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Intelligent transport systems — Interactive centrally determined route guidance (CDRG) — Air interface message set, contents and format

Systèmes intelligents de transport — Guidage routier déterminé centralement interactif (CDRG) — Jeu de message d'interface d'air, contenu et format

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 17384 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Introduction

The interactive CDRG system provides a driver with a recommended route to his or her destination. The recommended route is sent as a route object that is utilized to display the route on the navigation map or to produce driving direction instructions. This recommended practice, however, only describes the transferring information, such as route object, that is required for CDRG. How the transferred information is used onboard is left to the in-vehicle unit designer. Because, in some countries, interactive CDRG systems are being developed and implemented using beacon or cellular phone technologies, we recognize the necessity for standardizing message sets for interactive CDRG. By the standardized interactive CDRG message set, drivers will be able to receive CDRG service on the same in-vehicle unit regardless of which CDRG service area the in-vehicle unit has entered.

To help understand the functional and technical aspect of the interactive CDRG, implementation experiments of such a system are explained in Annex A.

Intelligent transport systems — Interactive centrally determined route guidance (CDRG) — Air interface message set, contents and format

1 Scope

This Technical Report describes the message contents and format of the air interface between the infrastructure and the in-vehicle unit in the Interactive CDRG system. The scope of standardization work will be the message set requirements for the air interface.

a) The air interface message set for route guidance information in the interactive CDRG system in this Technical Report is applicable to both vehicles equipped with an onboard map database and those which are not equipped (i.e. those equipped with simplified graphic output and/or text message display functions).

b) This Technical Report covers media independent systems. In this Technical Report, messages required for both cellular phone-based CDRG and beacon-based CDRG have been taken into account.

c) The size of each message is defined by considering the "In-vehicle Navigation Systems Communication Device Message Set Requirements".

d) When applying this Technical Report, which is recommended practice to the implementation of any CDRG system, any values less than the defined field size values are allowed, as great importance is attached to the communication efficiency, and the order of description of messages proposed in the message set of this Technical Report might not necessarily be observed.

2 Abbreviations

CDRG Centrally Determined Route Guidance

LDRG Locally Determined Route Guidance

SRG Static Route Guidance

MDRG Multi-mode Determined Route Guidance

OD Origin-Destination

3 Definitions of special terminology

Table 1 lists definitions of special terminology.

Table 1 — Special terminology

Term	Definition/explanation
Connecting network information	By indicating how the links and major roads ahead of the vehicle's present position are configured, connecting network information realizes Interactive CDRG even for vehicles not equipped with onboard map databases.
Downlink	The downlink refers to that portion of a communications link used for the transmission of information from the infrastructure to each in-vehicle unit.
Infrastructure	The infrastructure handles communications with each vehicle. Installed alongside the road, the infrastructure collects data from each vehicle, provides data to the vehicle and performs any related information processing.
Interactive two-way communication	Following the reception of destination and related information from the in-vehicle unit, the infrastructure provides the in-vehicle unit with information that defines the recommended route, describes route conditions, and provides an estimated travel time to the destination.
LDRG	Under LDRG, the vehicle follows a route in the routing information generated by the in-vehicle unit mainly using link travel time data received from the infrastructure.
Link	A link is defined as the roadway section between two nodes such as intersections and has directivity with respect to the flow of traffic.
Link travel time	Travel time of a specific link.
Local street	Local streets are all roads other than major roads.
Major roads	Major roads are subject to route guidance by the Interactive CDRG system. These are roads on which management personnel at the traffic control centre consider important such as national highways and other arterial roads with large amounts of traffic.
Multi-mode route guidance	Multi-mode route guidance provides route guidance under the combined operation of the Interactive CDRG, LDRG and SRG systems.
Node	The node refers to the starting point or ending point of a link in a road network. Basically, it is an intersection, a diverging point or a merging point. For convenience's sake, however, any other point may be taken as a node.
OD	The OD information includes both the departure and destination points.
Recommended route	The recommended route is a route calculated by the CDRG infrastructure and sent to the in-vehicle unit.
SRG	Under SRG, the vehicle follows a route generated by the in-vehicle unit using only fixed information such as distance and other data stored in onboard map databases.
Traffic assignment	Traffic assignment is the distribution of traffic in response to the needs of both the traffic situation and the intents of management personnel at the traffic control centre in order to realize a safe, smoothly flowing traffic environment.
Traffic control centre	The traffic control centre comprises necessary buildings, facilities and personnel to effectively execute traffic management and control.
Travel time	Travel time is the actual time required for a vehicle to pass through a specific roadway section in a route.
Uplink	The uplink refers to that portion of a communications link used for the transmission of information from each in-vehicle unit to the infrastructure.

4 The concept of interactive CDRG

4.1 Goals

4.1.1 Promoting Smooth Traffic Flow

a) An interactive CDRG system is intended to secure a more smooth flow of traffic through improved traffic management based on the high-precision prediction of traffic flow generated from OD information collected by the system.

b) In the future when in-vehicle units have become more widespread, the interactive CDRG system will help reduce traffic congestion through traffic assignment.

4.1.2 Securing traffic safety and improving the traffic environment

a) By providing a recommended route based on the driver's destination and preference for travel, the interactive CDRG system assists the driver with probable routing and travel times to his or her destination. Consequently, the system relieves the driver's stress. Moreover, for drivers travelling in an unfamiliar region, interactive CDRG will prevent accidents caused by drivers who are lost or have made a sudden route change.

b) By shortening both travel times and travel distances, the Interactive CDRG system will decrease the probability of accidents and reduce the environmental degradation caused by fuel consumption and noise pollution associated with vehicular traffic.

4.1.3 Promoting onboard unit market

This Technical Report assumes the use of an onboard navigation unit as the interactive terminal for CDRG.

a) Standardizing the message sets brings on benefits both to users, by realizing interchangeable onboard units, and to manufacturers, by standardized production.

b) Standardizing the message sets enables manufacturers to use interchangeable components for the applications that result in expanding the market.

4.2 Basic system functions

a) The system includes facilities for interactive two-way communication between the vehicle and the infrastructure.

b) Using data received from vehicles, traffic management administrators and other sources, the service provider determines a route to the vehicle's destination.

c) This recommended route, determined by the service provider is based on the driver's and/or provider's preference for that trip. Minimizing the predicted travel time to arrive at the driver's destination may be one such preference.

d) In the future when in-vehicle units have become more widespread, the system will determine recommended routes in such a way that its traffic assignments may alleviate traffic congestion.

e) The system will provide service to both vehicles equipped with map databases and those which are not equipped.

f) Portable navigation devices that could be brought into vehicles are not considered in this Technical Report.

4.3 Secondary effects

a) Because the driver can find his or her desired routing recommended by the system, based on predicted travel times and related traffic information, he can choose a route best suited to dynamic traffic conditions. Lacking this capability for prediction, it is difficult for LDRG and SRG to choose routes best suited to dynamic traffic conditions.

b) Because the recommended route is based on the driver's destination and preference for his trip, the amount of data provided to the in-vehicle unit is relatively small and the communication efficiency between the vehicle and the infrastructure can be increased.

c) As a result of b), the system can provide route information for distant destinations with a minimum amount of data that does not require wide bandwidth of the media for communication.

d) Because the infrastructure calculates recommended routes, the computational load on the in-vehicle unit can be reduced.

e) It is unnecessary to update the in-vehicle unit's software for routing calculation.

f) By shortening travel times, personal travel expenses can be reduced with positive economic consequences.

4.4 The possibility of multi-mode route guidance

a) In-vehicle units with map databases can provide more effective route guidance by skilfully combining information provided by the interactive CDRG with LDRG and/or SRG functions of the in-vehicle unit.

b) Both the LDRG and SRG can choose routes based on the local streets information included in the road network data stored in the onboard database. If the in-vehicle unit with LDRG function receives link travel time information from the infrastructure, the in-vehicle unit combines these data with the above road network data to arrive at its routing decision. However, accurate route selection based on prediction is difficult.

c) By providing routing information based on prediction, interactive CDRG is intended to handle links on major roads on which traffic is heavy. Consequently, interactive CDRG is best suited for route guidance on middle- or long-distance routes. For short journeys of only a few kilometres, LDRG or SRG will, in most cases, be more appropriate.

d) By combining the Interactive CDRG with the LDRG or SRG function of the in-vehicle unit, the following system can be realized. From his point of departure until arrival at a major road, a driver uses either LDRG or SRG. Guided by interactive CDRG on the major road, the driver nears his destination where once again the system switches back to either LDRG or SRG and guides him through the local streets to his final destination.

e) With vehicles not equipped with onboard map databases, without relying on LDRG or SRG, the driver must choose his or her own route. Arriving at a major road, the driver chooses his route according to Interactive CDRG using connecting network information. Overall, the same route guidance system operation as described above will be realized.

5 Message set — Contents and format

5.1 Comments on message set

The air interface message sets for the two systems, one based on DSRC and the other on cellular phone, are listed in two columns.

The differences in the message sets for DSRC and cellular phones are summarised in Table 2. The messages which are not listed in Table 2 are essentially the same for both systems. Other than the differences in media we assumed that the same processing style is imposed on the different systems; such as, the routes are processed by links of map data in all systems.

In Table 2, regarding item 2, “localized routing information”, turning point information such as the distance to a turning point is the distance to the nearest turning point on the route from the vehicle. For DSRC this information is effective because the roadside equipment such as a beacon has the location of the turning point and the vehicle position at the time it sends out the distance information to the vehicle. This information is not practical for cellular phone, because the required time for communication through cellular phone, or response time, is much longer than DSRC. Its connection time to the centre is also long and in some cases cannot even connect. When the vehicle receives the distance information to the turning point through cellular phone it may already have passed the turning point minutes or tens of minutes before.

Regarding item 5, this message is intended to send the location information to vehicle from roadside. The location information includes in which lane the vehicle is running. Since the cellular phone system cannot distinguish the vehicle’s running lane, this message does not make sense for the cellular phone system.

5.2 Outline of contents

5.2.1 Overview

The air interface message set is classified into the following five types:

- request for routing from in-vehicle unit (uplink);
- response to in-vehicle unit with map database (downlink);
- response to in-vehicle unit without map database (downlink);
- travel time responded by in-vehicle unit (uplink);
- position report to in-vehicle unit (downlink).

Of these five, the “travel time responded by in-vehicle unit” messages and the “position report to in-vehicle unit” messages are used for route calculations at each infrastructure and the position recognition of its own vehicle by the in-vehicle unit respectively, and enable the execution of more adequate route guidance.

5.2.2 Request for routing from in-vehicle unit (uplink)

These messages consist of the following information to make a request for route guidance from the in-vehicle unit to the infrastructure.

Routing constraint information: restrictive conditions for the provision of routing information such as vehicle type, the availability of any toll road, whether or not the vehicle is equipped with an onboard map database, etc.

Origin-destination designation information: information on the origin (departure point) and destination to be designated by the in-vehicle unit. With the beacon-based CDRG system, origin designation is not required because the beacon installation point is always assumed to be the origin for the destination designated by the in-vehicle unit.

5.2.3 Response to in-vehicle unit with map database (downlink)

These messages consist of the following information to be returned by the infrastructure in response to the request for routing information from the in-vehicle unit equipped with an onboard map database.

Repeat of request for information: the same information as the request for routing information received from the in-vehicle unit is repeated by the infrastructure so that the in-vehicle unit can confirm whether the response information from the infrastructure is in response to its request.

System status: information on the version number of link database in use by the infrastructure, the cause of any system failure when routing information is not properly transmitted, and the cause of any other service failure. The causes of system failures include system (CPU) down and the designation of an origin that is not always necessary and a destination not included in the link database, whereas the causes of other service failures include that the vehicle's current position is outside the service area of the system, no response to the requested information can be processed because static information stored in the beacon is being updated, and the system cannot determine any recommended route due to particular traffic problems.

Size of each route-specific information: data size of route-specific information on each route. This information is provided for the in-vehicle unit to find the first storage location of route-specific information on each route within the message set.

Route-specific information: information specific to each recommended route as follows.

— Route characteristics information for route selection: information to indicate the characteristics of each recommended route. This information is used by the in-vehicle unit (or the driver) for judgment on which of the two or more recommended routes should be selected. This information is provided with respect to each route and includes information related to the quality (or completeness) of routing information such as the provided predicted travel time information or path information is up to the destination or an en route point, information related to the quality of the route itself such as the availability of any toll road, etc., and information related to the travelling efficiency of the vehicle such as predicted travel time, distance, the number of left and/or right turns, etc.

— Infrastructure-localized routing information: information on detailed route guidance in the vicinity of the vehicle such as the distance to the nearest intersection, the recommended turning direction at the intersection, the number of lanes on the link (at an approach to the intersection), and the lane recommended for use (at the end of the link).

Route-specific messages: the name of each roadway point to pass through on the recommended route and traffic information such as an accident, congestion, etc. The point name and traffic data are provided in formats to enable text message display and phonetic output at the in-vehicle unit.

Path information: information on a path defined according to the travelling sequence of links comprising the recommended route. These links correspond to the links registered in the onboard map database of the in-vehicle unit. Based on this path information, the in-vehicle unit can display the route on the digital map.

5.2.4 Response to in-vehicle unit without map database (downlink)

These messages consist of the following information to be returned in response to the request for routing from the in-vehicle unit not equipped with any onboard map database:

Repeat of request for information: the same information as the request for routing information received from the in-vehicle unit is repeated by the infrastructure so that the in-vehicle unit can confirm whether the response information from the infrastructure is in response to its request.

System status: information on the version number of link database in use by the infrastructure, the cause of any system failure when routing information is not properly transmitted, and the cause of any other service failure. The causes of system failures include system (CPU) down and the designation of an origin that is not always necessary and a destination not included in the link database, whereas the causes of other service failures include the vehicle's current position is outside the service area of the system, no response to the requested information can be processed because static information stored in the beacon is being updated, and the system cannot determine any recommended route due to particular traffic problems.

Size of each route-specific information: data size of route-specific information on each route. This information is provided for the in-vehicle unit to find the first storage location of route-specific information on each route within the message set.

Route-specific information:

Information specific to each recommended route as follows.

— Route characteristics information for route selection: information to indicate the characteristics of each recommended route. This information is used by the in-vehicle unit (or the driver) for judgment on which of the two or more recommended routes should be selected. This information is provided with respect to each route and includes information related to the quality (or completeness) of routing information such as the provided predicted travel time information or path information up to the destination or an *en route* point, information related to the quality of the route itself such as the availability of any toll road, etc., and information related to the travelling efficiency of the vehicle such as predicted travel time, distance, the number of left and/or right turns, etc.

Route-specific messages: the name of each roadway point to pass through on the recommended route and traffic information such as an accident, congestion, etc. The point name and traffic data are provided in formats to enable text message display and phonetic output at the in-vehicle unit.

Path information for simplified graphic-type output: Path information on the recommended route for simplified graphic-type output: this information includes the distance to an intersection at the end of a link, the name of the intersection, the directions of roadway (link) connections to draw the vicinity of the intersection (on the map screen), the number of lanes, etc. Several intersections ahead from the current position of the vehicle are subject to the provision of this information. The intersection name and other data are provided in formats to enable text message display and phonetic output at the in-vehicle unit.

Path information for text-type output: Path information on the recommended route: this information includes the name of a roadway or street on which to travel until the vehicle arrives at the destination, the name of a roadway/street change point, the distance to the change point and the recommended turning direction at the change point. All roadways/streets and their change points between the current position of the vehicle and its destination are subject to the provision of this information. These data are provided in formats to enable text message display and phonetic output at the in-vehicle unit.

5.2.5 Travel time responded by in-vehicle unit (uplink)

These messages consist of the following travel-time information measured by the in-vehicle unit and transmitted to the centre for route calculations.

Beacon-to-beacon travel time: the travel time between two beacon points measured by the in-vehicle unit only via SRCD.

Database link travel times: the travel time between both ends of a link measured by the in-vehicle unit. Travel-time data on one or more links are transmitted all at once, but these links shall have been registered in the onboard map database of the in-vehicle unit.

5.2.6 Position report to in-vehicle unit (downlink)

These messages consist of the following information on the current position of the vehicle to be notified by the infrastructure to the in-vehicle unit.

Current position information: information on the current position of the vehicle only via DSRC.

Table 2

Item No.	Message	Flow	Via DSRC	Via cellular phone	Reason for difference
2	Localized routing information	Down	Turning point information (the nearest point)	Not defined	It is not practical for cellular phones because: 1 response time to a vehicle is much longer than DSRC; 2 connection time to the centre is also long; sometimes it cannot connect.
4	Beacon-to beacon travel time	Up	Vehicle measured travelling time (from previous beacon)	Not defined	Cellular system has no beacon.
4	Database link travel times	Up	Timer value when arrived at current beacon Timer value when arrived at previous beacon	The same as DSRC except following messages Timer value when arrived at current beacon Timer value when arrived at previous beacon	The same as above.
5	Current position information	Down	Current position code (including current lane number)	Not defined	Cellular system cannot distinguish the running lane of a vehicle.

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
REQUEST FOR ROUTING FROM IN-VEHICLE UNITS											
1	Header	UP	-Message code	I	16	F	1P	-Message code	I	16	F
			-Assigned vehicle ID	I	40	F		-Assigned vehicle ID	I	40	F
	Routing Constraint Information		-Number (N) of constraint code	I	4	F		-Number (N) of constraint code	I	4	F
			IF N=15: ..Routing constraint flags (for example, large-sized car, toll, without map databases)	I	8 (8*N)	F		IF N=15: ..Routing constraint flags (for example, large-sized car, toll, without map databases)	I	8 (8*N)	F
			ELSE: {repeated group: N times} ..Routing constraint code	I	8	F		ELSE: {repeated group: N times} ..Routing constraint code	I	8	F
	Origin-Destination Designation Information		-Origin designation code (0=not designate; 1=Standard Location Reference)	I	2 (72)	F		-Origin designation code (0=not designate; 1=Standard Location Reference)	I	2 (72)	F
			IF 1:	I	64	F		IF 1:	I	64	F
			..Standard location reference for a point (1)	I	8	F		..Standard location reference for a point (1)	I	8	F
			..Offset from reference point (20 meter resolution)	I	3	F		..Offset from reference point (20 meter resolution)	I	3	F
			-Destination designation code (1=Standard Location Reference; 2=Zones; 3=Area Specific Location Code: Type A, B, C, D)	I I	64 64	F F		-Destination designation code (1=Standard Location Reference; 2=Zones; 3=Area Specific Location Code: Type A, B, C, D)	I I	64 64	F F
			IF1: Standard location reference for a point (1)					IF1: Standard location reference for a point (1)			
			IF 2: Zones (Standard location reference for an area (1))	I	(34) 20	F		IF 2: Zones (Standard location reference for an area (1))	I	(34) 20	F
			IF 3A: Uniquely Designated Links (requesting route to designated link):	I	2	F		IF 3A: Uniquely Designated Links (requesting route to designated link):	I	2	F
			..Code for area in which link is located	I	12	F		..Code for area in which link is located	I	12	F
			..Code for type of road (general or limited access)					..Code for type of road (general or limited access)			
			..Link number					..Link number			
			IF 3B: Selectively Designated Links (requesting whichever is better of two : one is route to designated link and the other,	I	(34) 20	F		IF 3B: Selectively Designated Links (requesting whichever is better of two : one is route to designated link and the	I	(34) 20	F

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			route with link which is in opposite direction to designated link and taken	I	2	F		other, route with link which is in opposite direction to designated link and taken	I	2	F
			as destination):	I	12	F		as destination):	I	12	F
			..Code for area in which link is located		(34)			..Code for area in which link is located		(34)	
			..Code for type of road (general or	I	20	F		..Code for type of road (general or	I	20	F
			limited access)	I	2	F		limited access)	I	2	F
			..Link number					..Link number			
			IF 3C: Roadway Intersections (Nodes):	I	12	F		IF 3C: Roadway Intersections (Nodes):	I	12	F
			..Code for area in which node is located		(34)			..Code for area in which node is located		(34)	
			..Code for type of road (general or	I	20	F		..Code for type of road (general or	I	20	F
			limited access)	I	14	F		limited access)	I	14	F
			..Link number (any link to be connected to Node)					..Link number (any link to be connected to Node)			
			IF 3D: Zones within a larger area:					IF 3D: Zones within a larger area:			
			..Code for area in which zone is located					..Code for area in which zone is located			
			..Zone number					..Zone number			
RESPONSE TO IN-VEHICLE UNIT WITH MAP DATABASE											
2	Header	DOWN	-Message code	I	16	F	2P	-Message code	I	16	F
			-Assigned vehicle ID	I	20	F		-Assigned vehicle ID	I	20	F
	Repeat of Request for Routing		-Number (N) of constraint code	I	4	F		-Number (N) of constraint code	I	4	F
			IF N = 15:					IF N = 15:			
			..Routing constraint flags (for example, large-sized car, toll, without map databases)	I	8	F		..Routing constraint flags (for example, large-sized car, toll, without map databases)	I	8	F
			ELSE: {repeated group: N times}		(8*N)			ELSE: {repeated group: N times}		(8*N)	
			..Routing constraint code	I	8	F		..Routing constraint code	I	8	F
			-Origin designation code (0 = not designate; 1= Standard Location Reference)	I	2	F		-Origin designation code (0 = not designate; 1= Standard Location Reference)	1	2	F
			IF 1:		(72)			IF 1:		(72)	
			..Standard location reference for a		64	F		..Standard location reference for a	I	64	F
			point (1)	I	8	F		point (1)	I	8	F
			..Offset from reference point (20	I				..Offset from reference point (20			
			meter resolution)		3	F		meter resolution)	I	3	F

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			-Destination designation code (1=Standard	I				-Destination designation code (1=Standard			
			Location Reference; 2=Zones;3=Area Specific					Location Reference; 2=Zones;3=Area Specific			
			Location Code: Type A, B, C, D)		64	F		Location Code: Type A, B, C, D)	I	64	F
			IF1: Standard location reference for a		64	F		IF1: Standard location reference for a	I	64	F
			point (1)	I				point (1)			
			IF 2: Zones (Standard location reference					IF 2: Zones (Standard location reference			
			for an area (1))		(34)			for an area (1))		(34)	
			IF 3A: Uniquely Designated Links		20	F		IF 3A: Uniquely Designated Links	I	20	F
			(requesting route to designated link):	I	2	F		(requesting route to designated link):	I	2	F
			..Code for area in which link is located	I				..Code for area in which link is located			
			..Code for type of road (general or		12	F		..Code for type of road (general or	I	12	F
			limited access)	I				limited access)			
			..Link number					..Link number			
			IF 3B: Selectively Designated Links					IF 3B: Selectively Designated Links			
			(requesting whichever is better of two: one					(requesting whichever is better of two: one			
			is route to designated link and the other,		(34)			is route to designated link and the other,		(34)	
			route with link which is in opposite		20	F		route with link which is in opposite	I	20	F
			direction to designated link and taken as	I	2	F		direction to designated link and taken as	I	2	F
			destination):	I				destination):			
			..Code for area in which link is located		12	F		..Code for area in which link is located	I	12	F
			..Code for type of road (general or	I	(34)			..Code for type of road (general or		(34)	
			limited access)		20	F		limited access)	I	20	F
			..Link number	I	2	F		..Link number	I	2	F
			IF 3C: Roadway Intersections (Nodes):	I				IF 3C: Roadway Intersections (Nodes):			
			..Code for area in which node is		12	F		..Code for area in which node is	I	12	F
			located	I				located			
			..Code for type of road (general or		(34)			..Code for type of road (general or		(34)	
			limited access)		20	F		limited access)	I	20	F
			..Link number (any link to be	I	14	F		..Link number (any link to be	I	14	F
			connected to Node)	I				connected to Node)			
			IF 3D: Zones within a larger area:		32	F		IF 3D: Zones within a larger area:	I	32	F
			..Code for area in which zone is	I	8	F		..Code for area in which zone is	I	8	F
			located	I				located			
			..Zone number					..Zone number			
	System Status		- Central link database version		8	F		- Central link database version	I	8	F
			- System predicament code (1=Route calc	I				- System predicament code (1=Route calc			
			inoperative (system down); 2=Origin not					inoperative (system down); 2=Origin not			
			designated; 3=Destination not included in link					designated; 3=Destination not included in link			
			database)					database)			
					3	F			I	3	F

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			-Service predicament code (1=Veh position outside service area; 2=Static data being updating ; 3=particular traffic problems)	I I	(8*N1) 8	F		-Service predicament code (1=Veh position outside service area; 2=Static data being updating ; 3=particular traffic problems)	I	(8*N1) 8	F
	Size of Each Route-Specific Information Route-Specific Information		-Number (N1) of route-specific information groups {repeated group: N1 times} -Route-specific information data size : C bytes {repeated group: N1 times}	I	7	F		-Number (N1) of route-specific information groups {repeated group: N1 times} -Route-specific information data size : C bytes {repeated group: N1 times}	I	7	F
	Route characteristics information for route selection		-Route information flags ..Travel time completeness (travel time to destination or en route point) ..Path completeness (path to destination or en route point) ..Toll road (whether route includes any toll road) ..etc. - Predicted route travel time information ..Travel time presentation flag ..Most probable expected travel time ..Maximum predicted travel time - Route length -Number (N2) of additional route specific information {repeated groups: N2 times} ..Additional route-specific information (for example, number of right or left turns)	I I I I I I I I I I I I I	(41) 1 20 20 20 8 (16*N2) 16 (24) 8 4 4 8 4 8	F F F F F F F F F F F F		-Route information flags ..Travel time completeness (travel time to destination or en route point) ..Path completeness (path to destination or en route point) ..Toll road (whether route includes any toll road) ..etc. - Predicted route travel time information ..Travel time presentation flag ..Most probable expected travel time ..Maximum predicted travel time - Route length -Number (N2) of additional route specific information {repeated groups: N2 times} ..Additional route-specific information (for example, number of right or left turns)	I I I I I I I I I I I I	(41) 1 20 20 20 8 (16*N2) 16 4 8	F F F F F F F F F
	Localized routing information		-Turning point information (the nearest point) ..Distance to turning point	I I A A	8 8*D 8*E	F V V			I A A	8 8*D 8*E	F V V

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			..Recommended turning code ..Number of lanes on the link ..Recommended lane at end of link	I	4	F			I	4	F
			- Number (N3) of road points provided that will be passed on the route	I	8	F		- Number (N3) of road points provided that will be passed on the route	I	8	F
			{repeated group: N3 times}	I	8	F		{repeated group: N3 times}	I	8	F
			..Field size of road point name for display: D bytes	I	8	F		..Field size of road point name for display: D bytes	I	8	F
			..Field size of road point name for phonetic output: E bytes	A	8*F	V		..Field size of road point name for phonetic output: E bytes	A	8*F	V
			..Road point name for display	A	8*G	V		..Road point name for display	A	8*G	V
			..Road point name for phonetic output	I	2	F		..Road point name for phonetic output	I	2	F
	Route-specific messages		-Number (N4) of route-specific traffic information groups	I	8 (64*N 5)	F		-Number (N4) of route-specific traffic information groups	I	8 (64*N 5)	F
			{repeated group: N4 times} ..Information sentence number	I	64	F		{repeated group: N4 times} ..Information sentence number	I	64	F
			..Field size of Inserted characters for display: F bytes	I	8	F		..Field size of Inserted characters for display: F bytes	I	8	F
			..Field size of Inserted characters for phonetic output: G bytes ..Inserted characters for display	I	20	F		..Field size of Inserted characters for phonetic output: G bytes ..Inserted characters for display	I	20	F
			..Inserted characters for phonetic output	I	8	F		..Inserted characters for phonetic output	I	8	F
	Path information		-Path specific route code (0 = Random Links; 1 = Numerically Ordered Set of Links)	I I	8 2	F F		-Path specific route code (0 = Random Links; 1 = Numerically Ordered Set of Links)	I I	8 2	F F
			IF 0: Number (N5) of links remaining in the Route	I I	2 12	F F		IF 0: Number (N5) of links remaining in the Route	I I	2 12	F F
			{repeated group: N5 times}					{repeated group: N5 times}			
			…Route link ID's (standard location reference (1))					…Route link ID's (standard location reference (1))			
			IF 1: Number (N6) of areas through which the vehicle passes					IF 1: Number (N6) of areas through which the vehicle passes			
			{repeated group: N6 times}					{repeated group: N6 times}			
			…Area code …Number (N7) of sets of ordered links					…Area code …Number (N7) of sets of ordered links			

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			{repeated group: N7 times} ….Number of consecutive links ….Link layer code (0=standard; 1=”superlinks”) ….Code for type of road ….Starting link number					{repeated group: N7 times} ….Number of consecutive links ….Link layer code (0=standard; 1=”superlinks”) ….Code for type of road ….Starting link number			
RESPONSE TO IN-VEHICLE UNIT WITHOUT MAP DATABASE											
3	Header	DOWN	-Message code	I	16	F	3P	-Message code	I	16	F
			-Assigned vehicle ID	I	40	F		-Assigned vehicle ID	I	40	F
	Repeat of Request for Routing		-Number (N) of constraint code:	I	4	F		-Number (N) of constraint code:	I	4	F
			IF N = 15:					IF N = 15:			
			..Routing constraint flags (for example, large-sizedcar, toll, without map databases)	I	8	F		..Routing constraint flags (for example, large-sizedcar, toll, without map databases)	I	8	F
					(8*N)					(8*N)	
			ELSE: {repeated group: N times}	I	8	F		ELSE: {repeated group: N times}	I	8	F
			..Routing constraint code					..Routing constraint code			
				I	2	F			I	2	F
			-Origin designation code (0 = Not Designate; 1= Standard Location Reference)		(72)			-Origin designation code (0 = Not Designate; 1= Standard Location Reference)		(72)	
			IF 1:	I	64	F		IF 1:	I	64	F
			..Standard location reference for a point (1)	I	8	F		..Standard location reference for a point (1)	I	8	F
			..Offset from reference point (20 meter resolution)	I	3	F		..Offset from reference point (20 meter resolution)	I	3	F
			-Destination designation code (1=Standard	I	64	F		-Destination designation code (1=Standard			
			Location Reference; 2=Zones;3-Area Specific	I	64	F		Location Reference; 2=Zones;3-Area Specific	I	64	F
			Location Code: Type A, B, C, D)					Location Code: Type A, B, C, D)	I	64	F
			IF 1: Standard location reference for a point (1)		(34)			IF 1: Standard location reference for a point (1)			
			IF 2: Zones (Standard location reference	I	20	F		IF 2: Zones (Standard location reference		(34)	
			for an area (1))	I	2	F		for an area (1))	I	20	F
			IF 3A: Uniquely Designated Links					IF 3A: Uniquely Designated Links	I	2	F
			(requesting route to designated link):	I	12	F		(requesting route to designated link):			
			..Code for area in which link is located					..Code for area in which link is located	I	12	F
			..Code for type of road (general or limited access)					..Code for type of road (general or limited access)			

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
	System Status Size of Each Route-Specific Information		..Link number IF 3B: Selectively Designated Links (requesting whichever is better of two: one is route to designated link and the other, route with link which is in opposite direction to designated link and taken as destination): ..Code for area in which link is located ..Code for type of road (general or limited access) ..Link number IF 3C: Roadway Intersections (Nodes): ..Code for area in which node is located ..Code for type of road (general or limited access) ..Link number (any link to be connected to Node) IF 3D: Zones within a larger area: ..Code for area in which zone is located ..Zone number -Central link database version -System predicament code (1=Route calc CPU inoperative (system down); 2=Origin not designated; 3=Destination not included in link database) -Service predicament code (1=Veh position outside service area; 2=Static data being updating; 3=Particular traffic problems) -Number (N1) of route-specific information groups {repeated group: N1 times} -Route-specific information data size: C bytes	I I I I I I I I I I I I I I	(34) 20 2 12 (34) 20 2 12 (34) 20 14 32 8 8 3 (8*N1) 8 7	F F F F F F F F F F F F F F

No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
	..Link number IF 3B: Selectively Designated Links (requesting whichever is better of two: one is route to designated link and the other, route with link which is in opposite direction to designated link and taken as destination): ..Code for area in which link is located ..Code for type of road (general or limited access) ..Link number IF 3C: Roadway Intersections (Nodes): ..Code for area in which node is located ..Code for type of road (general or limited access) ..Link number (any link to be connected to Node) IF 3D: Zones within a larger area: ..Code for area in which zone is located ..Zone number -Central link database version -System predicament code (1=Route calc CPU inoperative (system down); 2=origin not designated; 3=Destination not included in link database) -Service predicament code (1=Veh position outside service area; 2=Static data being updating; 3=Particular traffic problems) -Number (N1) of route-specific information groups {repeated group: N1 times} -Route-specific information data size: C bytes	I I I I I I I I I I I I I I	(34) 20 2 12 (34) 20 2 12 (34) 20 14 32 8 8 3 (8*N1) 8 7	F F F F F F F F F F F F F F

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
	Route		**{repeated group: N1 times}**					**{repeated group: N1 times}**			
	characteristics				(41)					(41)	
	Information for		-Route information flags	I	1	F		-Route information flags	I	1	F
	route selection		.. Travel time completeness (travel time	I	20	F		.. Travel time completeness (travel time	I	20	F
			to destination or en route)	I	20	F		to destination or en route)	I	20	F
			..Path completeness (path to	I	20	F		..Path completeness (path to	I	20	F
			destination or en route)	I	8	F		destination or en route)	I	8	F
			..Toll road (whether route includes any					..Toll road (whether route includes any			
			toll road)					toll road)			
			..etc					..etc			
			- Predicted travel time information		(16*N			- Predicted travel time information		(16*N	
			. .Travel time presentation flag		3)			. .Travel time presentation flag		3)	
			. .Most probable expected travel time	I	16	F		. .Most probable expected travel time	I	16	F
			. .Maximum predicted travel time					. .Maximum predicted travel time			
			- Route length					- Route length			
			-Number (N2) of additional route specific	I	8	F		-Number (N2) of additional route specific	I	8	F
			information					information			
			{repeated group: N2 times}	I	8	F		{repeated group: N2 times}	I	8	F
			..Additional route-specific information (for					..Additional route-specific information (for			
			example, number of right or left turns)	A	8*D	V		example, number of right or left turns)	A	8*D	V
				A	8*E	V			A	8*E	V
				I	4	F			I	4	F
	Route-		- Number (N3) of road points provided that					- Number (N3) of road points provided that			
	specific		will be passed on the route	I	8	F		will be passed on the route	I	8	F
	messages		{repeated group: N3 times}	I	8	F		{repeated group: N3 times}	I	8	F
			. .Field size of road point name for					. .Field size of road point name for			
			display: D bytes	I	8	F		display: D bytes	I	8	F
			. .Field size of road point name for					. .Field size of road point name for			
			phonetic output: E bytes	A	8*F	V		phonetic output: E bytes	A	8*F	V
			. .Road point name for display	A	8*G	V		. .Road point name for display	A	8*G	V
			..Road point name for phonetic output					. .Road point name for phonetic output			
			-Number (N4) of route-specific traffic	I	8	F		-Number (N4) of route-specific traffic	I	8	F
			information groups {repeated group: N4					information groups {repeated group: N4			
			times}					times}			
			..Information sentence number	I	8	F		..Information sentence number	I	8	F
			..Field size of Inserted characters for	I	8	F		..Field size of Inserted characters for	I	8	F
			display: F bytes					display: F bytes			
			..Field size of Inserted characters for	I	8	F		..Field size of Inserted characters for	I	8	F
			phonetic output: G bytes					phonetic output: G bytes			
			..Inserted characters for display	A	8*H	V		..Inserted characters for display	A	8*H	V
			..Inserted characters for phonetic output	A	8*I	V		..Inserted characters for phonetic output	A	8*I	V

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
	Path			I	16	F			I	16	F
	information for		- Number (N5) of consecutive links					- Number (N5) of consecutive links			
	simplified		{repeated group: N5}	I	4	F		{repeated group: N5}	I	4	F
	graphic-type		..Turning point at end of link	I	4	F		..Turning point at end of link	I	4	F
	output		…Distance to turning point	I	8	F		…Distance to turning point	I	8	F
			…Field size of turning point name for	I	20	F		…Field size of turning point name for	I	20	F
			display: H bytes	I	2	F		display: H bytes	I	2	F
			…Field size of turning point name for	I	12	F		…Field size of turning point name for	I	12	F
			Phonetic output: I bytes					Phonetic output: I bytes			
			…Tuning point name for display	I	8	F		…Tuning point name for display	I	8	F
			…Turning point name for phonetic					…Turning point name for phonetic			
			output					output			
			..Direction code of road connected to					..Direction code of road connected to			
			the turning point	I	8	F		the turning point	I	8	F
			..Recommended turning code	I	8	F		..Recommended turning code	I	8	F
			..Number of lanes at end of link					..Number of lanes at end of link			
			..Recommended lane at end of link	I	8	F		..Recommended lane at end of link	I	8	F
			..Area code					..Area code			
			..Code for type of road	A	8*J	V		..Code for type of road	A	8*J	V
			..Link number	A	8*K	V		..Link number	A	8*K	V
	Path			I	4	F			I	4	F
	information for		-Number (N6) of consecutive roadways or					-Number (N6) of consecutive roadways or			
	text-type		streets to destination	I	8	F		streets to destination	I	8	F
	output		{repeated droup: N6 times}					{repeated droup: N6 times}			
			..Turning point for another	I	8	F		..Turning point for another	I	8	F
			roadway/street					roadway/street			
			…Distance to turning point	A	8*L	V		…Distance to turning point	A	8*L	V
			…Field size of turning point name for					…Field size of turning point name for			
			display: J bytes	A	8*M	V		display: J bytes	A	8*M	V
			…Field size of turning point name for					…Field size of turning point name for			
			phonetic output: K bytes					phonetic output: K bytes			
			…Tuning point name for display					…Tuning point name for display			
			…Turning point name for phonetic					…Turning point name for phonetic			
			output					output			
			…Recommend turning code					…Recommend turning code			
			. .Consecutive roadway/street name					. .Consecutive roadway/street name			
			…Field size of consecutive					…Field size of consecutive			
			roadway/street name for display: L					roadway/street name for display: L			
			bytes					bytes			
			…Field size of consecutive					…Field size of consecutive			

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			roadway/street name for phonetic output: M bytes					roadway/street name for phonetic output: M bytes			
			…Consecutive roadway/street name for display					…Consecutive roadway/street name for display			
			…Consecutive roadway/street name for phonetic output					…Consecutive roadway/street name for phonetic output			
TRAVEL TIME RESPONDED BY IN-VEHICLE UNIT											
4	Header	UP	-Message code	I	16	F	4P	-Message code	I	16	F
			-Assigned vehicle ID	I	40	F		-Assigned vehicle ID	I	40	F
	Beacon-to-Beacon Travel Time		-Vehicle measured traveling time (from previous beacon)		(40)						
			-Beacon Number (Site Identification) for previously passed beacon		(24)						
			..Beacon Controller number	I	8	F					
			..Beacon Location number	I	16	F					
			-Vehicle determined elapsed time between beacons (seconds)	I	16	F					
	Database Link Travel Times		-Timer value when arrived at current beacon	I	16	F					
			-Timer value when arrived at previous beacon	I	16	F					
			-Link database version	I	32	F		-Link database version	I	32	F
			-Number (N1) of information blocks about consecutive links measured by accomplished driving of vehicle	I	8	F		-Number (N1) of information blocks about consecutive links measured by accomplished driving of vehicle	I	8	F
			{repeated group: N1 times}					{repeated group: N1 times}			
			(Tracing upstream)					(Tracing upstream)			
			- Timer value when finished driving the last link of this block	I	16	F		- Timer value when finished driving the last link of this block	I	16	F
			- Number (N2) of links of this block	I	8	F		- Number (N2) of links of this block	I	8	F
			{repeated group: N2}					{repeated group: N2}			
			.. Area distinction flag (current link's area is or isn't distinct from previous link's area)	I	1	F		.. Area distinction flag (current link's area is or isn't distinct from previous link's area)	I	1	F
			.. Code for type of road	I I	2 12	F F		.. Code for type of road	I I	2 12	F F
			..Link number	I	20	F		..Link number	I	20	F

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			. .Area code if distinct from previous link's area . .Travel time (seconds)	I	16	F		. .Area code if distinct from previous link's area . .Travel time (seconds)	I	16	F
POSITION REPORT TO IN-VEHICLE UNIT											
5	Header		-Message code	I	16	F					
	Current Position Information	DOWN	-Current position code (1= Standard Location Reference; 2 =Verbal References)	I	2	F					
			IF 1:								
			..beacon Number (Site Identification)		(24)						
			...Beacon Controller number	I	8	F					
			...Beacon (L0cation) ID number	I	16	F					
			..Beacon location		(80)						
			...Standard location reference (1)	I	64	F					
			...Offset from reference point (1 meter resolution)	I	16	F					
			IF 2:								
			..Beacon Pair Identification		(40)						
			...Controller number	I	8	F					
			...First Beacon's ID	I	16	F					
			...Second Beacon's ID (for information	I	16	F					
			supplied in pairs)		(1 or						
			..Beacon Number (Site Identification)		24)						
			...Beacon controller number	I	8	F					
			...Extension number (0 = end of	I	1	F					
			repetition)	I	15	F					
			...Beacon (location) ID number								
			..Beacon location	I	16	F					
			...Map version	I	64	F					
			...Standard location reference for the								
			beacon	I	2	F					
			...Road type	I	12	F					
			...Link number	I	8	F					
			...Field size of road name for display :								
			A bytes	I	8	F					
			...Field size of road name for phonetic								
			output: B bytes	I	8*A	V					

No	Message	Data Flow	Data fields Comprising the Message	Field Type	Required Field Size	Field Format	No	Data fields Comprising the Message	Field Type	Required Field Size	Field Format
			...Road name for display	I	8*B	V					
			...Road name for phonetic output	I	8	F					
			...Field size of point name for display: C bytes	I	8	F					
			...Field size of point name for phonetic output: D bytes	I	8*C	V					
			...Point name for display	I	8*D	V					
			...Point name for phonetic output	I	4	F					
			...Current lane number								

Notes:
Standard Location Referencing definition is continuing, including CEN/TC278/SWG7.3 and ISO/TC204/SWG3.3.
- Field Type: A = Alphanumeric; F = Floating point; I = Integer; V = Variable type
- Field Size is in Bits
-Field format: F = Fixed length; V = Variable length

Annex A
(informative)

Realization of interactive CDRG — The case of Japan

A.1 General

Universal Traffic Management Society of Japan (UTMS) and the Tokyo Metropolitan Police Department are planning to realize the interactive CDRG. It will follow the providing of dynamic traffic information using two-way communication between infrared beacons and in-vehicle units, which started in the spring of 1996, in accordance with the Vehicle Information and Communication System (VICS).

The system is to select the recommended route using link travel time data, which is gathered by the traffic control system. Therefore, even in the early stages of its adoption when it cannot obtain large quantities of travel time data measured by in-vehicle units, the system can still provide guidance relating to the shortest route in terms of time required.

The trial system of interactive CDRG was constructed in central Tokyo in 1996 and the first- to third-step field tests have been conducted since then. The system functions of the trial system and the results of the third-step test are reported here.

A.2 Functions of the trial system

A.2.1 Basic structure

A trial system has been constructed in Tokyo which consists of infrared beacons, in-vehicle units, a CDRG central unit and a traffic control system. A vehicle sends a destination to a beacon passing through the communication zone, then immediately the beacon returns the route information that includes the recommended route and predicted travel time to the destination to the vehicle. In order to respond to any destination within the vicinity of a beacon (typically, 20 km radius), it accumulates the route information on all destinations in the range, which is calculated and supplied by a CDRG central unit every 5 min. The traffic control system periodically collects vehicle detector information and creates predicted travel times of all links from it, sending them to the CDRG central unit via LAN in time for updating the route information. Link predicted travel time would be obtained using travel time data measured and sent by in-vehicle units in the future when they become sufficiently widespread.

The length of the communication zone between an infrared beacon and an in-vehicle unit is approximately 3,7 m ahead of the vehicle. Table A.1 shows the detailed infrared beacon specifications.

Table A.1

Item	Specification
Emitting wave length	850 nm
Modulation method	Pulse amplitude modulation
Transmission method	Two-way communication
Transmission uplink	64 Kbps
Speed downlink	1 Mbps
Data capacity uplink	256 Bytes
Downlink	10 Kbytes
Communication zone	3,5 m × 3,7 m

A.2.2 Information provided by the system

The trial system at the current stage targets only in-vehicle units equipped with map databases. Main items of the route information provided by it are as follows:

- two recommended routes to driver's destination; one is the shortest time route on networks of general roads alone and the other one, the shortest time route on networks of general roads and expressways;
- two predicted travel times to the destination that are most probable in accordance with both above recommended routes;
- lengths of both recommended routes;
- name of road points on both recommended routes;
- distance to the nearest turning point, recommended turning direction and recommended lane at that point on both recommended routes.

A.3 Field test

A.3.1 Purpose of the test

A series of field tests has been conducted in a practical location in central Tokyo, where vehicles having an in-vehicle unit actually ran. In the first- and second-step field tests that were conducted in the autumn of 1996 and the spring of 1997, respectively, the performance of the system on general road networks was verified to be sufficiently high for practical use. Based on the above test results, the third-step field test was carried out from March 24th to 26th, 1998. The purposes of this test with respect to system performance were as follows:

- comparison of several route guidance methods on road networks including expressways;
- evaluation of route selection capability of responding to an emergency.

A.3.2 Trial area

The trial area extends for 20 km from east to west and 15 km from north to south in the central to western area of Tokyo, where a DRGS function was added to approximately 200 infrared beacons that had already been installed on general roads. Within this area, six pairs of ODs were set for testing as shown in Table A.2. Roads applicable to route guidance were general main roads on which vehicle detector information was collected and the Tokyo Metropolitan Expressway on which link travel time information was provided by the Tokyo Metropolitan Expressway Public Corporation.

Table A.2

OD No.	Origin	Destination
1A	Sengoku 1-chome	Kakinoki-zaka rikkyo
1B	Kakinoki-zaka rikkyo	Sengoku 1-chome
2A	Ochiai 1-chome	Onarimon
2B	onarimon	Ochiai 1-chome
3A	Shimendou	Seishoukou-mae
3B	Seishoukou-mae	Shimendou

The Tokyo Metropolitan Expressway is a toll road network extending for approximately 300 km around the central part of Tokyo with a flat rate tariff. On the expressway, radio beacons were installed instead of infrared beacons, which serve VICS information such as link travel time and congestion, but not CDRG route information. Ramp closure occurs often, but randomly, on the expressway for reducing traffic jams, thereby closing upstream entrances (ramps) and restricting traffic inflow to congested sections. So this system was designed to use plan information of ramp closure provided by the Tokyo Metropolitan Expressway Public Corporation when calculating recommended routes in order to avoid the ramp if it had been estimated to be closed by the time the vehicle arrived there.

A vehicle was provided with route information at a starting point and *en route* only on general roads, running along its recommended route.

— CDRG vehicles: driving under guidance with CDRG system.

— Taxis: driving in accordance with an experienced taxi driver's judgement.

— Ordinary vehicles: driving under human judgement with congestion information or guidance of the autonomous in-vehicle unit with shortest distance route selecting method.

Each group started at the same time and data on travel time between origin and destination were collected. Every type of vehicle was to choose a route either with or without expressways, with the driver surmising travel time for each route in the case of the vehicle other than a CDRG vehicle. As a result of a pre-conducted travel examination, running on the Metropolitan Expressway rather than on general roads had been found to be extremely advantageous for some ODs. In order to overcome this, we statistically obtained the travel time difference (handicap) between routes with and without expressways beforehand and had each vehicle select either route after adding the handicap to the routes using expressways.

The CDRG vehicle ran only on main general roads where route guidance was available and on expressways, while other vehicles ran on all but the narrowest general roads.

For all vehicles running on the expressway, a handicap was also added to the actual travel time for evaluation purposes.

A.3.3 Test Results

A.3.3.1 General

Each OD pair ran six times a day for three days, totalling 108 runs. Part of the data collected was inappropriate for system evaluation since such errors as failures of a CDRG vehicle's driver to follow the recommended route were included. Two indexes were obtained from data on 84 runs excluding the above cases.

A.3.3.2 Travel time per vehicle type

The following table shows the average and increased travel time compared with the CDRG vehicles for each type of vehicle. The travel time increase rate (%) is defined as follows:

$$\mathrm{TIR} = \frac{\mathrm{TTO} - \mathrm{TTC}}{\mathrm{TTC} \times 100}$$

Here, TIR refers to travel time increase rate, TTO to travel time for other than CDRG vehicles, and TTC to travel time for CDRG vehicles.

The results in Table A.3 show that the CDRG vehicles arrived at their destinations earliest on average, followed by taxis (later by 3,7 %) and ordinary vehicles (later by 12,4 %).

Table A.3

Vehicle type	Average travel time (s)							Increase rate (%)
	OD1A	OD1B	OD2A	OD2B	OD3A	OD3B	Total	
CDRG	3 695	3 902	2 919	2 375	4 054	3 552	3 397,8	0,0
Taxi	3 793	4 150	2 906	2 440	4 304	3 665	3 525,2	3,7
Ordinary	4 249	4 285	3 464	2 781	4 516	3 788	3 820,1	12,4

A.3.3.3 Winning rate of CDRG vehicle

Table A.4 shows another index, namely, the winning rate. This value is calculated by dividing the number of times a particular vehicle reached the destination earliest by the total number of runs. The winning rate for CDRG vehicles was the highest of all ODs except OD2A and 3B, occupying half, or 50,0 %, of all ODs. For the remaining two ODs, the winning rate for taxis was the highest. This was probably due to the fact that drivers of CDRG and ordinary vehicles stayed in a certain lane while experienced taxi drivers knew when to change lanes, resulting in a difference in travel time even when both used the same route. CDRG vehicles, however, did not arrive on average significantly behind taxies for OD2A and even earlier for OD3B. This indicates that the system is capable of consistently providing close-to-optimum routes even when the optimum routes cannot be obtained for some reason or other.

Table A.4

Vehicle type	Winning rate (%)						
	OD1A	OD1B	OD2A	OD2B	OD3A	OD3B	Total
CDRG	46,2	61,5	41,7	50,0	64,3	37,5	50,0
Taxi	46,2	30,8	58,3	31,3	14,3	43,8	36,9
Ordinary	7,7	7,7	0,0	18,8	21,4	18,8	13,1

A.3.3.4 Response to emergency

For this test, ramp closure on the expressway was an anticipated emergency. No CDRG vehicle encountered ramp closure during the actual running, although up to 10 ramps were closed when testing the same under normal conditions. This indicates that the system is capable of successfully recommending another route when a ramp is closed.

A.4 Conclusion

As the above field test results show, the CDRG vehicles using the route guidance information provided by this system arrived at their destinations in the shortest time on average, confirming that CDRG is more efficient than depending on experienced taxi drivers. Besides, the CDRG vehicles arrived at their destinations in almost as much as predicted travel time provided and without encountering any ramp closure, which also proves the high practicality of this system.

We will conduct the fourth-step field test aimed at putting the system to practical use in the near future. This test is intended to evaluate whether it is capable of providing effective route guidance to the final destination as a whole when a distant designation further than 20 km from a starting point is used.

Bibliography

[1] ISO 15075, *Transport information and control systems — In-vehicle navigation systems — Communications message set requirements*

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