From black spots to grey road sections in road safety management - Is it the right way?

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Abstract

Since the 1960s black spot management (BSM) has been an essential part of the site-specific traffic safety work in the safest countries. However, this work is not as effective as it formerly was, because the most significant black spots have been identified and treated.

Thus, for the last 5 to 10 years several of the most traffic safe countries have supplemented or even replaced the traditional black spot management with network safety management (NSM) consisting of identification, analysis and treatment of hazardous road sections. In Denmark these roads are called for grey road sections.

Despite this general trend it has not been systematic investigated, whether identification and treatment of grey road sections at all is the right way in the future site-specific traffic safety work. This is therefore been investigated in the PhD-thesis "Hazardous road sections in rural areas – development, application and assessment of severity based methods for identification, analysis and improvement of hazardous road sections" (Sørensen 2006).

The basic philosophy in the grey road section work is typically to combine the principle in black spot action and mass action. This means that the work both have a reactive nature as black spot management and a proactive nature as mass action.

This philosophy has been evaluated for nine grey road sections. On these road sections several faults and deficiencies have been identified and different measures to eliminate or minimize the problems have been proposed and implemented. However, an examination of the over 100 measures proposed shows that a majority of over 75 % of these only is of a proactive nature because they only relate to problems identified during the road inspection. Thus, there are only few proposed measures, which both have a reactive and a proactive nature through relating to problems identified in both the accident analysis and in the road inspection.

This shows that it is very difficult to find local accident factors on the identified grey road sections according to the accident history. The analysis of the road sections is thereby to a greater degree in the nature of a general road examination with special attention on standard improvements rather than treatment of local accident factors. There is no doubt, that general road examination and standard improvements contribute to traffic safety improvements, but since the standard improvements in principle are independent of the accident history on the specific road sections, the identification may be done in a better way as a non accident based method. The desirability to let the grey road section work be part of the site-specific traffic safety work can thus be questioned because the resources probably can be used in a better way for road examination and standard improvements.

Objective and background

The present paper is based on results from a Danish PhD-thesis (Sørensen 2006). The project treats the site-specific traffic safety work on main roads in the rural areas in Denmark. The objective was specifically to define what a grey road section is and to develop methods for their identification, analysis and treatment. The methods had to be well founded concerning accident theory and of practical use. At the same time, the objective was to develop methods for systematically incorporating the accident severity in all stages of the grey road section work. Finally, the objective was – based on Danish data – to evaluate whether identification and treatment of grey road sections at all is the right way in the future site-specific traffic safety work. This paper focuses on the developed method for identification and the last question whether grey road section work is the right way.

There are four reasons why this work is needed. Firstly, there has been a smaller decrease in the number of accidents in the rural areas compared to urban areas. This is unfortunate, as accidents are generally more severe in the rural areas.

Secondly, several objections can be raised against the present Danish black spot management. The method is based on almost 40 year old theory on accidents and there is a discrepancy between strategy and method (Madsen 2005). Furthermore, the most significant black spots have been treated, and the potential of the work is therefore limited (Sørensen 2005). In several of the safest countries focus is thus gradually turning on the grey road section work (NSM) rather than the black spot work (BSM) (European Commission 2003).

Thirdly, during the last 10 years the grey road section work (NSM) is to an increasing degree turning up in the Danish road administration authorities' site-specific traffic safety work. However, a common and unambiguous definition of the concept does not exist, and common, formalized and operational methods for the identification, analysis and treatment of these road sections have not been established. As a result, the Danish road administration authorities today identify grey road sections applying primitive methods.

Fourthly, in 2000 the Danish Traffic Safety Commission published a new traffic safety plan for the years 2001-2012 (Færdselssikkerhedskommissionen 2000). The aim of this plan is to reduce the number of people killed and severely injured on the roads by 40 %. This aim is an important change in relation to the previous one from 1998, which dealt with the total number of persons injured. Thus, the aim marks a significant strategic change in the traffic safety work from crash prevention to loss reduction. This means that the need for systematically taking into account the degree of severity of the accidents in the methods applied has increased. In Denmark, however, this has not been implemented satisfactorily.

Investigative method

To be able to fulfil the objective the following six part examinations have been carried out:

1. Literature survey of 30 Danish national and county traffic safety plans
2. Interview with 18 key persons working with traffic safety on main roads in rural areas
3. Literature survey of existing methods in 14 EU-countries, Norway and USA
4. Literature survey of 30 scientific articles, reports and textbooks from 1964-2004
5. Analysis of categories, where correlation between road design, traffic and accidents is analyzed and where the average accident cost weighted density of accidents has been estimated and statistically assessed for 50 defined road and traffic categories
6. Test, demonstration and assessment of the methods developed

The purpose of the literature surveys and the interviews was to gain knowledge and ideas on how a Danish method for the identification, analysis and treatment should be in order to be theoretically well founded as well as useful in practice. Based on these analyses, a number of general recommendations have been formulated. Then a specific category and severity based identification method has been developed. This has been tested and assessed in a concrete case, where identification, analysis and treatment of hazardous road sections are done for the county road network in the former Ringkøbing and Viborg counties.

Philosophy

Before recommending how to identify grey road sections it has initially been discussed and determined what the philosophy for the grey road section work should be, as this factor is crucial for the planning of the identification stage.

The basic philosophy in the grey road section work is to combine the principle in black spot action and the principle in mass action. This means that the work shall be local, remedial and retrospective as well as preventive and prospective. The identification stage is based on registered traffic accidents and therefore has a retrospective nature like the black spot safety work. In contrast the following stages of analysis and treatment both have a retrospective and prospective nature, because it is recommended that these stages both are based on accidents and general traffic safety problems and standard improvements. The idea is that remedial improvements on accident locations are spread out on the whole road section and thereby also gets a preventive and prospective nature.

Category and severity based identification method

Based on the results from the literature survey and the interview study a method for identification is developed. This method will be described in the following.

Identification principle

It is recommended that identification based on category and severity is made in such a way that the importance of the design of the road and traffic as such, as well as the severity of the accidents are taken into consideration.

Even though model based identification methods are to be preferred from a theoretical point of view (Sørensen and Elvik 2007), the development of a category based identification method will contribute with a substantial improvement of method in relation to the identification methods of grey road sections presently applied by the Danish road authorities. Likewise, the systematic inclusion of the severity of the accidents will be an improvement.

The identification is made based on a ranking taking into account the reduction potential index, RPI, of the road sections, which cf. table 1, is estimated as the absolute difference between the recorded accident cost weighted density of accidents and the average accident cost weighted density of accidents for the category to which the road section belongs.

The calculation of recorded and average accident cost weighted density of accidents is based on the formulas in table 1. The calculation comprises density of accidents with severe personal injury, minor personal injury and damage to property, weighted according to the average accident costs for the three categories of accidents for the given road category.

Identification criterion

By way of the absolute difference between recorded and average accident cost weighted density of accidents, the grey road sections are identified based on potential reduction of accidents. This is the obtainable reduction of accidents, if the road section after improvement reaches an average level of accidents. The potential reduction of accidents is recommended, as it immediately ensures the largest accident saving. In addition, the criterion creates focus on local and road section based risk factors, as well as probably yielding the most cost efficient traffic safety work.

The identification criterion itself is that the reduction potential index is to be larger than four. This applies to all road authorities. This gives a mutual understanding of the concept, gives the highest impact vis-à-vis politicians, makes identifications comparable and contributes to ensuring that the road sections identified are true grey road sections. One of the reasons is that a common identification criterion would prevent the single road administration authorities from downgrading the identification criterion, which would increase the risk of identifying false grey road sections.

It is a tricky balancing act to determine the identification criterion. On the one hand it is important to identify all the true grey roads and on the other it is important to minimize the number of false grey road sections in the identification. A high identification criterion is recommended because the identification method developed only to a certain extent takes into consideration the random variation of the accidents. By using a high identification criterion identifying false grey road sections should be avoided.

Reduction potential index:

$$RPI = RWACD - AWACD$$

Accident cost weighted density of accidents:

$$WACD = (W(k)_{acc,\,ser.} \cdot ACD_{acc,\,ser.}) + (W(k)_{acc,\,min.} \cdot ACD_{acc,\,min.}) + (W(k)_{acc,\,prop.} \cdot ACD_{acc,\,prop.})$$

Weights:

$$W_{acc,\,ser.} = \frac{AC_{acc,\,ser.}}{AC_{acc,\,prop.}},\ W_{acc,\,min.} = \frac{AC_{acc,\,min.}}{AC_{acc,\,prop.}},\ W_{acc,\,prop.} = \frac{AC_{acc,\,prop.}}{AC_{acc,\,prop.}}$$

Accident costs:

$$AC_{acc,\,ser.} = (CP_{kiled} \cdot x_{killed}) + (CP_{ser.} \cdot x_{ser.}) + (CP_{min.} \cdot x_{min.}) + CPr_{acc.}$$

$$AC_{acc,\,min.} = (CP_{min.} \cdot x_{min.}) + CPr_{acc.}$$

$$AC_{acc,\,prop.} = CPr_{acc}$$

Explanatory notes:

RPI:	Reduction potential index = -6.98-13.70 (0)
RWACD:	Recorded accident cost weighted accident density for the given road section = 0-20.75 (3.50)
AWACD:	Average accident cost weighted accident density for the given category k = 0.96-11.85 (4.29)
WACD:	Accident cost weighted accident density, recorded or average
$ACD_{acc,\,ser}$:	Recorded or average accident density for accidents with persons killed and serious injuries
$ACD_{acc,\,min}$:	Recorded or average accident density for accidents with minor personal injuries
$ACD_{acc,\,prop.}$:	Recorded or average accident density for accidents with property damage
$W(k)_{acc,\,ser}$:	Weight of accidents with persons killed and serious injuries for category k = 17.9-79.3 (36.3)
$W(k)_{acc,\,min.}$:	Weight of accidents with minor personal injuries for category k = 4.2-6.2 (5.1)
$W(k)_{acc,\,prop.}$:	Weight of accidents with property damage for category k = 1
$AC_{acc,\,ser}$:	Accident costs for accidents with people killed and serious injuries = 1,790,000-7,930,000 DKK
$AC_{acc,\,min.}$:	Accident costs for accidents with minor personal injuries = 420,000-620,000 DKK
$AC_{acc,\,prop.}$:	Accident costs for accidents with property damage = 100,000 DKK
CP_{killed}:	Costs related to people per person reported killed = 10,404,000 DKK
$CP_{ser.}$:	Costs related to people per person reported seriously injured = 1,085,000 DKK
$CP_{min.}$:	Costs related to people per person reported with minor injuries = 295,000 DKK
CPr_{acc}:	Costs related to property damage per accident = 100,000 DKK
x_{killed}:	Number of people killed per accident of the given severity category
$x_{ser.}$:	Number of people with serious injuries per accident of the given severity category
$x_{min.}$:	Number of people with minor injuries per accident of the given severity category

Table 1. Formulae for calculating the reduction potential index and recorded and average accident cost weighted density of accidents. In addition, specifications of estimated values, where brackets indicate mean value. The values for RPI and RWACD are indicated based on results from the specific case.

Severity

Despite the fact that the objective for the traffic safety work specifically relates to personal injuries, it is recommended that accidents are taken as the starting point rather than

personal injuries. The reason for this is that the number of personal injuries may be determined by coincidence and parameters which lie outside the road administration authorities' site-specific traffic safety work. As an example could be mentioned number of persons in the vehicles in question as well as lack of using the safety features.

The severity of the accidents is included by categorizing them in accidents with severe personal injuries, minor personal injuries and accidents with damage to property. These accidents are weighted on the basis of the average number of persons injured of varying severity in the three severity categories in each of the 50 defined road and traffic categories, and the average accident costs, connected with these personal injuries, cf. table 1.

Accidents of the same degree of severity have, in principle, cf. table 1, varying severity by way of different average number of persons injured per accident in the different road and traffic categories. Different weights have been used for the 50 road and traffic categories in order to take this into consideration.

Breakdown and length of road sections

The road system should be divided into sections of approximately equal category. This means that the road sections are homogenous regarding average daily traffic, category of net, number of lanes, buildings along the road, speed limit and presence of bicycle lanes and side strips. In order to make sure that the sections are homogenous, the sections may have different lengths. It is recommended that the length varies from 2 to 10 km.

Definition

Based on the identification method developed, it is recommended that the professional definition of grey road sections in the general road system in the rural areas is the following:

> *2-10 km long, homogenous road sections, where the reduction potential index calculated as the difference between the recorded and the average accident cost weighted accident density for the given road and traffic category is larger than four.*

A more popular version of the definition, which can be used in connection with communication with non-specialists, could e.g. be: Road sections where the potential for realising a reduction of the most serious accidents is the largest.

Category analysis

In order to be able to carry out the recommended category and severity based grey road section identification, it is necessary to make a category analysis, where the road system is broken down into a series of categories, for which the average accident cost weighted accident density is estimated.

Based on the 5-year accident period 2000-2004 such an analysis has been made for state and county roads in the rural areas in Denmark. The analysis comprises 9,707 km roads, which have been broken down into 7,313 part sections. In this road network 15,826 accidents have been recorded resulting in 13,025 people injured.

Based on the parameters related to roads; type of net, number of lanes, buildings along the road, speed limit and the presence of bicycle lanes and side strips, this road network has been broken down into 50 road and traffic categories. Table 2 indicates how the 50 categories are defined, and what the estimated average accident cost weighted accident density for the 50 categories is.

			Other roads								
					2 lanes						
						No buildings					
								80 km/h			
Road category	Free way	Motor way	4 lanes	3 lanes	Buil-dings	60 km/h	70 km/h	Side strip	One-way bicycle lanes	Double bicycle lane	None
	1	2	3	4	5	6	7	8	9	10	11
Under 1,000	0.96	1.72	6.77	3.44	3.52*	3.51	5.28*	1.19	2.67	2.05	1.01
1,000-2,999								2.05			2.25
3,000-4,999					2.80*	4.27*	7.18*	3.89	3.95*	4.03	3.67*
5,000-6,999		4.12		6.61*	6.28	5.98	11.47*	4.75	4.44	5.00	6.10
7,000-9,999	1.39	6.32*	11.17*	4.46	8.80*	8.57	7.39*	6.93*	7.02	6.95*	
10,000-14,999	2.39	10.08*			9.16		6.74	7.72	7.85	10.41	
15,000-30,000	5.60	9.39	11.85								
Over 30,000	9.76										

Table 2. The breakdown of the road network on the basis of parameters related to roads and average daily traffic in vehicles per day and the average cost accident weighted accident density for the 50 categories. * indicates that the average accident cost weighted accident density should be subject to some reservation, as the value indicated does not differ significantly from the value of the following category.

Identification in Ringkøbing and Viborg counties

Specific identification of grey road sections has been made on the county road in Ringkøbing and Viborg counties. The purpose has been to have the method tested and demonstrated, and on this basis to be able to make an assessment of the method.

		Ringkøbing	Viborg	Total
Road network	**Total (km)**	891	798	1,689
	In the analysis (km)	816	745	1,561
	Number of road sections	146	144	290
Section length	**Average length (km)**	5.6	5.2	5.4
	Percentage below 2 km (%)	7.5	7.6	7.6
	Percentage above 10 km (%)	10.3	5.6	7.9
Most abundant reason to division	**Start or ending (%)**	37	37	37
	Town (%)	23	19	21
	Main intersection (%)	15	16	15
Most abundant category	**8.2 (%)**	37	36	37
	8.3 (%)	30	19	24
	8.4 (%)	15	17	16
Homogeneity	**Homogenous (%)**	53	56	54
	Almost homogenous (%)	44	38	41
	Non-homogenous (%)	3	6	5

Table 3. Main results of the division of road network into sections in Ringkøbing and Viborg counties.

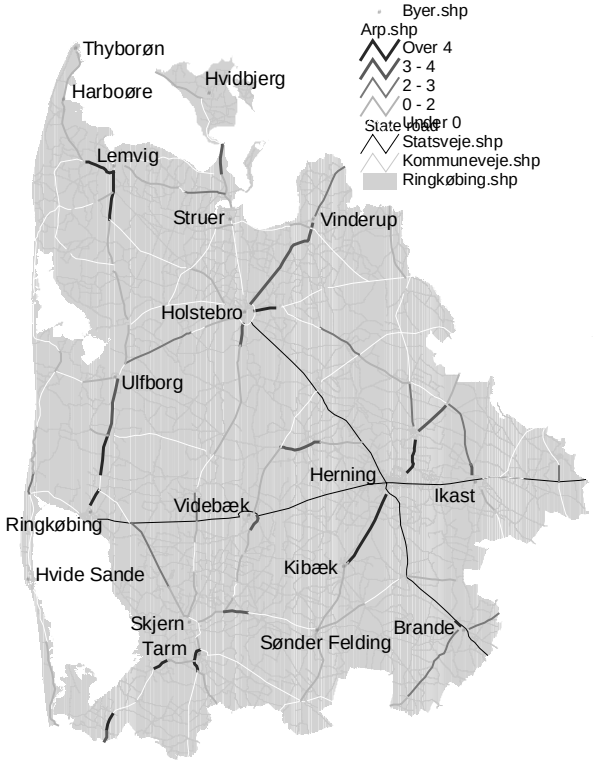

Figure 1. Reduction potential index for county road sections in Ringkøbing county.

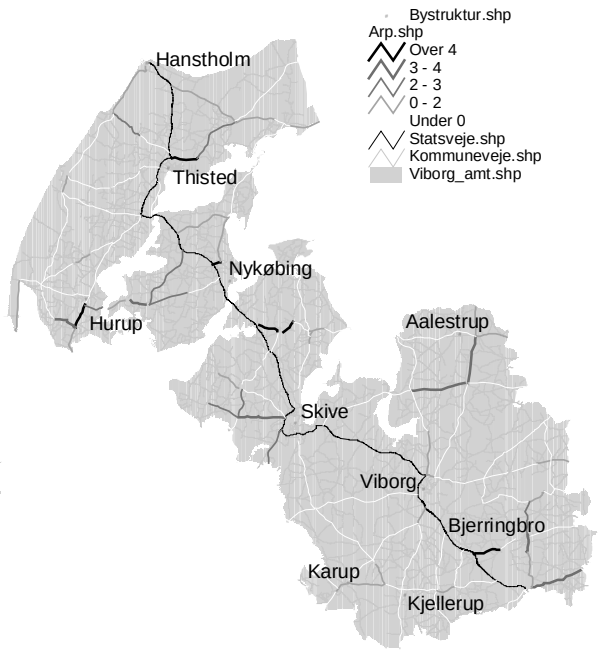

Figure 2. Reduction potential index for county road sections in Viborg county.

Name	Road	From	To	Length	Category	ADT	Accidents	Injuries	RPI
Ulfborg-Lemvig (R)	502	49,011	51,800	2.8	8.4	6,200	12	10	13.7
Viborg-Holstebro (R)	417	46,940	49,693	2.8	10.5	10,600	18	16	10.3
Viborg-Herning (R)	439	38,923	44,770	5.8	10.5	10,700	26	44	8.7
Tarm-Nr. Nebel (R)	521	16,258	18,750	2.5	8.2	2,500	5	11	8.3
Skjern-Varde (R)	333	28,191	31,295	3.5	8.3	4,000	8	14	8.2
Lemvig-Thyborøn (R)	476	0,126	4,125	4.0	8.4	5,900	13	10	7.3
Ulfborg-Lemvig (R)	502	45,108	48,957	3.8	8.3	4,500	9	6	6.6
Ringkøbing-Holstebro (R)	418	1,805	4,274	2.5	8.3	4,700	7	4	6.0
Tarm-Nr. Nebel (R)	521	5,176	6,840	1.7	10.2	3,600	3	3	6.0
Brande Nord (R)	559	41,602	42,520	0.9	8.3	3,200	3	1	5.1
Herning-Varde (R)	370	1,000	11,961	10.9	8.4	6,800	41	60	4.8
Ringkøbing-Holstebro (R)	418	6,990	12,481	5.5	8.4	5,600	12	14	4.0
Nykøbing-Elsø (V)	614	3,478	4,731	1.3	8.2	2,500	6	2	8.5
Harre-Roslev (V)	531	0,794	3,227	2.9	8.2	1,500	7	7	6.5
Thisted-Fjerritslev (V)	427	0,000	4,300	4.3	8.3	4,500	14	10	5.7
Ulstrup-Rødkærsbro (V)	546	34,164	38,738	4.6	Mixed	4,200	8	7	5.2
Thisted-Oddesund (V)	426	29,462	33,566	4.1	8.3	3,900	10	9	4.3
Vium-Sundsøre (V)	472	4,882	7,135	2.3	11.2	1,600	4	4	4.2

Table 4. The identified road sections in Ringkøbing (R) and Viborg (V) counties. Accident period: 2000-2004.

Initially the road system is divided into sections. The main result of this division is given in table 3. The reduction potential index has been estimated for the 290 road sections and sections where the reduction potential index is larger than four have been identified as grey road sections. The estimated reduction potential indexes are illustrated in figure 1 and figure 2 and some characteristics for the grey roads section are summarized in table 4.

Assessment of the method

Based on the results from the specific identification and results from subsequent accident analyses and road inspections of nine selected grey road sections an assessment has been made of the philosophy and the method for identification. The assessment of the identification method developed consists of a total of 10 different part assessments. The results from the most important assessments are summarized in the following.

Accidents on the grey road sections

For the grey road sections it applies that their accident density on an average is 2.9 times higher than the average level, while the density of fatal accidents and accidents with seriously injured people is 3.5 times higher than average. Thus, road sections with many accidents and especially many serious accidents have successfully been identified. The requirement for getting more focus on road sections with severe accidents is thus achieved.

Even though road sections with many serious accidents in general have been identified, there are single sections, cf. table 4 with only few reported accidents and personal injuries. It can therefore be considered to supplement the identification criterion used with a criterion about a certain minimum number of accidents and personal injuries.

Comparison with alternative rankings

For further assessment the identification method developed is compared with 10 alternative rankings. The 10 rankings are the following:

1. **RWACD/AWACD:** Ranking based on the ratio between recorded and average accident cost weighted accident density rather than absolute difference
2. **RWACD:** Ranking based on recorded accident cost weighted accident density without taking the average accident cost weighted accident density into account
3. **ACD:** Ranking based on recorded non-weighted accident density
4. **PIACD:** Ranking based on recorded non-weighted personal injury accident density
5. **SPIACD:** Ranking based on recorded non-weighted serious personal injury accident density
6. **ACF:** Ranking based on recorded non-weighted accident frequency
7. **PIACF:** Ranking based on recorded non-weighted personal injury accident frequency
8. **SPIACF:** Ranking based on recorded non-weighted serious personal injury accident frequency
9. **PIACD-EPIACD:** Ranking based on the absolute difference between expected and recorded personal injury accident density, where expected personal injury accident density is estimated by existing accident models
10. **PIACD/EPIACD:** Ranking based on the ratio between expected and recorded personal injury accident density, where expected personal injury accident density is estimated by existing accident models

The comparison serves two purposes. The first purpose is to assess whether the identified grey road sections are also ranked high in the other rankings. This will indicate that the "right" road sections have been identified. The second purpose is to assess whether the identification method developed is "better" than the alternative rankings meaning by way of better identifying road sections with the greatest saving potential.

The main result of the comparison is summarized in table 5. Is focus initially on the first eight alternative rankings it can be concluded that the grey road sections belong to those with the highest ratio between recorded and average accident cost weighted accident density (RWACD/AWACD), highest recorded accident cost weighted accident density (RWACD) and highest serious personal injury accident density (SPIACD). This indicates that it is the "right" road sections that have been identified in the method used. At the same time it can be concluded that the grey road sections are also ranked relatively high when ranking is based on traditional density and frequency of accident (ACD and ACF) and personal injury accident (PIACD and PIACF). With regard to comprehensibility, acceptance and implementation of the method this is very important.

In addition the recommended method can be considered as better than the eight alternative rankings because the potential to reduce the number of serious accidents is highest on the grey road sections. The reduction potential index is thus 1-104 % higher on the grey road sections than on the highest ranked road sections in the eight alternative rankings. The rankings based on recorded accident cost weighted accident density (RWACD) and serious personal injury accident density (SPIACD) are, however, almost as good as the recommended method. Despite the fact that these rankings are more simple and easy to make, the method developed will still be recommended because there is a risk of identifying road sections with a low or in worst case negative reduction potential index in the ranking based on RWACD or SPIACD.

In the last two comparisons the identification of grey road sections have been compared with identifications based on the current model estimated personal injury accident density. Here the conclusion is that there is a significant difference between the recommended and the model based identification methods. This is important because it, in principle, would not have been necessary to develop a new identification method if it gave the same result as the existing method. Secondly, it can be concluded that the category based method where severity systematically is taken into account is better than the model based method where severity only is taken into account to a very modest extent. It is thus very important that severity is taken into account in the category analysis or in the accident modelling.

		RWACD/ AWACD	RWACD	ACD	PIACD	SPIACD	ACF	PIACF	SPIACF	PIACD-EPIACD	PIACD/EPIACD
Repetitions	**R**	7	11	6	7	10	2	3	5	8	6
	V	3	5	3	2	4	3	2	3	2	2
Ranking of grey road sections (%)	**R**	16	10	27	27	10	36	36	39	60	50
	V	8	8	16	14	7	31	31	17	22	26
Difference on ∑RPI for grey road sections (%)	**R**	25	1	54	20	9	101	102	51	19	28
	V	22	10	104	67	15	57	79	30	57	64

Table 5. Main results of the comparison between the recommended ranking and 10 alternative rankings. Repetitions specify the number of grey road sections, which also is ranked among the 12 highest ranked road sections in Ringkøbing (R) County and among the six highest ranked road sections in Viborg (V) County. Ranking of grey road sections specify in which percentage the grey road sections are found in the alternative rankings. Difference on ∑RPI specifies how much the sum of RPI is higher in percentages for the grey road sections than the highest ranked section in the alternative ranking.

Analysis and suggestions for treatment

Among the 18 road sections identified, four road sections have been singled out for further analysis. The road sections are the following:

1. Ulfborg-Lemvig, road 502, stationing 49,011-51,800, Ringkøbing County
2. Ringkøbing-Holstebro, road 418, stationing 6,990-12,48, Ringkøbing County
3. Harre-Roslev, road 531, stationing 0,794-3,227, Viborg County
4. Thisted-Fjerritslev, road 427, stationing 0,000-4,300, Viborg County

In order to test and demonstrate the methods under various conditions, the four analysis sections have been singled out, in such a way that they differ in character regarding length, category, number of accidents and personal injuries, reduction potential index, ranking and proportion of black spots and road sections.

The analysis itself consists of a general accident analysis, which is compared with "normal pattern of accidents", a rendering and analysis of so called extended collision diagrams, relevant road and traffic analyses and road inspections. Analysis and road inspection was made in a co-operation with traffic safety employees from Ringkøbing and Viborg Counties. In the PhD-thesis (Sørensen 2006) there is further information on the analysing methods and the result of the analysis of the four road section.

On the four road sections several faults and deficiencies with regard to traffic safety were identified and different solutions to eliminate or minimize the problems are proposed. If the problems identified, however, are examined according to how they are identified the, conclusion is that they mostly are identified in the road inspection and to a minor extent through the accident analysis.

At the same time a similar examination of the measures proposed shows that a majority of these only are of a preventive and prospective nature because they only relate to problems identified during the road inspection. There are thus only few proposed measures, which both have a remedial and retrospective nature and a preventive and prospective nature through relating to problems identified in both the accident analysis and in the road inspection. This is summarized in table 6. Here it is shown that among the 54 overall proposed measures only one quarter relates to the recorded accidents, while the remaining three-quarters have nothing directly to do with the accidents.

	Analysis road sections					Other grey road sections						
	1	**2**	**3**	**4**	**total**	**A**	**B**	**C**	**D**	**E**	**Total**	**Total**
Remedial and preventive	7	3	1	3	14	3	5	2	3	4	17	31
Only preventive	9	11	7	13	40	5	9	6	5	12	37	77

Table 6. The number of measures proposed on the four road sections analysed respectively five other grey road sections which have remedial and preventive nature or only have preventive nature.

An illustrative example of this problem is the analysis of road section 4. Here most of the accidents happened in intersections on the road section, but according to the results from the road inspection the proposed measures are mainly focused on problems on the road sections between the intersections, while only a few minor errors, deficiencies and inexpediencies in the intersections are identified.

A criticism against this part of the assessment is that it is only based on four road sections. To meet this criticism a supplementary analysis of identified and analysed grey road sections from other projects has been made. This analysis includes the following five road sections:

A Lemvig-Thyborøn, road 476, stationing 0,833-5,028, Ringkøbing County

B Lemvig-Thyborøn, road 476, stationing 5,026-13,224, Ringkøbing County

C Lemvig-Thyborøn, road 476, stationing 13,225-23,336, Ringkøbing County

D Vejle-Viborg, road 348, stationing 52,552-62,940, Ringkøbing County

E Hjørring-Syvsten, road 611, stationing 5,100-10,800, Nordjyllands County

These road sections have been chosen among known grey road analyses, where it has been possible to collect necessary data about the accident analysis, the road inspection and the proposed measures to make an assessment of the nature of the measures.

Among the measures on the five supplemented road sections the situation is the same as for the four analysis road sections, cf. table 6. Thus, under a third of the measures relates to the recorded accidents.

108 proposed measures have in total been evaluated. Among these it is only 31 that both have a reactive and a proactive nature while 77 measures only are of a proactive nature because they only relate to problems identified during the road inspection. Thus, the assessment shows that it is very difficult to find local and road section based accident factors on the identified grey road sections according to the accident history. The analysis of the road sections is thereby to a greater degree in the nature of a general road examination with special attention on standard improvements rather than restoration of local accident factors.

Conclusion

In this paper an overall philosophy for the grey road section work (NSM) has been formulated. At the same time a method for identification of grey road sections on main roads in rural areas in Denmark have been developed, tested and assessed.

A category and severity based method for identifying grey road sections has been developed. In overall terms, the analyses and assessments made of the identification method point in the direction that the road administration authorities through the identification method developed will have a reliable and practicable method at their disposal for the identification of grey road sections, which is better than the identification options, which the Danish road administration authorities have at the present moment.

However, the actual accident analyses and road inspections show that it based on the recorded accidents is very difficult to identify site-specific local accident and injury factors on the grey road sections. The analysis of the road sections thereby gets the nature of being a general road examination with special attention on standard improvements. In relation to the formulated philosophy for the grey road section work where it is attempted to combine the principle in black spot action and the principle in mass action this is a problem. The problem is that a prime requisite for the formulated philosophy is that there is correlation between the identification, analysis and treatment stages, which in practice is probably not the case.

There is no doubt that general road examination and standard improvements contribute to traffic safety improvements, but since the standard improvements in principle are independent of the accident history the ranking may be done in a better way than the accident based identification method developed, for instance a non accident based method.

The desirability to let the grey road section work be part of the site-specific traffic safety work can thus be questioned because the resources probably can be used in a better way for road examination and standard improvements.

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