Accident Prediction Modelling: a literature review

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Abstract

This paper presents a comprehensive literature review on Accident Prediction Models (APMs) and Crash Modification Factors (CMFs) with focus on motorways and higher ranked rural roads, performed within PRACT Project (Predicting Road ACcidents - a Transferable methodology across Europe). The priorities for the review were determined by a questionnaire survey on APM and CMF availability and needs, addressed to National Road Authorities (NRAs) in Europe and worldwide. Salient literature was reviewed and existing APMs were assessed in terms of theoretical approaches, characteristics of models, implementation conditions, data requirements and available results. The review of CMFs focused on their background and development, the various methods for developing CMFs and on key issues in their application. The review resulted in the development of an APM and a CMF inventory that form the basis for an online repository, aiming to assist in practical application of gathered experience on accident prediction.

Keywords chosen from ICE Publishing list

Accident Prediction, Crash Modification Factors, Repository

1. Introduction

Decision making for road safety interventions is a complex procedure, involving a number of actors (experts, politicians, public etc.) and issues (environmental, mobility, economical) that compete for a limited amount of available resourcers. Furthermore, in many cases, decision makers need not only to justify expenditure on safety in terms of effectiveness but also to argue convincingly for measures in the face of sceptical and sometimes hostile lobbies (OECD, 2012). The criteria used, when deciding about policies, are mainly suitability, lawfulness, and/or legitimacy, but in the recent years, efficiency is often mentioned as a criterion for a good policy. The efficiency of an intended policy is determined by the use of efficiency assessment tools, which enable decision-making and identification of the most cost-effective and profitable road safety measures (Yannis et al., 2015). Thus, road safety policy is increasingly dependent on sound indicators of how effective different safety interventions are, in terms of accident or casualties reduction.

In recent years, road safety research has provided road authorities, designers and road safety practitioners with accident prediction tools, commonly known as Accident Prediction Models (APMs) that assist in the analysis of potential safety issues, the identification of safety improvements and the estimation of the potential safety effects of such improvements. Several researchers, in Europe and worldwide, have examined the safety effects of various road safety measures in an attempt to quantitatively assess road safety measures and interventions, in terms of accident frequency (number of accidents per year) and accident severity (level of injury due to accidents). As a result of this research, a large amount of relevant knowledge has been developed, as well as various methodologies and techniques to estimate future accident frequency and severity and to identify and evaluate options to reduce them.

The objective of this paper is to present a critical overview of existing literature regarding Accident Prediction Modelling and Crash Modification Factors which led to the development of an APM and a CMF inventory that forms the basis for a searchable online repository of current knowledge.

The following methodology was applied in order to complete the literature review in a structured way:

1. As a first step, a large number of relevant studies, research projects, handbooks, guidelines and manuals was collected and reviewed to provide the background for identifying relevant research work in accident prediction modelling. The main findings of this review are presented in Section 2.
2. Secondly, a questionnaire was designed and dispatched to several National Road Authorities (NRA) in Europe and worldwide, with the objective to identify current practices in accident prediction, data availability and, most importantly, the availability and need for prediction models and CMFs to address specific countermeasure type (Section 3).

3. Based on the results of the previous two steps, a second review process took place that comprised a detailed review of existing literature for available APMs and for 92 high priority CMF types, i.e. CMFs identified as much needed by Road Authorities in the aforementioned survey and CMFs included in the Highway Safety Manual models (AASHTO 2010, 2014). This detailed review process resulted in an APM inventory of 146 different models and a CMF inventory of 1,526 CMFs (Section 4). These inventories, after further elaboration and application of suitable quality criteria, will form the basis of an online APM and CMF repository.

2. Review of existing literature on Accident Prediction Modelling

As a first step in the review process, a broad overview of the existing literature regarding road safety measures assessment and accident prediction modelling was performed. The main findings of this review are presented in the following paragraphs, whereas the full review (Yannis et al. 2014) can be found at http://www.practproject.eu.

2.1 Highway Safety Manual and HSM related literature

A very important publication on accident prediction, based on several years of pertinent research, is the Highway Safety Manual (AASHTO, 2010; AASHTO, 2014). The HSM includes a predictive method for estimating the expected average crash frequency (by total crashes, crash severity or collision type) of a network, facility or individual site.

The estimate relies upon models developed from observed crash data for a number of individual sites. Different regression models, called base Safety Performance Functions (SPFs) have been developed for specific facility types (e.g. undivided segments of rural two-lane two-way roads, divided segments of urban and suburban arterials, three-leg intersections with "STOP" control in rural multilane highways etc.) and "base conditions", that are the specific geometric design and traffic control features of a "base" site. SPFs are typically a function of only a few variables, primarily Average Annual Daily Traffic (AADT) volumes and segment length. SPFs in the HSM have been developed through statistical multiple regression techniques using historic crash data collected over a number of years at sites with similar characteristics and covering a wide range of AADTs. Adjustment to the prediction made by a SPF, in order to account for geometric design or traffic control differences between the base conditions of the model and local conditions of the considered site, is made through the use of Crash Modification Factors (CMFs). Finally, a Calibration Factor (C) is used to account for differences between the road network for which the models were developed and the one for which the predictive method is applied.

Several reports and guides provide further guidance on the implementation of the HSM's methods and procedures. In FHWA (2013a), guidance is provided on whether a Road Authority should calibrate the Safety Performance Functions from the HSM or develop jurisdiction-specific

SPFs. Another guidebook (FHWA, 2013b), provides guidance on the statistical issues for developing SPFs and in NCHRP (2014) further guidance is provided on the calibration of HSM's Safety Performance Functions to local and current conditions.

Furthermore, a large number of CMFs are included in the HSM, for several types of roadway facilities. Further guidance on CMFs is also available through a series of complementary guides (e.g. NCHRP 2012, Gross et al. 2010, Gross & Hamidi 2011) that enhance the practical applicability of the predictive methodology of the Highway Safety Manual, thus making it a very valuable tool for road safety practitioners.

As far as the transferability of the HSM predictive method is concerned, researchers have examined the issue of effectively implementing it to conditions different from the ones for which it was developed, and properly adjusting and calibrating the various parameters and functions. Martinelli et al. (2009) applied the HSM two-lane two-way rural roads segment model calibration procedure to the road network of the Arezzo province in Italy, and came to the conclusion that the best approach is the base model with CMF calculation, but with the calibration coefficient calculated using a weighted average based on the total length of the sections in each class. La Torre et al. (2014) came into the conclusion that the models generally show a good transferability to the Italian network, especially for fatal and injury crashes. Improvements could be made considering variable calibration factors within the datasets or crash modification factors local calibrations.

2.2 Development of Accident Prediction Models

Several other references exist in pertinent literature dealing with the development of Accident Prediction Models. Pilot APMs for Austria, Portugal and the Netherlands were developed within RIPCORD (2007) project, according to the Generalised Linear Model (GLM) using a Negative Binomial Distribution. From the pilot studies it became clear that the availability of detailed and good quality data is an important issue to be considered when developing APMs. If such data are not available, only a few explanatory variables can be incorporated in the models, resulting in predictions of limited accuracy. Furthermore, a Safety Performance Function was developed for the analysis of two-lane two-ways rural roads (RIPCORD, 2008), based on accidents on the rural road network of Saxony, Germany.

Expanding the knowledge gained through the RiPCORD project, the RISMET research project also dealt with accident prediction. In RISMET (2011a), several accident prediction models in rural junctions were developed based on data from four European countries: Norway, Austria, Portugal and the Netherlands, and in RISMET (2011b), an accident prediction model for rural road segments was developed based on data from the road network of the German federal state Brandenburg, using a Poisson regression statistical approach. The developed model was later evaluated on a 42 km long stretch of the Portuguese road IP 04 and significant differences were found between the number of accidents predicted by the model and the real accident occurrence (predicted accidents being too low). This, attributed by the researchers to a number of reasons, highlights the necessity of calibrating APMs in order to take into account local (national) conditions in terms of accident structure, driving behaviour and standard of design.

In New Zealand, APMs were developed for two-lane rural roads (Turner et al. 2012), using Generalised Linear Model (GLM) approach for key crash types. Caliendo et al. (2007) developed a prediction model for Italian four-lane median-divided motorways, using a stepwise forward procedure based on the Generalized Likelihood Ratio Test (GLRT). Montella et al. (2008) developed APMs for Italian rural motorways, also using Generalized Linear Modelling techniques and assuming a negative binomial distribution error structure, and Cafiso et al. (2010) defined APMs for two-lane rural road sections based on a combination of exposure, geometry, consistency and context variables directly related to the safety performance, also based on the Generalized Linear Modelling approach (GLM), assuming a negative binomial distribution error structure. Using data from interchange influence areas on urban freeways in the state of Florida, US, Haleem et al. (2013) developed a SPF regarding the effect of changes in median width and inside and outside shoulder widths, applying a promising data mining method known as Multivariate Adaptive Regression Splines (MARS).

2.3 Web-based CMF databases and Road Safety Toolkits

Accident prediction knowledge is already available to road safety practitioners through web-based databases of effective road safety measures that usually include Crash Modification Factors (CMFs). Such databases are the FHWA CMF Clearinghouse (http://www.cmfclearinghouse.org), the SPF Clearinghouse (http://spfclearinghouse.org/), the AustRoads Road Safety Engineering Toolkit (http://www.engtoolkit.com.au/), and the iRAP Road Safety Toolkit (http://toolkit.irap.org/).

The FHWA CMF Clearinghouse offers transportation professionals a central, web-based searchable repository of CMFs, as well as additional information and resources related to SPFs and CMFs. It is directly related and provides support to the predictive methodologies included in the Highway Safety Manual. As far as the CMF repository is concerned, while the HSM provides only a selection of the available research-based CMFs, the CMF Clearinghouse is a comprehensive listing of all available CMFs, including the ones listed in the HSM.

The SPF Clearinghouse is owned and operated by Tatum Group LLC and aims to incorporate information on already developed Safety Performance Functions. Data are gathered primarily on a voluntarily basis from users. For each SPF, the website provides the mathematical equation, a graphical representation of the equations outcome, a list of keywords that describe its applicability range (e.g. for segments or intersections, the type of intersection, for rural or urban areas etc.), and an additional window with more details, where available. A search function navigates the user around the information included in the website. The graphical representation of the SPFs results is a valuable addition to the already existing repositories. However, the website is still under development and a limited amount of SPFs is currently available. Furthermore, a reference on the exact study in which the SPF was developed is not included, and thus the user is not able to assess the reliability and transferability of the presented SPFs to the specific circumstances at hand.

The Austroads Road Safety Engineering Toolkit is based on research in Australia and New Zealand on the effectiveness of road safety countermeasures. A total of 67 treatments, all concerning road infrastructure, are included in the Toolkit, with quantitative values for the expected crash reduction effectiveness of each measure. However, detailed information regarding the development of each expected crash reduction percentage is not available.

Finally, the iRAP Road Safety Toolkit is very similar in design and operation with the Austroads Toolkit, incorporating, however, less information and capabilities. Specific CMF values are not included in the iRAP Toolkit, only an assessment of each treatment's effectiveness using a four scale system (0-10%, 10-25%, 25-40%, 60% or more).

3. Priority APMs and CMFs according to questionnaire survey

In order to collect information about currently used APMs and data sources by different National Road Administrations (NRAs) in Europe and worldwide, and to identify the availability and need for prediction models and CMFs to address specific countermeasure types, a questionnaire was designed and dispatched to several NRAs in Europe and worldwide (Yannis et al., 2014). A total of 23 completed questionnaires were received, mostly from NRAs, but also from Road Managing Companies, Academia/Research Institutes or Highway Consultants. The survey was completed by road authorities and institutions from Austria, Belgium, Cyprus, Denmark, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Norway, Slovenia, Spain, Switzerland, UK, USA and Australia.

According to the questionnaire survey, the CMFs presenting the highest need in motorways and divided freeways are "workzones" (86.7%), "roadside features: clear zone width" (75.0%), "high friction treatments" (73.3%) and "effect of traffic - volume/capacity - % trucks & buses" (68.8%). In two-lane, two way rural roads, the highest need is exhibited by "roadside features: presence of a barrier" (81.3%), "shoulder type - paved/unpaved" (80.0%), "shoulder width" (78.6%) and "workzones" (76.9%). As far as availability of a CMF or countermeasure assessment is concerned, in motorways and divided freeways the highest availability is exhibited by "number of lanes" (61.5%), "roadside features: presence of a barrier" (50.0%), "variable message signs" (43.8%), "roadside features: crash cushions" and "automated speed enforcement", both at 43.8%. In two-lane, two way rural roads, the highest availability is exhibited by "roundabouts"

(60.0%), "passing lanes" (41.7%), "segment lighting" (41.7%) and "intersection left turn lanes" (40.0%).

Based on the above information, it was decided that the review should focus on the CMFs included in AASHTO's HSM - being of sufficiently high quality since they have been systematically evaluated by expert groups regarding their reliability and quality - along with CMFs that more than 50% of NRAs considered as highly desirable. The survey identified 20 CMFs for rural motorways and 32 CMFs for two-lane two-way rural roads that more than 50% of NRAs considered as highly desirable, and, taking also into account the HSM CMFs, a total number of 92 high priority CMF types was identified. 54 CMFs types originated from the Highway Safety Manual, 49 CMFs types from the questionnaire survey and one further CMF type (CMF type 26: Horizontal Curve Delineation on Freeway Segments) was considered important and was added in the review list by the project team. 12 CMF types originated from both the Highway Safety Manual and the results of the questionnaire survey. A complete list of the 92 high priority CMF types is available in Yannis et al. (2016). As far as APMs are concerned, the detailed review also focused on the aforementioned categories.

4. Detailed CMFs and APMs review

4.1 CMF review

4.1.1 Methods for CMF development

Several methodologies have been used in the literature to estimate CMFs and are presented in the following paragraphs. A review of methodologies currently employed for CMF estimation with a larger focus on practical implementation can also be found in FHWA (2010).

The most basic method for estimating a CMF, the so-called **naive Before-After approach**, involves a simple comparison of accident rates before and after implementation of a treatment (e.g. Allaire et al. 1996; Graham and Harwood, 1982; Outcalt 2001; Pitale et al. 2009). The approach is simple to apply, but has several limitations: it does not take into account changes in traffic volumes that can affect accident rates, and even if accidents rates are normalised by some measure of traffic volume (as is done, for instance, in Graham and Harwood 1982, Outcalt 2001, Pitale et al 2009) the approach still does not account for other factors that could potentially affect accident rates, such as general time trends.

The methodology can be improved by using reference sites that are similar to treatment sites to estimate potential effects on accident rates that are due to factors other than the treatment (**Before-After with comparison group approach**). Changes in accident numbers at reference sites are used to estimate changes in accidents numbers at treatment sites that are due to factors other than the treatment (Brabander and Lode Vereeck 2005; Mutabazi et al. 1999; Noyce and Elango 2004; Retting et al (2002). For the approach to give unbiased estimates, treatment implementation must be random rather than related to accident rates (e.g. a blanket treatment) and reference sites must have similar characteristics to the treatment sites, including with respect to accident rates in the before period. However, in most cases these conditions are unlikely to be true. Firstly, countermeasures tend to be implemented in high risk sites. The non-random allocation of treatments can cause self-selection bias, including the so-called regression to the mean effect: observed high values may be randomly high and, thus, will tend to be closer to the mean value for future observations. Consequently, observed reductions in accident numbers could be random rather than due to the treatment. Furthermore, selecting suitable reference sites can also be challenging, and in some cases the treatment may also affect accident rates at reference sites if they are located close to reference sites.

Currently, the most widespread used methodology is the **Empirical Bayes Before-After approach**, which aims to control for the effects of regression to the mean. Similarly to the Before-After with comparison group approach, it uses reference sites to estimate the expected number of accidents in the treatment sites that would have occurred in the after period in the absence of the treatment. This is achieved by estimating Safety Performance Functions (SPF) for accident prediction using data from reference sites. The model usually takes a Negative Binomial form (e.g. Harkey et al. 2008; Khan et al. 2015; Park et al. 2012; Patel et al. 2007; Persaud et al. 2004; Persaud et al. 2012). SPFs provide estimates of the expected accident rates and the variance of accidents rates. These estimates are combined with observed accident rates in the before period to estimate the expected number of accidents in treatment sites in the after period in the absence of the treatment.

Lately, some authors have implemented a **Full Bayes approach** to estimate CMFs (e.g. Miaou and Lord 2003; Pawlovich et al 2006; Persaud et al 2010), but the use of the methodology is still not widespread. The approach also uses a group of reference sites, but instead of point estimates of the expected number and variance of accidents, it estimates a probability distribution for the expected accident rates. This is then used to estimate the expected number of accidents at treatment sites in the after period had the treatment not been implemented.

Crash modifications factors can also be derived from **multivariate regression models** of accident rates, where accidents are modelled as a function of a set of explanatory variables. Typical explanatory variables are traffic volume and segment length, but other variables (e.g. geometric design, driving density, friction) are commonly also included. Typically, Negative Binomial (e.g. Cafiso et al 2010; Fitzpatrick et al 2008; Labi 2011; Persaud et al 2012; Turner et al 2012; Wu et al 2008) or Poisson (e.g. Baruya 1998; Dinu and Veeraragavan 2011; Wichert and Cardoso 2007) models are estimated, although other modelling forms have also been used (e.g. log-linear in Zegeer et al 1988; zero-inflated Poisson in Qin et al 2004). Multivariate regression models can be useful when only cross-sectional data are available. Nevertheless, simple multivariate regression models also do not take into account that treatment implementation is not random. The treatment variable will therefore be endogenous in the model (correlated with error term) and more advanced modelling techniques (e.g. instrumental variables) are needed to obtain unbiased estimates of the effect of the treatment.

4.1.2 CMF review and inventory

The detailed CMF review focused on presenting a comprehensive overview of different CMFactors and CMFunctions. The review enables an insight in the data bases and resources behind the CMFs (scope of road network data, timeframes and amount of accident data), the backgrounds of CMF development (developing method, bias and issues), evaluation basics (standard error, reliability rating) and also definition and application of resulting CMFs (restrictions for valid usage on special road network elements, different traffic volumes or application just for specific accident severity levels, accident or road user types).

As already stated in section 3, 92 different CMF types were investigated. These were grouped in six roadway element categories: (1) Freeway segments, (2) Speed change lanes, (3) Ramp segments, (4) Crossroad ramp terminals, (5) Rural road segments (two-way two-lane), and (6) Rural road intersections. For each of the 92 CMF types a one-page summary was developed, concisely presenting the most important information of the review. An example summary for CMF type 85: "*Rural road intersections - Roundabouts*" is presented in Figure 1. A complete presentation of all the CMF review summaries can be found in Yannis et al. (2016).

Furthermore, the review resulted in a comprehensive inventory (Yannis et al., 2016) that includes a total of 1,526 CMFs (Factors and Functions). For each CMF detailed data have been compiled, such as:

- Basic information: differentiation between values and functions, CMF type and roadway element category, variables in the case of a CMFunction.
- CMF development information: study design, potential standard errors, the sample sizes of considered number of sites (study area), number of years with accident data, number of involved accidents for safety evaluation. Moreover, some information about the containing accident prediction model are indicated, such as any further explanatory variables in the model, the general model form of multivariate cross-sectional models and potential sources of bias.
- Information about the study from which the CMF was retrieved.
- Information on the considered road elements: geographic origin of data, road network length, types of road elements, number of lanes per direction and minimum and maximum traffic volume (which can be seen as an area of validity for the mentioned CMFs).
- If the considered road element is a not a road section, then additional data is provided. This includes ramp terminal types (e.g. diagonal four-leg D4, Parclo A4), types of intersections and the potential types of traffic control at the intersections.
- Basic accident information: period of accident data, levels of accident severity, accident types (e.g. head-on, rear-end, etc.), number of involved vehicles in the accidents (single or

multi-vehicle accident), accident boundary conditions (weather and lighting conditions) and different road user types (e.g. cars or heavy vehicle only).

- Information about the relevant safety deficiency, the corresponding countermeasure as well as lifespan, acceptance and cost of the countermeasures.

4.2 APM review and inventory

The APM review was conducted in a similar way to the aforementioned CMF review. Models were also grouped into the six roadway element categories: (1) Freeway segments, (2) Speed change lanes, (3) Ramp segments, (4) Crossroad ramp terminals, (5) Rural road segments (two-way two-lane), and (6) Rural road intersections. Also, a second level grouping considered the form of the model: **Regression Equation APMs** are stand-alone models that are able to predict accidents based on a series of road and traffic related data (independent variables). On the other hand, **SPF and CMF APMs** (such as the HSM models), use a Safety Performance Function (SPF) to calculate an initial accident frequency by a very limited number of parameters (e.g. AADT and segment length), for specific 'base' conditions. At a second stage, CMFs are used to account for geometric design or traffic control features differences between the base conditions of the model and local conditions of the site under consideration.

Within the APM review, a total of 146 different Accident Prediction Models were examined; 85 Regression Equation models and 61 SPF & CMF models. The models were also grouped into categories, based on the considered road elements: freeway segments, freeway speed change lanes, freeway ramps, crossroad ramp terminals, two-way two-lane rural roads and two-way two-lane rural road intersections. As in the case of CMF types, a one-page summary was developed for each of the six APM categories, concisely presenting the most important information of the review. An example summary for APMs regarding two-lane two-way rural road segments is presented in Figure 2. A complete presentation of all the APM review summaries can be found in Yannis et al. (2016).

Furthermore, these 146 models were compiled (Yannis et al., 2016) in an APM inventory of 273 entries (several models were compiled as more than one entry, in order to properly handle complex parameters, e.g. parameters included in a tabular form in the model). For each APM detailed data are available:

- Basic information: differentiation Regression Equation APMs and SPF and CMF APMs, roadway element category, variables of the models.
- APM development information: study design, sample sizes (number of sites, number of years, and number of crashes).
- Information about the study from which the CMF was retrieved.
- Information on the considered road elements: geographic origin of data, road network length, types of road elements, number of lanes per direction and minimum and maximum traffic volume (which can be seen as an area of validity for the mentioned APMs).

- If the considered road element is a not a road section, then additional data is provided. This includes ramp terminal types (e.g. diagonal four-leg D4, Parclo A4), types of intersections and the potential types of traffic control at the intersections.
- Basic accident information: period of accident data, levels of accident severity, accident types (e.g. head-on, rear-end, etc.), number of involved vehicles in the accidents (single or multi-vehicle accident), accident boundary conditions (weather and lighting conditions) and different road user types (e.g. cars or heavy vehicle only).

5. Discussion and Conclusions

The paper presents a critical overview of existing literature regarding Accident Prediction Modelling and Crash Modification Factors for rural motorways and rural two-way two-lane roads and resulted in the development of an APM and a CMF inventory. APM and CMF needs were identified through a questionnaire survey of worldwide National Road Authorities, and a two-stage comprehensive review of pertinent literature resulted in the development of a CMF inventory for 92 selected CMF types and an APM inventory of 146 different models.

From the review results it can be concluded that there are several CMF types for which no CMF estimates are available in the literature. For rural motorways these include roadside clear zone width; number of lanes; traffic composition; sight distance and sight obstructions; use of passively safe structures on the roadside; replacement of barrier terminals with crashworthy terminals; effect of ramp entrance/exit (distance to the analysed section); right shoulder width and the presence of a right side barrier on ramp segments. For two-way two-lane rural roads, CMFs with no or limited availability include presence of a barrier on the roadside; sight distance and sight obstructions; use of passively safe structures on the roadside; presence of workzones; realignment of road segments; replacement of barrier terminals with crashworthy terminals; audible road markings; roadside barrier class; advanced warning devices, signals or beacons; raised islands and pedestrian refuge islands; automated speed enforcement; segment lighting; variable message signs; dynamic feedback speed sign; and motorcycle protection devices on the roadside.

Additionally, both CMF estimates and Accident Prediction Models tend to be based on US data, and the limited existing European estimates mostly refer to a small set of countries, namely Portugal, Spain, Germany, Norway, UK and Italy.

However, despite recent advances in the field of accident prediction modelling, according to the questionnaire survey most National Road Administrations (NRAs) and other organisations do not systematically use such methods during decision making for the implementation of road safety treatments. Only 30% responded that they use APMs "*always*" or "*usually*", compared to 70% that responded "*rarely*" or "*never*", and if only NRAs are taken into account, the use of APMs is further reduced.

Since accident prediction modelling provides a scientifically sound basis for efficient decision making on road safety improvements with limited funds availability, it is important to further promote the use of APMs by NRAs, designers and road safety practitioners. Thus, the development of easily accessible and user friendly tools that will offer guidance to relevant scientific knowledge and research is highly recommended and expected to improve decision making process in Europe and worldwide. In that sense, the APM and CMF inventories that are presented in this paper and will form the basis of an online APM and CMF repository, hopefully, will become a valuable tool in the hands of road safety professionals.

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<u>Figure/ Table captions (images as individual files separate to the MS Word text file)</u>

Figure 1: CMF review summary page for CMF type 85: "*Rural road intersections - Roundabouts".*

Table 1: List of reviewed APMs.

Figure 2: APM review summary page for APM category: "*Two-lane two-way rural road segments".*