CAN in fire-fighting trucks

Dipl.-Ing. Oliver Hrazdera, Rosenbauer International AG

Fire-fighting trucks are needed in truly precarious situations, regardless of whether it's a fire fighting or rescue operation. The vehicles and, therefore, the installed electronics systems as well, have low operating hours. During an operation, 100% availability is vital in the truest sense of the word. The variance of the vehicles is tremendous, no two vehicles are the same (aside from rare large-scale productions).

Figure 1: 3-axle ARFF vehicle with boom (HRET)

Every little boy daydreams about fire-fighting trucks, an emotional connection that is not lost as we get older.
The worldwide annual demand for fire-fighting trucks is 17.000 units, whereby the industry is divided into a group of global, international players and a group of very small-scale manufacturers.
There is at least one local manufacturer in every country on Earth. This structure is given, because the procurement of fire-fighting trucks typically occurs through municipalities (states, state governments, communities) or large organizations (UN), and municipalities typically try to buy local.
The service life of vehicles varies widely across the globe; professional fire departments replace vehicles approximately every ten years and a typical volunteer fire department in Germany and Austria every 25 years.

From a global perspective, vehicles in countries with extreme weather conditions (tundra, desert, salty air, industrial waste-water) have a significantly shorter service life.

Once an original owner decommissions a vehicle, it is typically refurbished and will be used by the next owner for many years to come. The higher-quality the vehicle, the more frequently this method is used, especially for turntable and aerial ladders.
Fire-fighting trucks are subject to very rigid regional standardisation in many countries. Even the average layman can recognize the big hemispheres of the USA and Europe, which utilize completely different vehicle concepts and operational tactics. The result is that vehicles utilize drastically different operations, lights, weights, electronics and technology, with the exception of a few large-scale productions.

Figure 2: USA vehicle

The equipment even differs drastically among smaller European markets, which is why single unit custom-built vehicles are so widely discussed.

In terms of electronics, there are three primary challenges.

a) First, the extremely long service life of the vehicles and thus the permanent necessity to somehow replace discontinued units in order to keep the vehicles operational.

b) Differing levels of technology when compared worldwide. On the one hand, state-of-the-art, highly technological functions and operations, automated if possible, in divergent markets and thus an absolute focus on simplicity and robustness, far removed from any gimmicks. To achieve this wide range with corresponding common parts in terms of electronics is a very big challenge.

c) Once each vehicle is equipped with all of the various functions, equipment and components desired by the customer, the respective variance is primarily reflected in the software. Keeping the software lean while satisfying the needs of customers and being able to debug represents a big challenge.

A fire-fighting truck consists in principle of two parts, the chassis (purchased or developed in-house) and the specific fire department body module.

Chassis scope:

There are two different types of chassis.

a) The fire department manufacturer develops and produces its own chassis.

This version is more widespread in the USA, even for municipal vehicles; absolute specialty vehicles prevail in Europe (e.g.: ARFF vehicles).

The problem lies therein that very few providers even offer such a specific custom chassis (52 tons, 130 km/h). The only alternative to being dependent on these providers is the construction of the chassis in-house.

The entire drivetrain with the standard SAE J 1939 bus connections is in the hands of the manufacturer.
So technologically very challenging in terms of the concept and integration, sometimes with multiple gateways.

The chassis body differs here, above all due to the drive concept, since there are vehicles with a different number of axles (2-4) on which various gearboxes and up to three diesel motors are installed. The electronics needed for the gearbox, engine, ABS, etc. are connected by way of SAE J 1939, whereby complex CAN structures with multiple gateways are created through serial electronic systems with identical node numbers (e.g.: node ID 0 for engine). Even the control of the individual components using CAN is different from supplier to supplier; nearly identical for frequently used functions; sometimes vastly different for lower priority functions. The differences stem from the „freely definable“ CAN messages section, primarily, however, the manufacturer-specific interpretation.

b) The fire department manufacturer buys standard truck chassis.

In this case, the superstructure is connected using the chassis interface from the respective chassis manufacturer.
This is to ensure that the vehicle gateway will not have an unintended effect on the drivetrain.
This interface mostly offers its own hardware in- and outputs, where the most important functions can be activated/accessed (e.g. PTO, 1st intermediate speed, stop light activated, etc.).

Nearly every chassis manufacturer now offers a CAN interface that enables the functional scope of the hardware signals, supplemented with an entire series of additional signals and functions (e.g. diesel filling level).

The inconsistencies of the different chassis manufacturers is problematic in both solutions. Neither the hardware interface, nor the CAN interface is the same amongst the different brands. Sometimes the CAN interfaces differ significantly even when they are the same brand and model (e.g.: Euro 5 to Euro 6 vehicles).
For superstructure manufacturers, this leads to significant costs and incompatibilities time and again.

Fire department body module:

A typical fire department municipal vehicle consists of multiple segments.

a) Driving compartment
b) Crew cab
c) Basic superstructure with tanks and equipment compartments
d) Pump
e) Additional components

Many different fire department manufacturers place the control architecture in accordance with this spatial division.

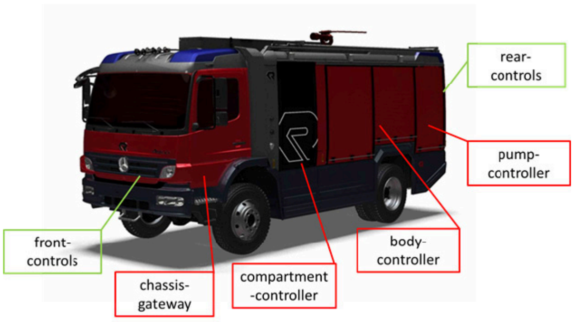

Figure 3: typical electronics distribution for municipal vehicle

a) Driving compartment:
At least one electronics assembly sits here, which on the one hand controls the interface to the chassis, and in addition at least for the warning device as well (rotating beacon, front flashers, country- and operator-specific tone sequences). An operator's panel is always located in the driving compartment, which has anywhere from just a few standard switches up to highly complex displays depending on the design.

b) Crew cabin:
Two different crew cab types are available, from the scope of delivery of the chassis manufacturer or as a crew cab specific to the superstructure manufacturer. Only in the 2nd case must the different illumination, LED bars, door contacts, central locking, etc. be read in by way of an additional electronics assembly.

c) Basic superstructure with tanks and equipment compartments.
A typical municipal vehicle has a large number of side roller shutters and locker hatches, whose status (open/closed) is read into the superstructure module and displayed on control lamps or displays in the driving compartment. The fill levels of the different water and foam compound tanks must be recorded and forwarded by way of CAN.
The control of the vehicle's surrounding field illumination and the general illumination of the equipment compartments is essential. Due to the LED technology, the total power consumption of the illumination has naturally been reduced; the current peaks are not to be ignored though and must be taken into account accordingly when diagnosing the electronics outputs.

d) Pump
The pump is the actual centrepiece of the fire-fighting truck. The pump itself is largely driven via the power takeoff, since the power requirement is quite significant. Of course there are also solutions using a separated pump motor.

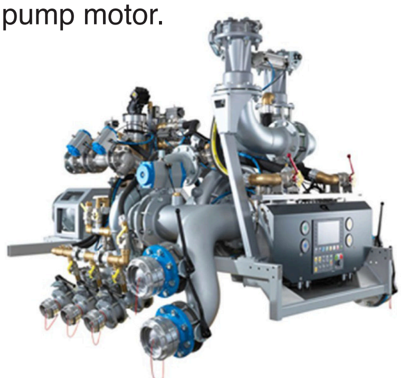

Figure 4: Extensive pump unit

The individual pressure and temperature sensors are read in from the pump electronics and the pneumatic valves are controlled, which are between 3 and approx. 25 pieces depending on the vehicle's equipment.

e) Additional components
The abundance of installed functions is determined above all by additional components and thus electronics optionally connected to the CAN.
These commonly include pressurized foam proportioning systems, road hazard traffic control devices, various light masts, an array of built-in generator systems (from 6 kVA to 60 kVA), hybrid systems up to 130 kVA, portable generators, portable pumps, water monitors (from 800 l to 13,000 l/min) and many more.

Figure 5: Water monitor 6,000 l/min

DIN 14700 (section 1-11) was created so that many of these units, regardless of brand, can communicate with the bus systems of any fire department manufacturer. These units are separated by way of a gateway with a standardized interface from the bus specific to the fire department and function with Plug & Play. Using this interface, for example, portable power generators from multiple manufacturers can be operated on the vehicle's own display, even providing enhanced diagnostics.

Operations:

Operating elements are a very important issue, which is always being discussed among fire fighters.
This is where the interests of multiple groups collide, because in the end the subject is an emergency vehicle that must be able to be safely operated by a potentially large group of users with varying levels of knowledge in the event of an emergency.
Some swear by highly technological display applications (whereby touch displays still represent a shrinking minority due to protective clothing and operational control requirements), while other users want only conventional switches that are easy to exchange.

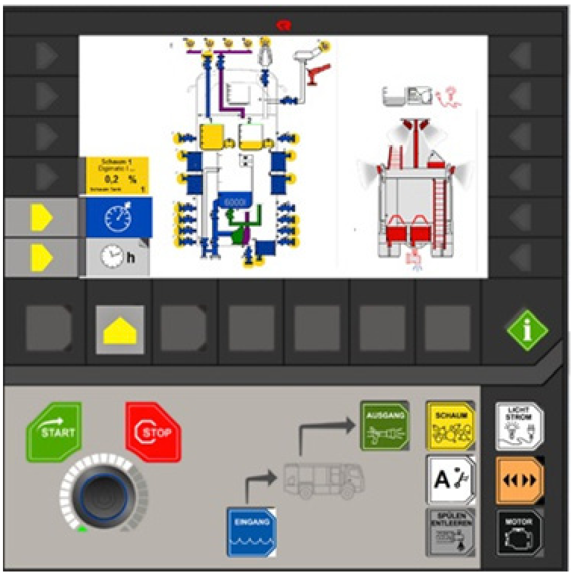

Figure 6: Operation via displays

This divide, of course, causes problems for superstructure manufacturers, lower quantities per implementation and thus higher costs. The age pyramid within the fire department also plays a role: that which is cool and absolutely necessary for some is seen by other users as an unnecessary gimmick.
An increasingly noticeable trend is the use of key panels connected by way of CAN, key banks and small, compact display units. Therefore, simple vehicles as well as those with a complex functional scope can be easily mapped by increasing the number of control panels.

Figure 7: Operation via CAN key pane

The negative branching into sub-screens is thus forgone and the key label can be adapted to the desires of the customer without software adaptation.

Safety according to EN 13849:

Safety standards specifically for the functional scope of emergency vehicles do not currently exist.
Therefore, they are subject to EN 13849, analogous e.g. to machine tools.
In disaster control, however, availability extends far beyond safety. In an emergency situation, the fire department must be able to absolutely rely on its equipment. Switching off or reducing of peripherals and services is counterproductive.
The diesel engine of the pump unit must, e.g. continue to run even if the oil is low, as long as the extinguishing crew has been evacuated from the seat of the fire.
What counts is lives saved and not avoiding damage to equipment.

The formation of a work group at the VDMA is currently under way with the aim of creating a safety classification that is more suited to disaster protection.

Figure 8: "Escape Stair" as a typical safety application

Limits of the current bus systems:

Since the quantities are manageable in the fire department industry, CAN has emerged as the most common bus system in various „Slangs".

Cheaper systems (e.g. LIN) are available, but they lead a shadowy existence, for the maintenance costs are higher over the service life than the potential savings.

Many fire department manufacturers rely more or less on the exact implementation of CANopen during development.
With existing solutions, there is a limit to bus speed. In the case of highly complex regulations (e.g.: turntable ladders) with multiple sensors and low latency, bus loads soar to problematic heights, commonly at 250 kBit/sec.

Secured transmission is receiving more and more attention. This also leads to an increase in bus traffic and overhead.

The industry is currently attempting to offer better options. In the USA, attempts are being made by electronics suppliers to increase the bus speed starting in 2016 towards 500 kBit/sec based on a SAE J1339/14 physical layer; in Europe, the trend is more toward CAN FD.
Time will tell how things will really pan out. International fire department manufacturers would naturally prefer a global solution, since significant expenses are expected for development as well as production and after sales with the introduction of an improved standard.

Dipl.-Ing. Oliver Hrazdera
Rosenbauer International AG
Haidfeldstr. 37
AT-4060 Leonding

Tel.: +43-732-6794-348
Fax: +43-732-6794-94348
oliver.hrazdera@rosenbauer.com
www.rosenbauer.com