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IN-DEPTH INVESTIGATION OF ACCIDENTS THE EXPERIENCE OF INRETS AT SALON-DE-PROVENCE

I) INTRODUCTION

Since 1980, the Department of Accident Mechanisms at INRETS in Salon-de-Provence (France) has been conducting an in-depth investigation of road accidents (Etude Détaillée des Accidents: EDA). According to the definition given by OECD (OECD 1988), an in-depth accident investigation is one which goes much greater into depth than those currently available. That such a vague definition be applied to such a wide range of activities could, indeed, be questioned. But, these different activities can in fact be grouped together under the same heading, as they have to respond to the same theoretical and methodological questions (Pettersson, 1991; Girard, 1991).

It is not my intention to consider the problematic of in-depth accident studies at great length. This work has already been dealt with by a group of scientific experts at OECD. The purpose of this paper is to present some of the choices made at Salon-de-Provence in answer to the questions that are raised when deciding to conduct an in-depth accident study.

The first of these questions is the necessity of a more in-depth approach: when launching an in-depth study it is assumed that the questions have been defined, and that it is impossible to respond to these questions using available accident collections.

We must then indicate the additional information needed to respond to these questions and define the direction and contents of an in-depth study collection. We must, at the same time, check that this information is readily accessible, and develop the most appropriate data collection method.

Finally, we should not forget to previously define the way in which this data will be used and the context in which it will be interpreted.

This last point assumes the use of a theoretical framework. It is in fact obvious that the question of choosing a theoretical framework is raised as soon as the initial questions are formulated, and also determines which data is to be collected. Experience has shown that this theoretical framework is rarely specified. In all events, conducting an accident analysis assumes that there is a grid by which to read the accident. Many misunderstandings could be avoided if, instead of remaining implicit, this theoretical framework was clearly indicated.

II) EDA OBJECTIVES AT SALON-DE-PROVENCE

The aim of those working to improve road safety is to reduce the number of accidents, and the seriousness of their consequences. But, what do we know about accidents?

An accident is an event that is already over when we are informed of its occurrence. It is too late to observe or record the sequence. The data collected is for the most part the descriptive characteristics of those involved, the vehicles, the road infrastructure, the circumstances in which the accident occurred and its consequences. The statistical use of this descriptive data does indeed enable us to identify groups at risk, the implications and factors that are statistically significant. But this data only provides a static description of the accident.

Investigation into the accident dynamic is aimed at establishing responsibility, and can be resumed in terms of the violation of traffic regulations.

EDA was set up for research purposes. The intention of those who initiated this work was to go beyond the traditional approach of identifying accident-causing factors, to reach the actual mechanisms that produce accidents, by reconstructing their scenarios and analysing their sequences.

In line with this objective, in-depth research work should be directed more towards the stages prior to impact, than to the consequences.

The methodological consequences of this choice was to prioritize clinical case analysis, whilst disregarding statistical representativity. Between 1980 and 1987 four hundred accident cases were analyzed.

III) THEORETICAL BACKGROUND

III-A) The accident:

We consider that we are dealing with a system of mobility. The basic mobility system components are the users, tools and infrastructures used for this purpose. Normally the "output" of this system is to satisfy mobility requirements. If the system is operating correctly, this means that there is a successful combination of the three basic components. Modifying one of the system components will determine the modifications of its interaction with the other components: they cannot operate independently one from another.

An accident is an undesirable "output" of the system, and the occurrence of an accident is the symptom of a malfunction within this system. Operating failures are not to be sought in one or another of the components on its own, but in the relationships and interactions between these different components.

The methodological consequence is that both collection and analysis should be multi-disciplinary, and include the three system components: user, vehicle and infrastructure.

III-B) The user:

This type of approach assumes the use of a human operating model. In the light of developments in cognitive psychology, man is seen to be an information processing system. We are well aware that it is restrictive but it is in our opinion, the most effective at present when used for research directed towards prevention action (Hale, Quist & Stoop, 1988; Hale & Stoop, 1988; Michon, 1985).

This model maintains that the user, as he gains experience, draws up, in his permanent memory, a catalog of road situations that operate increasingly as prototypes to which he refers, and to which utilization modes are associated. A balance is formulated between adapting knowledge acquired when faced with unusual road situations, and assimilating the situations encountered into previously acquired knowledge.

As a result of this, the information provided by the environment is filtered and interpreted according to acquired knowledge. With time, these processes for information processing and use of knowledge become more and more automatic.

Insofar as an accident is an unwanted event, it can be said to illustrate a failure in the information processing process sequence, a malfunction that could be located at different stages and at different levels of the human activity (Rasmussen, Duncan, Leplat eds, 1987; Reason, 1990).

The first consequence of this approach is that particular attention is focused on the account of the accident and the interaction between these road situations and the interpretations of these situations by users. A second consequence is that collection will be directed towards the human conditions that we know, or assume, influence the information processing process.

IV) DATA COLLECTION

Data collection is aimed at reconstructing the scenario that results in impact, and identifying the mechanisms that make up this scenario. It is conducted by a team of two specially trained operators: a technician specialised in infrastructure and vehicles, and an interviewer. The quality of collection is continually monitored by researchers involved in the study.

We are alerted that an accident has occurred at the same time as the emergency services. Survey strategy is based on collecting as much information as possible at the scene of the accident itself. Data collection is three-fold: the user, the vehicle and the road infrastructure. It covers vanishing data: accounts given by those involved and witnesses, location of final standstill point, location of the crash itself, skid marks, traffic and weather conditions, and so on...

The driver is interviewed on the spot, or in the hospital emergency service. He is asked to describe "what happened", and then give further details: what he had intended to do, what he had seen, what he was aware of, what action he had taken, what he had intended or tried to do. The interviews are recorded, photographs are taken, a plan is drawn up.

We then attempt to reconstruct the accident scenario. This is followed by a second complementary collection. This second collection enables us to collect longer-lasting data, such as descriptive characteristics of the driver and the on-going journey, description of the route, road infrastructure and environment, technical vehicle inspection. It is also directed by assumptions made during the first reconstruction attempt.

The final reconstruction is backed up by kinematic calculations: initial speed, time to collision, speed at impact (Lechner & al., 1990).

V) ANALYSIS

The first stage of analysis consists of drawing up the accident scenario in terms of the sequence of events and, in particular, the description of the initial system status, the identification of the triggering event, the reconstruction of the emergency manoeuvre. The second stage is to identify the mechanisms that contribute to the production of this sequence of events: these mechanisms are found in the system component interaction. To achieve this, the scenario is divided up into four phases.

V-A) The driving phase:

The driving situation is, for the driver, the "normal" situation. It is "normal" because there are no unexpected demands made upon him. The driver can adapt effectively, the events unfold according to his predictions, expectations and anticipations. He controls his speed and course, he is "master of his vehicle". On a more basic level, this means that there is a balance between the demands and ability of the system components to respond to one another: alignment, skid-resistance, sight distance, tyre wear and pressure, condition of shock absorbers, speed, degree of driver awareness... It should be noted that "normality" in this case refers to effectiveness, but not necessarily to compliance with traffic regulations. The advantage of this situation is to reveal what the driver considers to be both desirable and feasible in a particular place and in a particular context.

V-B) The discontinuity phase:

Discontinuity is an unexpected event that interrupts the driving situation by destroying its balance and thus endangering the system. The effect of the discontinuity situation is to switch the system components from a bearable level of demand to a suddenly excessive demand in terms of ability to respond.

It should be noted that an "unexpected event" does not necessarily mean "unpredictable", which raises the question of to what extent it really was unpredictable, and if not, why it was unexpected. The driving situation is of considerable use when seeking this explanation.

V-C) The emergency phase:

The emergency phase covers the space and time between discontinuity and impact. If the discontinuity situation is a statement of the problem, the emergency situation is the space-time "credit" available in which to solve it. This "credit" is, by definition, extremely limited.

The emergency situation can be determined in relation to the driving situation by the suddenly excessive demand level imposed on the system components. The driver must solve, within a given time, a problem that is, in principle, entirely new to him. The range of solutions depends on the environment in terms of hostile obstacles or space available for evasive action. The capacity of the vehicle to perform the required manoeuvre depends not only on its design and state of repair but also, with regard to the vehicle-ground liaison, on the state of the infrastructure. The emergency situation reveals the insufficiencies or defects in one or another of the system components, weaknesses that remain tolerable when faced with normally moderate driving situation demands.

The emergency manoeuvre is an attempt to find a solution to the problem. As there is an accident this manoeuvre has failed. The emergency situation is followed by the crash phase.

V-D) The crash phase:

The crash phase includes the crash and its consequences. It determines the severity of the accident in terms of material damage and bodily injury. Once again, the contents of the situation depend on what has occurred previously and the interaction

between the three components: an elderly person is more vulnerable, modern vehicles are better designed to absorb
impact, a protection rail prevents impact with a hostile obstacle.

VI) ILLUSTRATION

One Sunday in March at half past eight in the morning we were alerted by the emergency services and went immediately to the scene of the accident.

VI-A) "On the scene" collection:

- the accident resulted from the vehicle leaving the road on a right-hand bend. Only one vehicle was involved. There were three people in the car, one of them was slightly injured.

- we noted skid marks made by locked wheels on leaving the bend, starting on the left hand side and moving towards the outside of the bend, the vehicle crossed over the shoulder and fell into a ditch on the left.

- it was daytime but the light was not very good, the sky was overcast, the road surface wet, although it was not raining at the time of the accident, there was little traffic.

- the vehicle was a Citroën Visa GTI: a sports model, 105 HP Din, with a top speed of 185 km/h. There were three people in the car.

- The driver, a young man, was unharmed. In brief, he stated he must have approached the bend at between 70-80 km/h, and did not consider this speed to be excessive. He had just changed into third gear and was then taken unawares when half way through the bend: he realised he was "taking it wide" and that his left-hand wheels were crossing over the central white line. He stated that he was afraid of meeting an oncoming car, and braked lightly. The car went straight ahead, and then it all happened! He indicated that finally, there was no one approaching, and that if he had not braked he could have driven through, but as he had kept his foot on the brake, he continued straight ahead into the ditch. He also said he was surprised that his wheels had locked, as he did not think he had braked very sharply.

VI-B) Additional collection:

a) Road and pavement characteristics:

- two-lane rural road
- pavement width: 6.30m
- this occurred when leaving a built-up area, in an area where vehicles pick up speed. The bend is preceded by a straight stretch of 400 m.
- sight distance is sufficient to detect the bend. However, vegetal masking on the right-hand side prevents the driver from seeing around the curve and thus assessing its real difficulty.
- curve radius: the radius on entering the bend is 94m, but this decreases to 60m on leaving.
- the road surface is average in quality when approaching the bend, but deteriorates in the bend (bumpy), and skid resistance is very poor.
- there is no warning of danger, nor any specified speed limit.

b) Vehicle:

- a light and high powered sports car.
- one year old and had covered 40 000 km.
- the car was in excellent condition and no defect was noted in either the steering, brakes, suspension or tyres.
- it should be noted that the brakes on this model are particularly sensitive.

c) Driver:

- a young man aged 23.
- had held a driving licence for 5 years.
- had just purchased a second-hand Citroën Visa and had only been driving it for one day. His previous vehicle was an old saloon car, cumbersome with limited performance.
- in contrast to his previous vehicle, he stated that the brakes of the Visa were sharper, and that he had to look at the speedometer to realise what speed he was travelling at.
- the purpose of his journey was to attend a car rally. He left home at about 7:15h, the route so far had been well maintained and easy. He wanted to arrive on time to find a good place on the rally circuit.
- this was the first time he had driven over this route.

VI-C) Analysis: breakdown and interactions:

a) Driving phase:

- a young male driver, at the wheel of a sports car he is not familiar with and driving over a route he does not know. The car was considerably different to any he had driven before.
- a time constraint: to arrive before the start of the rally to find a good vantage point.
- leaving a built-up area, in an area where vehicles pick up speed, with a good quality road surface.
- the speed was limited to 90 km/h, with no other specific restrictions. The approach speed of the Visa was thought to be 80 km/h. This is high, although the driver is still within the legal limit.

b) Discontinuity phase:

- the acceleration zone leads on to an unexpected difficulty.
- the bend radius is shorter when leaving than when entering.
- reduced sight distance of bend exit.
- no indication of any specific difficulty on this bend.
- Visa thrown off balance by bumps in the road.
- the driver is taken by surprise and has difficulty controlling the course of the Visa: he "takes the bend wide" and starts to panic.

- N.B.: we went through this bend under dry conditions and with a new road surface at the wheel of specially equipped Citroën BX: we recorded a lateral acceleration of 0.7 g at 70 km/h... This poses a genuine course control problem for any driver who is taken unawares.

c) Emergency phase:

- the driver brakes: the Visa, which is more responsive, does not behave as expected and he locks the wheels.
- the road surface is wet and skid resistance poor: he starts to skid towards the outside of the bend.
- he had no experience of this type of situation and keeps his foot on the brake: the Visa continues its skid in the same direction.

d) Crash phase:

- the shoulder is narrow making it impossible to take remedial action.
- it is bordered by a ditch.
- the Visa falls into the ditch and comes to a standstill on its side.
- the front passengers wearing seatbelts are unharmed. The passenger at the rear is slightly injured.

e) Conclusions:

The police report came to the conclusion that this was a typical case of loss of control, due to carelessness and excessive speed, by a young driver who liked driving sports cars. The in-depth analysis shows that the origins of this accident were more complex and could not be limited to a single cause, but were the result of interaction between the three system components. The police diagnosis leaves little place for the prevention of this type of accident, except for clamping down on youthful carelessness, or preventing young people from driving sports cars. The diagnosis of the in-depth study opens wider perspectives. First, it is easier to modify a bend than change someone's personality, and this is something all users can benefit from. Beyond, however, this localised solution, this raises the question of situation sequences and the homogeneity of road sections, and their effect on user expectations and behaviour. Finally, even if the users are guilty of carelessness or errors with negative consequences, it can be seen that these are not committed at random...

VII) CONCLUSION

When the EDA was undertaken, it corresponded to our knowledge and queries at that time: to improve accident analysis methods, better our understanding of the accident process and encourage new directions of research.

This gave rise to work covering such themes as:
- accidents at light-controlled junctions in urban areas,
- accidents at cross-junctions in the open country (Girard, 1988),
- accidents involving heavy goods vehicles (Fleury & al., 1988),
- an analysis of the driving task as seen through malfunctions (Malaterre, 1990).

It has formed a basis for research programmes: reconstruction of emergency situations leading to mathematical modelings, road and driving simulator experiments (Lechner & al., 1991).

It has also provided information on which to base a study of driving aids (Van Elslande & al., 1993).

In-depth accident investigation enables the principal safety problems to be rapidly identified, especially when and where there is no existing accident data base. It provides an open, flexible and manageable investigation framework, which takes account of local specificities. It also provides road safety personnel with educational aids. It leads to the formulation of new assumptions to be validated by alternative methods such as on-site observations, on-board and laboratory experiments.

From this point of view, in-depth accident studies reveal their full potential when they are not required to provide information they cannot produce, and when they are combined with other complementary methods as part of a co-ordinated research programme.

REFERENCES

Fleury D., Fline C., Peytavin J-F. (1988): Road accidents involving heavy goods vehicles, analysis of in-depth accident study files. RTS, English Issue n°3, 1988.

Girard Y. (1988): Analyse de comportements d'accidentés sur carrefours aménagés. Actes de la Conférence Internationale de la Route et de la Circulation Routière, Berlin, 6-9 septembre 1988.

Girard Y. (1991): Comments on "In-depth investigation" by H. E. Pettersson. Proceedings of Third European Workshop on Recent Developments in Road Safety Research, April 26-27, 1990. VTI Rapport 366A, 1991.

Hale A. R., Quist B. W., Stoop J. (1988): Errors in routine driving tasks: a model and proposed analysis technique. Ergonomics, 1988, vol 31, n°4, 631-641.

Hale A. R., Stoop J. (1988): What happens as a rule? Communication between designers and road users. Paper to Conference: Traffic Safety Theory & Research Methods, Amsterdam, 26-28 April 1988.

Lechner D., Ferrandez F. (1990): Analysis and reconstruction of accident sequences. XXIII FISITA Congress, Torino, 7-11 may 1990, The Promise of New Technology in the Automotive Industry, Technical Papers, vol I.

Lechner D., Malaterre G. (1991): Emergency manoeuvre experimentation using a driving simulator. SAE Technical Paper Series 910016, reprinted from "Fifth Autotechnologies Conference Proceedings", Monte-Carlo, Monaco, 23-25 january 1991.

Malaterre G. (1990): Error analysis and in-depth accident studies. Ergonomics, 1990, vol 33, n°10/11, 1403-1421.

Michon J. A. (1985): A critical view of driver behavior models: what do we know, what should we do? in Evans & Schwing eds, Human Behavior and Traffic Safety, Plenum Press, 1985.

OECD (1988): Road accidents: on-site investigations.

Pettersson H. E. (1991): In-depth investigation. Proceedings of Third European Workshop on Recent Developments in Road Safety Research, April 26-27, 1990. VTI Rapport 366A, 1991.

Rasmussen J., Duncan K., Leplat J., eds (1987): New technology and human error. John Wiley & Sons, 1987.

Reason J. (1990): Human error. Cambridge University Press, 1990.

Van Elslande P., Nachtergaële C. (1993a): A qualitative evaluation of Prometheus CE4 and CED5: an a priori analysis based on in-depth accident reports and opinion data. Convention Report REGIONOV-GIE-PSA/INRETS/35.

Van Elslande P., Nachtergaële C. (1993b): A qualitative evaluation of RTI demonstrators using in-depth accident analysis and opinion investigation. ICTCT Congress 1993, Salzburg, october 27-29 1993.