

Traffic and Traveller Information — (TTI) — TTI Messages via Dedicated Short-Range Communication —

Part 1: Data Specification — Downlink (Roadside to Vehicle)

ICS 35.240.60

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Committees responsible for this Draft for Development

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- Automatic Identification Manufacturers Association (AIM UK)
- British Telecommunications plc
- Consumer Policy Committee of BSI
- Department of Transport
- GAMBICA (BEAMA Ltd.)
- Road Signalling Development Association
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National foreword

This Part of DD ENV 12315 has been prepared by Technical Committee EPL/278, and is the English language version of ENV 12315-1:1996, published by the European Committee for Standardization (CEN).

This draft for Development is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature because the level of innovation on this subject is currently high. It should be applied on this provisional basis so that information and experience of its practical application may be obtained.

Comments arising from the use of this Draft for Development are requested so that the UK experience can be reported to the European organization responsible for its conversion to a European Standard. A review of this publication will be initiated 2 years after its publication by the European organization so that a decision can be taken on its status at the end of its three-year life. The commencement of the review period will be notified by an announcement in BSI Update.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into a European Standard, to extend the life of the prestandard or to withdraw it. Comments should be sent in writing to the Secretary of BSI Technical Committee EPL/278 at BSI, 389 Chiswick High Road, London, W4 4AL, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

Cross-references

Publication referred to	Corresponding British Standard
ISO 8824	BS ISO/IEC 8824:1990 <i>Information technology. Open systems interconnection. Specification of abstract syntax notation one (ASN.1)</i>
ISO 8825	BS ISO/IEC 8825:1990 <i>Information technology. Open systems interconnection. Specification of basic encoding rules for abstract syntax notation one (ASN.1)</i>

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ENV title page, pages 2 to 90 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

ICS 35.240.60

Descriptors: Teleprocessing, road transport, traffic, traffic control, information interchange, radiocommunications, open systems interconnection, data transmission, messages, data, specifications

English version

Traffic and Traveller Information (TTI) — TTI Messages via Dedicated Short-Range Communication — Part 1: Data Specification — Downlink (Roadside to Vehicle)

This European Prestandard (ENV) was approved by CEN on 1996-07-24 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into an European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Foreword (informative)

This Prestandard has been prepared by Working Group 4 (Sub-Working Group 4.2) of Technical Committee CEN/TC 278 “*Road transport and traffic telematics*”, the secretariat of which is held by NNI to cover the Work Item 4.2.2.

In the field of Traffic and Traveller Information, the innovative rate is high, with many research and development projects under way in many countries, and there is a need to establish prospective standards which allow competitive manufacturers to introduce products to the market in the knowledge that they can accommodate the future issues of the standard(s) without fundamental change to equipment.

It has been submitted as a first draft to TC278 for consideration and review by TC278 plenary meeting members, for initial comment, as CEN Stage 32. All comments have been reviewed and the document updated. It is hereby issued to CEN Central Secretariat for distribution in accordance with Internal Regulations (Part 2, Section 7) at CEN Stage 49, for formal voting.

No known national standards (identical or conflicting) exist on this subject.

This document constitutes: Part 1 of a two-part European Prestandard, being the data specification for one way (roadside to vehicle direction) of a two-way communications link. Part 2 of this Prestandard covers the reverse direction (vehicle to roadside).

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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Introduction (informative)

Traffic and Traveller Information may be disseminated through a number of services or means of communication, covering static displays, interactive terminals and in-vehicle equipment.

For all such services, the data to be disseminated and the message structures involved in the various interfaces require clear definition and standard formats, in order to allow competitive products to operate with any received data.

This pre-Standard focuses on the data specification for an air-interface via dedicated short-range communication, whereby the information is produced at a central location (known as the in-station, central office or traffic information and control centre) and disseminated via a network of roadside beacons. It enables messages to be exchanged between different systems and service providers adopting a variety of applications' specifications. Other pre-Standards are being produced by the CEN TC278 Working Group 4, to cover TTI dissemination via other means or services.

It is anticipated that the uses of the data set(s) described in this document will be closely linked to the widespread use of in-vehicle equipment which utilises them — known as “beacon data” — in an efficient manner to guide drivers through the road network accurately and safely. The principle of operation is to follow detailed guidance, step by step, from one beacon to another. The in-vehicle equipment is expected to offer “fall-back” facilities to assist the driver whenever he or she is travelling in an area unequipped with beacons or if the beacon data is unavailable, for whatever reason.

1 Scope (normative)

1.1 GENERAL

This pre-Standard provides a common message structure for Traffic and Traveller Information messages which are disseminated via dedicated beacon infrastructure (for short-range communications, only).

It, therefore, provides the framework to enable the providers of information services to utilise such a means of dissemination to supply information into a large number of equipped vehicles, together with the suppliers of such in-vehicles equipment to receive, process and/or display the messages to the traveller (driver or passenger).

The message is structured to fit into the protocol framework for DSRC links, as defined in the standards produced by CEN TC278 WG9. Such links may carry data other than Traffic and Traveller Information, as shown in Figure 1, and, in itself, TTI comprises several (potential or optional) data sets, including:

- route guidance data
- messages and warning
- car park information
- park and ride information
- “yellow pages” directories of other services.

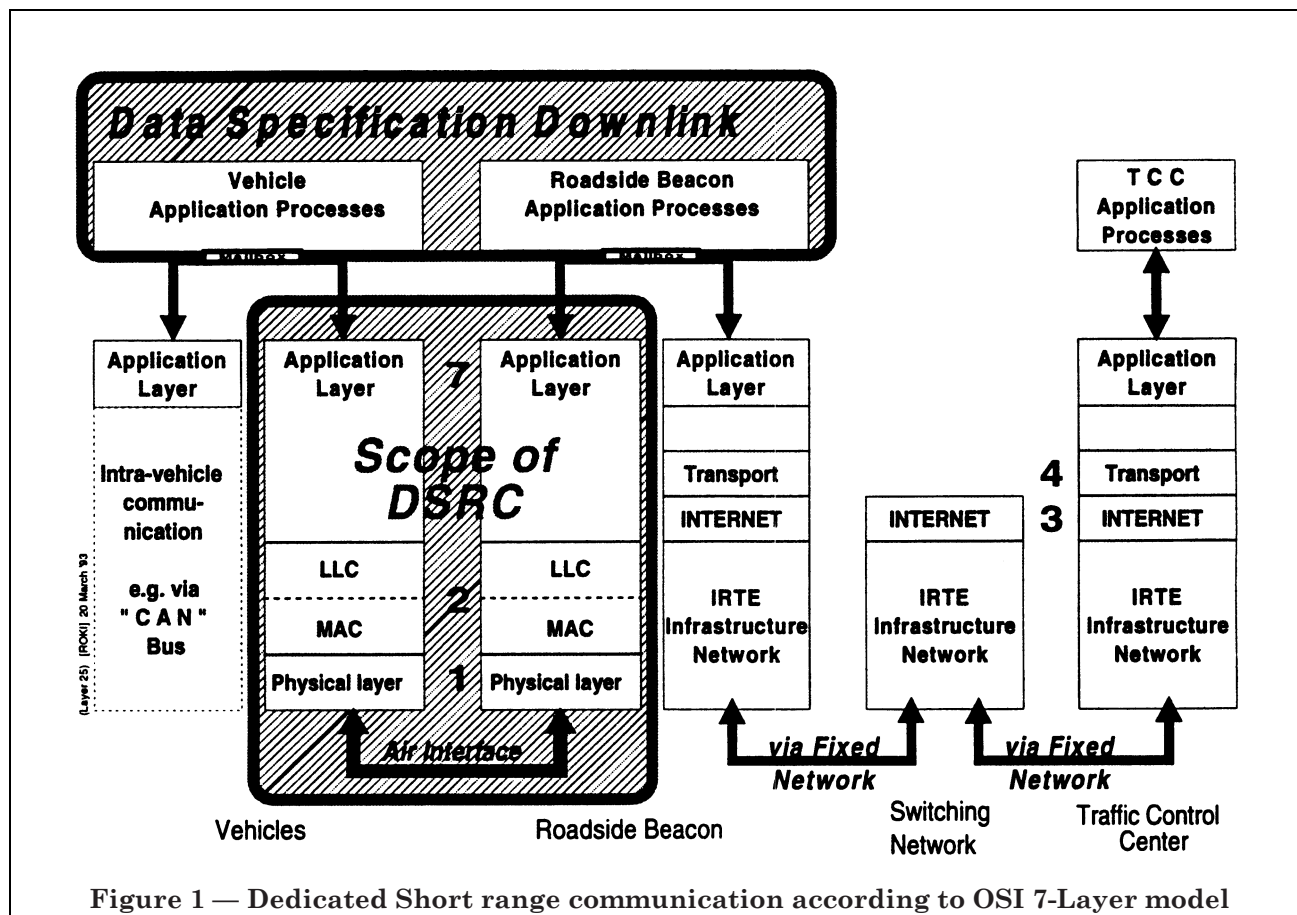
This pre-Standard covers all discrete data sets which comprise TTI. However, since research and development of several data sets is incomplete, at this time, this issue of the pre-Standard details only the “route guidance data”, which is covered by chapter 5 – 10.

It is anticipated that the other functional data sets will be included with the (pre-)standard, as future issues of the same-numbered document, once R & D activities have produced clear, firm results which may be applied to the standardization process.

1.2 EMBEDDANCE IN OSI 7-LAYER MODEL

This document describes the elements (structure and format) for input to the algorithms encompassing RGI and other applications (see below) in an In Vehicle Unit (IVU).

Figure 1 shows the inclusion of this standard with the separate communications means – supplementing the deliveries of other WGs, where the protocols and communications “data frame” structures are defined.



1.3 APPLICATIONS

An infrastructure based vehicle information system consists of a Central Office (C.O.) with a complete set of global information and many roadside substations (beacons), which distribute local information to vehicles. This local information is prepared individually for each beacon by the C.O.. Principally, only the information a vehicle needs after passing one beacon and before arriving at the next one has to be transmitted by a beacon.

Many vehicles may pass one beacon at the same time. It has to be guaranteed, regardless of their number, that all vehicles can receive the necessary information.

Therefore, it is not possible to transmit all the information by dialogue between beacons and vehicles. Instead of this, the total information for each possible destination is transmitted as broadcast data. The vehicle knows its own destination and extracts the appropriate Route Guiding Information out of the complete data set.

1.3.1 ROUTE GUIDANCE DATA

This data contains all necessary information for route guidance from the position of the actual beacon to any destination.

If the routing calculation were to be done in the vehicle, details of the whole road network and complete information about time-of-day-dependent traveltimes and current variations (caused by accidents, roadworks or other factors) would need to be available to the vehicle on-board unit. To allow, and co-operate with, on-board units which do not need to carry such a large database and storage facility, to ease the difficulty of transferring “current variations” to all vehicles and to eliminate the need of on-board units to carry out time consuming route calculations, the routes are pre-calculated in the CO and then distributed to the relevant beacons.

Consequently, each beacon contains only those parts of the routes which are necessary to travel from that beacon to the next or next but one beacon. This encompasses the different routes to cope with Road Restrictions and driver-selected Route Types. In this way, current variations are taken into account at the earliest opportunity and fed into the vehicle equipment from the next beacon.

The description of this part of the road network is called “**Route Guidance Information**” (RGI). The RGI consists of the following parts:

1.3.1.1 GENERAL GUIDANCE DATA

- Position data, to re-synchronise (accurately — to within 10 metres) the in-vehicle tracking of its position.
- Positions of neighbouring beacons (From the beginning of a journey vehicles will be directed to the next appropriate beacon to get more detailed information to continue its trip).
- General parameters (different beacons may have different overall default values for some of their information).

1.3.1.2 ENTRY- AND EXIT DESCRIPTION

As beacons may use existing infrastructure (such as poles, mains and cables as for traffic signals), they are often positioned directly at traffic junctions. As a vehicle arriving at an intersection is unable (easily) to change lane, it cannot be guided until it has passed the junction. Therefore any new information can only be displayed to a driver after the junction has been passed. That means different guidance information will be used for the same destination, depending on the exit where a vehicle leaves a junction. The description of beacon junction entries and exits is stored in this Part.

1.3.1.3 DESTINATION AREAS

It is not possible to transmit different routes for every different destination point, only for so-called “destination areas”. The geometry of those regions is described here in a set of tables.

1.3.1.4 RESTRICTION CLASSES

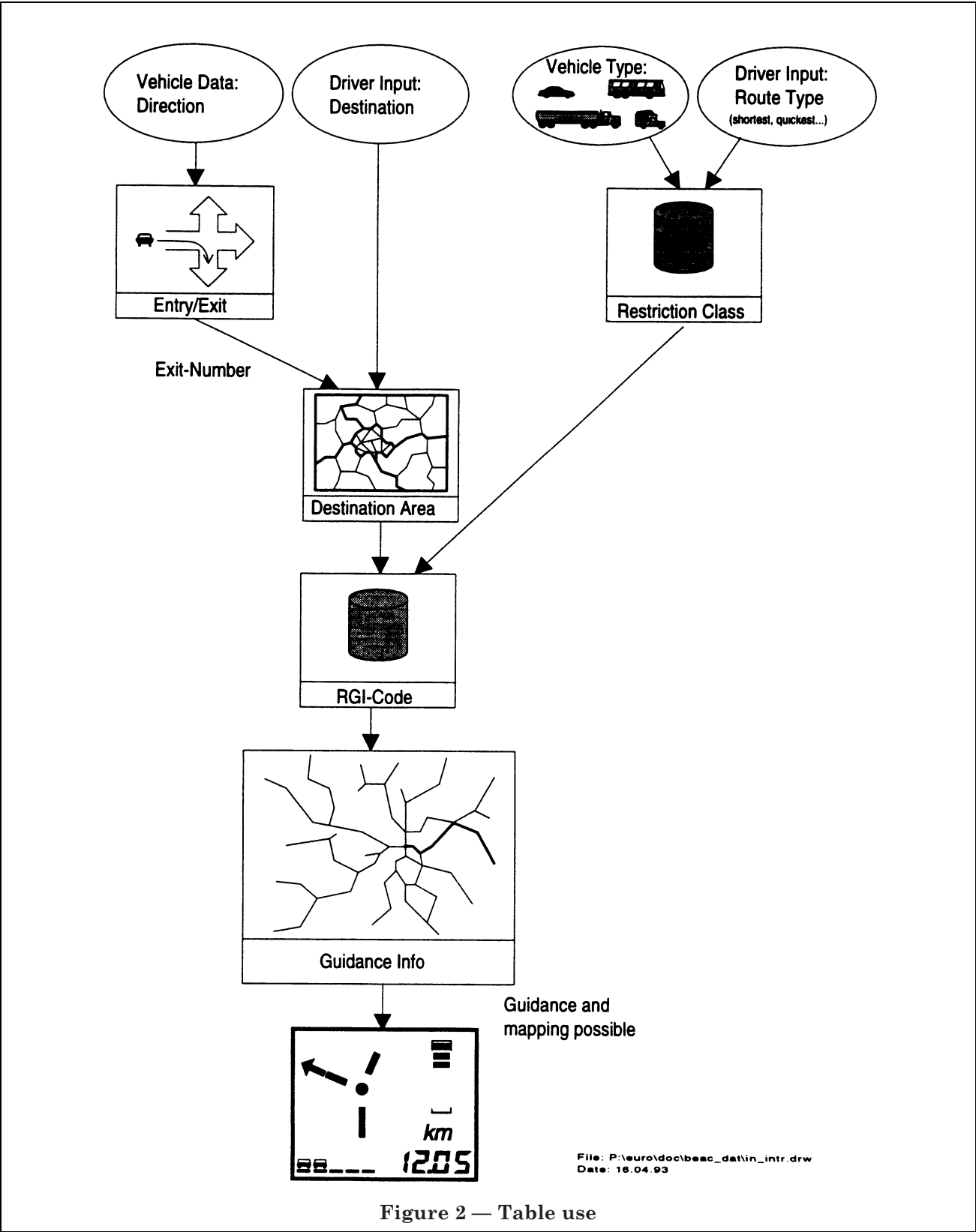
Road Restriction Groups are combinations of different road restrictions. A Route Type Group is a specific route type or a combination of different route types. Pairs of Road Restriction Group and Route Type Group define Restriction Classes to qualify the RGI.

1.3.1.5 ROUTE GUIDANCE INFORMATION CODE

For each destination area, a unique set of guidance information exists. In each set there exists a code for the guidance information for each possible Restriction Class.

1.3.1.6 GUIDANCE INFORMATION

A guidance information is a chain of “links”, a vehicle has to follow from its actual position to the next beacon or directly to its destination zone, if nearer than neighbouring beacons. Both the sequence of those links and their exact geometrical representation are described here, together with attributes, to be displayed to the driver.



1.3.2 MESSAGES AND WARNINGS

Specification under review

1.3.3 CAR PARK INFO

Specification under review

1.3.4 PARK & RIDE INFO

Specification under review

2 Normative references (normative)

This document complements the “Data Specification RGI Uplink (Vehicle to Beacon)” specification prENV278/4/2/0016-2.

Additional references:

- ISO/IEC 8824, *Specification of Abstract Syntax Notation One (ASN.1)*.
- ISO/IEC 8825, *Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1)*.
- ISO/IEC DIS 8825-2, *Information technology — Open Systems Interconnection — Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1) — Part 2: Packed Encoding Rules*.
- prENV (WI: 00278051), *DSRC Application layer (OSI-Layer 7)*.
- prENV 278/9/#61, *DSRC Communication Architecture*.
- prEN726-3, *Requirements for IC-cards and terminals for telecommunication use — Application independent card requirements*.

3 Definitions (normative)**3.1 DEFINITIONS**

For the purpose of this standard, the following definitions apply:

bargraph	Symbols the distance to the next turn manouvre. The length of one bargraph element can vary and is controlled by the CO.
beacon	A roadside facility which is capable to communicate: Via “air interface” in a limited communication zone with IVU of passing vehicles. Via fixed network with centrally or decentrally located control units like central route guidance computer (optional). A beacon consists of a beacon controller and one or more connected beacon heads as transceivers for the air interface
beacon exit	This is the physical exit which a vehicle takes from a beacon equipped junction. It is important to be able to unambiguously identify the correct exit taken by a vehicle from a beacon site because the route guidance information is referenced to this.
beacon head	It is the remote (infrared or microwave) transmit and receive unit of the beacon. Usually they are closely allied with signal heads of traffic lights. On downlink all heads transmit exactly the same information, provided by the controller (broadcast mode). On uplink depending on the applications supported by the beacon, heads can receive selected information offered by vehicles at the same sequence.
beacon region	Is the area surrounding a beacon containing all Destination Zones which can be reached using guidance information from this beacon only. These Destination Zones must be the lowest level zones in any hierarchical system of zones.
beacon site	A beacon installation location. There are several possible locations for beacon installation: beside the road — left and/or right hand, above the road — on gantries at intersections — on entry and/or exit.
boundary line	The border between two destination areas.
central office	The central computer centre responsible for origination and generation of transmitted information.
confidence angle	Relative angle on each side of a vector to detect if a driver complies to the given RGI.

corner point	These are the corner points represented by geographical coordinates which identify the destination zones and areas.
dead reckoning	Calculating a vehicle's position by keeping track of the distances and directions travelled from a known starting point.
departure point	Is the point on the link chain near to the destination at which guidance is switched back to autonomous mode in vehicle system to direct drivers to their destination.
destination area	The combination of one or more destination zones which have the same RGI. Destination areas are described with boundary lines and exist only in the Outer Regions.
destination zone	These are closed polygons of any type (except concave) with 7 corners maximum within a beacon region. Individual destinations within a zone are considered to have the same destination by the system thereby reducing significantly the possible number of destinations and the guidance information necessary. Zones can be of any size to suit the terminal guidance accuracy required and large zones can be sub-divided if required.
display information	This is an information transmitted by the beacon and intended to be presented to the driver on the IVU.
downlink	Communication directed from roadside to IVU.
guidance information	A guidance information is a chain of "links", a vehicle has to follow from its actual position to the next beacon or directly to its destination zone, if nearer than neighbouring beacons. Both the sequence of those links and their exact geometrical representation are described here, together with attributes, to be displayed to the driver.
link	A link is a road section between two junctions. The link is the smallest individual addressable network element. Unidirectional connection between two nodes, mostly representing a connection between two intersections, in traffic assignment one intersection can be dissolved into several turning links or one link can comprise a sequence of connections between intersections.
link chain	Complete chain of links describing the route to the next beacon or to an departure point for the destination area.
mapping information	Is the information transmitted by the beacon which describes the network in the beacon region and allows the vehicle to track its position as it moves in the network.
measurement point	Several traffic measurements (such as queueing time, number of stops etc) are assigned to a measurement point. These measurements are taken between the last and the actual measurement point. At least a measurement point is defined at the end of each link by default, but it is possible to define additional measurement points at the end of the vectors the link is build with.
mode, autonomous	Is the mode of operation of the vehicle equipment in which the guidance information comprises the compass ("crow-fly") direction and distance to the chosen destination. This can be derived from the vehicle current position and the co-ordinates of the destination. The vehicle unit may be in either Autonomous Mode or Guided Mode of operation. Usually the Autonomous Mode occurs before reaching the first beacon and after reaching the Departure Point for the destination.
orientation bar	Information to support the driver's orientation within an intersection.
outer region	Is the area surrounding a beacon containing all Destination Areas with passing one or more beacons.
position detection line	This is a reference position at a beacon site where the vehicle detects a specific characteristic from the beacon (e.g. change of phase, Maximum field strength, loose of signal...).
queue speed limit	Speed limit which is used to measure the queueing time. This value can be defined for each link individually.

restriction classes	Road Restriction Groups are combinations of different road restrictions. A Route Type Group is a specific route type or a combination of different route types. Pairs of Road Restriction Group and Route Type Group define Restriction Classes to qualify the RGI.
road restriction	Some links may have restrictions for specific vehicle types, e.g. width, height, weight and consequently the RGI has to differentiate.
route guidance information code	For each destination area a unique set of guidance information exists. In each set there exists a code for a guidance information for each possible restriction class.
route restriction group	To limit the number of routes the restrictions of the road network and the route types are combined to so called route restriction groups.
route type	A selection offered to the driver, e.g. fastest, shortest, cheapest route.
speed segment	A regular division of a link which can be defined individually for each link used for taken the speed profile.
speed profile	A sequence of averaged vehicle speeds. These speeds are determined by the IVU for each speed segment of a link.
stop	A stop of a vehicle is recognized if its speed goes below a predefined stop speed limit.
stop speed limit	Speed limit which is used to recognize vehicle stops. This value can be defined for all links in common only.
total region	Is the entire area in which the Route Guidance System operates (e.g. Europe, 4.000 km 4.000 km).
travel time	Travel time is the taken driving time on a Link including all queuing times. Travel times are measured by IVUs and transmitted via beacons to the CO. At measurement the travel time is assigned to the actual time related to the start of the link and the link number. Consequently it is possible to assign all travel times to real time and location in the CO.
uplink	Communication directed from IVU to roadside.
vector	A vector is a section of road that can be described as a length and direction only. A link can be made up of one or more vectors depending on physical layout of the road.

3.2 SYMBOLS AND ABBREVIATIONS

ADES	Application Descriptor
ASN.1	Abstract Syntax Notation One
BST	Beacon Service Table
CDRG	Centrally Determined Route Guidance
CEN	European Committee for Standardization
CO	Central Office
CSI	Coding Scheme Identifier
DSRC	Dedicated Short Range Communication
EN	European Standard
ENV	European pre-Standard
FLEN	File Length
ISO	International Standardization Organisation
IVU	In Vehicle Unit
RGI	Route Guidance Information
RTTT	Road Transport and Traffic Telematics
TTI	Traffic and Traveller Information

4 Data organization structure (normative)

4.1 FILE STRUCTURE

This standard complies with the ASN.1 Packed Encoding Rules from ISO 8825-2. Its usage provides maximum interoperability and conformance to existing standards and meets a generic, standard model for RTTT in that it

- uses existing Standard Encoding Rules;
- is adaptable and expandable;
- does not include unnecessary information for a specific application;
- incurs a minimum of overhead in storage and transmission.

For a set of (beacon) broadcast data comprising only Traffic and Traveller Information, the following overall structure is assumed (following ASN. 1 Encoding Rules):

- a) BST: Beacon Service Table
These data elements are specified by the pre-Standard related to DSRC, CEN prENV 278/9/#65 (for example see Annex C.1). They identify communication parameters and present interactive applications — if available.
- b) Directory (uses one specific coding scheme identifier)
These data elements are specified by the pre-Standard related to DSRC, CEN prENV 278/9/#65 (for example see Annex C.2). They identify the beacon and the number of files included in the complete message, together with pointers to those files.
- c) Files of Traffic and Traveller Information, each of which uses a discrete Coding Scheme Identifier (i.e. one CSI for each of the functions: Route Guidance, Messages and Warnings, Car Park Information, Park and Ride Information etc...).

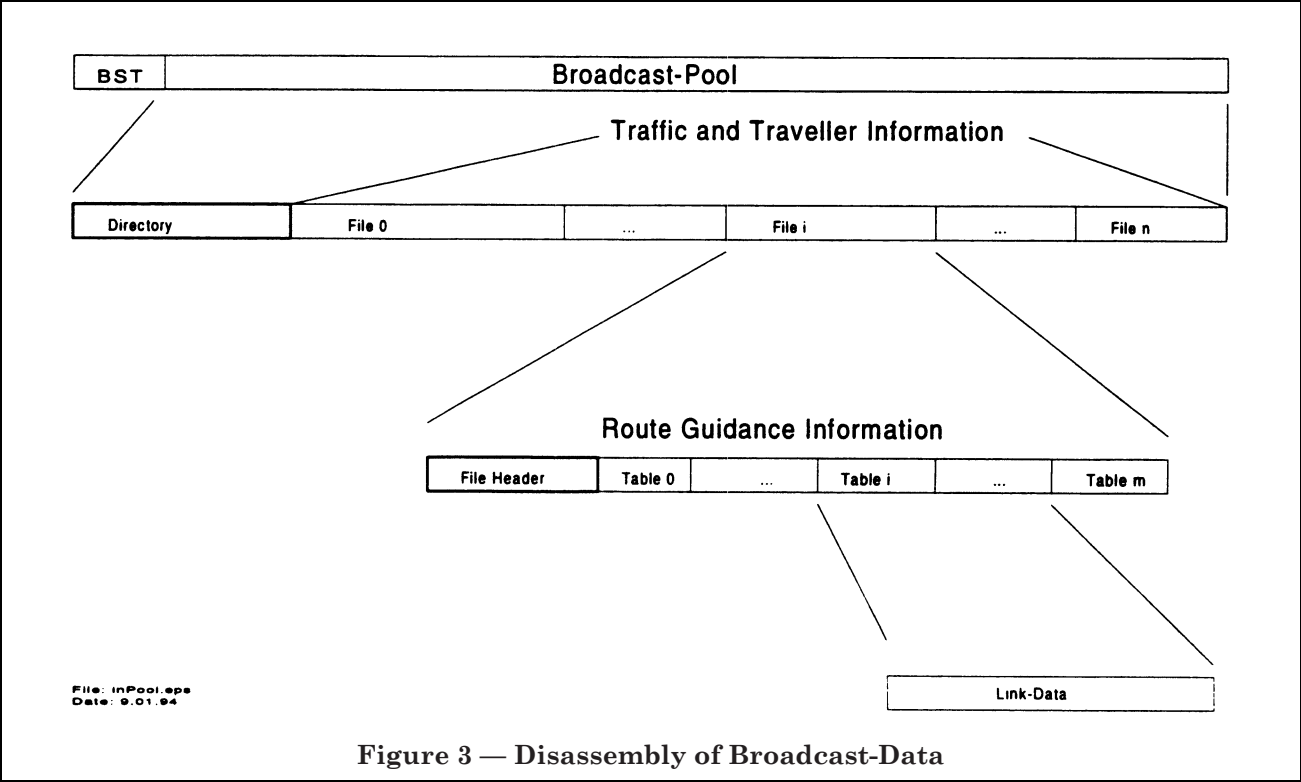


Figure 3 — Disassembly of Broadcast-Data

This standard describes the file structure required for Traffic and Traveller Information (TTI), only. Each file (see Figure 3) starts with:

File Header	
ADES	ADES: Application Descriptor (2 byte = 1byte + 1 octet)
FLEN	FLEN: File Length (3 byte) (including File Header)

The allocation of codes (numbers) within the appropriate fields is the responsibility of CEN TC278 WG4. This standard allocates the following codes for CDRG downlink within the Application Descriptor (ADES):

Class	(4 bits) :	0	(Broadcast)
CIS	(8 bits) :	1	(Route Guidance Information)
Vers	(4 bits) :	0	(European 1 code structure)

4.2 TABLE STRUCTURE

The data files containing the “Traffic and Traveller Information” (TTI) are organized in a table structure as shown in Figure 4. Each data table is defined separately for the particular kind of data and is described later in this document.

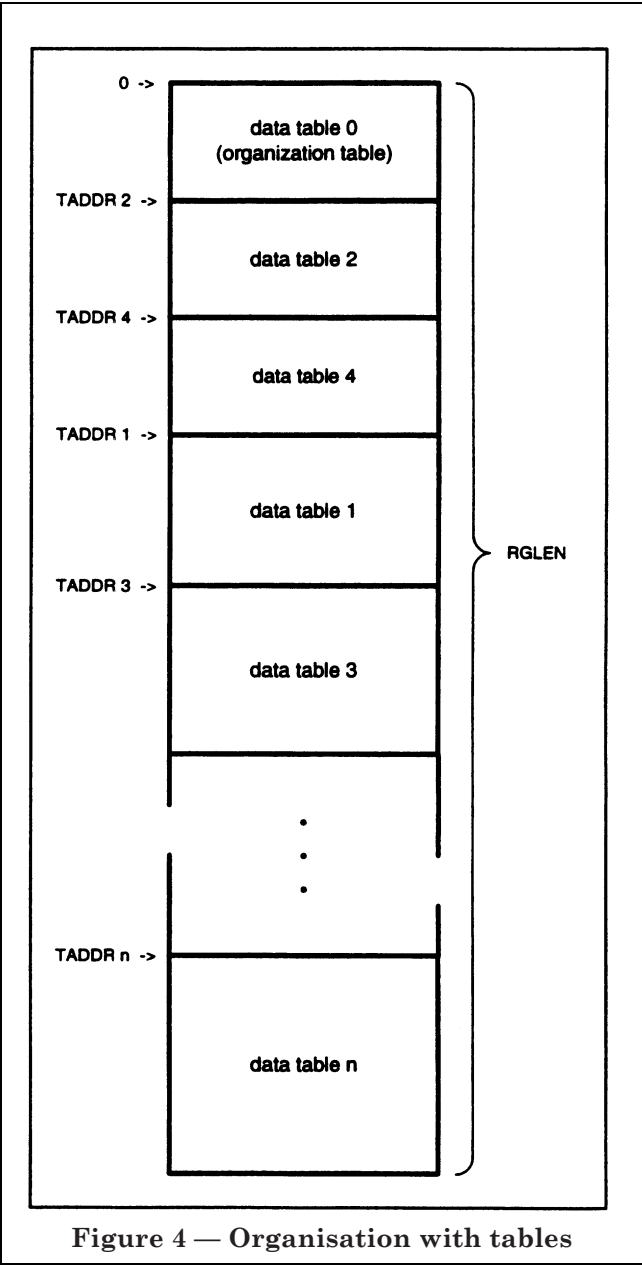
Data Table 0 has a special meaning: it is called the “Organization Table” and contains a table of contents. Thus, all of the following tables are registered in the Organization Table with start-address (TADDRi), length and a checksum. With that, the receiving program is able to check if a required table is present within the data file and if it is valid.

The tables are identified by their table identifier and by their exit number. Normally, the exit number is used to distinguish between the different physical exits of a beacon intersection. So several tables may have the same table identifiers, but different exit numbers. If a table is defined only once for all exits (data are independent from any exits), their exit number can be used as a “second level identifier” to define more than one table with the same table identifier.

All the tables except the Organization Table itself — which goes first — may be listed in any order.

As in general any transmission could be disturbed, the table structure proves to be a benefit because only some of the tables are used for proper RGI of one specific IVU. Another IVU may then use other tables of the RGI-file.

Consequently, all unused tables may be disturbed.



4.3 CHECKSUMS

4.3.1 PURPOSE OF CHECKSUMS

The checksums used in the beacon data set are built by C.O. and transmitted to IVU without modifications by B.C. or other devices used for transmission. Therefore these checksums allow to detect errors, which occurred between C.O. and IVU including B.C. (data assembling).

4.3.2 CHECKSUM ALGORITHM

All the checksums used in this document are realized by a two-byte Frame Check Sequence (FCS). The FCS bytes are denoted FCS1 and FCS2, whereby FCS1 is represented by the lower byte of the checksum (bits 7 to 0) and FCS2 by the higher byte (bits 15 to 8). They are generated by the sender and checked by the receiver, as follows.

Each byte of the frame is treated as a positive integer in ones complement representation: i.e., all arithmetic is performed modulo 255 (if an addition overflows beyond 8 bits, the overflow is added back as an “end-around” carry in the least significant digit); a number is negated simply by complementing all bits in its representation; both [00h] and [FFh] represents zero.

The **sender** and receiver each maintain two one-byte checksums denoted C0 and C1, which are initialized to zero at the start of a frame. Each byte B sent, except for the FCS bytes, is incorporated into the checksums by:

- 1) $C0 := C0 + B$
- 2) $C1 := C1 + C0$

The sender generates the FCS bytes as:

$$FCS1 = -(C0 + C1)$$

$$FCS2 = C1$$

using the values of C0 and C1 accumulated at the end of the last byte of the frame.

The **receiver** accumulates all bytes of the frame in its checksums according to 1) and 2). If the frame has been transmitted without error, either the final values of both C0 and C1 including the FCS bytes will be zero (in either ones complement representation) or the new values of FCS1 and FCS2 generated by the receiver (excluding the FCS bytes received) are equal to the FCS bytes generated by the sender; other values indicate an error.

4.4 ENCRYPTION

To protect the route guidance information the C.O. is able to encrypt particular tables. The checksums for these tables (marked with the encryption flag E — see Organization Table, chapter 4.5) were calculated after encrypting within C.O. and therefor must be checked before decrypting within IVU.

The encryption conforms to the prEN726-3 (Requirements for IC-cards and terminals for telecommunication use — Application independent card requirements), February 1993.

To enable the encryption-feature a “transportation key” is passed to the IVU. This “transportation key” is submitted to e.g. a “smart card” to create a “working key” used for decryption of data tables.

The “transportation key” is part of the General Data (chapter 5) and is frequently changed, but public. In combination with the “smart card” the secret “working key” is generated.

The decryption of data is done with an appropriate procedure.

4.5 ORGANIZATION TABLE — ORG (TID 0)

RGLen	
TCODE	
NOE	
Table Header₁	} NOE
.	
.	
.	
Table Header_{NOE}	
CHECKSUM₀	

This table contains the organization data for the whole beacon data set and the data required to handle all following tables. Each of these tables corresponds with a table header which holds the ID, length, address and checksum of this table. The table headers are sorted in ascending order by exit number (primary key) and by table ID (secondary key)

The organization table is always the first of all tables and starts at beacon data address 0.

4.5.1 ITEM DESCRIPTIONS

RGLEN		0
7		
l_7 ..	RGLEN	.. l_0
l_{15} ..		.. l_8

RGLEN (16 bit) = 2 .. 65535 [1 byte]

Total length of transmitted route guidance information including organization table.

TCODE		0
7		
m_7 ..	MINUTES	.. m_0
m_{15} ..		.. m_8
m_{23} ..		.. m_{16}
i_7 ..	IDCO	.. i_0
i_{15} ..		.. i_8
r_7 ..	reserved	.. r_0

MINUTES (24 bit) = 0 .. $2^{24}-1$ [1 min]
IDCO (16 bit) = 0 .. 65535

MINUTES represents the creation time, day, month and year of the current beacon data set measured in minutes since 1.1.1990, 0:00:00. It allows an identification of the associated timeslot. IDCO names the transmitting CO by a unique identifier.

NOE		0
7		
n_7 ..	NOE	.. n_0
n_{15} ..		.. n_8

NOE (16 bit) = 0 .. 65535 [1 entry]

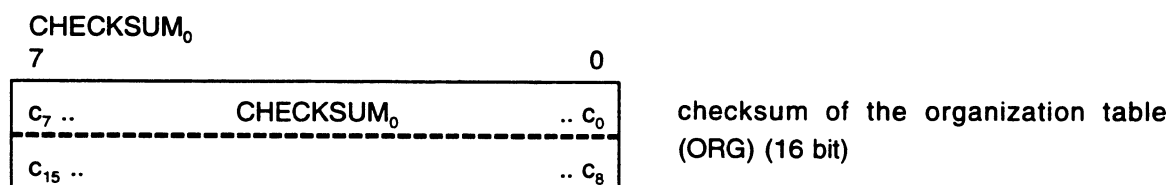
Number of the following directory entries (table headers).

Table Header i,k		0
7		
i_7 ..	TID _i	.. i_0
0	0	E
0	e_3 ..	EXIT _k .. e_0
a_7 ..	TADDR _{i,k}	.. a_0
a_{15} ..		.. a_8
l_7 ..	CLEN _{i,k}	.. l_0
l_{15} ..		.. l_8
c_7 ..	CHECKSUM _{i,k}	.. c_0
c_{15} ..		.. c_8

organization data for each following table
TID (8 bit) = 1 .. 255
EXIT (4 bit) = 0, 1 .. 15
E (1 bit) = 0/1
TADDR (16 bit)= 0 .. 65535 [1 byte]
CLEN (16 bit)= 0 .. 65535 [1 byte]
CHECKSUM (16 bit)

The entries in this section are used to manage the particular tables and allow an error checking via checksums and redundant informations (length/address). A unique identifier (TID) exists for each table. If a table is defined for several exits with the same identifier the tables are distinguished by the exit number (EXIT). The entries are sorted in ascending order by the exit number and the table identifier (e.g. EXIT/TID: 0/1, 0/2, 0/4, .., 1/3, 1/5, .., 2/3, 2/5 .., 3/3, 3/5,..).

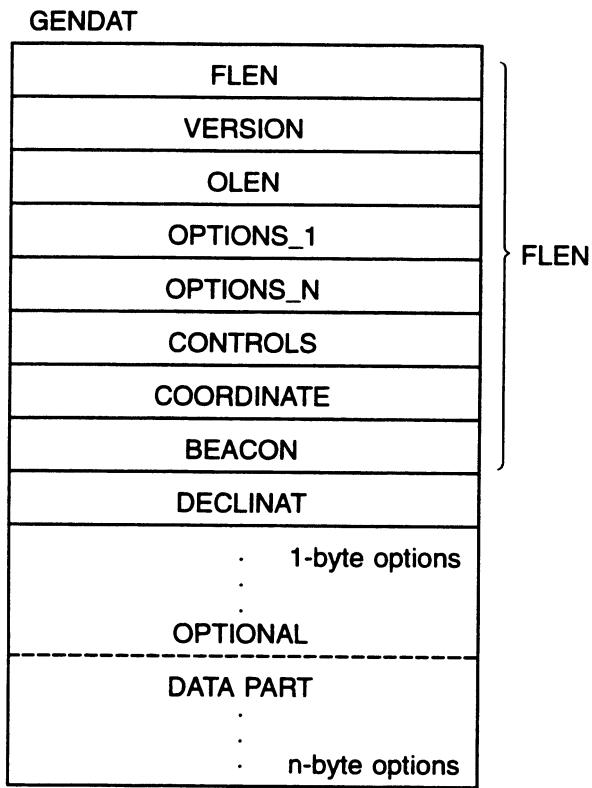
TID	unique table identifier as specified later in this document
EXIT	specifies the exit number starting with 1. If the table is independent of any exit, EXIT is set to 0.
E	if true (= 1) the table is encrypted (for encryption see chapter 4.4)
TADDR	beacon data address (offset) of the table relative to the start of the organization table)
CLEN	complete length of the table
CHECKSUM	checksum of the table evaluated over the whole length of the table (for algorithm see chapter 4.3). For encrypted tables the checksum is calculated after encryption and therefore has to be checked before decryption.



The checksum is built over the organization table (ORG) starting with RGLen and without the checksum word itself (for algorithm see chapter 4.3).

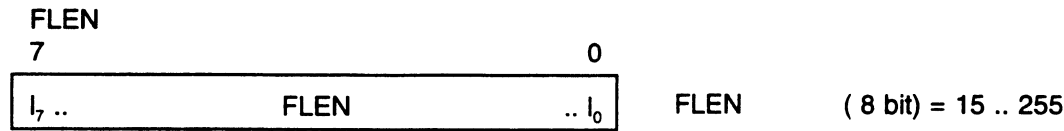
5 General data — GENDAT (TID 1) (normative)

This General Data Table contains data items which are of common use for the **route guidance functions**. It consists of a fixed data part and an optional data part. The first one is always present and contains information absolutely necessary for the navigation and guidance functions. The second one allows to overwrite default settings defined within the IVU program and to define additional information which are not absolutely necessary. Each option in this section can be used independently from any other option.

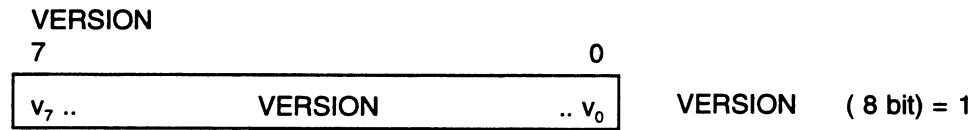


5.1 ITEM DESCRIPTION

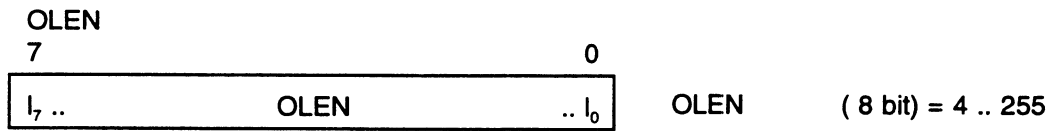
5.1.1 FIXED DATA PART



Length of the General Data Table without the optional data part but including FLEN itself as shown in the overview.



Version number of the Downlink Data Format. It corresponds with the version number of the IVU program. An IVU program version x will be able to process the Downlink Data Formats with the same and preceding version number (x and x-1). This version of the specification is identified by VERSION = 1.



Total length of the three following flag fields OPTIONS_1, OPTIONS_N and CONTROLS including OLEN itself.

OPTIONS_1

7							0
F	0	0	0	BS	BI	CA	SS

at least 1 byte

This flag field indicates which of the possible 1-byte-option exists inside the optional data part (flag = 1) or not (flag = 0). For a detailed description of the particular options see section 5.1.2.1. OPTIONS_1 may consist of several bytes controlled by the bit F (follow flag). It is set to 1 if another byte follows. F has to be set to 0 in the last byte to mark the end of the flag field.

- SS stop speed limit
 CA default confidence angle
 BI default length of bargraph info
 BS minimal length of bargraph segments

OPTIONS_N

7							0
F	0	0	TK	SL	QS	MS	NB

at least 1 byte

This flag field indicates which of the possible n-byte-option exists inside the optional data part (flag = 1) or not (flag = 0). For a detailed description of the particular options see section 5.1.2.2. OPTIONS_N may consist of several bytes controlled by the bit F (follow flag). It is set to 1 if another byte follows. F has to be set to 0 in the last byte to mark the end of the flag field.

- NB neighbouring beacons
 MS maximum speed limits
 QS queue speed limits
 SL speed segment lengths
 TK transportation key (encryption)

CONTROLS

7							0
F	0	0	ET	LQ	LN	MT	RL

at least 1 byte

This flag field controls particular features of the IVU program. It may consist of several bytes controlled by the bit F (follow flag). It is set to 1 if another byte follows. F has to be set to 0 within the last byte to mark the end of the flag field.

- RL defines the traffic type: driving on the right (RL=0) or driving on the left (RL=1)
 MT enables the "Maintenance Table" within the uplink telegram (MT=1) or disables it (MT=0).
 LN defines the type of link numbering used in tables ENEX and LINK_PT: either 2 bytes (LN=0) or 3 bytes (LN=1) are used for each absolute link number.
 LQ defines the entry length of tables LC_QUEUE and RG_INFO: either 1 byte (LQ=0) or 2 bytes (LQ=1) are used for each entry.
 ET enables the "Evaluation Table" within the uplink telegram (ET=1) or disables it (ET=0).

COORDINATE

7 0

x ₇ ..		LONGITUDE		.. x ₀	
x ₁₅ ..				.. x ₈	
0	0	x ₂₁ ..		.. x ₁₆	
y ₇ ..		LATITUDE		.. y ₀	
y ₁₅ ..				.. y ₈	
0	0	0	y ₂₀ ..		.. y ₁₆

LONGITUDE (22 bit) = ±180° [10⁻⁴]

LATITUDE (21 bit) = ±90° [10⁻⁴]

Absolute geographical coordinates (longitude and latitude) of the beacon location related to Greenwich. The precision of 10⁻⁴ degrees corresponds to a resolution of about 11 m at equator.

BEACON

7 0

b ₇ .. BEACON_ID .. b ₀	
b ₁₅ b ₈	

BEACON_ID (16 bit) = 0 .. 65535

Beacon identification number. This number identifies a single beacon and will be unique in connection with the central office id contained in table 0. In case that more than one beacons are necessary to supply an intersection they will have different id's.

DECLINAT

7 0

d ₇ .. DECLINAT .. d ₀
--

DECLINAT (8 bit) = ±127° [1°]

Declination angle at beacon position measured clockwise in degrees. This means, east is a positive angle and west a negative one.

5.1.2 OPTIONAL DATA PART

5.1.2.1 OPTIONAL DATA WITH A LENGTH OF 1 BYTE

These options have always a length of one byte and are controlled by the item OPTIONS_1 in the fix data part. They are placed first in the optional data part in the same order as the bit order in OPTIONS_1. If an option is not activated in the flag field the default value of this option will be used.

stop speed limit (option SS)

7 0

l ₇ .. LIMIT .. l ₀	
---	--

LIMIT (8 bit) = 0 .. 255 [1 km/h]

Speed limit to detect a stop. This limit is used to get the measurements for the uplink telegram.
Default value: 3 km/h

7 0

a ₇ .. ANGLE .. a ₀

ANGLE (8 bit) = 0 .. 255 [1°]

Default confidence angle — on each side of the vector — to detect if the driver goes the wrong way.
Default value: 20°

default length of bargraph info (option BI)

7		0
l_7 ..	LENGTH	.. l_0

LENGTH (8 bit) = 0 .. 255 [10 m]

Default length of bargraph information.

Default value: 300 m

7		0
l_7 ..	LENGTH	.. l_0

LENGTH (8 bit) = 0 .. 255 [10 m]

Minimal length of a bargraph segment.

Default value: 30 m

5.1.2.2 OPTIONAL DATA WITH A LENGTH OF MORE THAN 1 BYTE

These options have always a length of more than one byte and are controlled by the item OPTIONS_N in the fixed data part. They are placed behind the one-byte options in the optional data part in the same order as the bit order in OPTIONS_N. If an option is not activated in the flag field the default values of this option will be used.

Each option field is leaded by a length byte (LEN) which contains the number of bytes of this field including LEN itself.

neighbouring beacons (option NB)

7		0
l_7 ..	LEN	.. l_0
x_7 ..	OFF_LONG ₁	.. x_0
x_{15} ..		.. x_8
y_7 ..	OFF_LAT ₁	.. y_0
y_{15} ..		.. y_8
	.	
	.	
	.	
x_7 ..	OFF_LONG _{LEN/4}	.. x_0
x_{15} ..		.. x_8
y_7 ..	OFF_LAT _{LEN/4}	.. y_0
y_{15} ..		.. y_8

LEN (8 bit) = 1 .. 255
 OFF_LONG_i (16 bit) = $\pm 3.2^\circ$ [10^{-4}°]
 OFF_LAT_i (16 bit) = $\pm 3.2^\circ$ [10^{-4}°]

Geographical coordinates of the neighbouring beacons measured as offsets of longitude and latitude to the geographical coordinate of the actual beacon (item COORDINATE, described within the fix data part). The particular neighbouring beacons may be sorted in any order.

Default values: none

maximum speed limits (option MS)			7	0
$l_7 \dots$	LEN	$\dots l_0$	LEN	(8 bit) = 17
$l_7 \dots$	LIMIT ₀	$\dots l_0$	LIMIT _i	(8 bit) = 0 .. 254,
$l_7 \dots$	LIMIT ₁	$\dots l_0$		255 [1 km/h]
.				
.				
.				
$l_7 \dots$	LIMIT ₁₅	$\dots l_0$		

Allocation table of maximum speed indices to maximum speed limits used on links. LIMIT=255 is used if the maximum speed is unlimited.

Default values [km/h]:

index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
value	30	40	45	50	55	60	65	70	75	80	90	100	110	120	130	∞

queue speed limits (option QS)			7	0	LEN LIMIT _i	(8 bit) = 9 (8 bit) = 0 .. 255 [1 km/h]			
l ₇ .. LEN .. l ₀									
l ₇ .. LIMIT ₀ .. l ₀									
l ₇ .. LIMIT ₁ .. l ₀									
.									
.									
.									
l ₇ .. LIMIT ₇ .. l ₀									

Table of queue speed limits to detect traffic jams. These limits are used for the uplink telegram.

Default values [km/h]:		index	0	1	2	3	4	5	6	7
		value	20	25	30	35	40	50	60	70

speed segment lengths (option SL)

7		0
$l_7 \dots$	LEN	$\dots l_0$
$l_7 \dots$	LENGTH ₀	$\dots l_0$
$l_7 \dots$	LENGTH ₁	$\dots l_0$
	.	
	.	
	.	
$l_7 \dots$	LENGTH ₇	$\dots l_0$

LEN (8 bit) = 9
 LENGTH_i (8 bit) = 0...253, 254, 255
 [10 m]

Table of speed segment lengths to create a speed profile. These lengths are used for the uplink telegram. The value selected for a link measured in meters should be greater than the maximum speed allowed in km/h. Special codings are:

LENGTH=254 a single average speed is measured between 2 measurement points instead of a complete profile

LENGTH=255 no segmentation is defined (one average speed entry per link).

Default values [m]:

index	0	1	2	3	4	5	6	7
value [m]	10	20	50	100	250	500	1000	none

transportation key (option TK)

7		0
$l_7 \dots$	LEN	$\dots l_0$
$k_7 \dots$	TKEY	$\dots k_0$
$k_{15} \dots$		$\dots k_8$
	.	
	.	
	.	
$k_{63} \dots$		$\dots k_{56}$

LEN (8 bit) = 9
 TKEY (64 bit) = 0 .. $2^{64}-1$

The "transportation key" is submitted to e.g. a "smart card" to create a "working key" used for decryption of data tables.

The "transportation key" is frequently changed, but public. In combination with the "smart card" the secret "working key" is generated.

The decryption of data is done with an appropriate procedure.

6 Entries and exits (normative)

6.1 GENERAL

Arriving at an intersection the driver is in the entry, leaving this intersection he is in the exit.

At beacon intersections the in-vehicle system has to fulfill several basic functions with the entry/exit data. It

- **adjusts the actual vehicle position, to correct cumulating errors of the navigation unit;**
- **finds the chosen exit in order to be able to select the correct route guidance information (RGI) towards the selected destination;**
- **determines the actual vehicle position on the 1.link of RGI (on guided routes).**

The following chapters describe

- how to chose convenient intersections for beacon installation,
- how and when the in-vehicle system adjusts the vehicle position,
- how the in-vehicle system determines the actual position after the exit recognition on the 1.link,
- the method of exit recognition for different beacon types,
- how to find suitable exit recognition zones,
- the entry/exit data structure for different entry/exit relations and their difficulties.

6.2 TYPES OF BEACON JUNCTIONS

Entry Beacons

Beacon heads are installed in the entries, the in-vehicle system is able to recognize the line of cutoff unambiguously, because of the unambiguous vehicle direction at this point.

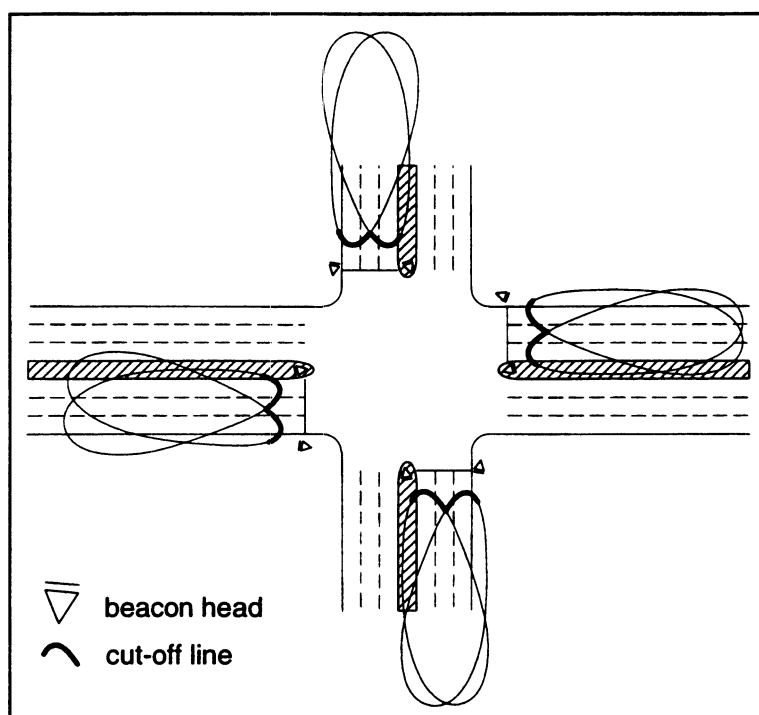


Figure 8 — Principle of junction with beacon heads in the entry and their infrared communication areas

The line of cutoff is the example for a position detection line in an infrared based technology system. To ease the understanding this example will be used in this document.

Exit Beacons

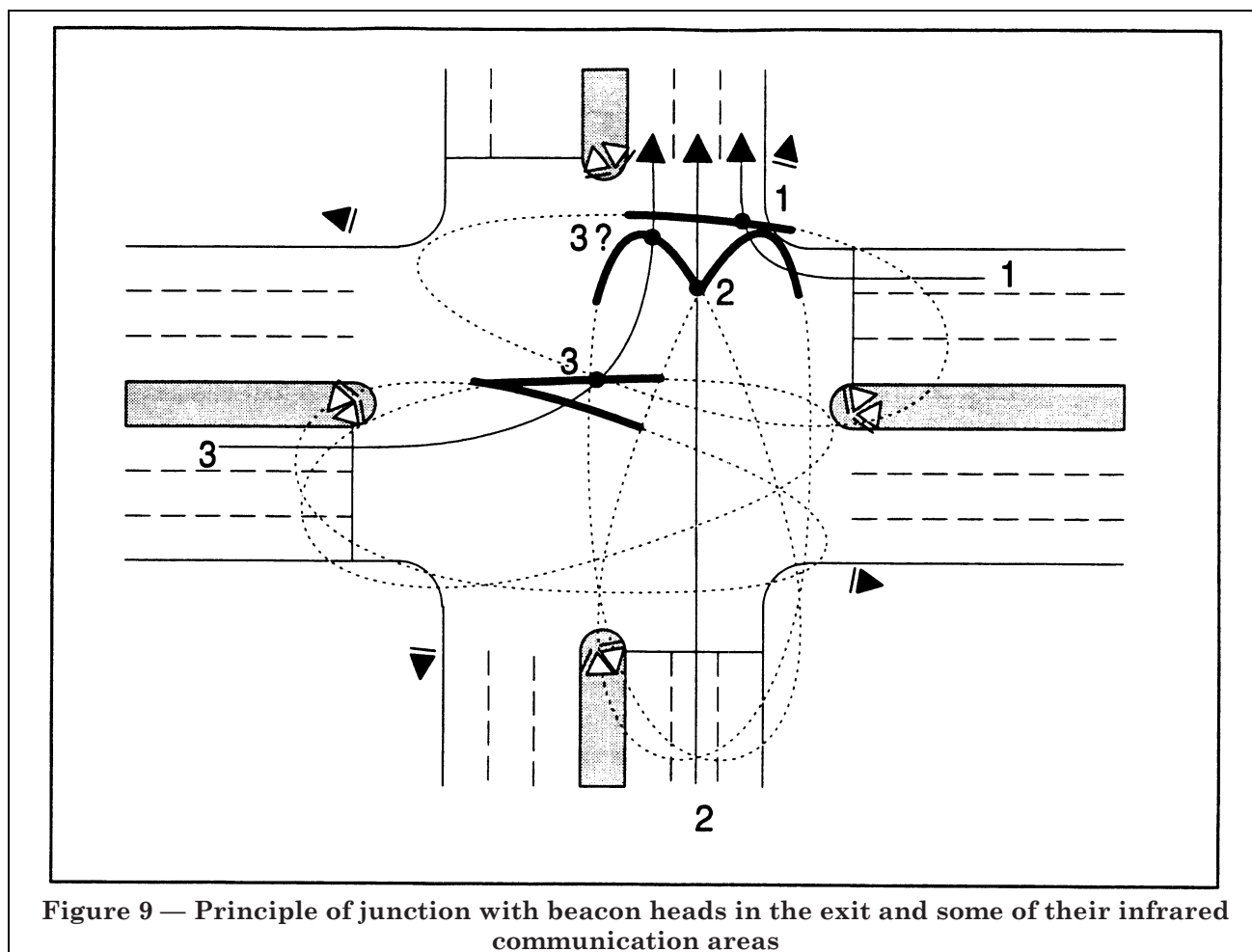


Figure 9 — Principle of junction with beacon heads in the exit and some of their infrared communication areas

Beacon heads are installed in the exits, normally we have a lot of different cut-off lines for the same exit. It is difficult to recognize which of these cut-off lines has been passed, because the vehicle direction isn't unambiguous and because often more than one cut-off line occurs. A vehicle coming from direction 1, turning right, will have the cutoff line at point 1, vehicle 2 at point 2. Those two points are normally close together. A vehicle entering the junction by entry 3, and turning left, may have its point of cutoff on one of the marked points 3, with a quite big difference in the position and the vehicle heading!

Mixed Entry/Exit Beacons

The third way to install beacon heads is to mix the first two installation types.

6.3 CRITERIA FOR THE CHOICE OF BEACON JUNCTIONS

Exits of a beacon junction have to be unambiguous. This means that

- the differences between two exit directions have to be at least 40°
- the distance between exit and next branch must have a certain length. This length depends on
 - * the position of the exit recognition area after the starting point of the 1.link (at least 50 m after all possible cut-off-lines due to the completed turn at a junction);
 - * the length of the exit recognition area;
 - * time between the finished exit recognition and the first display of guidance information;
 - * reaction time of the driver.

In summary, if there are no magnetic distortions, on ordinary roads inside a town (no motorway), a length of 100m will do. On motorways, where the speed is twice or three times as high as on ordinary roads, a minimum length of 200m/300m will be necessary for the first link.