INTACT - National Initiative for Enhanced Crash Investigations

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Abstract - A national initiative from the vehicle manufacturers, safety system suppliers, the road administration and universities in Sweden took off in 2007. The aim was to develop a national investigation network and a methodology focusing on all phases of a crash (pre-crash, in-crash and post-crash) as well as all parts of the road transport system (road user, vehicle and road environment). The initiative is formally run as a project with the acronym INTACT (Investigation Network and Accident Collection Techniques). It was a three year pilot with the aim to develop methodologies for an extended national crash investigation activity. During the first year the INTACT partners agreed on the aim for the investigation and methods for retrieving the data were developed. During the second and third year the methodology was tested in real-world investigations and further refinement was made. The paper describes the methodology developed to obtain high qualitative in-depth road crash data.

INTRODUCTION

More knowledge is still to be found when investigating road crashes. High quality real-world data is needed when developing safety systems, standards and policies for vehicles and roads to increase safety for all road users. In Sweden, investigations of road crashes have been undertaken by the vehicle industry, the road administration, hospitals and universities during decades. Naturally each organisation has focused their investigations to areas where safety measures could be foreseen and implemented.

Many in-depth databases exist around the world. USA has one of the longest running and largest in-depth activity which has been going on since the 1970s i.e. NASS-CDS (National Automotive Sampling System - Crashworthiness Data System) [1]. Data collected in NASS-CDS is used to investigate injury mechanisms to identify potential improvements in vehicle design. More recently, CIREN (Crash Injury Research and Engineering Network) started in the 1990s, which includes fewer cases but has more depth focusing on improving the prevention, treatment and rehabilitation of car crash victims [2]. In Europe, there are some well established national in-depth accident databases existing in for example Germany, France, Finland and the UK.

In the Framework Programs funded by the European Commission there have been several attempts to harmonise in-depth data collection protocols. The first attempt was STAIRS (Standardization of Accident and Injury Registration Systems) [3] focusing on crashworthiness which lead to the in-depth data collection activity in eight EU countries creating the database PENDANT (Pan-European Co-ordinated Accident and Injury Database) [4]. Another EU project, RISER (Roadside Infrastructure for Safer European Roads) [5], harmonised the data variables for roadside infrastructure focusing on run-of-road accidents. It was identified that most databases lacked sufficient information on the causation of accidents therefore parts of the SafetyNet [6, 7] project, that includes the development of methods and collection of data to find risk factors for accident occurrence, was initiated.

There are also many other in-depth accident collection activities in European projects focusing on special topics such as child safety, truck accident causation, roll-over accidents, accident involving motorcycles and accidents involving coaches. These studies have their own set of protocols and methodology to collect and analyse road accidents. Some of the databases are based on already existing accidents records and some collects new information according to developed methodologies.

METHODOLOGY

In line with the aim of preparing INTACT for a harmonised activity in Europe the methods, as far as possible, are not constrained to national limitations and all documentation from the project are produced in English.

During the first year the INTACT partners used their common expertise within behaviour science, medicine, biomechanics, vehicle design, and road design to agree on sampling criteria and a set of variables as a minimum base for the accident investigations. The sampling criteria was based on two main points; the aim of the project and countermeasure development i.e. for which accidents the partners in the project have the possibility to develop countermeasures. Previous activities in the European projects mentioned above were used as a base for selection of the data variables. Additions and exclusions of variables were made on the relevance for the project and the partners. It was also desired to develop a questionnaire and procedures for long term injury follow-up. Questionnaires from previous and on-going studies were reviewed.

A working group was formed to explicitly look at how to collect and analyse data from the pre-crash phase to understand the contributing factors to accident occurrence. The aim was to investigate which different pre-crash methods that exist and examine how well they work in finding risk factors in different traffic situations. The evaluation and the discussion were based on the guiding principles [8] that were formulated in the beginning of the work. In summary the guiding principles were:

- It is required that the method can handle case analysis, preferable also aggregated analyses.
- Theoretically described accident model.
- Clearly description/documented of the analysis.
- It is required that the analysis does not stop with defining guilty participants.
- It is required that the method covers contributing factors rather than accident causes.
- It is required that the method can have several levels at the same time and that it can handle several different contributing factors and not just a single causation chain.
- It is required that the variables are clearly described (to increase the reliability).
- It is desirable that variable values like time, position, and action, and the driver's apprehension of these things are analysed in the method.
- There should be a clear connection between the results of the analysis and possibilities to find countermeasures.
- It is desirable that the method is/can be implemented in a database.
- It is desirable that the results of the analysis can be searchable (in a database).

Methods for retrieving the data from the accidents were tested during the second year in real-world investigations. Both on-scene and retrospective methods where evaluated. The purpose of an on-scene investigation method is to collect physical evidence before it has been removed which means that the investigation team departs directly to the accident scene when the accident has occurred. In retrospective investigations the investigator team visit the accident scene within days after accident occurrence.

To have a uniform way of working among the partners a manual for investigations and a codebook for variables was developed. It was important that additions or updates were easily distributed to investigators and analysts, therefore, a web based on-line manual was developed using the free

software program “PMwiki” [9]. The advantage of choosing this program was that any additions or changes to the manual are performed online and changes take effect immediately.

For storage and analysis of data a computer system was developed called the “INTACT system”. The method for system development used, DSDM (Dynamic Systems Development Method), put a lot of emphasis on end-user-participation in the requirements process to make sure that the system meets the expectations and demands of the people who are going to use the system, a factor which is critical for the system implementation phase. The INTACT system requirements were divided into two parts. The first part of the requirements contained written descriptions of functions and technological solutions for the INTACT system. It contained the description of the complete accident investigation process and overall fundamental requirements of the system. The second part contained visual representations (mock-ups) or in some cases written descriptions of the different parts of the user interface, to provide end-users and system developers with a common view of what the user interface should look like, and how it should work.

RESULTS

The aim of the INTACT project was methodology development and during this process accident investigations were carried out in periods to test and evaluate the methods. Throughout the project 110 accidents were investigated in total. Further analysis of these accidents will not be presented here. However, it can be mentioned that the response rate on telephone interviews and injury follow-up questionnaires were approximately 80% and 65% respectively.

In INTACT an accident investigation is divided into two parts; data collection and case analysis. It is important that the analysis is performed after the data collection is finalised to ensure optimum analysis results. A condensed process flow of an INTACT accident investigation is shown in Figure 1.

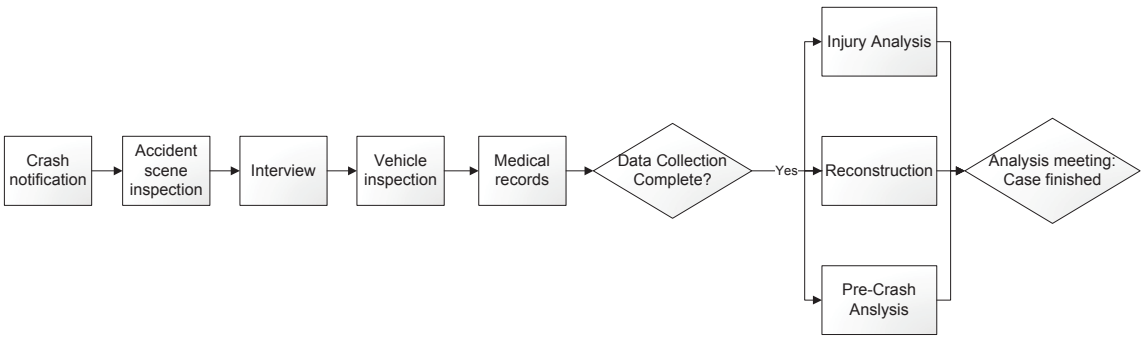

Figure 1. Process flow of an accident investigation in INTACT, all data collection should be finalised before the case analysis starts.

Accident investigations were decided to be performed in seven municipalities around the main location from which the accident scenes could be reached within 30 minutes. Road accidents in which a car, truck or bus was involved and an ambulance was called to the accident scene were investigated. It was desired to have scheduled sampling covering all hours but investigations during night time and weekends were only tested during a short period of time and were not fully archived within the project timeline. The main sampling of accidents occurred in the time span from 6 am to 8 pm on weekdays.

On-scene investigation method was selected after comparing with retrospective investigation methods. Even if on-scene investigations are used the vehicles are inspected retrospectively. It was found that

the quality of data was the most important factor but also investigation time and safety for the investigators were considered. There were four main quality issues identified which was part of the selection of on-scene accident investigation method:

- In on-scene investigations it is often possible to find witnesses at the accident scene when the team arrives and/or get a short description of the accident scenario by the police or rescue services.
- The INTACT methodology includes telephone interviews and therefore it is crucial to obtain the contact information to the involved road users as soon as possible. Uninjured or slightly injured road users can be difficult to find in due time if the team is not on-scene.
- To draw a good accident sketch of the accident scene it is important to acquire as much information of the involved vehicles trajectory, collision objects and their rest points as possible. In retrospective investigations it can sometimes be difficult to find the exact accident spot.
- In on-scene investigations it is possible to obtain information about the involved vehicles that might be missing at the retrospective inspection such as technical accessories, child seats and cargo.

From the group looking into pre-crash analysis methods the DREAM (Driving Reliability and Error Analysis Method) [10] together with STEP (Sequentially Timed Events Plotting) [11] was recommended. The group thought that these methods had a great potential for complementing each other, thus providing a clear description of the chain of events and the factors leading to the accident. However, after using both methods it was concluded that the STEP method was somewhat redundant because it is a way of describing the chain of event which is also described by the accident summary and the reconstruction of the accident. Therefore for the final working process only DREAM is used for describing the contributing factors in the crash.

To meet the holistic viewpoint of accidents that INTACT aimed for, data collection about the human, vehicle and road environment before the crash, in the crash and after the crash is required. The diagram in Figure 2 shows an overview of the variables collected.

<table>
<tr><td colspan="14">Accident (80)</td></tr>
<tr><td colspan="5">Vehicle (600)
Including car, truck, bus</td><td colspan="4">Road (110)</td><td colspan="5">Road user (230)</td></tr>
<tr><td>Impacts</td><td>Interior</td><td>Exterior</td><td>Safety Systems</td><td>EDR</td><td>Lane</td><td>Road side</td><td>Barriers</td><td>Collision objects</td><td>Rescue</td><td>Treat-ment</td><td>Inter-view</td><td>Injuries</td><td>Long term</td></tr>
<tr><td colspan="14">Analysis (140+contributing factors in DREAM)</td></tr>
<tr><td colspan="5">Pre-crash analysis/DREAM</td><td colspan="4">Impact analysis/reconstruction</td><td colspan="5">Injury analysis</td></tr>
</table>

Figure 2. Data variables groups, approximate number of variables in brackets

A number of routines were developed to support investigators during different parts of an investigation and as an aid to standardizing how vehicle inspections, photos and sketches are carried out for quality assurance. The photo routine describes how photos should be taken, both at an accident site and on vehicle inspections. The accident site part includes instructions for accident scene, traces and marks, run-in and run-out paths. The vehicle part describes a standardized way of taking external and internal photos of cars, trucks and busses and photos of deformations and impact marks. The photo routine also describes photo management, including how to remove identifying features from photos. The road routine describes how the accident sketch should be conducted and what should be included in a sketch for a number of different accident scenarios. The vehicle routine describes how a vehicle

inspection should be performed, from initial contact with workshop, safety precautions, preparations, external and internal documentation and photo management at the office. The road user routine describes five different processes which explain how contact with road users in accidents should be established for collecting background data, information about pre-crash behaviour and the necessary information to establish injury mechanisms and follow-up questionnaires for injured road users. Additional routines handling the working environment for the investigators were also developed such as safety on the scene of the accident and crisis management for investigators.

The INTACT manual, called the "INTACTwiki", developed is available on-line to the partners and includes the working process, the routines and the variables described above. Each variable has a short description which is linked to the tool tips for the same variable in the INTACT system, a range of allowed values and a long description. The definition also describe in which database table it is stored, the database variable name, the introduction date and expiration date of the variable. Each variable are prepared for a second language, in this case it is translated to Swedish. Photos are included where applicable to clarify items like measurements.

The INTACT system developed is a web-based computer system which is one part of the working process of INTACT. The system helps the investigators to input, analyse and store the collected data and keeps track of what needs to be finalised in the investigation. The INTACT system includes input rules for several variables which maintain high quality on the data stored in the database.

DISCUSSION AND CONCLUSION

The holistic view of INTACT accident investigations is mainly based on a compilation of existing methods and standards for accident investigations. Some refinement of existing methods and some new methodology developments have been carried out but hopefully the methodology can be easily adjusted for European harmonisation.

The development of the INTACT system was delayed and this had great influence on the methodology development since the methods could not be tested and evaluated properly without the system e.g. the fill-out rate for variables was not easily assessed and the support from the system in the working process could not be examined. It was desired to use handheld units for data collection but it was not possible to develop these protocols before the database was in place. Coding errors cannot be directly identifiable on paper protocols therefore the usage of handheld units for on-scene data collection and vehicle inspections can shorten the investigation time, improve the data quality and reduce office work to some extent.

Approximately 30% of the accidents collected in INTACT were not reported to the Swedish Traffic Accident Data Acquisition (STRADA) by the police or emergency hospitals who report road accidents. These results indicate that 30% of the cases have an accident severity of "uninjured". Since the investigations in INTACT is based on the notification from the emergency services with the injury criteria "ambulance sent to the scene" accidents with no or minor injuries was investigated. It should be further investigated how many persons travel by ambulance from the scene, how many persons that are injured according to INTACT follow-up questionnaire and to what extent the police might underreport road accidents with injuries.

To investigate the accidents retrospectively might give a better injury assessment for accident sample but trials during the project showed that it was very difficult to retrieve information about the road users, vehicles and the accident spot. However, the extent to which retrospective investigations has

been tested is quite limited in the project. Nevertheless, the cases from the two different investigation methods shows that the on-scene investigations have a higher fill-out rate of variables.

One of the difficult issues during the project was how to make the measurements at the scene as effectively and safely as possible. If the accident scene is cleared quickly on a heavily trafficked road it can sometimes be difficult to take all the measurement needed to make the subsequent sketch. Different measurement methods have not been tested fully and for example GPS based measurements and partly-automated sketch drawing should be evaluated in future studies.

The identification of active safety systems and their activity status in the involved vehicles is very important for their effectiveness assessment in real world. Currently there is no substantial method for system identification/activation existing. In future activities methods on how to retrieve information about system introduction date, the affected models with serial or extra equipment and relational information on sensor fusion systems, etc. should be considered.

Interviews were conducted mainly over the telephone as it was found being the most efficient way. Both telephone and face-to-face interviews were trailed initially, but there was however no qualitative comparison made between the two methods.

The injury coding in INTACT depends on the approval of involved persons in returning the permission to gather their medical records. If the permission is not returned or signed, medical records cannot be used. On-scene approval or other methods might help to increase the feedback rate and should be further investigated.

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REFERENCES

1 National Automotive Sampling System – Crashworthiness Data System (NASS-CDS), http://www.nhtsa.gov/people/ncsa/nass_cds.html
2 Crash Injury Research and Engineering Network (CIREN), http://www.nhtsa.gov/CIREN
3 G Vallet, B Laumon, JL Martin, P Lejeune, P Thomas, R Ross, I Kossmann, D Otte and B Sexton, Standardisation of Accident and Injury Registration System, Final report of the EU FP4 project STAIRS, contract no RO-96-SC.204, 1999
4 P Thomas, A Morris, E Tomasch, G Vallet, Pan-European Co-ordinated Accident and Injury Databases, Final report of the EU FP5 project PENDANT, contract no GMA2-2001-52066 S07.17215, 2007
5 H Fagerlind, H Hoschopf, C Naing, A V Martinez, Accidents databases for collisions with roadside infrastructure, D1 of the EU FP5 project RISER, contract no GRD2/2001/50088/RISER/S07.15369, 2006
6 S Reed, A Morris, Fatal accident database development and analysis, D5.7 of the EU FP6 project SafetyNet, contract no TREN-04-FP6TR-SI2.395465/506723, 2009
7 K Björkman, H Fagerlind, M Ljung Aust, E Liljegren, A Morris, R Talbot, R Danton, G Giustiniani, D. Shingo Usami, K Parkkari, M Jaensch, E Verschragen, In-depth accident causation database and analysis report, D5.8 of the EU FP6 project SafetyNet, contract no TREN-04-FP6TR-SI2.395465/506723, 2008
8 Björklund, G, Björkman, K, Rosén, E, Karlsson, J, Viström, M, Andersson, A-L, Johansson, E, Gustafsson, H and Patten C. (2007). INTACT Report: Pre-crash analysis method, Göteborg, Sweden
9 PmWiki, www.pmwiki.org
10 Wallén Warner, H, Ljung Aust, M, Sandin, J, Johansson, E and Björklund, G. (2008). Manual for DREAM 3.0, Driving Reliability and Error Analysis Method, Deliverable D5.6 of the EU FP6 project SafetyNet, TREN-04-FP6TRSI2.395465/506723
11 K Hendrick and L Jr Benner, Investigating Accidents with S-T-E-P, New York: Marcel Dekker, 1987