FRENCH STUDY TO ENHANCE PASSIVE AND ACTIVE SAFETY ON MILITARY VEHICLES

Vincent Denis
Philippe Cornu
Islem Hammouda
Hervé d'Achon
Xavier Dissoubray
Altran Technologies
Vincent Schmitt
Christian Renou
Norbert Guiguen
DGA/ETAS (Etablissement Technique d'Angers)
France
Paper number 07-0488

ABSTRACT

An ETAS study (ETAS is a French MoD RDT&E facility) was launched for reducing fatalities and damages due to traffic accidents involving military vehicles. Such vehicles were indeed identified as being subject to specific constraints bound to their particular operational use. Therefore, the French Defence Procurement Agency (*Délégation générale pour l'armement, DGA*) and Altran Technologies conducted for two years a joint study with the following goals:

1) identify the main drivers of traffic accidents involving military vehicles through a statistical survey over the past decade;
2) identify and assess active and passive safety systems able to mitigate traffic accidents without altering military vehicles' operational capabilities;
3) draw the specifications of safety demonstrators to be manufactured, implemented and tested later on.

Tasked by the DGA, Altran technologies conducted a statistical survey using the French Army data on traffic accidents in metropolitan France, overseas territory, and operational theatres. At the end of the survey, the results clearly showed that occupants in military vehicles run peculiar risks given specific uses and designs of such vehicles. In order to identify relevant technical as well as feasible solutions, the DGA and Altran technologies established new state-of-the-art of active and passive safety systems list of requirements/designs. The results show that the emphasis shall be put primarily on finding ways to improve:

- static and dynamic stability;
- traffic lights efficiency;
- inter vehicle compatibility;
- occupants restraint systems' efficiency.

For each of the themes, Altran Technologies defined a set of requirements that shall permit to improve the overall safety of the military vehicles during retrofit and design activities.

INTRODUCTION

The French MoD tasked Altran Technologies to conduct a study program aiming at reducing human and material losses due to traffic accidents involving military vehicles out of military operations activities. Accidents concerned included open road accidents appending on national territory or during transport activities in extra territorial operations.

Focusing on high traffic vehicles, this study distinguished different categories of vehicles such as light vehicles, heavy logistics trucks, heavy trucks with trail, armoured wheeled vehicles and armoured track vehicles.

This program was made up of different parts as detailed in this document which were meant to be exhaustive towards all potential active or passive security systems that shall improve the safety of the military vehicles. The main goal is to define technical requirements for future vehicles or necessary evolutions that will leverage the benefit of civilian safety systems developed by the automobile industry.

GENERAL SURVEY

In order to identify the main driver of traffic accidents involving military vehicles, the first step of the study program was to conduct a statistical survey involving military vehicle accidents over the past decade. Three sources of information were used in order to fill up this database (see figure 1):

- the technical service for road and highways of the French MoT (Service d'Etudes Techniques des Routes et Autoroutes, SETRA);

- the French land forces staff (Etats-Majors de l'Armée de Terre, EMAT);
- the regional land forces legal departments (Service contentieux des commissariats des régions terre).

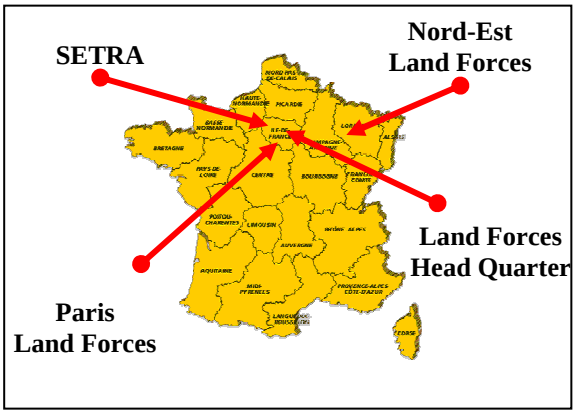

Figure 1. Data sources for home country and external operations accidents

A structured database was built up in order to identify the facts necessary for the identification of the most exposed vehicles and the main causes of accidents. In order to restrain the study to relevant cases, only the accidents that satisfied either one of the three following conditions were taken into account:

- severe injuries or fatalities of civilians or military personnel;
- material losses estimated at more than 10,000€;
- failure of the military mission due to the accident.

The information registered in this database was focused on the type of vehicle involved in the accident, the conditions of the accident, and the damage and fatalities resulting from it (see example in figure 2) .

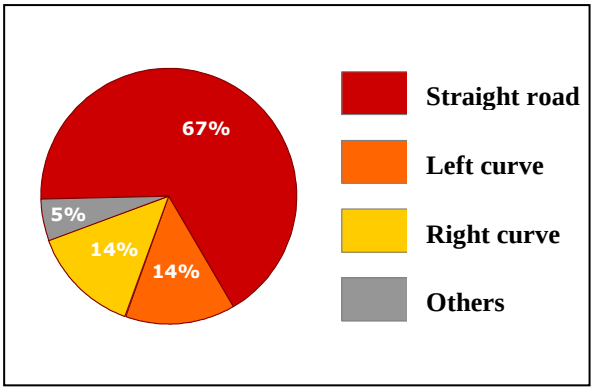

Figure 2. Accident data : road profiles

Over 900 accidents involving one or several military vehicles have been identified. For each kind of vehicle, it was estimated the ratio of the number of accidents vs the number of travelled km (see figure 3). The analysis of these data permit to identify the main causes of military vehicle accidents:

- due to design constraint the military vehicles are not appropriate to operate on roads and highways;
- the military personnel are not trained enough in order to safely operate the military vehicles.

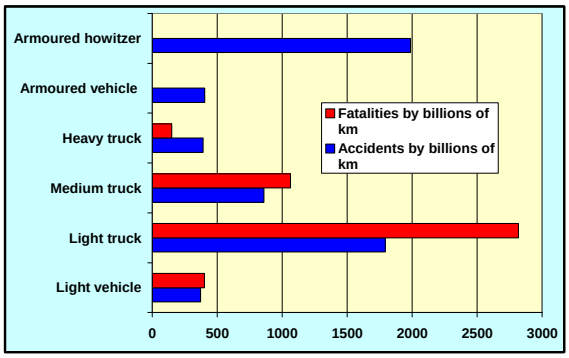

Figure 3. Number of road accidents by type of military vehicle

The military vehicle designs are subject to operational requirement including discretion. The colour and the signalisation lights are defined to ensure the maximum discretion and therefore safety during military activities. However, this discretion becomes a threat on the road: military vehicles are not as visible as civilian's and their signalisation lights do not permit other drivers to clearly understand the behaviour of the vehicle. Indeed, 80% of the accident between two vehicles in the same lane is back shocks for the military vehicle generally explained by a bad perception of the vehicle's behaviour or speed.

The second identified cause of accident through the statistical survey is training and insufficient experience of military personnel towards their capacity to drive and operate military vehicle. In 70% of the accident, drivers were under 25. By their design and specifically their off-road capacity and high charge capacity, military vehicles are not easy to operate on road or highways. The military vehicles off-road capacity and the armoured structure are the origin of instabilities and specific behaviour that can only be handled by a well trained and experienced driver. Despite the fact that the driver respected speed limits, in 25% of the accidents, the vehicle's speed was considered inappropriate.

These two causes are significant in accident risk for military vehicles. In addition, the statistical survey identified two other causes that lead to an increase of the accident consequences:

- military vehicles' designs are not optimized for accident damage mitigation;
- military vehicles' seats and restrain systems are not optimized for injury mitigation.

The off-road military vehicles' design is not appropriate for damage mitigation especially with civilian vehicle. On one hand, this configuration exposes vehicle vital organs to shocks like the drive axle. The study underlined that 40% of the damaged vehicles are not economically repairable. On the other hand, the relative height of the military vehicles is a real threat for the civilian vehicles' occupants.

30 years old design vehicles are still in operation among the French forces. Those vehicles do not satisfy today's seats and restrain systems. The automobile sector has shown a significant amelioration of vehicle occupants' safety by an improvement of the seats and restrains systems design. A proper use of a restrain system can reduce by two the risk of severe injuries.

The statistical survey showed that in order to reduce the material damage and fatalities due to military vehicles' accidents, the French MoD will have to investigate active systems in order to reduce the number of accidents and passive systems in order to reduce the severity of these accidents.

STATE-OF-THE-ART SAFETY SYSTEMS

In order to provide valuable technical basis for recommendations, Altran Technologies has conducted a state–of-the-art analysis of the actual

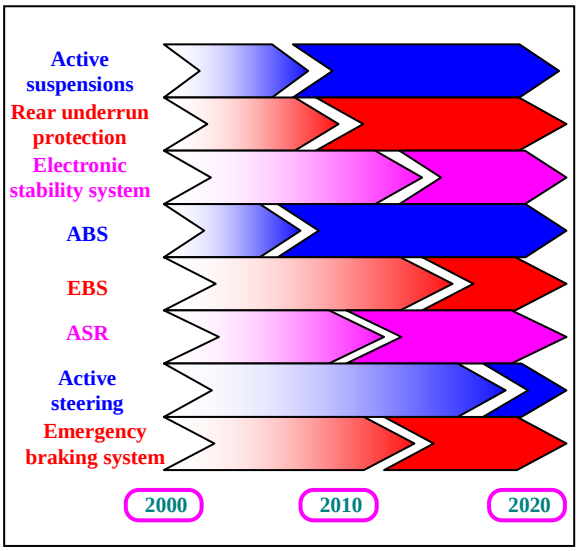

Figure 4. State-of-the-art and future developments of the active stability system concerning military vehicles

and future active and passive safety systems that are in operation in the automobile sector (see figure 4).

The active safety systems have been distributed among three categories:
- stability improvement and control systems;
- driver assistance systems;
- collision avoidance systems.

The evolution of the active safety systems is characterized by the integration of automated control loop systems over the various components of the vehicle. Generation after generation, this systems increased their time integration capacity as well as the number of parameters that they are able to integrate e.g. from Anti-lock Braking System (ABS) to Emergency Brake Assist (EBA) to Anti-Skid Resolution (ASR) and Electronic Brake-force Distribution (EBD).
The passive safety systems have been distributed among three categories:
- occupants' protection;
- vehicle protection;
- close environment protection.

The evolution of the passive safety systems is characterized by a progressive protection of the outside of the vehicle. A few decades ago, the engineers started improving the occupants' protections through the optimization of restrain systems and the development of airbags. Later on, the technical efforts were oriented towards reinforcing the passengers' compartment in order to avoid any deformation of this safety space. Today, research programs aim at reducing the risk the vehicle may represent toward its close environment like the others vehicles or the pedestrians.

The sate-of-the-art safety system identification provided several axis of improvement through the integration of actual or near future technology from the civilian automobile sector.

AXIS OF SAFETY IMPROVEMENT

In order to mitigate the risk of military vehicles' accidents, Altran Technologies identified four axis of improvement that shall be primarily addressed in order to scientifically reduce the number of accidents and the severity of the damages and fatalities:
- improvement of the vehicle's static and dynamic stability in order to ease the driving;
- improvement of the signalisation lights' effectiveness in order to better inform the other drivers;
- improvement of the inter vehicle compatibility in order to reduce material damages and fatalities;
- improvement of the seats and restrain systems in order to reduce the injuries due to the accident.

To ease the driving of the vehicle and therefore compensate the drivers' lack of experience, the vehicle shall integrate an active safety system that shall improve its stability. The first step was to improve the static stability of the vehicle through an optimization of the brakes, suspensions and the tires. Then, a research program was undertaken in order to evaluate the benefits of dynamic systems such as the ABS or ESP. The preliminary studies show that the static stability speed limit is close to the speed limit of the vehicle in normal operational conditions with no security margin: through the integration of active systems or by limiting the vehicle's speed of operation this speed limit shall be raised at least 20% above the maximum operation limit speed in order to avoid any specific unexpected behaviour of the vehicle.

Over the past 5 years, lots of breakthroughs have been accomplished by the automobile and electronic sectors in the field of signalisation. The actual military vehicles' signalisation lights are designed under discretion requirements and classical light bulb systems. The LED technologies are presently replacing the old signalisation system with a better efficiency and management of the light intensity. A research program has been proposed in order to develop an adaptive signalisation light system that shall be able to meet the discretion requirements during military operations but still warn other drivers of the vehicle's manoeuvres with no ambiguity.

The actual military vehicles' designs do not allow a mitigation of damage and fatalities in case of an accident generally resulting from the all-road conception. During the past decade, several study programs were undertaken and regulations were implemented in order to prevent the threat that represents a heavy truck to light cars or motorbikes. Altran Technologies recommends implementing these systems as soon as possible on the current land forces vehicles in order to meet the civilian regulations and to prevent any fatalities that will legally consider as "fragile skeleton" issue.

Through the past decades, the occupants' safety systems have evolved and the safety regulations have progressively integrated this evolution by taking into account the technical progresses achieved by the automobile sector. At present, some old vehicles have no restraint systems (see picture 1). Three points restraint system for all occupants, airbag system for front occupants and reactive seats are today standard in the automobile sector. Altran Technologies recommends undertaking retrofit programs in order to upgrade the actual military vehicles to civilian standard and ensure the safety of the military personnel.

Picture 1 : example of an old military vehicle without restraint systems

The detailed analysis of the opportunity for safety improvement shows that a significant safety improvement can be achieved by implementing the actual automobile sector safety standard to military vehicles.

CONCLUSION

Designed for most of them during the 60's and the 70's, military vehicles were at the edge of the technology at that time. However the acceleration of new research and developments in the automobile sector during the past decade as well as advances in the transportation infrastructures and the social perception of driving risks made this systems nearly obsolete and bring the urgency of actions to be undertaken in order to improve the safety of the military vehicles.

The study program shows that several available civilian safety standards could scientifically reduce the number of military vehicles' accidents as well as the damage and the fatalities due to these accidents.

In the near future, the integration of the civilian safety standards to the military vehicles shall make it possible to divide by two the number of accidents and save lives and money to the French Army.