Development of CAN-based rescue stairs

Rosenbauer has improved its rescue stairs which implement a CAN system. The company explains its new way of software development and introduces how all relevant characteristics of the 33-ton and about one million Euro rescue stairs were put in one controller.

When it comes to operations on or around the runway, time is of the essence: Rosenbauer developed an Aircraft Interior Access Vehicle, better known as rescue stairs in order, to be able to come to the aid of passengers and crew as quickly as possible in the event of an emergency. The vehicles have been designed to arrive on the scene of emergency quickly and dock with the aircraft equally fast. This is not only to enable evacuations in a controlled manner, but also to allow firefighting and rescue teams quick and safe access. Rosenbauer put a lot of effort in the development of the rescue stairs. The company reduced electronics, cooperated with other companies, and used a new way of software development.

Set-up times and safety

The E5000 and E8000 rescue stairs have already proven to be the ideal vehicles that are equipped for such scenarios. During the development, particular focus was placed on safety, operation, and setup time. As a result, the crew can select an individual door at the respective type of aircraft, to automatically extend the rescue platform to the correct height. The approach to the aircraft is supported by audible and optical aids, such as distance sensors, camera imaging, and an overhead window, to ensure the best possible view in every scenario. The platform can be adjusted to match the aircraft fuselage, and the side rails can be manually docked onto it. This makes alignment easier and ensures gap-free and secure access. Thanks to sophisticated technology, the platform and steps are held in a horizontal position regardless of the incline of the staircase. This means that both evacuations and rapid access by rescue teams can be undertaken safely.

Improved operation concept

Rosenbauer, however, continuously strives to improve products that have already been refined. This is precisely why the operating concept of the rescue stairs have been revised and the latest lighting technology integrated. Feedback from Rosenbauer's customers has had a significant impact upon this further development. The crew is now given a 10-inch HD touchscreen display, both in the driver's cab and on the rescue platform, through which the rescue stairs can be controlled.

The display was specifically developed together with Ginzinger Electronic Systems for the usage on rescue vehicles. The embedded system is based on an i.mx6

Figure 1: A medical emergency, smoke in the cabin, or an evacuation - in the event of an incident on board an aircraft, action must be taken quickly; Rosenbauer has improved its rescue stairs for this purpose (Source: Rosenbauer)

dual-core processor for automotive application. All functions can also be operated via hard keys if the environmental conditions or the worn gloves do not allow a touch operation. Further the display features a brightness sensor to adjust its brightness and color theming to ensure not to irritate a driver during a night drive and still be easy to read in direct sunlight with its brightness of up to 1 000 cd/m². With the RBC LCS (logic control system) operating system, the rescue stairs fit into the Rosenbauer product family. This makes it easier for crew members to switch between the different vehicle types. The operation system is based on CAN technology. The control panel in the driver's cab is ▷

Figure 2: The rescue stairs in action (Source: Rosenbauer)

mounted on a swivel arm that can be rotated to either the driver's or passenger's side. In this way the operator can have everything exactly where they want it to be.

Rosenbauer's new way of software development

Not only the operation has been overhauled, but the CAN system has also been implemented from scratch. A reduction of ECUs (electronic control unit) was achieved by using ECUs from TTControl, which are certified for safety purposes. The risk and hazard analysis showed that there are safety requirements up to PLd. In the first generation of the product, the controllers available within Rosenbauer with an established software framework had PLb only. Without the software framework, the controllers could not have been configured with the Rosenbauer service tool. Due to this constraint all safety features, like emergency stops had to be hardwired. Some safety features could only be met by software, like the tipping of the machine or level- ▷

Figure 3: With the simulation, the development iterations can be driven to a maximum and the programmer gets off all the external influences (Source: Rosenbauer)

ling the platform. These features had to be programmed on different CPU (central processing unit) types and compared via CAN in terms of redundancy. This setup led to an electronic system with many relays and many different controllers. Hence it was very difficult to handle in point of servicing and troubleshooting.

Now Rosenbauer achieved to put all safety features in a single TTControl ECU which features the redundancy internally. Safety requirements like tilting and levelling are programmed by two independent developer teams, one team at TTControl in Brixen and another team at Rosenbauer in Leonding. On the ECU the multitasking real-time system Safertos is operating both developed algorithms in parallel. The safety algorithm stops the machine all at once. The application algorithm takes care that the machine never moves at a position where the safety algorithm would need to take control and warns the user in advance on the display. As the TTControl ECUs combined with the Safertos guarantees the freedom of interference, the non-safety relevant application software can be maintained and deployed on the same controller. This is enabled without the need to repeat all the safety certification on every new software version. As Rosenbauer's products are varying greatly based on final customer, this is an important feature to reduce the maintenance efforts of the safety software.

Electronics reduction

With this safety architecture we achieved a reduction of ECUs from six units of three different types to three units of identical type. Another reduction of electronics was performed on the hydraulic valves. In the previous generation was a valve manifold, where each valve had a small electronics module integrated, which was controlled via an individual PWM signal. Now the complexity of the system was reduced by eliminating the electronics on the valves, but to use two outputs for each valve. The TTControl ECU has everything on board for this purpose. It has sufficient outputs and each PWM output can measure its current. The accuracy of the current measurement is sufficient for moving the valve in every position via current control without a sensor on the valve. Only actuators with position control are equipped with sensors, while all speed control is performed without sensors.

In this project, pioneering work was done in the way of application software development at Rosenbauer. A virtual model was created for the whole hydraulic system, with two PWM signals for each actuator as an input. All sensor signals were measured in reality, and used as outputs like hydraulic pressures, end positions of the actuators, CAN signals and current values. This model was used in two ways:

On one hand, it was deployed by automatic code generation onto another TTControl ECU to enable the safety software development team to perform software tests without travelling to the rescue stairs. All relevant characteristics of the 33-ton and about one million Euro rescue stairs were put in one controller.

On the other hand, the model was used to develop the application software. Therefore, the hardcoded current and position controllers from TTControl were imported into Simulink. In this way, external delivered code pieces and the model of the mechanics were operating in one PC simulation, independent of the production status of the machine and with no hardware at all. Before this model-based approach, at Rosenbauer the software development started on the desk as well, but nobody knew how it would behave on the machine. The real work started at the point of time when the programmer sat in the machine. With the new method the programmer knows that the application software is functional and must search the differences or the missing testcase during the commissioning only. It turned out that everything working in the simulation also worked in real life, like the tricky part of finding correct resting positions and keeping the first and last stair of the mainframe telescope in a flat position.

Simulation before release

With the simulation, the development iterations can be driven to a maximum and the programmer gets off all the external influences. A machine of this size can be run only outside, so the programmer is exposed to the weather and to the noise of the diesel engine. For each iteration, the software needs to be downloaded to the controller and interesting variables must be monitored and plotted for each iteration. In practice the days get very long and are very stressful, as it usually takes very long until all I/O checks and mechanical and electrical installations are 100 % finished.

The delivery date never changes, but all the other processes take longer as planned, which must be compensated by extra working hours of the programmer. With the simulation, the software development and testing can be done efficiently in the office, decoupled from noise, stress, and bad weather conditions. The quality and the possibility of maintenance of the generated software is much better this way.

At the software development itself Matlab/Simulink/ Stateflow and the embedded code generator give the programmer the possibility to concentrate on the software design. The hard work of writing the code after drawing the stateflow diagram is automated by the code generator. Even if it turns out during the commissioning that there was a wrong assumption in the model, adding an extra state or ▷

DIN 14700 and DIN 14704

The DIN German standardization body specifies two CAN-based solutions for firefighting body applications. The DIN 14700 standardizes a CANopen-based network for add-on devices. Such devices are exchangeable and provide therefore the same functionality. The specified PDOs are not configurable regarding the communication and mapping parameter sets. The add-on device includes water cannon, light mast, frequency inverter, and electrical power supply.

The DIN 14700 standard is currently under review. It is written in German language. The DIN 14704 standard specifying the gateway to the in-vehicle networks is written in English language. It is based on the DIN 4630 standard also provided in English language. It is under development and uses a J1939-based application layer. The specified Parameter Group messages are referenced (DIN 4630) or specified in detail including the mapped parameters. *hz*

transition is only a matter of drawing and has no big impact on a software that is already programmed. Another advantage of the model-based design is that the drawings of the software can be understood by the customer service and other stakeholders, who are no programmers. The self-speaking drawings in Simulink/Stateflow can be exported to html and published to everyone.

Fine-tuning for optics and lighting

Rosenbauer's engineers have also further improved the scene and staircase lighting systems. Instead of the previous LED spotlights, the latest LED light strip technology is used, which ensures more homogeneous and improved illumination of the steps and the surrounding area. This further increases the safety of passengers and emergency crews, especially when operating in the dark. The rescue stair's rear has also been given a facelift: the lighting has been adapted to the appearance of the rest of the Rosenbauer fleet, and thus fits seamlessly into the modern and visually appealing vehicle range.

The innovations integrated into the rescue stairs are yet another example of how consistently Rosenbauer works on the further development of existing products and the introduction of new technologies. Rosenbauer is committed to providing maximum safety and efficiency in emergencies to emergency crews around the world with the best products for their daily work. ◀

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