

STANDARDS FOR DRIVER INFORMATION SYSTEMS

Luc Heres
Philips Car Systems, CIS-lab
Building SK-3, PO Box 80002
5600 JB Eindhoven, The Netherlands

Abstract

Many Driver Information Systems, especially those that provide location information and route guidance instructions, rely on some form of digital map data, i.e. data that represent the location and other properties of earth-bound objects.

A deeper information analysis of the data needs of the systems reveals that many needs are very close to the demands that a human navigator makes on a classical paper map. But it also reveals some hidden needs, which relate to the fact that the current Driver Information Systems have only a very poor or no general knowledge.

To guarantee the efficiency of a road network database and to guarantee the exchangeability of traffic messages, a certain standardization will be inevitable. One possibility is to standardize the finished article, i.e. the map data in the form in which they are represented on the medium used by the system itself (e.g. CD, coded beacon message). This is the solution that has been chosen in Japan, where a CD-ROM based standard has been defined. It is also the solution chosen by the European manufacturers of beacon-supported systems such as Autoguide and LISB, who have defined a standard for the road-vehicle communication link. Another possibility is to standardize the semi-manufactured article, i.e. the map data as they occur in a general purpose road database or in the datafiles produced by data suppliers. This solution has been chosen by the partners in the project European Digital Road Map and had led to their GDF, in which they define the data contents, the data model, the data structures and the record format for these files. If the systems are going to combine data coming from different sources, the need arises for standard reference numbers. This means that an organizational

infrastructure will have to be set up to create and maintain such a reference numbering system.

Introduction

The term "Driver Information Systems" is a generic term that covers a wide range of different systems. These systems differ in functionality: some systems only determine the position of the vehicle and display this on a small screen, whereas other systems also have route planning and route guidance facilities. These systems differ also in their technical implementation: some of them are stand-alone systems that have all the necessary system components on board the vehicles, whereas other systems rely on one or more components outside the vehicle to which they are connected by means of satellites, beacons or other communication devices. What all these systems have in common, however, is that they rely to some extent on a certain amount of geographical data, i.e. data that represent the location and other properties of earth-bound objects.

This article endeavours to present a summary of these data. It further describes the efforts currently being undertaken in Europe, the United States and Japan to achieve a certain degree of standardization in this field.

System functions

A Driver Information System will always have one or more of the following functions:

- Gazetteer: allows the driver to specify a geographic location by translating an address given in terms of a street name, a town name and such like into an internal, system dependent, reference number.
- Positioning: constantly determines the position of the vehicle.
- Route Planning: looks for the best route to reach a given destination.
- Route Guidance: gives audio-visual driving instructions.

- Driver Information: gives general information about weather conditions, tourist attractions etc.
- Pre-journey Planning: helps the driver to select a destination (e.g. hotel, restaurant, camp site) appropriate to his wishes and financial means.
- Map Display: Shows geographic information in graphic form on a display.

Data needs

All these functions have their own particular data needs.

The Gazetteer needs proper names of objects of all kinds, in particular streets, public buildings, settlements and political areas. Also the relationships between these objects must be known. Knowledge about house number ranges may improve the performance.

In theory it should be possible to build a Positioning function that does not require any map data at all. In practice, however, all current systems make use of a sub-routine that corrects the measured position, if necessary, by comparing it with a digital representation of the road centre lines, as this representation is supposed to have a higher accuracy than the measured position [Thoone, 1987]. This implies that the Positioning function requires an accurate and reliable representation of the position and shape of the road network.

The Route Planning function first of all needs a correct knowledge of the topology of the road network, i.e. knowledge about what roads are directly connected to each other and what roads cross each other by means of a bridge or a viaduct. Furthermore, this function needs to know some particular features of the roads. The most important features are road classes and traffic restrictions (one way roads, prohibited turns, private roads etc.). The performance may further be improved by means of data on average traffic speed, road gradient, scenic value, variation of travel throughout the day, junction turning delays and by means of dynamic information about road works, deviations and traffic jams.

The Route Guidance function is oriented towards a more aggregated and

generalized view of the road network. It needs to know what carriageways together form a motorway and what road elements constitute an intersection or roundabout. The performance can be improved by including the town names and road numbers that occur on sign posts.

The Driver Information function needs a diversity of data, ranging from static data about the presence of objects of interest along the road side (e.g. petrol stations) to dynamic data about weather conditions and traffic accidents.

The Pre-journey Planning function requires information about places of interest such as hotels, restaurants, museums, theatres, including data about prices, opening times etc.

To be able to produce a readable map image, the Map Display function needs data about land use units (forests, water, built-up areas), railways, rivers, canals and other landmarks.

All these demands correspond broadly to the data needs of a human navigator. That is the reason why many of these data can be found in a more or less explicit form on town plans, road maps and tourist guides. However, there are some important differences. The first one is that human navigators all have some general geographic knowledge that helps them to read and to interpret the maps in a sensible way, filtering out all nonsensical interpretations. Current Driver Information Systems do not have this general knowledge, or have it in a poor rudimentary form at most. This implies that these systems expect this general knowledge to be built in some form into the data. Good examples are the generalized and aggregated representations required by the Route Guidance function. A second difference is that a human navigator uses other "sensors" than a Driver Information System (DIS) does. A Driver Information System has sensors (compass, GPS etc.) that give very reliable information about the position of the vehicle but which do not provide any information about the direct neighbourhood. A human navigator on the other hand, is very poor in keeping up his absolute position but has sensors (eyes) that provide him with very detailed information about his direct surroundings. This means that the interaction between a human navigator and a paper map will

be different from the interaction between a Driver Information System and the geographic database, not only on the physical level, but also on a more conceptual level.

Standards for static data

If two persons work in an independent way on a data model, data structures and formats in order to represent the required information as mentioned above, they will come to different solutions. In principle it will be possible to translate the information represented in the data model of the one into the data model of the other. However, when the models and structures used are quite different, and usually they will be, this translation is a cumbersome task.

That is the reason why everyone working in this field feels a need for some degree of standardization.

Several standardization plans are underway, each addressing a specific topic.

They can be split into attempts to standardize the data in the form in which

they are represented on or in the finished article (e.g. on a CD, or in the database that is connected to a road beacon) and into attempts to standardize

the map data in the form they are represented in some semi-manufactured

articles (e.g. a general purpose database or datafiles)

Standardization of the finished article

A first standard to be mentioned is the CD-I standard as proposed by Philips

and Sony and supported by Matsushita. This standard specifies how datafiles

should be organised on a CD. It is based on the CD-DA (Digital Audio) and CD-

ROM (Read Only Memory) standards. The use of the CD-I standard guarantees

compatibility between any CD-I player and any CD-I formatted disk.

To a certain extent it can be stated that CD-I plays the same role for CD-

based information systems as MS-DOS currently plays for personal computers.

This means that compatibility up to the operating system level is guaranteed.

However to guarantee that a particular application program can work with a

particular set of data, also the higher order data structures have to be

standardized [Thoone, 1987], [Gall 1986].

This approach has been followed in Japan. In this country the Navigation System Study Group, in which all major Japanese automotive, electronic and mapping companies are represented, has defined a CD-MAP standard which, like CD-I, is based on the CD-ROM standard but entirely oriented to the representation of geographical data, road data in particular. CD-MAP distinguishes four different "layers". One layer gives a topologically structured description of the road network, including a road classification, and is able to support a map matching function. The other three layers are more graphically oriented and only able to support the visualisation function. One of these graphic layers is meant for area symbols (forests, built-up areas etc), the second one for point symbols and the third one for the textual contents of the map. A CD produced according to this standard can be read by every CD-ROM player and can be used by any CD-MAP oriented application program. The functionality of these programs is, naturally, limited by the kind of data being stored. As release CD-MAP 1.0 contained only the road geometry and a rough road classification, this solely allows applications that have a positioning and a visualisation function. Release 2.0, however, is extended with information about one way roads and other traffic restrictions, thus also allowing a route planning function to be supported.

A third product that has to be mentioned in this context is the Draft Standard for the Road-Vehicle Communications Link which has been developed and published by the British and German Departments of Transport. This standard is strongly related to beacon-supported navigation systems such as Autoguide and Euroscout. It provides specifications for how to structure and format the information to be transmitted from beacon and vehicle or vice versa. This information contains all the necessary data elements to support vehicle location, route planning and route guidance.
[Department of Transport, 1988]

Standardization of the semi-manufactured article Philips and Bosch, each working on a car navigation system (called Carin and Eva respectively), both realized at an early stage that standardization in the field of map data was essential, because otherwise the systems could never

become cost-effective.
However, standardization of the finished article (the CD) was not possible, at least not at short notice, because different computing devices, using processors of different families (Intel and Motorola), had already been chosen by each company.
That was the reason why the solution was sought in a common road network database, containing all required information for both systems, from which each individual system could extract all information required. A Eureka project called Demeter (Digital Electronic Mapping of European Territory) was created for this purpose. [Claussen et al., 1988]
A first step was the definition of common specifications for data acquisition and representation, thus allowing data collected and digitized on behalf of one company to be used without additional effort by the other as well. This resulted in a Draft Standard called Geographic Data Files 1.0, shortened to GDF [Philips and Robert Bosch, 1988].
GDF 1.0, based on the data needs of car navigation systems only, has been evaluated in the DRIVE projects PANDORA and Task Force EDRM [McCallum, 1991] [Möhlenbrink, 1991]. The results of these evaluations have been used to improve the specifications and to extend GDF to include the needs of other applications using road traffic information [Claussen et al., 1989]. This has resulted in GDF 2.0, which was released in December 1991 and which will be commercially available in February 1992.
The structure of the documents has been adapted: GDF now contains 9 different volumes, each addressing a particular topic. These topics have been chosen such that the number of interdependencies are kept to a minimum. This makes it possible to produce independent updates of the different volumes. In fact, the individual volumes can be considered as standards in their own right, together forming a family of standards.

After Volume 1, which is the general introduction, GDF has 3 "catalogues": the Feature, the Attribute and the Relationship Catalogue respectively. They each correspond to one of the three fundamental grammatical categories which are distinguished nowadays in geo-linguistics: the "feature", the "attribute" and the "relationship".
The Feature Catalogue provides clear definitions about concepts such as

roads, buildings, administrative areas and settlements that are the concern of the area of application of the GDF - namely the road environment. The Attribute Catalogue defines the characteristics of each feature. The Relationship Catalogue describes relations between features that may be used to convey information in a realistic manner, for example a relationship between road elements and buildings such that a building "is along" a road element.

The next volume is the Feature Representation Scheme, which provides the link between the realm of features and the realm of "cartographic primitives" (Nodes, Edges and Faces), widely used in modern geographic information systems. For each feature class the primitive by which it must or may be represented, is specified. The main reason for keeping the feature representation separate from the feature definitions, is to allow for a situation in which two different application fields use the same Feature Catalogue, but different Feature Representation Schemes (e.g. buildings seen as point features in the one and as area features in the other).

Volume 6 is the Data Content and Quality Specification. It indicates which data are required for the various applications. For example, Vehicle Navigation Systems have different requirements to Highway Maintenance Systems or other Road Traffic Information Systems.

The last 3 volumes have been designed for the particular case where users want to transfer data from one data base system to another of a different make.

The first of these "Data Transfer Volumes" is the Global Data Catalogue. It specifies what data of an administrative nature should go with the actual geographic data. These data become important when users start to exchange geographic data in industrial quantities. Without this additional "meta" information, the identification and registration of the individual files will be a cumbersome task.

The next volume is that containing the Logical Record Specifications. Here a number of data structures (records) are defined that make it possible to represent the global and geographic data modelled according to the preceding volumes. The data structures have been designed specially for data transfer and exchange and have been kept as simple as possible. They do not contain constructs as indexes and do not require particular record sequences. The record specifications are "logical" in the sense that they do not specify

what kind of field and record controls have to be used to let a user system know where field and records start and end. This specifications can be found in the final GDF volume, the Media Record Specifications. The current GDF still uses a field and record control technique which has been inherited from the British NTF. For future versions of GDF however, use will be made of the ISO 8211 standard, which is being increasingly used for data transfers.

Standard reference systems

As long as systems use only one information source at the same time, there will be no need to use standard references. Each system may use its own coordinate values and its own link and node numbers and this will work as long as these remain consistent. However, if systems use information from different, independent sources (e.g. static map data from a CD in combination with traffic messages from a dynamic Road Traffic Information System), the need arises for common references, because otherwise the information cannot be combined in a useful way. One approach is to use a common coordinate system (e.g. geographical coordinates or UTM, allowing road elements to be addressed by means of their coordinates. The advantage of this approach is that the effort devoted to standardization can be kept to a minimum. The disadvantages of this approach are of a technical nature. Two databases that have been created independently of each other will, due to idealisation and other inaccuracies, never share exactly the same coordinate values for one and the same object (e.g. a road junction); these will only be more or less the same. It is possible, of course, to write routines that can cope with such coordinate differences. However, the routines developed until now are, without exception, very error prone. The risk of misinterpretations remains very high. The other approach consists of using a standard set of node and link numbers. From a technical point of view this is the best solution, as it never results in misinterpretations. The level of standardization required by this solution, however, is very high. The idea of a unique and standardized reference number for all road elements and road junctions implies in fact a standard set of road elements and

junctions. This assumes the existence of a "parent database" to which the different "subsidiary databases" are topologically isomorphic. A working group of the above-mentioned European projects has made a study of this topic, and is weighing up the merits and drawbacks of the two alternatives.

RDS/TMC

The first communication link that will be used to broadcast coded traffic messages is the Traffic Message Channel of the Radio Data System. The Radio Data System (RDS) is a facility which allows the transmission of data using the side bands of existing FM radio stations. RDS has the primary purpose of identifying radio broadcasters and allows self-tuning receivers to select the strongest signal carrying a particular program. Many other RDS applications have been proposed. The Traffic Message Channel is one of the most important candidates. TMC provides coded messages which will trigger a display or speech synthesizer in the receiver. The messages are language-independent since they can be decoded into the language of the user's choice. [Davies, 1989] Standards for the traffic message channel have been defined by the RDS-ALERT project. This standard defines codes for the message types and gives requirements with respect to how the location referencing codes should be formatted. The standard, however, does not provide the code values themselves (i.e. the assignation of a particular value to a particular road or road element). Generating these code lists is considered to be a task of the national authorities.

GSM

Another important future communication link for the distribution of traffic messages is constituted by the Cellular Radio network, also often referred to as GSM. An important difference from RDS/TMC is the fact that GSM not only provides a down link from station to user but also up links from user to station, so that the users can be used to collect data. Another important difference concerns the transmission speed. GSM can transmit far more bits per second than RDS/TMC. This allows longer messages and more details. This also allows longer identification numbers and consequently more instances of geographic objects

that can be addressed. In theory, information on each residential road can be broadcasted (assuming that it is available) without making the system unacceptably slow.

Standardization of the location references and the traffic messages broadcasted via GSM is not nearly as well advanced as the standardization of

RDS/TMC. This is due to the fact that the use of GSM for collecting traffic

data and broadcasting traffic information is still at the stage of a feasibility study (e.g. in the DRIVE project SOCRATES). But it is clear that

when GSM becomes an important medium for traffic data, the standardization of

these messages will become a very important topic [Catling & Op de Beek, 1991]

Why do Driver Information Systems need their own standards ?

The sceptical reader may ask whether Driver Information Systems need their own

standards at all. Is it not possible to make use of other standards already

available or emerging?

The answer to that last question is partly yes and partly no. Indeed, Driver

Information Systems standards can on the one hand partly be based on existing

standards or on the other hand on the same standards that will be developed

for related (geographic) information systems. In fact, the current drafts are

already based on existing standards (eg. ISO 8859-1, 8-bit character sets) or

envisage adopting other ones (ISO 8211, file information interchange). Joint

working groups with other parties active in the field of geographic data have

been set up to coordinate specifications. The first result is the European

Conceptual Data Model, currently implemented in GDF 2.0, which ensures that

GDF is in this respect the same as other standards such as DIGEST [DGWIG,

1989] and EDIGéo [AFNOR, 1991]. Other aspects, e.g. data quality, have also

been coordinated with these parties.

As stated, the answer is also partly no. Driver Information Systems have their

own idiosyncractic data needs which are not yet covered by existing standards.

This has to do with the fact that Driver Information Systems are one of the

first Geographic Information Systems that truly try to communicate with humans

using their concepts. Therefore, these systems need representations of

geographic space that reflect the way in which this space is perceived by

humans. It is currently more and more recognized that classic Euclidean

geometry alone is not sufficient. [Nunes, 1991]. That is why Driver Information Systems need their own -additional- standards.

Conclusion

Driver Information Systems will not be sold until there is sufficient corresponding digital road data available. Digital road data, however, will never be produced and maintained until there is a sufficiently wide range of applications that can use them. They will not be produced either, if society does not take measures to protect the copyrights of these data. Altogether one can consider this as a Driver Information Industry, consisting of mutually dependent activities. A powerful European starter motor will be needed to rev up this industry.

References

- Association Française de Normalisation (AFNOR; Echanges de Données informatisés dans le domaine de l'Information Géographique (EDIGéo); Paris, juillet 1991;
- Benning, H.J.G.M.; Digital Maps on Compact Discs; SAE Technical Paper no. 860125; SAE International Congress and Exposition, February 1986
- NV Philips" Gloeilampenfabrieken and Robert Bosch GmbH; Geographic Data Files Release 1.0; Philips Consumer Electronics, Divisional Standardization Department, Eindhoven, October 1988
- Daimler Benz AG, Intergraph Inc., Philips Electronics BV, Renault, Robert Bosch GmbH, Teleatlas International BV; Geographic Data Files Release 2.0; Philips Car Systems, CIS-lab, Eindhoven, December 1991.
- Catling, I., Op de Beek, F, et al.; SOCRATES: System of Cellular Radio for Traffic Efficiency and Safety; Proceedings of the DRIVE Conference Volume I, pp. ,Brussels February 1991
- Claussen, H., Heres, L., Lichtner W., Schlögl D.; Digital Electronic Mapping of European Territory (DEMETER); Proceedings of the 18th ISATA, Volume 2, paper 88082, Florence, June 1988
- Claussen, H., Heres L., Lahaije P., Lichtner W., Siebold J.; GDF, a Proposed Standard for Digital Road Maps to be used in Car Navigation Systems; Proceedings of the First Vehicle Navigation & Information Systems Conference,

pp. 324 - 330, Toronto, September 1989.

Davies, P.; The Radio System-Traffic Channel; Proceedings of the First Vehicle Navigation & Information Systems Conference, pp. A-44 - A-48, Toronto, September 1989.

Department of Transport, England, Bundesministerium für Verkehr, Germany;
Route Guidance Information Systems Draft Standard for the Road-Vehicle Communications Link; 1988

Digital Geographic Information Working Group (DGWIG); Digital Geographic Information Exchange Standards (DIGEST); Feltham U.K, December 1989.
French, R.L.; Automobile Navigation in the Past, Present and Future; Proceedings AUTO-CARTO 8, Baltimore, 1987 pp. 542-551

Haywood, P. et al.; The National Transfer Format, Release 1.0; Ordnance Survey, Southampton, United Kingdom; January 1987

Lichtner, W.; The Integration of Digital Maps in Vehicle Navigation Systems; In: "Nachrichten aus dem Karten und Vermessungswesen". No. 46, Series II, p. 83-92

McCallum, D.; Secrets of Pandora's Box - Creation of Digital Road Networks for Vehicle Navigation in Europe; In: The Journal of Navigation 44-1, pp. 58-66 ; Cambridge University Press, Cambridge UK, 1991.

Möhlenbrink W.; Task Force European Digital Road Map; Proceedings of the Second International Symposium on Land Vehicle Navigation, Münster, July 1989, pp. 403 - 417

Neukirchner, E., Zechnall, W.; EVA, ein autarkes Ortungs- und Navigationssystem für Landfahrzeuge; BOSCH Technische Berichte, Band 8, Heft 1/2 p. 7-14, 1986, Stuttgart

Neukirchner, E., Suchowerskyj, W., Zechnall W.; Vehicle Navigation Systems Status and Developments in Europe - An Overview; Paper presented at the 18th ISATA, Florence, June 1988

Nunes, J.; Geographic Space as a Set of Concrete Geographical Entities; In: Mark D. and Frank A., Cognitive and Linguistic Aspects of Geographic Space, NATO ASI Series D.63 pp. 9-34; Kluwer Academic Publishers, Dordrecht, the Netherlands 1991.

Siebold, J; Nutzung digitaler Strassendaten für KFZ-
Navigationssysteme; In:
"Nachrichten aus dem Karten- und Vermessungswesen" No 103, Series II;
Institute for Applied Geodesy, 1986, Frankfurt

Thoone, M.L.G.; CARIN, a Car Information and Navigation System;
Philips
Technical Review, Volume 43, No.11/12

Thoone, M.L.G., Driessen, L.M.H.E., Hermus, C.A.C.M., and van der
Valk, K.;
The Car Information and Navigation System CARIN and the Use of
Compact Disc
Interactive; SAE Technical Paper 870139; SAE International Congress
and
Exposition, Detroit, Michigan