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The display of information by means of road markings: a review of some practices.

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Summary

Road markings are applied in different ways; there are also international differences. Examples of this are given, which are related to the objective of giving information to road-users with markings and alternative means.

1. PURPOSES OF INFORMATION DISPLAY

Purposes of applying road markings and placing lights and signs may be:

1. to furnish information on general and permanent features applicable for every road section, relevant for guiding the vehicle along the road and relatively to other road-users;
2. to indicate the presence and any further characteristics of place-, time- and/or time- and place-related variations in road features;
3. to indicate the category of the road.

1.1. Information on general and permanent features applicable for every road section relevant for guiding the vehicle along the road and relatively to other road-users

This relates to:

Indicating the boundaries of the lane or carriageway (the geometry of the road) for being able to perceive the track of the road and the position in the road track of the own vehicle and of other vehicles (markings, and position references functioning as such trees, lamp standards - along the road).

Longitudinal markings, which the road-user is deemed to be able to perceive constantly (in the central or peripheral parts of the visual field) are suitable sources of information for this part of the driver's task requiring more or less continuous observation and response.

1.2. Indicating the presence and any further characteristics of place-, time- and/or time- and place-related variations in road features

These characteristics may be:

1. place-related, for instance bends and intersections. This is done by means of signs and (often) also by means of unusual centre-line marking; centre-line markings which must not be crossed from one or

both sides.

2. time-related (and applying to the entire road surface), for instance slippery surface, congestions, for which signs or lights might be used.

3. place and time-related, for instance lane indication, signposting of alternative routes achieved by means of signs; sometimes, at diversions, with unusual markings (yellow studs).

Further characteristics mentioned are:

on straight sections: beginning and end of narrow sections, variations in the state of the verge in connection with the extent to which crossing the marking is critical (signs);

in bends: for instance beginning and end, radius, cross slope or indicated speed (signs);

at intersections: geometry, possible routes, right-of-way rule (signs, sometimes markings on road surface as well), presence of intersecting traffic (not indicated separately).

1.3. Identifying the category of the road

It is assumed that when a road-user enters a road section he needs information regarding the entire section, applying to general, more or less permanently valid features.
Identification of the category of the road on the basis of general and more or less permanent features is given by means of signs placed at the beginning of the section in question; in some countries (U.S.A., France) also continuously by means of colour and configuration of the marking.

Category indication must be distinguished from indication of the route of which the road section forms part. Routes are indicated according to destinations.
The category or class of the road could relate to drive-ability and the features of importance for this.

In practice, the two principles of classification will be related, and

more important routes will thus consist of higher categories of roads. For a destination that can be reached via a motorway, roads of a lower category are usually available as well, sometimes even a number of motorways. On the other hand, routes used by motorists will often consist of roads of different categories, e.g. residential streets, trunk roads, motorways.

In the Netherlands the type of route can sometimes be recognised by the design of road signs: black characters on a white background on signs for local destinations in built-up areas. Temporary diversions and special routes are indicated with the combination of black and yellow. In Western Germany, however, this combination is proposed for trunk routes (Most, 1971).
Green and white is used for the number code of international routes (on blue and white boards). In the United States, however, direction signs are green, and blue is reserved for service signs (Conner, 1971). In the Netherlands tourist routes are given on white hexagonal boards with blue characters (Brand, 1971). In America, brown is reserved for signposting these routes (Conner, 1971).

In some cases, route indication may be assisted by means of the (colour of the) marking. For instance in the United States, experiments have been reported with coloured catadiopters as extra entry lane markings and on exit lanes (Roth, 1970; Taylor, 1971). In Western Germany experience has been obtained with colourmarking of road sections intended for traffic turning left (Sparten, 1971).

2. ROAD MARKINGS AND ALTERNATIVE MEANS

2.1. Indicating the category of the road

The categories of roads defined according to the regulations are indicated by signs at the beginning of the road section. Different categories are also usually recognisable on maps. In the Netherlands roads in different categories are not distinguished by different markings: unless the road is so narrow that the centre and/or edge lines are omitted, all roads are in principle marked in the same way (Department of Roads and Waterways, 1971).
There are indications that the customary signs at the beginning of the road section are not satisfactory in all cases. Repeated signs or, better still, continuous indication of the category of the road might therefore be advisable.

In other countries the category of the road is sometimes indicated by continuous markings on the road surface. In the U.S.A. for instance (Conner, 1970) roads with and without oncoming vehicles are distinguished by the colour of the centre-line marking (yellow and white respectively).

France applies a similar system, with a further differentiation according to number of lanes and traffic density (Frybourg, 1970).

In the U.K. (James and Reid, 1969), it has been proposed that roads with separate carriageways should have not only the customary white markings, but also catadiopters: yellow at the right and red at the left. This would distinguish them from roads without separate carriageways which have only the white markings (flat reflective sheeting).

In the Netherlands a left (white) - right (red) distinction is also made, but not only on motorways.

In view of the need - also internationally, for the use of additional means besides signs for indicating the category of road and the use of road markings for this purpose - standardisation of type, colour, position on the road and configuration of road markings is necessary. An

obstacle to this is the lack of a satisfactory system for the division of roads into categories. For a speedy solution linking up with the types of roads now distinguished by the regulations, the American system might be envisaged, plus an additional distinction between the category of (two or more lane) roads with mixed traffic and the category of (two or more lane) motor roads. For instance a double (yellow) centre-line or, in addition to the centre-line also yellow edge lines for mixed traffic roads. In some countries, however, a double dividing line is customary for indicating roads with "reversible lanes" (tidal flow). In using yellow edge lines it must be remembered that these already mean "no parking".

Some of the objections that can be raised against the American system are:

1. after dark the visibility of the colour of the marking when illuminated by headlamps is slight owing to the small angle of illumination. This can be offset by using vertical illumination (street lighting) or reflectors slightly elevated in the road surface.

2. the colour impression (white or yellow) depends on (the colour of) the light with which the marking is illuminated (sodium street lighting, yellow headlamps). Solving this necessitates uniformity in the colour of headlamps and street lighting.

3. yellow markings have lower reflection than the corresponding white markings.

4. specific meanings of yellow markings already exist: place-related no parking, temporary change in geometry owing to road works; while yellow generally indicates a warning.

In choosing an alternative system, viz. a single broken centre-line for roads without oncoming traffic and two broken centre-lines for roads with oncoming traffic, these objections do not apply, while simple and clear combinations with solid centre-lines (which must not be crossed from one or both sides) remain possible:

2.2. Indicating the presence and any further characteristics of place and/or time-related variations in road features

Where the existence of variations in road features is indicated with road-surface markings, this relates primarily to place-related geometrical characteristics, especially bends, narrow stretches, intersections and junctions.

Signs or markings, or a combination of signs and markings are used for indicating these characteristics. Further characteristics, such as the actual geometry, route-selection possibilities, right-of-way rule, are usually indicated with signs alone. Exceptions are direction and lane-selection arrows on the road surface, which may or may not be combined with names of routes painted on the road surface.
Drivers are sometimes forced to choose a lane while the direction it leads to is only apparent later.

Practice in the Netherlands is to change the 3 - 9 marking (3 metres white, 9 metres black*) to the opposite 9 - 3 warning pattern about 100 metres ahead of an intersection.

A change-over from the normal 3 - 9 pattern to a 9 - 3 pattern may be intended to draw road-users' attention to the existence of a local discontinuity.

No data are known, however, about the distance at which the difference in marking pattern can be perceived. The same applies to the interpretation - by road-users - of this difference in terms of "pre-warning of a discontinuity"**.

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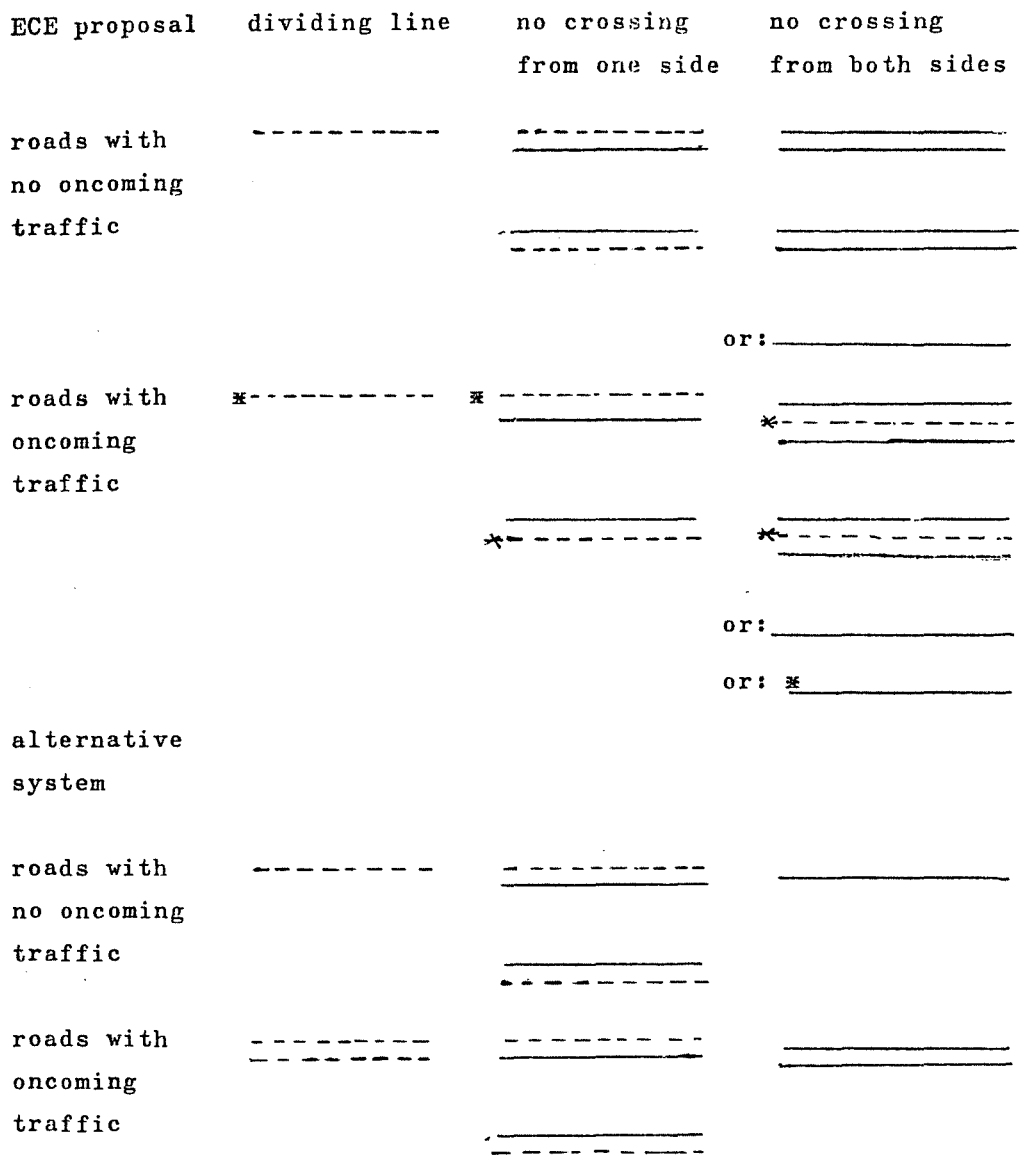
* Other countries have different values: U.K. 0.9 - 7.2;
America 4.5 - 7.5, with a proposal (for financial reasons) to change this to 1.5 - 10.5 metres (Taylor, 1971).

** A variation is to make the distance between markings or catadiopters either in edge posts or not progressively shorter as the intersection approaches (Taylor, 1971).



⁎: yellow marking

2.3. Indicating general and more or less permanent road characteristics for guiding the vehicle along the road and relatively to other vehicles

The recommendations below are assumed to be compatible with the use of markings for route guidance and classifying roads, time and/or place-related characteristics. Next, it is assumed that applying markings for guiding the vehicle along the road also promotes guidance relatively to other vehicles.

The reflectance - and hence the visibility - of the commonly used reflectorised paint diminishes rather quickly in use. This applies far less to catadiopters (slightly elevated on the road surface), the average reflectance of which is also higher. Further information, also as regards cost, is given by Taylor (1971); James and Reid (1969) and Dale (1970). The various materials are reviewed by Frédéric (1972).
Applying easily visible centre-line and/or edge marking favourably influences the average lane position of vehicles and/or variability in that position; and also the speed in bends (Taylor et al., 1971; Seydell 1967).
Favourable effects on accident rate also have been reported, a review of which is given by O'Flaherty (1972).
Applying a marking within the visible lane boundaries showing the desirable track could increase the accuracy of manoeuvring (Mulder, 1970). This assumption should take into account the - possibly adverse - effects on the possibility of determining the (lateral) position of other vehicles. Rumble strips along the carriageway, or paving the entire verge differently offers an additional possibility of informing drivers of extreme divergences in their lateral position. This is specially useful for fatigued and/or non sober drivers, and in general when visibility is poor.
For conditions in which the primary system fails (snow-covered, or wet and hence specular reflecting road surface) an emergency system (reflectorised edge posts) should be available.
Off-road position references are of primary importance for an impression of speed (Salvatore, 1968). Where there are good road surface markings,

they seem to be of little importance for road tracking. This applies in principle to flat edge posts too (Taylor, 1971).
The visibility of markings can be increased by combining them with catadiopters slightly elevated in the road surface, for instance as developed for the American NCHRP (Dale, 1970).
If light (coloured) road surfaces instead of dark ones are used, it is advisable not to reduce the contrast between road surface and marking (in daytime too).

3. CONCLUSIONS

3.1. Possible variations in road-surface markings relate to: colour, line thickness, configuration (longitudinally and laterally), location on road.

3.1.1. Colour

When (reflectorised) road paint is used only a limited number of colours are suitable owing to the decreasing reflectance of more saturated colours. The colour impression, which is determined partly by the surroundings (brightness) and by (the colour of) the incident light is weak owing to e.g. the small angle at which the road-surface marking is illuminated by the car headlamps or perceived by the driver. These drawbacks can largely be eliminated by using slightly elevated catadiopters in the road surface. Moreover, this method is less liable to specular reflection (with wet road surfaces). The choice of colour is limited to the definitions and purposes already contained in the regulations, unless new colour codes should be introduced.

Colours used in practice (Netherlands) are:

(a) white: painted arrows, centre-line and/or edge markings; catadiopters in edge posts at the off side of the road;

(b) yellow: studs where there are road works; painted edge markings to indicate no-parking;

(c) red: catadiopters in edge posts at the one side of the road.

3.1.2. Line thickness

The discrimination of differences in line thickness depends on the visible existence of possible alternatives. Moreover, a minimum thickness is required because of visibility requirements, and in deciding the maximum thickness the consequences regarding the required lane width must be taken into account.

Variations occurring in practice are associated with changes in the

configuration, for instance at intersections.

3.1.3. Longitudinal configuration

The minimum quantity of white (in the Netherlands 3 metres with 9 metres black) is determined by the minimum necessary sight distance (conditions interfering with visibility such as heavy rain and fog). With an increasing distance, i.e. a decreasing angle of observation - differences in longitudinal configuration will be more difficult to distinguish; this effect is stronger the greater the amount of white that is chosen in the configuration.
In practice, differences in longitudinal configuration are used as an aid in indicating discontinuities and for distinguishing different lanes at discontinuities (such as entry and exit lanes, lanes at intersections).

3.1.4. Location on the road

The location of the marking on the road is determined by the information required for guiding the vehicle along the road and relatively to other vehicles. Roads are provided with uniform centre-line and/or edge markings with this intention.

3.1.5. Lateral configuration

For the distinguishability of various configurations, for instance either one or two (broken or solid) lines, the visual acuity of the eye and its sensitivity to contrast are important; this assumes a minimum distance apart and a minimum contrast with the road surface. Since the differences that have to be perceived appear laterally, the angle of observation is only a limiting factor as far as there is any distortion of perspective. A separate indication (with signs) will therefore be necessary for indicating at the required distance the areas where changes occur.
The application is the place-related indication that centre-line markings must not be crossed from one or both sides on roads with oncoming traffic. A possibility consistent with present uses but as yet unused is a distinction (between roads with and without oncoming traffic) by having

two and one broken centre-line marking respectively.

3.2. Besides alternatives such as signs and signals, road surface markings can be regarded as providing information on:

(a) the category of the road;

(b) place and/or time-related variations in road features;

(c) guiding the vehicle along the road;

(d) route guidance.

The primary function of road surface markings is to create an information system for guiding the vehicle along the road, as there will be no reliable alternative sources of information available to the road-user.
The use of variations in longitudinal road-surface markings for indicating place-related variations, for instance in the geometry, will in many cases have to be regarded as secondary to the use of alternatives (signs and signals). This likewise applies to road-surface markings as a route guidance element.
Possibilities of distinguishing categories of roads by means of differences in road-surface marking are limited as regards perceptibility, to differences in lateral configuration (one as compared with two broken centre-lines) and perhaps also in colour (white as compared with yellow markings).

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