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Best practice in European traffic incident management

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Abstract

Road networks are part of a country's transport infrastructure and are therefore subject to general transport policies. Efficient road networks are increasingly seen by governments across Europe as being the key to supporting and sustaining economic growth as they enable the movement of goods and services around the country. Traffic incidents have a significant impact on the normal operation of the road network. Economic constraints are causing National Road Authorities (NRA) to innovate as they look for cost efficient ways to tackle congestion and develop more effective traffic Incident Management (IM) measures. This has led to an emphasis in many European countries being placed on better use of existing infrastructure and IM capabilities rather than investing in more costly systems, equipment and working methods. The Conference of European Directors of Roads (CEDR) investigates how countries, can develop their IM capabilities to support policy goals and the needs of road users. The purpose of this study is to facilitate the cooperation, on a European level, by exchanging experience and information. This will support countries across Europe to minimise the economic cost of incidents, improve road safety and, decrease mobility problems through the implementation of relatively low cost IM measures.

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1. Introduction

An 'incident' is defined as "an unforeseen event that impacts on the safety and the capacity of the road network that causes extra delays to road users" (EasyWay, 2010). Traffic IM is "the systematic, planned and coordinated use of measures and resources to safely handle an incident from discovery to restoration of normality" (EasyWay, 2010). In practice IM is a set of measures that aims to minimise the negative

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effects on safety and traffic flow conditions, by reducing the clearance time following an incident. The main goal of traffic IM is to manage and resolve incidents in a safe, effective and quick way considering the following needs (CEDR, 2009):

- To ensure the safety of all involved IM responders, traffic safety and the safety of casualties;
- To limit the impact of incidents on traffic flow and return traffic flow to normality in the shortest time;
- To control the damage of the vehicles and load involved in the incident as well as the road infra structure.

IM can be broken down into phases progression through which constitutes the timeline of an individual incident. There is no general written agreement on the different Traffic IM phases and objectives (Steenbruggen *et al*., 2012 forthcoming). The phases of the TIM process can be visualised as extending along a linear timeline (see for example Özbay and Kachroo, 1999; Zwaneveld *et al.*, 2000; Nam and Mannering, 2000; Corbin and Noyes, 2003). This allows for some overlap between phases. With the exception of detailed planning, it is felt that the nature of these overlaps are not well defined, and therefore the cycle model could offer some clarity of these phases and the progression through them. The traffic IM cycle, adopted from England (UK FHA, 2009), contains the following timelines (CEDR, 2011): discovery, verification, initial response, scene management, recovery, restoration to normality and normality. Incident response time and clearance time are two critical components of the overall incident duration. Incident duration is generally defined as the time elapsed between the occurrence of an incident and the time at which roadway is restored to its capacity (Garib *et al.*, 1997; Nam and Mannering, 2000; Chung, 2010). Strategies to prevent incidents occurring are of course in favour in terms of safety and mobility rather than developing strategies to respond to incidents. Incidents can be caused due a number and combination of reasons. In many cases human error or technical failure plays an important role, e.g. driver distraction, alcohol abuse or motor breakdown (Wegman, 2007). Some incident preventing measures for both primary and secondary incidents have previously been identified (see CEDR 2011).

Traffic IM involves the coordinated interactions of multiple public agencies and private-sector partners. Road authorities, police, fire and rescue, and ambulance services can ensure safe and reliable transportation operations by helping to prevent incidents and rescuing accident casualties. On the other hand, the transportation network enables access to emergency incidents, and, increasingly, provides real-time information about roadway and traffic conditions. In the next section we look in more detail at the results of the CEDR 'Best Practice' survey. A framework guide has been produced based on the outputs of the survey. This provides the basis for concepts of effective traffic IM.

2. Results from European survey on traffic IM

2.1. Research goals and methodology

The CEDR Task 13workgroup 'Incident and Emergency Management' followed the strategy of CEDR Strategic Plan 1 (CEDR 2008). From April 2009 until March 2011 they produced the document "*Best practice in European Traffic IM"*. The IM survey was designed as a secure, online web survey showing a mixture of multiple-choice and open questions. It was addressed to all CEDR members including the workgroup members and a couple of practitioners outside of Europe who had agreed to participate. The web survey was posted online and made available to all CEDR member countries for which an NRA contact could be identified, amounting to 21 European countries for a period of 4 months. During this time 7 countries provided detailed responses, and 2 others general responses. Three other countries provided information by email or phone, other data for 6 other countries was obtained from other sources.

The survey was designed to interpret the context of IM techniques. The first part of the survey included a set of detailed questions to characterize each country, what they are currently doing well, and

what plans they have for communications, data collection and, incident prevention measures etc. The second part of the survey was about future thinking and long term plans in more general terms.

2.2. Responsibilities in Traffic IM

The role of each National Road Authority (NRA) within its own country varies greatly across Europe and the rate of development of individual NRA's is an important factor. Some are government organisations, others are private companies. Some are tasked purely with maintaining the highway, while others are more involved with managing the traffic. Several workshops identified two key points:

1. NRA's have differing levels of responsibility for incident management, and in many countries the Police have sole responsibility;
2. Countries have different incident management priorities, dictated by geography, climate and driver culture.

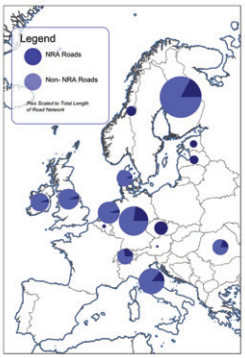

Fig. 1. Extents of networks for which National Road Authority (NRA) are responsible (CEDR, 2010)
Pies scaled to total length of road network

These two points dictate the variation in terms of NRA budgets, size and legislative responsibilities. One key indicator of the scope of an NRA's responsibility is in the size of the road network for which it is responsible. Figure 1 shows a selection of EU countries for which the size of the total road network is identified and the proportion of that network for which the NRA is responsible for. It shows that NRA's typically run between 10% and 25% of the total road networks. These are usually the most trafficked roads such as motorways and primary trunk roads. The leadership roles for traffic IM in terms of incident clearance, resulting congestion, diversion strategies, traveller information, responder leadership, monitoring and safety for traffic IM varies for each country. IM should at least be introduced on the roads belonging to the TERN network. The results have been tabulated for the countries that responded and are shown in Figure 2.

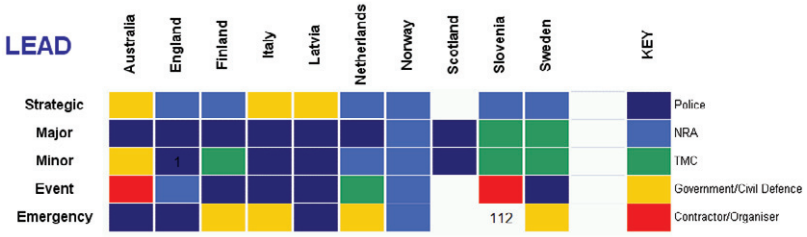

Fig. 2. Responders taking lead role in Incident Management (not necessarily exclusive).

These figures show the variety of national protocols for incident management. In many countries, especially Latvia and Italy, incident management is led by the police. In Finland they also play a large part in congestion management, indeed in Latvia the police have sole responsibility for traffic flow. The Netherlands, Slovenia and Sweden have more varied leads. Based on the leadership roles, future intentions, and level of service provision, three levels of approach to IM have been identified. Countries which indicated their intention to take more responsibility for incident management are indicated with a "+" symbol next to the categorisation (Figure 3).

- Network Maintainers: clear roads after incidents and return the infrastructure to operating standard;
- Network Operators: coordination role, detecting when incidents occur using various technology, directing responders to the scene and informing road users though variable message signs, speed limitation signs etc.;
- Network Managers: role in managing incidents, leading on scene management in a similar way to Police to minimise network disruption from incidents.

NRA/Country	Classification
ANAS (Italy)	Network Operator
ASFiNAG (Austria)	Network Operator +
Danish Roads Directorate	Network Operator +
English Highways Agency	Network Manager
Estonian Roads Administration	Network Maintainer +
Federal Ministry of Transport, Building and Urban Development (Germany)	Network Maintainer
Finnish Transport Agency	Network Operator +
Flemish Roads Administration (Belgium)	Network Operator
Latvian Roads Administration	Network Maintainer
National Road Authority, Republic of Ireland	Network Maintainer
Norwegian Public Roads Administration	Network Operator
Rijkswaterstaat (Netherlands)	Network Manager +
Road and Motorway Directorate (Czech Republic)	Network Operator
Slovenian Road Authority (DRD)	Network Operator
Swedish Traffic Administration	Network Operator
Swiss Federal Roads Authority (FEDRO)	Network Operator +

Fig. 3. NRA Categorization (+ indicates intention to extend responsibilities).

2.3. IM Policy review

The survey asked the responders if they held multi-responder policy reviews and if so to provide details. The information provided indicates a preference for Traffic Management Center (TMC) and the three emergency services over the secondary support services for the purposes of policy planning, as would be expected.

Country	Group name	Meetings Per year	Achievements	TMC	Police	Ambulance	Fire	Recovery service	Media	Civil defense	Government
Austria		1	Point out deficiencies and identify improvements, with particular concern for tunnels	■	■	■	■				
Denmark			To align with Danish broadcasting about information	■	■	■	■	■	■		■
England	ACPO	4	Issues and opportunities to enhance working partnerships	■	■						
Finland		1	Share information and develop cooperative actions	■	■						
Italy	COEM		To plan for major incidents and emergencies, big events and the seasonal exodus	■	■		■			■	
Latvia		2	Collaboration schemes, address EU regulation and support national legislative process	■	■		■				
Netherlands	IM council	4	Aim to reduce response times by 25 per cent by 2015	■	■	■	■	■			■
Norway		2	Identify need for cooperation of routines and cooperation between stakeholders	■	■	■	■				■
Slovenia		Ad-hoc	Analyse major incidents to approve response times for each stakeholder, perform exercise in tunnels	■	■	■	■				■
Sweden		5/6	Discuss problems handling accidents efficiently on the road network and achieve improvements	■	■	■	■				■
Victoria State		4	Determine responsibilities, discuss improvements, improve coordination between agencies	■	■	■	■				■

Fig. 4. Countries policy reviews and responder attendance.

2.4. Targets in response times

Many countries have formal agreements or contracts specifying target or maximum response times. Effective traffic Incident Management (IM) consists of reducing response and clearance times, reducing the risk of secondary incidents, ensuring the safety of incident responders and maximising the use of available responses. The incident clearance stage, which constitutes the safe and timely removal of stalled vehicles, wreckage, spilled materials and debris from the roadway or shoulders is usually the most time consuming portion of the incident management process (Pearce, 2000). In the survey most see IM as a mechanism for reducing congestion. There are several reasons underlying these difference, one major reason is the difference in density of population and congestion problems in countries. Another issue is that there is not yet a common agreement on the definition of the structure of the IM process phases as mentioned before. Figure 5 gives an overview of the difference in response times for some European countries.

Country	Circumstance	Response Time (minutes)
Belgium-Flanders	Urban	15
	Rural	20
Denmark	Contracted	30
England	Traffic Officer Service - high priority section	15
	Traffic Officer Service - heavily trafficked	80% within 20
	Traffic Officer Service - lower priority section	25
	Incident Support Unit on scene minimum	20
	Incident Support Unit on scene maximum	90
	Recovery of light vehicle	30
	Recovery of goods vehicle	45
	Clearance	80% within response+30
	Local broadcast radio traffic updates every	15
Germany	Response time legal obligation	90% within 8-12
Netherlands	Ambulance	15 min (95%)
	Fire	10 min
	TOS high priority IM	15 min (80%)
	TOS IM	30 min (80%)
	Recovery	20 min (90%)
	Goods vehicle	45 min
USA	Clearance minor incident – FHWA target	30
	Clearance major incident – FHWA target	90

Fig. 5. Response time targets across Europe and other OECD countries.

2.5. Accident rates across Europe

In the last ten years a big effort has been made, by the European Commission and all Member states, to reduce the impact of road transport in term of fatalities and injuries. Initiatives in technology, enforcement, education and with particular attention to vulnerable road users are the key to drastically reduce the loss of lives even further. The overall objective to halve the number of fatalities between 2001 and 2010 has not quite been reached but significant improvements have been made. In 2009 around 34,500 people were killed on EU roads. Accident rates across Europe (and other OECD countries) vary greatly as shown in Figure 6. The new European goal is a zero-vision' on road safety for 2050 (see Directive 2011/144/EC).

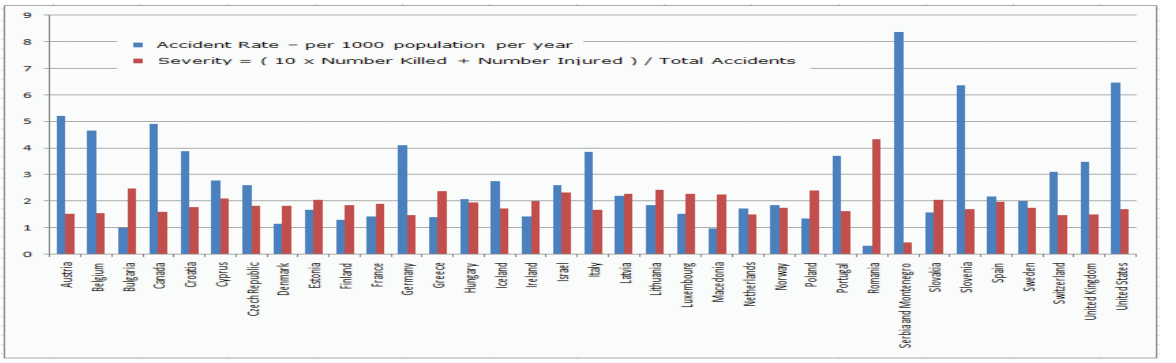

Fig. 6. Accident rates across Europe and other OECD countries (CEDR, 2011).

2.6. Economic costs of congestion and benefits from Incident Management

Recurring congestion occurs when normal traffic demand exceeds the physical capacity of the freeway. This congestion typically occurs due to systematic capacity shortages during high traffic volume periods (e.g., morning and afternoon peak periods) and is predictable in terms of its location, duration, time, and effect (Skabardonis *et al.*, 2003). Nonrecurring congestion is the result of a short-term reduction in the capacity of a roadway (e.g., traffic incidents, work zones, special events etc). In the Netherlands traffic accidents and delays are estimated to cost €10.4-13.6B/year of which delays alone cost €2.8-3.6B/year. Delays attributable to incidents amounts to 12% of this, ie €336-432M/year. IM is estimated to avoid €100-130M in social costs compared to an annual investment of €27M, implying a high Benefit/Cost Ratio (BCR) of between 4 and 5 (Berenschot 2009). The UK Department for Transport (DfT 2010/2011) has estimated figures based on queuing principles. The values are considered conservative as secondary effects also increase congestion further and may also contribute to congestion on diversion or alternative routes. On average, for every 30 hours of queuing there will typically be one additional secondary collision from a vehicle running into the back of another vehicle in the queue. A study of 163 incidents on the M6 motorway in England showed that 48 (29%) also resulted in clearly identifiable congestion on the opposite carriageway from 'rubbernecking'. For instance a 2 hour incident can cause up to 600.000 Euro of economic costs on a blocked, busy three lane highway.

3. IM in the Netherlands

3.1. Development in stages

The Ministry of Transportation in the Netherlands is responsible for public works, transport and water management which includes the maintaining of the primary road network of 3,249 km, ensuring that the infrastructure is safe and in a good state, and that the flow of vehicles is as smooth as possible. The Netherlands is the first country in Europe where a formal structure for IM was introduced in the nineties. Before 1975 there were a limited number of highways and traffic jams did not lead to serious mobility issues. Between 1975 and 1995 many new main roads where built leading to a large increase in mobility which led to serious congestion problems. Traffic jams caused by incidents became high priority on the political agenda. Till this time incidents were handled only by the police. Between 1995 and 2010 the development of IM in the Netherlands started to take shape and was introduced in six different stages. (based on Zwaneveld *et al.*, 2000). Some visits to the USA, England and Sweden confirmed and stimulated the ideas on IM in the Netherlands (Dutch Ministry of Transportation and Water Management, 1998; 2002; 2006; 2009).

The 'orientation' stage started at the end of the nineteen-eighties with an orientation on international IM activities. This concluded that incidents contributed significant to congestion (McKinsey and Company, 1995). This led in 1995 to the publication of an Incident Management Manual (Dutch Ministry of Transportation and Water Management, 1995).

The 'pilot project' stage started in 1994 and ended in 1997. Following the recommendations from McKinsey and Company (1995) between 1996 and 1997 this resulted in the preparation of the national implementation of four pilot projects. Different IM measures were tested, which created the basis for national introduction of the IM policy rules (Dutch Ministry of Transportation and Water Management, 1999).

The 'organisation' stage ended in January 1997 with the foundation of the 'Project office Incident Management' which has formulated agreements about the cooperation between emergency services on motorways (Dutch Ministry of Transportation and Water Management, 2005a). This included

organisations such as the police, fire brigade, transport authorities, motorway operators and insurance companies. The main task was to implement the national IM regulations and different IM measures.

The 'implementation' stage started in 1997, and consisted of the national introduction of IM measures based on a covenant with the Insurers Association and the sector organisations. The aim of these IM measures is to ensure the safe and quick handling of incidents so that the traffic flow restrictions caused by an incident are lifted as quickly and as safely as possible and, to limit the social damage that occurs when traffic jams form around incidents.

The '*professionalisation*' stage was created with the establishment of the IM Consulation in 2008 and the report "*Guide to professional IM*" (Immers, 2007a; Immers 2007b) and the report "*Smart goals for IM*" (Immers and Landman, 2008). This phase is characterized by the increasingly close cooperation of partners and the sharper demarcation of responsibilities and powers.

Currently we are in the 'integration phase' which is characterised by an increased road use, higher expectations of road users, and high ambitions in terms of traffic flows and safety. This is closely linked to financial cuts in IM services and a slowly retreating Police in IM tasks, which make it necessary to work even more closely with an emphasis on better communication and information sharing.

Since the start of the professionalisation and integration phases, information sharing between involved emergency services has become increasingly important for quick and appropriate response. The efforts directly correlated with public safety and mobility. Information sharing allows multiple agencies to identify needed resources and provide coordinated traffic incident management; it also provides the motoring public with information upon which to base their travel choices. With the introduction of various measures (organisational and technical) it seemed to be possible to shorten the total incident duration and lost vehicle hours. Since the introduction of IM in 1994, the average time of incident-related IM actions was reduced by 25 per cent in 2004 (Grontmij, 2004). Between 2004 and 2008 the incident duration decreased by another 10 per cent. The ambition is that by 2015 the 2008 process time will be reduced by another 25 per cent (Dutch Ministry of Transportation and Water Management, 2008a). Also the use of telecom data to improve Situational Awareness for traffic IM is a relevant topic in the Netherlands (Steenbruggen *et al.*, 2011).

3.2. Legal basis and regulation

The Dutch national government has only limited possibilities to enforce imperative rules regarding IM because of the large amount of involved organisations and many laws that are indirectly dealing with IM. Therefore IM was built upon existing rules and responsibilities of the parties involved. Tuning and safeguarding the interest of all involved parties makes adequate acting possible on the basis of violating Article 5 Wegenverkeerswet 1994 (endangering road safety), create additional rules based on Article 2 Wegenverkeerswet or Wrongful act (ex Article 6:162 BW and Rijksweg 12-arrest HR 19 december 1975, NJ 1976/280) against RWS or infringement of title of ownership of RWS as road owner. Removing damaged vehicles (incidents), stalled vehicles and lost cargo (spilled loads) from roads is based on laws in the private domain a result of a tort (wrongful act) committed against the road operator. This power is described in the IM Policy rules (Staatscourant April 27, 1999, No. 89 and amendments of March 5, 2003, September 15, 2004 and November 19, 2007).

IM in the Netherlands is primarily based on two basic regulations. First, the national private car regulation whereby every private car in the Netherlands must have compulsory car insurance for primary post-accident recovery. The policy thus covers the costs (in kind) of the recovery of the vehicle at the scene of the incident and transfer to the first available safe location, such as a petrol-filling station or parking place. This means that immediately after an accident a salvage company can be called to remove

the vehicle(s) from the main lane. This saves not only time in dealing with an incident but also reduces the risk of subsequent accidents.

The second regulation is the national truck regulation. Many trucks in the Netherlands are not insured for primary post-accident emergency recovery. The Dutch main road authority, (Rijkswaterstaat), guarantees the transport costs to a safe (working)spot. For this first initial recovery, the towing company nearest to the incident location will be used. In 2008 there were more than 4000 truck incidents took place (of which approx. 750 were accidents), with a monthly average of more than 330. In incidents involving trucks it tends to take some time before the main lane can be cleared for other traffic, thus causing traffic congestion. Other important regulations are "The Initial Safety Measures" for Incidents on motorways. These define how emergency workers, towers, or traffic officers can secure an incident situation (Dutch Ministry of Transportation and Water Management, 2005b, renewed in 2010) .

3.3. Type and number of incidents

On a yearly basis there are over 100.000 incidents take place (Berenschot 2009), varying from small accidents to major multi-vehicle incidents causing casualties and damage to the road and its supporting structures. While relatively few incidents involve trucks, these incidents cause immediate, large-scale traffic jams that catch public attention. Because there are different organisations involved in the operational handling of IM there are some difficulties in finding the exact numbers on IM. There are five regional traffic management centres in the Netherlands that each use their own registration and information systems and also have different interpretations of incident categories. Also not every incident with a breakdown vehicle is registered. Another aspect is the registration process. For example the primary task of the road inspector is to clear the incident site as soon as possible. Registration is seen as a secondary task. However towing services are financial regulated in contracts which gives another economic drive for good registration. Table 1a and 1b contains the incidents registered by towing services.

Table 1 (a). Registered private cars; (b) Registered trucks

number of incidents with passenger cars	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
break down	1141	1912	3096	3582	4831	5893	11380	15847	22736	24558
unknown	7471	5861	6098	6157	6047	6041	153	171	198	7399
accident	15832	18138	17661	18663	20798	20692	24366	25294	24465	20571
Total	**24444**	**25911**	**26855**	**28402**	**31676**	**32626**	**35899**	**41312**	**47399**	**52528**

number of incidents with trucks	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
break down	440	639	771	948	1051	1204	1559	2057	2678	3008
load	7	14	21	11	2	4		3	1	
unknown	6	5	8	38	8	16	10	4	20	12
accident	644	835	787	709	764	927	777	1034	1058	933
Total	**1097**	**1493**	**1587**	**1706**	**1825**	**2151**	**2346**	**3098**	**3757**	**3953**

4. Best practices for Traffic IM

4.1. Framework guide

The main goal for a European IM framework for best practice is to facilitate the cooperation on a European level by exchanging experience and information to minimise economic cost of incidents, improve road safety and, decrease mobility problems. 'On-Line' components are those needed immediately in response to an incident, while the 'Off-Line' components are those that improve overall TIM effectiveness, either before or after an incident. A third category of 'Up/Down Line' captures longer term issues that affect the overall way that TIM operates.

Table 2 Traffic IM components

On-Line	Off-Line	Up/Down Line
Coordination	**C**overage	**P**olicy
Cooperation	**A**nalysis and Evaluation	**L**earning from Experience
Communication	**D**ebriefing of Responders	**A**spirations
Control	**E**xercises	**N**ew Technology and Intelligence
Command	**T**raining of Responders	**S**trategies for Improvement
Access	**P**lanning of Responses	
Personnel	**P**erformance Indicators	
Equipment	**I**nformation Services	
	Education of Road Users	

Certain procedures have been found to be successful, and the following ten points are offered as forming the backbone of Traffic IM practices:

1. Speedy detection and response;
2. Good information about location, severity and any attendant hazards;
3. Protection of the scene, and ensuring safety of responders, victims and the public;
4. Coordinated response with a clear structure of authority, roles and responsibility;
5. Reliable communications between responders and the public;
6. Provision of appropriate equipment, facilities, access paths and control centres;
7. Sufficient backup services to ensure speedy clearance to minimise congestion;
8. Training and debriefing systems;
9. Written guidelines and formal agreements where necessary;
10. Monitoring, performance assessment and feedback into practice.

4.2. Concepts for effective Incident Management

The IM concept is gradually being introduced in the EU. The level of deployment of IM varies across Europe (CEDR, 2011). Many countries have some form of IM covering primarily motorways and main roads. Agreements are typically regional or local and occasionally national. In some countries IM includes road works and recurring congestion. In other countries only unforeseen events, which require action by different IM responders. Three substantial sources on best practice in Incident Management have been identified:

- The English Highways Agency's Traffic Incident Management Guidance Framework, developed with the UK's Association of Chief Police Officers (ACPO) and supported by a pocket-sized Aide Mémoire (UK Highways Agency, 2009);
- The Netherlands 'red-blue book' available in both Dutch and English (Dutch Ministry of Transportation and Water Management, 2005a);

- The EasyWay Guideline for the deployment of Incident Management, which is in the form of a report but includes definitions of service levels and actions (Easyway, 2010a; 2010b).

Examples of more or less local or integrated, national measures are: implementation of the Traffic Officer, use of incident Support Units, recovering contracts, maintenance contracts with performance indicators, regulation to remove abandoned cars, Traffic Management or Control Centres, guidelines on Traffic IM, use of incident screens, use of incident protection vehicles, 3D or laser location devices to survey the incident spot more quickly.

4.3. Developing capabilities as Traffic Incident Management

EasyWay is a project for Europe-wide harmonised ITS deployment on main TERN corridors, driven by NRAs and operators with associated partners including the automotive industry, telecom operators and public transport stakeholders. EasyWay's Guideline for the Deployment of Incident Management (EasyWay 2009b) defines several elements or components of Incident Management at three different levels of service, as summarised in the Table 3.

Table 3. Different levels of Incident Management services.

Component of Incident Management	**Level of Service**		
	Basic	**Enhanced**	**Intensive**
Coverage of IM	Critical sites and/or critical periods	Selected parts of the TERN-network during specific times of the day	The whole TERN-network, all day, every day
Communication	Phone based	Some dedicated systems	Fully dedicated systems
Cooperation and coordination	Individual systems, procedures, education & training	Partly common systems, procedures, education & training	Fully common systems, procedures, education & training
Discovery and verification	Human sources 112 calls or ERT Road and exit location signs	Camera surveillance Traffic surveillance Location signs within 500 m	Automatic incident detection and camera display Full coverage location signs
Exercises	None	Table-top and meetings	Live multi-responder exercises
Evaluation	Individual evaluation Individual criteria	Individual evaluation Common criteria	Common evaluation Common criteria
Road Authority involvement	Traffic information on traffic radio and other media Recovery service	Traffic information and regulation at the scene	Traffic Management Plans (TMPs) for rerouting Traffic Officer service
Responder coordination	Ad hoc using existing public emergency services	Police led, other responders on call	Traffic Officer service and Control Centres
Responder education and training	Ad hoc	Guidelines	Formal training and certification
Road user instruction	Instructions given to road users when making a emergency call	Pre-trip information on road user behaviour via the Web	Pre-trip advice on road user behaviour in leaflets (to put in the car)

To combine NRAs' responsibility, (as Network Maintainer, Operator or Manager), coverage or penetration (that is where and when TIM is implemented), and level of service, which in practice means the structures and organisations through which TIM is implemented and the specific capabilities they represent could be the guidelines for improving the IM capabilities of different EU countries. These depend on the NRA's policies, and can vary according to need and resources.

5. Conclusions and way forward

The way countries apply IM, in terms of organisation, responsibility and specific measures, varies greatly across Europe. The research and development efforts in Europe are very fragmented. A major challenge is to find an effective way in which different initiatives, like CEDR, EasyWay, ITS and FRAME, can work together to create a European framework in which countries are able to align their individual IM activities to their own national policy goals. It should be noted that not all member states participate in the CEDR survey. However a joint effort based on the findings of the CEDR results form a stable basis for the next steps.

Successful traffic IM presupposes a multidisciplinary approach and relies in particular on flexible communications and information systems between all public and private IM partners. In the Netherlands the main challenges are the introduction of eCall (see Directives 2001/370/EC; 2003/311/EC; 2003/542/EC; 2005/431/EC; 2006/59/EC; 2006/723/EC) and real time information systems for communication and coordination between the different emergency services. These are based on new concepts like netcentric working (Cebrowski and Gartska, 1998; Boyd *et al*., 2005), Common Operational Picture (Harrald and Jefferson, 2007; Wark *et al*., 2009) and improved Situational Awareness (Endsley 1988; Endsley, 1995; Endsley and Garland, 2000; Wickens, 2008).

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References

Berenschot (2009), Eindrapport Kwalitatieve jaarmeting IM 2008, Leopold, J-H and Doornbos, H.

Boyd, C., Williams, W., Skinner, D. and Wilson, S. (2005). A comparison of approaches to assessing Network-Centric Warfare (NCW) concept implementation, Systems Engineering / Test & Evaluation (SETE 2005) conference, http://www.concepts.aero/documents/SETE-2005-NPI.pdf (last accessed 12-01-2011).

Cebrowski, A. K. and Garstka, J. (1998). Network Centric Warfare: Its Origins and Future, *Proceedings of the US Naval Institute* 124(1), pp. 28-35.

Chung, Y. (2010). Development of an Accident Duration Prediction Model on the Korean Freeway Systems. *Accident Analysis and Prevention*, 42 (1), pp. 282-289.

Conference of European Directors of Roads – CEDR (2008). Strategic Plan 2009-2013. Submitted by: Strategic plan ad-hoc group, 7 October 2008.

Conference of European Directors of Roads – CEDR (2009). Projectplan Task 13 Incident and Emergency Management. Submitted by David Stones - Chair Task 13, 4 February 2009.

Conference of European Directors of Roads – CEDR (2010). Task 13 Incident and Emergency Management, Interim Report including Survey Results and Analysis, version 1.1. June 2010.

Conference of European Directors of Roads – CEDR (2011). Best Practice in European Traffic Incident Management. Final Report of Task 13, March 2011.

Corbin, J. and Noyes, P.B. (2003). Traffic Incident Management Planning: The Case for Mainstreaming. *Institute of Transportation Engineers Journal*, 73(2), 38-41.

Dutch Ministry of Transportation and Water Management (1995), Handleiding Incident Management, Adviesdienst Verkeer en Vervoer (1995) (Eng: Manual Incident Management), Ministerie van Verkeer en Waterstaat, Rotterdam, Nederland. in Dutch.

Dutch Ministry of Transportation and Water Management (1998). Incident Management, Putting people together, verslag van een studiereis naar de U.S.A., november 1998.

Dutch Ministry of Transportation and Water Management in the Netherlands (1999). Policy rules Incident Management Rijkswaterstaat, 1999.

Dutch Ministry of Transportation and Water Management (2002). See your taxdollars at work, Verslag studiereis naar de USA, VCNL september 2002.

Dutch Ministry of Transportation and Water Management (2005a). Red blue booklet, the roles of Emergency services in Incident Management in the Netherlands, ISBN 90-369-0097-2 April 2005.

Dutch Ministry of Transportation and Water Management (2005b) "Directive Initial Safety Measures for Incidents on Motorways in the Netherlands", Verkeerscentrum Nederland, 2005.

Dutch Ministry of Transportation and Water Management (2006). Studiereis Incident Management naar de USA, VCNL.

Dutch Ministry of Transportation and Water Management (2009).Verslag studiereis Incident Management naar Engeland (Lees) en Zweden (Stockholm), Ministerie van Verkeer en Waterstaat, Rijkswaterstaat, oktober 2009.

EasyWay (2010). Guidelines for the deployment of Incident Management. Core European ITS Services and Actions, TMS-DG08, August 25th , 2010.

Endsley, M. R. (1988). Design and evaluation for situation awareness enhancement. In Proceedings of the Human Factors Society 32nd Annual Meeting (pp. 97-101). Human Factors Society, Santa Monica, CA.

Endsley, M. R. (1995). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors* 37(1), pp. 32-64.

Endsley, M. R. and Garland, D. G. (2000). Situation Awareness, Analysis and Measurement, Lawrence Erlbaum Associates, Publishers, Mahway, New Jersey.

European Commission, EU Directive 2001/370/EC. European transport policy for 2010: time to decide, Brussels, 12.9.2001.

European Commission, EU Directive 2003/311/EC. European Road Safety Action Programme: Halving the number of road victims in the European Union by 2010: A Shared responsibility, Brussels, 2.6.2003.

European Commission,. EU Directive 2003/542/EC. Information and Communications Technologies for Safe and Intelligent Vehicles, Brussels, 15.9.2003.

European Commission, EU Directive 2005/431/EC. Bringing eCall to Citizens (2rd eSafety Communication), Brussels 14.9.2005.

European Commission, EU Directive 2006/59/EC. On the Intelligent Car Initiative: Raising Awareness of ICT for Smarter, Safer and Cleaner Vehicles, Brussels 12.2.2006.

European Commission, EU Directive 2006/723/EC. Bringing eCall back on track - Action Plan (3rd eSafety Communication), Brussels, 23.11.2006.

European Commission, EU Directive 2011/144/EC, Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, Brussels, 28.3.2011.

Garib, A., Radwan, A. E. and Al-Deek, H. (1997). Estimating Magnitude and Duration of Incident Delays, *Journal of Transportation Engineering,* 123 (6), pp. 459–466.

Grontmij (2004). Richtlijn voor incident evaluaties. De Bilt: Grontmij Advies & Techniek B.V.

Harrald, J. and Jefferson, T. (2007). Shared Situational Awareness in Emergency Management Mitigation and Response, Proceedings of the 40th Hawaii International Conference on System Sciences, 1530-1605/07, 2007 IEEE.

Immers, L.H. (2007a). Guide to professional Incident Management, TNO-rapport 2007-D-R1242/B, (in Dutch: Wegwijzer naar professioneel Incident Management), November 2007.

Immers, L.H. (2007b). Vision Incident Management, Verkeerscentrum Nederland, 2007.

Immers, L.H. and Landman, R. (2008). "SMART" goals for the application of Incident Management measures to the Dutch road network, TNO-rapport 2008-D-R0667/A, (in Dutch: 'SMART' doelstellingen voor de toepassing van Incident Management maatregelen op het Nederlandse wegennet), Juni 2008.

McKinsey and Company (1995) Filearm wegbeheer (Eng: Tailback free traffic management), Ministerie van Verkeer en Vervoer, The Hague, in Dutch.

Nam, D. and F. Mannering (2000). An Exploratory Hazard-Based Analysis of Highway Incident Duration, *Transportation Research Part A: Policy and Practice,* 34 (2), pp. 85–102.

Özbay, K. and Kachroo, P. (1999). *Incident Management for Intelligent Transportation Systems (ITS)*, Artech House, Massachusetts.

Pearce, V. (2000). *Incident Management Successful Practices: A Cross Cutting Study, Improving Mobility and Saving Lives,* U.S. Department of Transportation, Federal Transit Administration and Federal Highway Administration, April 2000, Washington D.C.

Skabardonis, A., Petty, K. F., Bertini, R. L., Varaiya, P. P., Noeimi, H., and Rydzewski, D. (1997). I-880 Field Experiment: Analysis of Incident Data, In *Transportation Research Record: Journal of the Transportation Research Board*, No. 1603, Transportation Research Board of the National Academies, Washington, D.C., pp. 72-79.

Steenbruggen, J., Borzacchiello, M.T., Nijkamp, P. and Scholten, H. (2011). Mobile phone data from GSM networks for traffic parameter and urban spatial pattern assessment: a review of applications and opportunities. *GeoJournal* (4 May 2011), pp. 1-21. doi:10.1007/s10708-011-9413-y.

Steenbruggen, J., Nijkamp, P., Smits, J. and Grothe, M. (2012, forthcoming). Traffic Incident Management, A Common Operational Picture to support Situational Awareness of Sustainable Mobility, *International Journal of Transport Economics* (IJTE), forthcoming 2012.

UK Highway Agency (2009). Traffic Incident Management Guidance Framework. Highway Agency and association of Chief Police Officers, January 2009.

US Federal Highway Administration (FHWA) (2000). Traffic Incident Management Handbook, Office of Travel Management.

Wark, S., Lambert, D., Nowina-Krowicki, M., Zschorn, A. and Pang, D. (2009). Situational Awareness: Beyond Dots On Maps To Virtually Anywhere. SimTecT Conference, June 2009, Adelaide, Australia.

Wegman F. (2007). Road traffic in the Netherlands: Relatively safe but not safe enough!, SWOV Institute for Road Safety Research, The Netherlands, AAA Foundation for Traffic Safety.

Wickens, C. D. (2008). Situation Awareness: Review of Mica Endsley's 1995 Articles on Situation Awareness Theory and Measurement, *Human Factors***,** 50(3), pp. 397-403. DOI 10.1518/001872008X288420.

Zwaneveld P., Wilmink, I., Immers, B. Malipaard, E. and Heyse, D. (2000) An overview of Incident Management projects in the Netherlands. Peter Zwaneveld, Isabel Wilmink TNO Inro Ben Immers, TNO Inro and K.U. Leuven, Department of Civil Engineering Emst Malipaard, Grontmij, Dick Heyse Rijkswaterstaat, Projectbureau Incident Management (2000).