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## A Common Methodology for Truck Accident In-depth Study

### Abstract

Road safety is a major preoccupation of the European Commission and the road transport industry and depends on numerous significant factors.

In order to improve road safety and to plan effective safety improvement actions for truck transport, we must first identify the problems to be addressed, i.e. what are the main causes of truck accidents.

The ETAC project, initiated by the European Commission and the IRU, was launched in order to set up a heavy goods vehicle accident causation study across European countries to identify future actions which could contribute to the improvement of road safety.

The results will be based on a detailed analysis of truck accident data collected in seven European countries according to a common methodology which has been elaborated through numerous national and European projects.

This paper describes the common methodology used to collect the information on the scene of the accident and to analyse the data so that the reconstruction of the crash events may be carried out. CEESAR proposes a methodology using its experience gained from over 10 years of accident data collection. This methodology is based on an in-depth investigation of the parameters involved in an accident and linked to the driver, the vehicle, the road and their environment. In-depth investigation requires accident investigator presence on the scene of the accident in order to collect volatile information such as marks on the road, weather conditions, visibility, state and equipment of the vehicle, driver interview. Later, passive and active information is gathered, either at the hospital for the

driver, at the garage for the vehicle or on the spot for the road geometry. A reconstruction carried out with the help of specific software and the analysis of the data collected and calculated enables the identification of the main causes of the accident and the future actions to plan in order to improve road safety as regards truck traffic.

### Introduction

Road safety is a major preoccupation of the European Commission and the road transport industry, and depends on numerous significant factors. Many projects and research initiatives have been launched (or will be launched) by the EC to reduce the number of road accidents. Although the overall aim is always the same, the specific objectives of these projects are different: some of the road safety problems can best be tackled by vehicle manufacturers by the improvement of passive or active safety (projects such as EACS, MAIDS, ECBOS), others by infrastructure (RISER), others again by European regulations, driver training, etc. Despite the common goal of improving road safety, each study is specific and it is often very difficult to find common elements to link or combine different studies.

## I – General overview of the ETAC Survey

### I – 1 The Survey

This project was initiated by the IRU (International Road Transport Union) and the EC (European Commission).

IRU invited CEESAR to coordinate activities and to set up a commercial vehicle database, based on previous experience in accidentology and participation in several important European road safety projects.

This means:

- selecting the truck accident investigation teams who will participate,
- developing the empty database,
- providing the questionnaire and guide for use by the truck accident investigation teams,
- ensuring that the quality of all aspects of the survey, especially of the data entered into the database by the truck accident investigation teams, meets the quality criteria defined.

## I – 2 CEESAR's Activities

CEESAR is a non-profit association created in 1993 to undertake research and studies into road accidentology and biomechanics.

CEESAR's aims:

- Knowledge exchange, sharing of experience and savoir-faire to improve safety, primarily road safety.
- Research and experimentation for accident risk and injury reduction.
- Biomechanical research for the study and analysis of human body and dummy movement during crashes.
- Training methods for socio-economical specialists in accidentology.
- Driver and road user training programmes.

CEESAR's different activities are:

- DESA Accidentology and Epidemiology Department "In-depth accident investigation"

ACTIONS: conduct accidentology research programmes, collect accident data, elaborate statistical and epidemiological studies from this data.

- DPEB Experimental Pathology and Biomechanics Department "Study of occupant movements resulting from a car crash"

ACTIONS: evaluate human traumatological tolerances, implement numerical modeling and develop the expertise necessary to ensure dummy biofidelity.

- DESC Experimentation and Behavioral Science Department "Study of vehicle related movements"

ACTIONS: analyze human behavior based upon physiology, postural and cognitive ergonomics and human movement science.

## I – 3 IRU's Activities

The IRU, through its national associations, represents the entire road transport industry worldwide. It speaks for the operators of coaches, taxis and trucks, from large transport fleets to driver-owners. In all international bodies that make decisions affecting road transport, the IRU acts as the industry's advocate. By working for the highest

professional standards, the IRU improves the safety record and environmental performance of road transport and ensures the mobility of people and goods. Among its practical services to the industry, the IRU is international guarantor of the TIR carnet system under which trucks are sealed by customs upon departure and can cross several borders without further checks until they reach their destinations.

The IRU:

Takes the initiative in making sure that vehicles are safe, clean, efficient, and economical in fuel consumption,

- encourages sound fleet management, strict vehicle maintenance and good working conditions for drivers; - helps to make roads safer and less congested,
- seeks improvements in the environmental performance of vehicles,
- maintains close working relationships with the competent national, inter-governmental and non-governmental organisations,
- works for harmonisation and simplification of procedures affecting road transport,
- alerts the industry to changes in national and international legislation,
- strives to lift the barriers to international transport and trade.

## I – 4 The Project and its Objectives: Identify the Main Causes of Truck Accidents

This project, initiated by the European Commission and the IRU, was launched in order to set up a heavy goods vehicle accident causation study to identify future actions which could contribute to the improvement of road safety.

If we want to improve road safety and to plan effective safety improvement actions for transport by trucks, we must first identify the problems to be addressed, i.e. what are the main causes of truck accidents.

The ETAC database will enable the:

- identification of the main causes of accidents involving trucks;
- reconstruction of the pre-collision phases;
- identification of critical situations;

- analysis of malfunctions;
- definition of scenarios of accident types;
- study of the information needed by drivers in the “pre-collision” phase;
- a priori quantification of the potential interest of certain driver aids.

## II Teams

### II – 1 Teams

Institutes in seven European countries are participating in this project (figure 1).

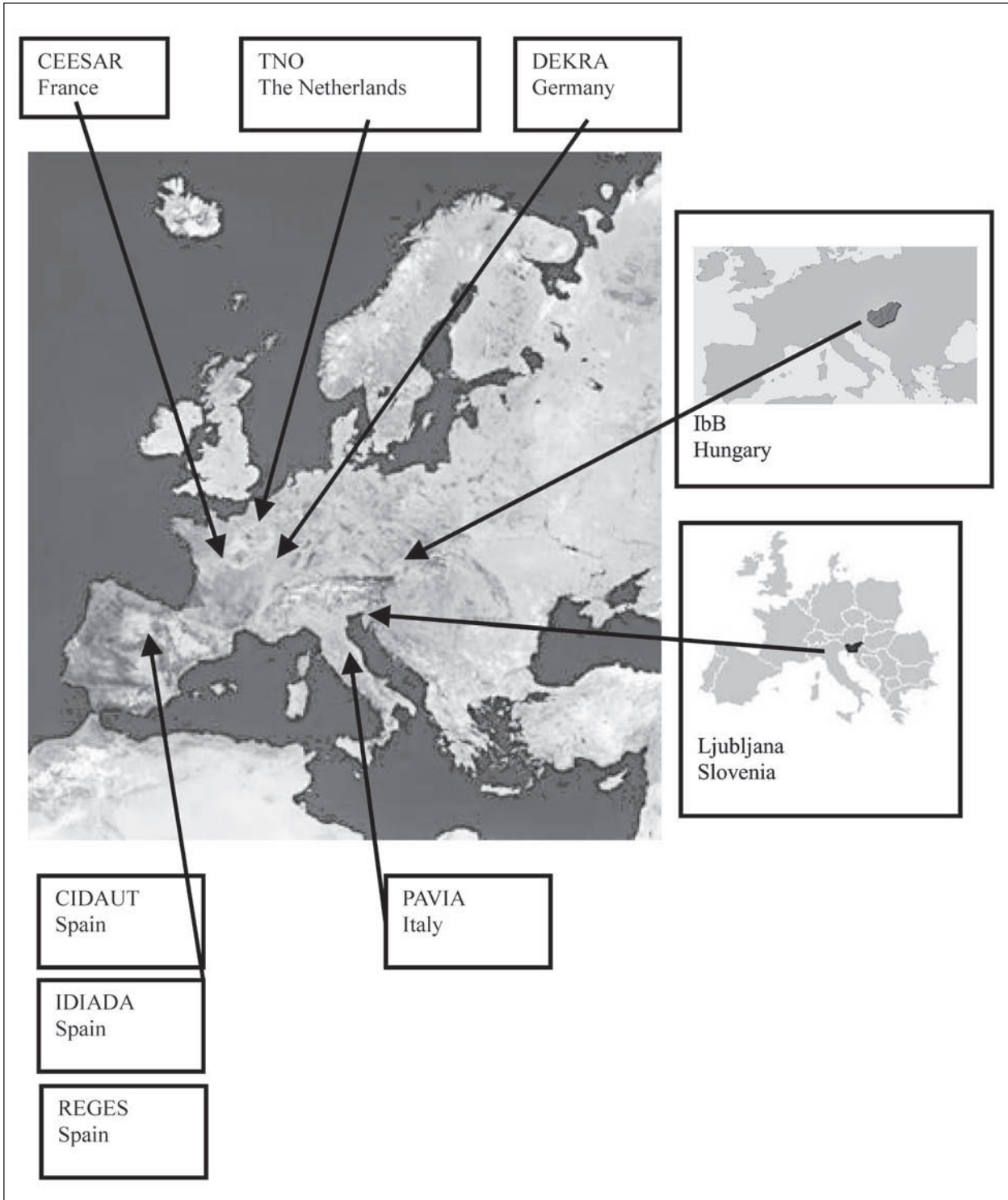


Fig. 1: Team geographical distribution

## II – 2 Team Requirements

Teams must:

- investigate accidents on site and in real time,
- control the sampling. Each team shall report its national accidents statistics and its local Statistics in relation to their survey area for the period of the survey. They are to be compared to the sampled accidents in order to establish the representativeness of the sample,
- collect as much objective and descriptive data as possible (on scene, by interviews or physical examination) according to the team's experience and the methodology agreed by IRU and CEESAR for the ETAC project,
- as far as possible, interview all people involved (drivers, passengers) and if possible the policemen, eye witnesses, doctors...,
- use the common questionnaire supplied with the common manual as a guideline to accident investigation,
- study the vehicle and the accident scene using the team's experience and the ETAC methodology,
- collect medical information directly from hospitals in order to be able to encode the injuries according to the AIS code,
- carry out encoding according to the instructions contained in the manual,
- take as many relevant photos as possible,
- include the best photos in the ETAC database,
- draw an accident site map and prepare the reconstruction according to the ETAC methodology,
- write a short narrative of the accident,
- respect team safety requirements as regards: safety during the journey to and from the crash site (compliance with speed limits and all relevant traffic rules), safety on the site of the accident (regulatory and phosphorescent clothing).

## III Accident Investigation Method and Accident Selection

### III – 1 General Requirements

- A minimum of 600 truck accident cases occurring between 1 April 2004 and 31 March 2006 must be investigated.
- All truck accidents will be investigated using the same methodology.
- Truck accidents will be collected from a sample area considered to be as representative as possible of the national truck accident situation.
- All accident cases will be investigated on the spot as soon as possible after the accident (in real time if possible) by a team composed of accidentology and data collection experts.
- Each accident studied must involve at least one truck (commercial vehicle of gross weight >3.5t).
- Accidents may involve a single truck (rollover, against a fixed obstacle...)
  - or a truck and another vehicle (truck, car, 2-wheelers).
  - or a truck and a pedestrian.
- All accidents must involve at least one injured person.
- The accident should be studied in depth, covering both passive and active safety. Accident cases must be well documented. It is important to keep only accidents for which teams have a high level of information. Because the aim of this project is to understand accident causes, only cases where the causation is available will be retained.

### III – 2 Data Quality

#### III – 2-1 On the Spot

It has been proven that the best way to understand the causation process is to go to the scene of the accident as soon as the accident occurs. Deferred investigations (several hours or even days after the accident) prevent the analysts from getting useful information such as participant interviews, witnesses, evidence, road state, and vehicle marks on the road, traffic conditions and so on. It is true that some of the information can be found in police

reports but experience has shown that police reports do not provide in-depth information. Policemen are not professional safety researchers.

Therefore, when using data taken from police reports, teams must be confident that they provide the quality and objectivity needed for the ETAC study.

### III – 2-2 Accident Investigators

Each team must collect the information directly on scene and later on at the hospital, garage. They should use the police report as little as possible. If they are called by the police and reach the accident scene after the driver has left or the vehicles have been moved and the crash or final positions of the

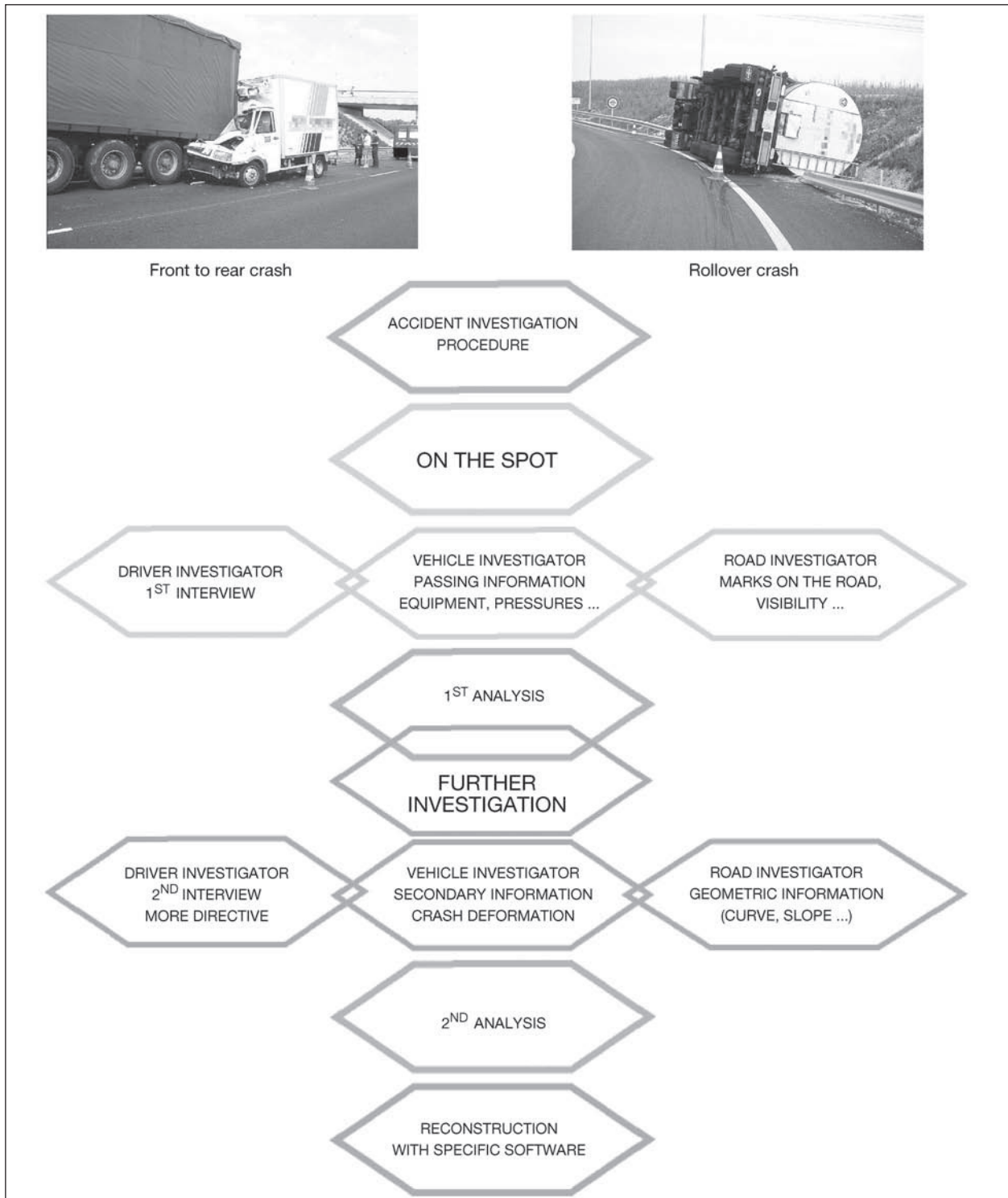


Figure 2

vehicles or other participants in the accident cannot be determined, the accident must not be investigated. The objective is to obtain as much information as possible to enable cognitive and cinematic reconstruction of the accident.

After the collection of the information on site, complementary information is collected at the hospital (especially second interview of the person involved and collection of the injury form), at the garage to collect crush deformations or at the local transport authority for further details about the traffic or road configurations.

### III – 2-3 Accident Coding

Most of the information can be coded and entered into the database according to the instructions in the Manual. The coding is the essential link to be able to draw conclusions as to the main causes of accidents which is the aim of the study. Information that cannot be coded is conserved in original files along with photos, sketches and video movies if necessary and can be indicated in the window reserved for the accident summary or in the textual fields provided in the database.

### III – 2-4 Methodology Assessment

This accident investigation methodology has several benefits. It is the best way to understand the accident because teams arrive at the same time as the police and the rescue services and collect as much information as possible on the spot. They have in-depth knowledge of each accident and its causation.

## III - 3 Accident investigation procedure

### III - 3-1 General Outline (figure 2)

#### III - 3 2 On the Spot of the Accident

##### Driver investigator role

When possible, the “driver investigator” interviews drivers on the scene of the accident, about the pre-crash, crash and post-crash situations. They discuss the conflict situation, the driver’s perception of it and his evasive actions. The driver thus benefits from visual references on the accident scene and his account of the accident scenario is richer. If the driver is injured and needs immediate medical treatment, the length of the first interview depends on his state. The investigator collects as much information as possible on the

scene of the accident from passengers and witnesses and then heads to the emergency ward of the hospital.

The first interview takes place just before or after initial medical treatment on the spot, unless the driver is unconscious or undergoing emergency surgery. In that case the interview takes place as soon as possible after medical treatment at the hospital.

The interview is recorded if possible in order to corroborate the other information and to complete the phase definitions throughout the reconstruction.

##### Road Investigator Role

The “road investigator” marks the final position of the vehicles, identifies and measures all the marks that vehicles leave before, during and after the crash (point of crash, braking, sliding, driving and scratching marks). He then takes photos of the accident scene from a road infrastructure point of view (final position, skid marks, road geometry, road surface, weather conditions...). Once all this volatile information has been photographed, he draws up a sketch of the accident scene which includes the approach path of each vehicle, the marks, their final positions, the road and roadside geometry and road signs...

##### Vehicle Investigator Role

The “vehicle investigator” photographs the vehicles in their final position, the deformations, the state and use of vehicle equipment, load, etc. Once this is done, he examines the use and the state of the various equipment (lighting, radio/telephone,



Fig. 3: Driver interview recorded



**Fig. 4:** Vehicle marks on the road and rest position of the vehicle



**Fig. 7:** Driving marks on the roadside



**Fig. 5:** Sliding marks



**Fig. 8:** Vehicle investigation



**Fig. 6:** Scratching marks, point of impact

seat position and belt use, gear level position, tyre pressure, etc.) in detail. He also talks to the emergency services about their extraction methods and any other changes that they might have made to the vehicle.

### III - 3-3 Further Investigation

The “driver investigator” meets the driver once again, at hospital or at home, to discuss personal and medical details, general driving habits, training, previous accidents and sanctions, before coming back to the accident situation. The information collected from the other driver and the other accident investigators is used to corroborate or to contradict the driver’s initial declarations.

The “road investigator” collects complementary information about the road geometry, pavement friction and traffic conditions (density, speed, etc.). He uses this information to complete his accident sketch and then draws up a scale plan of the accident scene.

The “vehicle investigator” returns to see the vehicle and carries out a more in-depth study of the vehicle, engine, braking, steering systems, other equipment and its condition. He also measures vehicle deformation and looks for impact zones



Fig. 9: International vehicle deformation measurement



Fig. 10: Crush deformation



Fig. 11: Crush deformation

inside and outside the vehicle, which may correspond to injuries sustained by the participants or a pedestrian or the impact of another vehicle.

### III - 3-4 Accident Analysis (Primary and Secondary Safety Point of View)

Experts encode the information about the crash: vertical and horizontal overlap of the crash,



Fig. 12: Crash vertical overlap

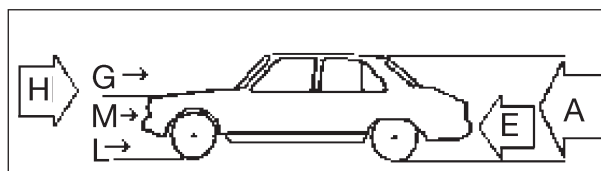


Fig. 13: Crash vertical overlap

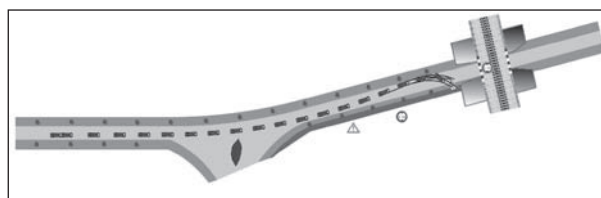


Fig. 14: PC-Crash 2D simulation

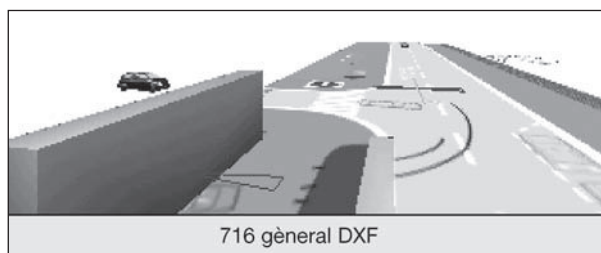


Fig. 15: PC-Crash 3D simulation

crushed surfaces, depth of the crash deformations...

They evaluate the energy dissipated through vehicle deformations (so-called Equivalent Energy Speed) with the support of a crash test library, previous reconstruction and experience.

The information collected by the three investigators is then used as the basis for a dynamic reconstruction using PC-Crash software<sup>1</sup>. The conservation of energy equations is used to give initial dynamic parameters. The scale 3D map serves as the background for a reconstruction which starts at the rest position of the vehicles and goes back in time through the post crash, the crash and the pre-crash phases. Each phase is based on the information collected by the investigators.

<sup>1</sup> Dr. Steffan Datentechnik, Linz, Austria



The accident is analysed according to a sequential model based on:

- Accident type(s) (loss of control/intersection crash/rollover...)
- Failure type(s)
- Failure function(s)
- Failure mechanism(s)
- Sequence of events (driving/conflict/emergency/crash/postcrash)

The results of these cinematic and cognitive reconstructions are used to determinate the main causes and contributing factors and allow active safety improvements throughout regulation, active safety countermeasures (determination, evaluation), driver formation, and road improvements.

From a passive safety point of view, the participant's medical report, which is supplied by the local hospital, is used to correlate the injuries sustained with the accident injury mechanisms and the zones impacted inside or outside the vehicle. This correlation is the basis of passive safety improvements through passive safety equipments.

## IV – Database: Data Coding and Data Manual

### IV - 1 Database Content

A common database is created to record all accident cases. Data is collected and encoded according to the common questionnaire. The same data codification is used by all the investigation teams according to a common manual.

In order to be able to carry out accident research, additional information is required. We have added a multi-media database which provides:

- Digital photos of

- o vehicles: photos around vehicle, the inside of the vehicle, specific information or vehicle defects,
- o roads: the surface and its state, the friction problems (if pertinent), visibility problems, road markings, the point of impact, skid marks, sliding marks, scratching marks...
- o the conditions of the journey just before the crash: photos of the immediate surroundings of the approach route (visibility, geometry of the road)...

- Sketches (JPEG format) of the accident scene drawn with specialised software.

We require 2 types of sketch:

- o 1<sup>st</sup> sketch: an accurate drawing with the rest positions of the involved vehicles, the marks on the road surface (skid marks, scratching marks, sliding marks, point of impact...). Visibility problems, road friction coefficients, road and shoulder profiles (described in the database presentation) should figure on the sketch, as well as everything that can help to understand the accident. An indication of the scale is necessary. For instance see figure 17.



Fig. 16: The curve before the crash

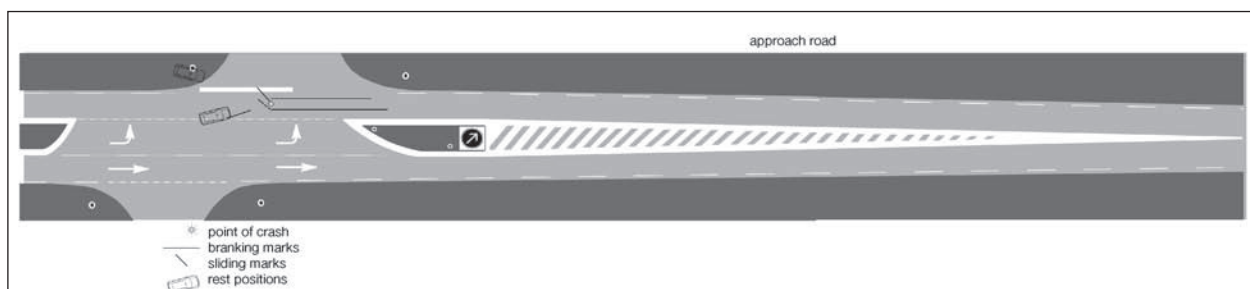


Fig. 17: Sketch of the accident

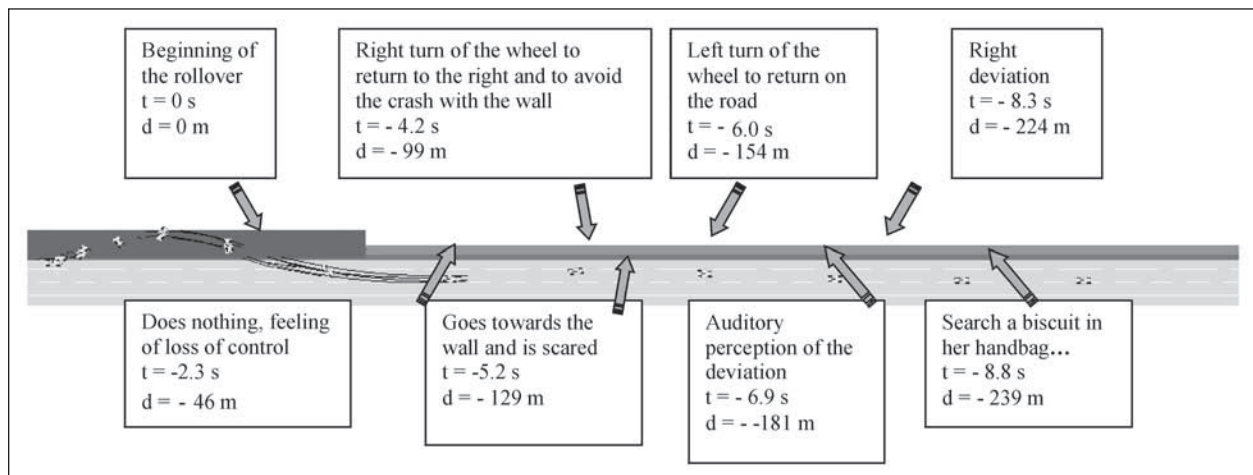


Figure 18

For instance:

- o 2<sup>nd</sup> sketch: in relation to the reconstruction and the pre-crash table (further detailed in the database presentation), a sketch with the relative position of the vehicles linked to their time to crash and their distance to crash see figure 18.
- o And a summary of the accident in which the investigators relate the accident and add qualitative complements to the coded information. Because the analysis is performed on the basis of the database, we need both comprehensive and summary information. We especially require accurate information without subjective judgements. This means facts and expert analysis.

#### IV - 2 ETAC Database Contents

The final multimedia database contains:

- Conclusions: main accident causes
- Data: entered using a common software package provided by CEESAR (questionnaire and manual provided),
- Sketches: plan with final position, tyre marks (or others) before and after the crash, the point of impact, the curb measurement, the road level, etc.
- Summary: general circumstances, comments, etc.
- Digital photos: of the vehicles, the accident site, the marks, the road

#### IV – 2-1 ETAC Questionnaire Contents

CEESAR provides a questionnaire which takes into account each aspect of the accident. This questionnaire allows the identification of the principal and subsidiary causes of the truck accident.

The questionnaire form is based on CEESAR's (Centre Européen d'Études de Sécurité et d'Analyse des Risques), INRETS's (Institut National de Recherche sur les Transports et leur Sécurité) [1], TNO's and NHTSA's (National Highway Traffic Safety Administration) experiences and on EACS (European Accident Causation Survey) [2], MAIDS (Motorcycle Accident In-Depth Study), RISER (Roadside Infrastructure for Safer European Roads) databases.

The questionnaire oriented to truck accident causation is divided into 6 different parts:

- General information
  - Identification
  - Vehicles, objects, pedestrian involved
  - Location
  - Weather conditions
  - Light conditions
  - Common infrastructure equipment
  - Accident type
  - Accident severity
  - Summary and comments
  - Photos
- Road and environment information for each vehicle
  - Identification
  - Road type

- Road restrictions
  - Road geometry
  - Horizontal and vertical signalisation
  - Junctions/round about
  - Curves/straight lines
  - Road edges
  - Road surface
  - Road equipment
  - Traffic
  - Breaks in the infrastructure
  - Geometrical visibility and limits
  - Detailed scale sketch
- Vehicle information for each vehicle including the trailer
    - The whole vehicle
      - Identification
      - Accident severity
      - General information
      - Visibility of the vehicle (colour and contrast)
    - Motor vehicle except 2 wheelers: Common information (car, bus and trucks)
      - Identification
      - General administrative and technical information (manufacturer, model, VIN (Vehicle Identification Number) year of 1<sup>st</sup> registration, type of profile, colour and contrast, general weight and power information...)
      - Design or geometric specifications (length, width, overhang, height from the ground of the vehicle, ...)
      - Tyres, wheels and suspension
      - Technical design (gear box, engine position, type of brake, tank position, lights...)
      - Equipment (visibility: mirrors, driving aids: ABS, ESP, cruise control..., and the use and state of the secondary safety equipment: seat belt (fixed in the vehicle and used), airbag, pretensioner, and underrun protection..., comfort: radio, television, fridge...)
      - Vehicle general technical state before the crash
      - Load during trip and load securement
      - Vehicle defects before the crash (general, steering, braking, suspensions, lights, mechanical failures...)
      - State at the time of the accident (use of the radio or CD player or phone..., use of lights or position of sun visor...)
    - Reading of the speed recorder or tachograph (speed before the braking, speed before the crash, respect of rest pauses, respect of speed limits, time after the last pause...)
    - Accident collision recorder
- The trailer
    - Identification
    - General technical information
    - Design specification
    - Vehicle parameters
    - Load during the trip (nature, position, fixed, danger, aspect, form...)
    - Tyres and wheels
    - Rear underrun protection
  - 2 wheelers
    - Identification
    - General information
    - Specific bicycle/motorcycle information
- Road user information
    - For the driver and each participant
      - Identification
      - Personal status
      - Vehicle occupant report/secondary safety
      - Child restraint data
      - Two wheeler occupant data
      - Injury report (MAIS Main Abbreviated Injury Scale, AIS 90)
    - For the driver only
      - Identification
      - Personal status
      - Long and short-term illness
      - State of the driver or rider
      - Driving license for this vehicle (available or not, training, date...)
      - Driving experience with this sort of vehicle
      - Vehicle and equipment knowledge
      - Intoxication level
      - Trip in progress (type, purpose, destination, the choice of the itinerary, the start of the trip, the frequency...)
      - Previous infractions
      - Previous accidents
      - Accident and emergency situations (perception, understanding, actions...)
      - Blind spot
    - For the pedestrian
      - Identification
      - Personal status
      - Health, long and short-term illness

- Intoxication level
  - Trip in progress
  - Accident and emergency situations
  - Injury report (MAIS Main Abbreviated Injury Scale, AIS 98)
- Reconstruction information for each vehicle
    - Aspects recorded on the site of accident (volatile information, equipment, tire pressures, skid marks, visibility...)
    - Impacts and the vehicle (crash deformations, overlap, EES (Equivalent Energy Speed), a crash library will be available if necessary, TDC (Truck Deformation Code) ...
    - Fire
    - Pre-crash phases (phases described before the collision or the beginning of rollover...)
    - Pre-collision table (each phase is described with the time to crash, the speed, the deceleration, the distance, the driver's action...)
  - Analysis
    - Accident causation (accident analysis – main accident causes)
    - Accident avoidance systems

#### **IV – 2-2 ETAC Manual**

CEESAR has written a data coding protocol, explaining each item to ensure coherent coding by the different data collection teams. As a complement to this guide, the project is also interspersed with seminars to exchange experiences, questions and to ensure the common encoding manner and understanding.

The manual is integrated in the software and is thus available as soon as the coding task needs it. A paper manual is also provided.

#### **IV – 2-3 ETAC Software**

CEESAR has provided an electronic data template programme to ensure that the accident data coding form is the same for each investigation team. The software allows data quality control in each table and between tables. The variables may be encoded either directly or with a drop down list. All “other” responses require explanation in a textual field in order to complete the data.

Each team must then use the integrated quality control process included in the software before delivery.

#### **IV – 2-4 ETAC Quality Control**

In order to monitor the quality of the database throughout the survey, CEESAR will undertake rigorous quality inspection presented below.

At the beginning of the project, a data collection schedule was agreed in order to ensure that objectives would be reached in due time.

In order to assist in the quality control process, each team must check its data before sending it to CEESAR. As explained above, the software helps to identify incoherent information, missing values and mistakes.

#### **Conclusion**

The accident investigation methodology has been tested and improved by CEESAR teams over 10 years of data collection. European experience has also been used to develop the common database. All this experience enables us to take into account European preoccupations and different goals.

One such European preoccupation is the understanding of truck accident causes. So, even though common databases exist for car (EACS) and 2 wheeler accidents (MAIDS), a common truck accident database is a new target. The success of such a common database depends upon the strict respect of the commonly accepted methodology.

The methodology takes into account all aspects of the accident, following a sequential study, including the reconstruction and the analysis of the data which are both essential and additional expertise in the identification of accident causes.

Developing a common truck accident database is an additional step towards a common database for all vehicle types. It is very important to improve the contents and the quality of the collected data. This quality target will allow European road safety improvements throughout the understanding of the different travelling and risk exposures of the different countries.

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