FRENCH STUDY PROGRAM TO IMPROVE ACTIVE AND PASSIVE SAFETY ON MILITARY VEHICLES

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ABSTRACT

As far as military vehicles are concerned, in particular heavy logistics trucks, French land forces must face various constraints, often unknown to classical safety requirements.

In fact, the main requirements for these vehicles are :

1) long life, which implies, after years' service, the risk of old-fashioned vehicles lagging behind, when it comes to new technologies ;
2) cross-country capacities, which are often possible using off-road tyres and big-stroke suspensions, with sound behaviour on muddy or sandy soils, but only fair or even poor behaviour on asphalt roads ;
3) important payload with a high centre of gravity, which is detrimental to sound behaviour, increasing the risk of rollover in cornering conditions.

To improve safety on these vehicles, a study program is in progress within the French MOD. In this paper, we are describing the genesis of this program, and the means we have chosen, summarised as follows :

- 1) an analysis of all accidents involving French military vehicles will be carried out, as a result of which a complete accident database will be set up ;
- 2) an exhaustive list of active or passive safety systems will be established ;
- 3) a global matrix between all real accidents and all these safety systems will be created, using such methods as simulation : for each accident and, with the vehicle equipped independently with each safety system, this matrix is aimed at estimating if :
  - the accident would ever have occurred (with a level of likelihood) ;
  - the seriousness could have been reduced ;
  - no real changes would have occurred at all.

At the end of the study due 2007, a list of the top 10 safety systems, in terms of a cost/efficiency ratio, will eventually be drawn to equip new or refurbished military vehicles, and a specific safety demonstrator made and tested.

INTRODUCTION

A study program is in progress within the French MoD, aiming at reducing human and material losses due to traffic accidents involving military vehicles. Accidents concerned are of all kinds, from single open road accidents to accidents happening during military operations, for example in cross-country conditions.

Likewise, all kinds of military vehicles could be integrated within this study ; different categories such as light vehicles (4x4), heavy trucks, and armoured tanks are defined to distinguish them.

This program is made up of different parts detailed below ; it is meant to be exhaustive towards all potential sources of loss reduction. The main goal is to obtain a global quantification of the potential contribution of actual, new or future civilian safety systems, issued from automobile industry, in relation to real accidents pertaining to military vehicles.

GENERAL SURVEY

On military vehicles, there are four essential elements likely to constitute a risk factor :

. The vehicle,
. The load of the vehicle,
. The driver,
. The environment.

The vehicle can be a risk factor if its conception is inadequate or obsolete, if the maintenance is not sufficient, or in case of a sudden breakdown, such as for example a brake system failure ;

The load of the vehicle can be a risk factor if it is inappropriate in relation to the vehicle (too heavy, or with a centre of gravity too high), or in case of the vehicle bad coupling securing;

The driver can be responsible if he makes a driving mistake, if he is under the influence of drugs or alcohol, if he is inattentive because of

smoking, phoning, or if he does not respect road regulations, etc ;

The environment constitutes the last factor ; external environment includes other vehicles, meteorological conditions (rainy, foggy, snowy and all slippery conditions), roads and their adhesion or flatness characteristics, and off-road specific tracks (sandy, muddy or underwater) ; internal environment includes noises and typical cold or warm conditions in armoured vehicles with enclosed cell, and big stress due to the military operations.

Accident causes obviously vary ; one generally speaks of lack of attention, excessive speed or skidding, as the primary elements bearing a direct influence on the accident ; and as secondary or complementary causes, those which only contribute to the realization of the accident, the last case being considered as an aggravating factor.

SHORT RETROSPECTIVE

In France, the accident toll on the roads has decreased from about 17 000 to 5 200 (i.e. year 2004) in the last thirty years ; during the same period, the number of kilometres travelled has been multiplied by about 3. It means that the risk of having a fatal road accident is at present the same for a 1000 km trip as it was three decades earlier for a 100 km trip.

Risk reduction is due to multiple factors apparently difficult to quantify precisely; one can however safely pinpoint among those and for the last thirty years : the compulsory seatbelt, the reduction of legal alcohol intake, the MOT technical check-up of old vehicles, the vehicle on-board active and passive safety systems growing in importance, the improvement of road infrastructures and road markings, etc.

Concerning active and passive safety systems, we wish to note that light vehicles have been equipped before heavy trucks (e.g. ESP program, airbags, etc…).

MILITARY VEHICLES IN FRANCE

1. Military vehicles constitute a specific category ; they often have a very long service-life, of up to 40 years, contrary to civilian vehicles, which can only boast of a life ranging from 8 to 15 years. Refurbishment is always possible, but it will only be after a long time (often half-way through a life span), hence the other problem of having similar safety equipments on both types of vehicles.

2. A lot of technical points could also cause problems, when it comes to integrating new safety systems to military vehicles. Here are some examples regarding active safety :

- armour causes the kerb mass to be heavier on military vehicles than on civilian vehicles ;
- the load often has a high level of centre of gravity ;
- road mobility and behaviour can be limited by off-road capacities, not always compatible among themselves ;
- small windscreens and armours are detrimental to external visibility.

And other examples of passive safety are :

- the capacities for structural deformations to occur during a crash are very poor for an armoured vehicle ;
- a lot of metallic and hard elements in the driver's cab or passenger cell could easily become blunt. Very often, doors, roof or pillars do not have any padding at all.

3. The actual state of safety equipments on military vehicles point out a lot of potential improvements ; some examples of which are :

- ABS systems only appeared about five years ago on military vehicles ; and only for new or refurbished ones ;
- ESP systems (and other similar systems) do not exist at present ;
- safety belts, when they are present, are old-fashioned models, often with only two points of anchorage ;
- head restraints rarely exist ;
- no vehicle is equipped with airbags.

POSSIBLE ANSWERS

Statistical survey

Before dealing with the reduction of accident losses properly speaking, one should first acquire a sound knowledge of the accident typology involving military vehicles. In fact, we must establish the nature of accidents occurring most frequently, and the type of vehicles to which they apply. This question needs a statistical survey of French military road accidents in the last decade, based on the practices of specialised civilian laboratories.

We shall thus constitute a database of all military accidents, with a lot of details, making it possible to acquire a good knowledge of real-life accidents.

In this database, we shall have for example the following standard data :

- a description of the circumstances (date of accident, estimated speed, meteorological and traffic conditions, type of road…) ;
- the probable main cause ;
- the aggravating factors ;
- crash type : frontal, rear or side impact, rollover, location of first impact, eventual second impact ;
- number of vehicles or pedestrians involved ;
- toll of dead or injured ;
- cause of injuries (e.g. head impact on steering-wheel) ;
- etc

And specific data linked with the military field :

- the type of vehicle involved (light 4x4 vehicle, armoured vehicle, logistics truck, heavy tank…) ;
- the type of movement (within or outside France) ;
- the cancellation or not of the military mission because of the accident ;
- the global estimated cost of the accident (considering human losses, material costs, and other costs linked with the military mission) ;
- etc…

This statistical survey could last about six months ; it will be necessary to obtain all detailed accident reports from French land forces authorities, in different regiments.

Once this database is complete, the second phase of the study can start.

Security improvement

In France, in Angers in particular (ETAS, MoD unit), specific skills required to assess road and off-road behaviour have been developed. This competence makes it possible to impose within an internal regulation frame (French MoD instruction, partially published in April 2004), specific behaviour tests, compulsory for all military vehicles, whether they be new or refurbished.

These tests include, for example, steady-state circular tests, braking in a 100m-radius turn, severe lane change manoeuvre, emergency braking, etc. On these grounds, ETAS has been granted ISO/CEI 17025 accreditation.

For each test, a minimum threshold is required to qualify a military vehicle. Specific test conditions are described in official documents.

Thanks to this regulation, only vehicles having at least a fair behaviour will be selected ; vehicles with bad or poor behaviour are eliminated. However important this can be for active safety, it is always possible to go beyond.

A lot of work has been carried out by the civilian vehicle industry in the last decade (e.g. : VDC or ESP with different functions such as cornering braking control), and research laboratories keep working on these safety elements (e.g. : CWAS –crash warning and avoidance system) ; the development of such safety systems could be of great interest to improve military vehicles.

Passive safety has, likewise, made great progress ; airbags have become standard ; new vehicle structures can now absorb an important kinetic energy, passenger protection is drastically different from those which still existed in the ’80s.

For that matter, a complete study of existing or future safety systems is needed, to evaluate which ones could have a real interest to military vehicles.

METHODOLOGY CHOSEN

Once the accident database has been established, a complete state of the art, concerning safety systems, must be carried out.

ETAS proposes a global organisation of this state of the art, by grouping existing and future systems into specific categories.

The table 1 defines the different categories and the corresponding systems ; it must be correctly completed :

Safety improvement by…	In detail	Examples
environment analysis	detection of other road users detection of obstacles vision improvement (night vision, fog vision, rain vision…) detection of slippery conditions detection of nearby road profile (curvatures, crossings, bumps…)	CWAS[1], Infrared sensors, Grip estimator, GPS system with precise map,…
vehicle static state analysis	detection of overload detection of a bad position of the centre of gravity payload	No example (not yet!) for in-board sensor

[1] Collision warning avoidance system

Safety improvement by…	In detail	Examples
vehicle dynamic state analysis	detection of rollover threshold detection of inadequate speed in relation to road profile	Accelerometer and GPS, pre-crash systems, ABS, ESP,…
driver behaviour analysis	detection of inattentiveness detection of alcohol or drug detection of excessive duration of driving,…	Driver surveillance camera, specific sensor on steering-wheel, autopilot, …
use of regulation constraint	limitation of regulation derogations (usually made for military needs)	Addition of a rear protective device (eventually retractable)
improvement of the road-holding ability	Improve behaviour by mechanical components	New chassis or suspension components, …
analysis of the effects of crash on armoured vehicles	understand the problematic of military vehicle during a crash	Will be dealt with later
structure improvement	creation of capacities to absorb kinetic energy	specific bumpers,…
improvement concerning passenger protection	Shock absorbers for vehicle occupants	Airbags, padding systems, enhanced seatbelts…
Improvement concerning pedestrian or other road users' protection	Other road users crushing avoidance	Protective devices around vehicles,…

Table 1
Categories of safety systems

At this point of the study, the important thing is to evaluate how each safety system could have an impact on the different accidents in the database.

So, for each system and each accident, experts must analyse, with different tools such as dynamic simulation, the probability of :

- the event suffering no real changes ;
- avoiding accidents ;
- reducing the seriousness of accidents ;
- or, on the contrary, increasing the seriousness of accidents.

For a proper evaluation of each system, this analysis must be carried out in terms of global costs.

For example, if the cost of one accident is estimated at 70 000 € (10 000 € for injuries, 25 000 € for the vehicle and 35 000 € for the military system), the best safety system will be the one which makes it possible to reduce the cost of 70 000 € (probability of 100% for accident not happening) ; but often, a good system will be the one allowing a cost reduction of at least 50%.

At the end of this procedure, we shall obtain a table (table 2) summarising all the results :

Type	Accident case (#)	Global cost (€)	COST REDUCTIONS				
			System #12	System #2	System #3	System #4	etc
Frontal	#1- F	15000	4500	7500	1500	0	…
	#2- F	28000	12000	14000	7000	3000	…
	#3- F	12000	0	3000	etc	…	…
	#4- F	180000	15000	165000	…	…	…
	etc	…	…	…	…	…	…
Rollover	#1- Ro	66000	0	66000	21000	…	…
	#2- Ro	94000	45000	45000	etc		…
	#3- Ro	185000	0	0	40000	…	…
	#4- Ro	12000	12000	12000	2500	…	…
	etc	…	…	…	…	…	…
Rear	#1- Re	14000	0	0	2000	3500	…
	#2- Re	35000	0	0	1500	6000	…
	#3- Re	67000	etc	…	…	…	…
	#4- Re	110000	…	…	…	…	…
	etc	…	…	…	…	…	…
Side	#1- S	45000	0	4500	1500	15000	…
	#2- S	72000	2000	18000	3000	…	…
	#3- S	48000	etc	…	…	…	…
	#4- S	12000	…	…	…	…	…
	etc	…	…	…	…	…	…

Table 2
Accident cost reduction vs safety systems

This table records, for each type of accident, and eventually each category of vehicle, the best

[2] example : #1 = ABS , #2 = ESP, #3 = Frontal airbags, etc…

systems available in terms of accident cost reduction.

CONCLUSION

So, it will be possible to extract a “top ten” marking of the best systems, in accordance with their respective costs. In fact, this last parameter will also have to be taken into account for the best possible choice.

A global refurbishment programme based on this “top ten” marking system will eventually be launched for the main land forces vehicles.

Prior to this refurbishment, we mean to carry out an experimentation on demonstrator vehicles, including different systems derived from our “top ten” marking system, testing vehicles in hard conditions, ranging from bad weather with slippery conditions, to off-road configurations with important vibrations.

In the near future, a lot of military vehicles will hopefully have a global safety performance at a high level, with a minimum factor two accident reduction cost.