extremes in terms of per-sign cost -- the radio transmitter being the most expensive option, the passive modulating reflector being the cheapest. Nevertheless, the one-beacon-per-sign concept creates the highest infrastructure cost, and it seems likely that this cost would be borne by some governmental entity.

Narrow Area Regional Broadcast (NARB)

Toward the other extreme, the NARB concept uses one beacon for a larger geographical area. The beacon transmits static sign data (message, location and direction of applicability along the road) and can also be used to relay dynamic information for traffic and weather. Because many fewer beacons are needed than for the preceding concept, the infrastructure modification costs are reduced. However, the complexity of the information and the number of signs per beacon create a larger bandwidth requirement than the one-beacon-per-sign model At some point, the required bandwidth could be greater than the off-board system can transmit and the on-board system can process in real time. Moreover, there would be a considerable amount of unneeded information transmitted, since a vehicle typically only needs a fraction of the information available from the fixed sign base currently in the infrastructure. Other problems exist with the NARB concept. The spacing of signs along a rural interstate highway makes that setting ideal for use of relatively few beacons, as does the fact that there are few intersections which require signs and where vehicles can change direction and hence need new sign information. On the other hand, a metropolitan area with many intersections and a consequently higher sign density, presents a significant challenge to the NARB concept.

An example of such a broadcast system has been implemented with the Traffic and Road Information Communication System (TRICS) in Europe (10). The TRICS system uses a 5.8 GHz radio communications technology to bi-directional transmission between vehicles on the roadway and roadside beacons. Two bandwidths are used for the roadside-to-vehicle (downlink) transmission, 500kbit/sec and 250 kbit/sec, to accommodate various equipment suppliers. For the uplink, 125 kbit/sec is used. This technology has a number of technical standards created (such as the bitrates just cited), transmission protocols, and data formats. Such a system demonstrates the feasibility of a mechanism for a NARB system. The TRICS technology also includes the ability to provide various types of traffic information gleaned from the uplink portion of the system, or to serve an automatic toll-debiting function.

A hybrid IVS system

A hybrid IVS system can be created by combining map-based and beacon-based concepts to cover all regions. Such a system requires that both tehcnologies be installed in vehicles, but the cost would not be excessive because the vehicle requires a receiver for wireless broadcast even with the map-based system. In metropolitan areas where sign and poplulation density are quite high, a map-based system used as a database for the IVS system may be more economically attarctive to commercial database providers. In less densely populated areas, including rural ones, beacon technology could more easily provide the signage information. This approach also permits the flexibility of broadcast signals to operate in areas where population growth is most likely, which results in changing traffic patterns and therefore in changing signage. Beacon technology would require only changes to a single database, the one from which sign information is transmitted, rather than to all the databases which reside in individual vehicles with the map-based concept.

As with the other system concepts, there are problems with this hybrid concept which must be solved during the design process. One of the biggest problems is defining the transition stage from map- to beacon-based information sources. Issues such as the sizes of the metropolitan areas which can best be served by the two different technologies, and the prediction of where population growth is likely to occur, must be addressed. Of course, there is no reason why an area could not be served at different times by the two different technologies, depending on whether signage is static or changing.

SUMMARY AND CONCLUSIONS

The functional requirements defined for IVS constitute an initial operating capability for IVIS that will determine what sign information to display to drivers, how it will be displayed, and when it will be displayed. A structured requirements flowdown process was created to support the definition of six system level functions and their associated subordinate functions and information requirements. The flowdown process will permit traceability of all levels of requirements and subsequent design decisions back to the IVS goal.

The alternative system concepts for IVS differ only in the ways in which sign information will be brought into the system. Map-based and beacon-based concepts were discussed, as well as the issues associated with a hybrid system.

ACKNOWLEDGEMENTS

This work was supported by the Federal Highway Administration under contract #1883E020-A1.

REFERENCES

1. J.D. Lee, J. Morgan, W.A. Wheeler, M. Hulse, and T.A. Dingus, Development of Human Factors Guidelines for Advanced Traveler Information Systems and Commercial Vehicle Operations: Task C Working Paper: Description of ATIS/CVO Functions (Washington, D.C.: U.S. Department of Transportation, FHWA, 1993).

2. D.R. Tufano, In-Vehicle Signing Functional Requirements Specification, draft report, (Washington, D.C.: U.S. Department of Transportation, FHWA, 1995).

3. P.F. Spelt, In-Vehicle Information System Analysis: In-Vehicle Signing Concepts, draft report, (Washington, D.C.: U.S. Department of Transportation, FHWA, 1995).

4. D.J. Mace and R. Gabel, "Modeling Highway Visibility: Minimum Required Visibility Distance," Proceedings of the 71st Annual Meeting of the Transportation Research Board (Paper No. 920709). (Washington, D.C.: TRB, 1992).

5. H.W. McGee and W. Moore, B.G. Knapp, and J.H. Sanders, Decision Sight Distance for Highway Design and Traffic Control Requirements, Report No. FHWA-RD-78-78. (Washington, D.C.: U.S. Department of Transportation, FHWA,1978)

6. American Association of State Highway and Transportation Officials, A Policy on Geometric Design of Highways and Streets, (Washington, D.C.: AASHTO, 1990), pp. 117-129.

7. Federal Highway Administration, Manual on Uniform Traffic Control Devices, (Washington, D.C.: U.S. Department of Transportation, FHWA, 1988), p.4B-11.

8. L.E. Sweeney, Jr., A. Norman, & M. White, In-vehicle navigation with standard portable PCs. Proceedings of the 1995 Annual Meeting of ITS America, Washington, D.C., March 15-17, 1995

9. Bhandal, A. S., W. Deltefsen, J. Graf, and P. K. Kimber Progress towards a European standard on 5.8 GHz microwave short range communication systems for road traffic informatics. Journal of International Mechanical Engineering, pp. 57-60, 1994.

9. H. Bantli, Instrumented STOP and YIELD sign to transmit to a vehicle display. Personal communication, 1994.

In-Vehicle Signing Functions and System Concepts

Daniel R. Tufano, Philip F. Spelt, and Helmut E. Knee,
Oak Ridge National Laboratory
United States of America

96ATT049

ABSTRACT

This paper describes functional requirements and system concepts for an In-Vehicle Signing (IVS) system, which will bring information from roadway signs, signals, and pavement markings into the vehicle for presentation to the driver. Information filter functions will assure that the only messages displayed are those which are important to the driver and which apply. Display functions will optimize the presentation of the message to ambient conditions, driver preferences, the number of simultaneous messages, and the urgency of the message. Timing functions will display a sign as soon as it is needed, for the entire time that it applies, and only while it applies. IVS is one of the core components of an integrated In-Vehicle Information System, which will manage and fuse all driving-related information. Two different IVS system concepts have been investigated: one based on a map database, the other on beacon technology. This work is being conducted by the Oak Ridge National Laboratory for the U.S. Federal Highway Administration as part of the Intelligent Transportation System Program.

INTRODUCTION

An IVS system is one which will bring information from roadway signs into the vehicle and present it to the driver, in such a manner that IVS will be an enhancement of the signing technology which is currently on the roads. The functions and system concepts described here represent an initial operating capability to be manifested in a protoype, which will be designed, built, and tested in a follow-on effort. The initial capability will form the basis for future functional and informational enhancements, when IVS is eventually integrated with other driver information systems to become an In-Vehicle Information System (IVIS), which will manage and fuse all driving-related information from many sources. These sources will include all Advanced Traveler Information Systems (ATIS) and related information services developed within the Intelligent Transportation System (ITS) program. The unified system will incorporate the human factors guidelines being developed, under a separate program, by the Battelle Seattle Research Center and its associated team partners (see e.g., 1).

This paper describes the process by which IVS functions were derived. The functions are defined to the system level, since the detailed, subordinate functions are too numerous for the present paper. The system concepts discussion focuses on how the sign information may be brought into the vehicle, since other aspects of IVS (e.g., processor, display) are likely to be the same across concepts. For a more complete accounting of IVS functions and system concepts, the reader is referred to the "Draft In-Vehicle Signing Functional Requirments Specification" (2) and to the "Draft In-Vehicle Information System Analysis: In-Vehicle Signing Concepts" (3), from which substantial portions of this paper were excerpted.

IVS FUNCTIONAL REQUIREMENTS

Flowdown Process

The process of defining the functional requirements of an IVS system began with the stated goal of improving the presentation of roadway sign information to drivers. From this initially stated goal, two high level functional goals were derived: tailor the presentation of sign information to the driver; and tailor the presentation to the operating environment (e.g., the vehicle, the roadway, sign type, weather). Each of the functional goals imply certain classes of information which will be required to fulfill the goals. These classes of information are the supersets of all of the information requirements associated with the lower level functions. Similarly, all of the lower level functional requirements are derived from the functional goals in a hierarchical flowdown

In-Vehicle Signing Functions and System Concepts

Daniel R. Tufano, Philip F. Spelt, and Helmut E. Knee,
Oak Ridge National Laboratory
United States of America

96ATT049

ABSTRACT

This paper describes functional requirements and system concepts for an In-Vehicle Signing (IVS) system, which will bring information from roadway signs, signals, and pavement markings into the vehicle for presentation to the driver. Information filter functions will assure that the only messages displayed are those which are important to the driver and which apply. Display functions will optimize the presentation of the message to ambient conditions, driver preferences, the number of simultaneous messages, and the urgency of the message. Timing functions will display a sign as soon as it is needed, for the entire time that it applies, and only while it applies. IVS is one of the core components of an integrated In-Vehicle Information System, which will manage and fuse all driving-related information. Two different IVS system concepts have been investigated: one based on a map database, the other on beacon technology. This work is being conducted by the Oak Ridge National Laboratory for the U.S. Federal Highway Administration as part of the Intelligent Transportation System Program.

INTRODUCTION

An IVS system is one which will bring information from roadway signs into the vehicle and present it to the driver, in such a manner that IVS will be an enhancement of the signing technology which is currently on the roads. The functions and system concepts described here represent an initial operating capability to be manifested in a protoype, which will be designed, built, and tested in a follow-on effort. The initial capability will form the basis for future functional and informational enhancements, when IVS is eventually integrated with other driver information systems to become an In-Vehicle Information System (IVIS), which will manage and fuse all driving-related information from many sources. These sources will include all Advanced Traveler Information Systems (ATIS) and related information services developed within the Intelligent Transportation System (ITS) program. The unified system will incorporate the human factors guidelines being developed, under a separate program, by the Battelle Seattle Research Center and its associated team partners (see e.g., 1).

This paper describes the process by which IVS functions were derived. The functions are defined to the system level, since the detailed, subordinate functions are too numerous for the present paper. The system concepts discussion focuses on how the sign information may be brought into the vehicle, since other aspects of IVS (e.g., processor, display) are likely to be the same across concepts. For a more complete accounting of IVS functions and system concepts, the reader is referred to the "Draft In-Vehicle Signing Functional Requirments Specification" (2) and to the "Draft In-Vehicle Information System Analysis: In-Vehicle Signing Concepts" (3), from which substantial portions of this paper were excerpted.

IVS FUNCTIONAL REQUIREMENTS

Flowdown Process

The process of defining the functional requirements of an IVS system began with the stated goal of improving the presentation of roadway sign information to drivers. From this initially stated goal, two high level functional goals were derived: tailor the presentation of sign information to the driver; and tailor the presentation to the operating environment (e.g., the vehicle, the roadway, sign type, weather). Each of the functional goals imply certain classes of information which will be required to fulfill the goals. These classes of information are the supersets of all of the information requirements associated with the lower level functions. Similarly, all of the lower level functional requirements are derived from the functional goals in a hierarchical flowdown