Ready for the real thing: Fire simulation system supports firefighter training

Fire simulation systems help firefighters, rescue teams and other emergency staff train by recreating complex scenarios under realistic conditions. Fitra Systems & Software, a subsidiary of Hoka GmbH, specializes in the production, maintenance and optimization of such fire simulation systems. The software solutions developed by Fitra (short for fire training) are based on TwinCAT automation software from Beckhoff in connection with Industrial PC technology, EtherCAT as the communication platform, and a selection of corresponding I/O components.
There is a differentiation between “hot” and “cold” systems for fire simulation. The former involves real fire, which is produced and controlled with gas as the fuel source, while the latter simulates flames via LED bars. Electronic control technology is used to simulate complex fire emergency scenarios with various flame heights and smoke outbreaks. Audio-controlled calls for help and mobile rescue mannequins complete the setting for fire simulations.

**Fire simulations require complex control scenarios**

In 2014, Fitra was commissioned to develop an emergency simulation system for the State Fire Academy in Würzburg, Germany. “Their training hall is the largest in Germany. The size of the space, and the multitude of the technical building systems that had to be integrated, made this job highly demanding,” explains Karl Keupp of the Würzburg Building Authority’s technical department. The academy can create a multitude of scenarios ranging from fires in underground parking garages, to room fires in nursing homes or hospitals and remotely control them via computer. Sound and light effects as well as fog machines are used to realistically simulate fire outbreaks in
which more than 70 lifelike, articulated mannequins as “residents” must be rescued from buildings. Fitra had to meet the following requirements for this project:

- Enable a central server for networking and coordinating six buildings
- Create a central audio server to simulate calls for help, either automated or via announcements
- Network LED bars for firelight simulations
- Synchronize 38 mannequin cabinets, shutters and switches
- Provide hot-connect options for 60 mobile simulation racks (smoke, light, sound, etc.)
- Integrate safety technology
- Facilitate interfaces to real fire alarm systems

The project’s control topology shows the implementation approach of the solution:

- Measuring 4 height units (4U), a C5102 rack-mount computer in the control cabinet integrates the server functionality for the six downstream CX5130 Embedded PCs used as controllers. The C5102 also runs the database for the deployment scenarios, audio files, and the web server for visualization. The cabinet also houses the KL6301 KNX master terminal for interfacing with the room and hall lighting as well as window shutters.
- The audio hardware components (DA converter, pre-amplifiers, power amplifiers, etc.) take up two sections of the neighboring control cabinet.
- Each of the CX5130 Embedded PC controllers runs an EtherCAT network for the process data. EtherCAT is also used as the backbone for the EL6851 DMX master that communicates with the LED bars.
- The safety technology is integrated into the EtherCAT network via EK1914 TwinSAFE Couplers.
- The connect and disconnect cycles for up to 60 mobile simulation racks are implemented by configuring EtherCAT hot-connect groups on Beckhoff CU1128 EtherCAT junctions and via unique device IDs.

The control system topology illustrates the high level of complexity of the fire simulation system.
The developers at Fitra paid special attention to the software structure. Besides the basic requirements for automated or manual fire simulations, various scenarios had to be configurable via prefabricated function modules, in a user-friendly manner that did not require any additional programming. The results were impressive. The developers specified various layers with defined interfaces, and since each layer can be maintained and replaced individually, modifications for service purposes can be implemented quickly and efficiently.

Hardware configuration with TwinCAT
The TwinCAT System Manager forms the lowest layer of the software architecture. This is the level on which bus systems are selected, various settings for fieldbus components are made, and basic links to software variables are established. It also provides various diagnostic pre-check functions prior to commissioning and troubleshooting features for ongoing operations (wiring, etc.).

The hardware server generates application-specific process objects, such as:
- combining process variables into application modules
- generating standardized formats and arranging them in classes
- scaling data to application-specific values (e.g., actuator drive opening by percentage, temperatures in °C, etc.)
- adding object properties such as threshold or limit values, statuses (stands, moves, opens, closes) as well as complete motion profiles for actuator drives and monitoring functions

These objects are available to higher-level layers within these defined interfaces.

The Fitra Server – a framework for fire simulations
At the core of the system is the Fitra Server, a framework that provides the complete fire simulation functionality in a modular, structured manner. It combines individual modules, including:
- flame height management (simulated via LED bars)
– mannequin scenario management (sequence control of mannequin cabinets)
– sound generation and distribution (types and locations of calls for help)
– general fire scene simulation

These elements are joined together in logical scenarios, which can then be controlled manually or run automatically. Each module has a basic functionality and an associated sequential control application, which the user merely has to parameterize or configure. Let’s take a rescue mannequin scenario as an example: The user starts out by defining when a mannequin will be activated. This is followed by automated event sequences and user-defined actions. An example of an automated event would be the opening of the mannequin cabinet doors. User actions are required when windows must be opened or when the speed and position of a mannequin is determined, etc. The scenarios of the pre-programmed modules and event sequences are also handled via a graphical XML configurator.

"With our fire simulation system for the State Fire Academy in Würzburg, we have achieved an unprecedented level of automation. As a result, all simulation scenarios can be mapped in a realistic manner in accordance with official regulations to notify security authorities and organizations in case of fire. In the past, the lack of integration made this level of realism impossible," says Andreas Hovestadt, Managing Director of Hoka GmbH and Fitra Systems. "The fieldbus master terminals for EtherCAT and K-bus from Beckhoff were a great help when it came to integrating building technology communication systems like KNX or DMX into our standard automation environment. They made it easy for us to marry the standard automation
systems with the building automation systems with no need for special editors or configurators for the building technology applications. The capabilities Beckhoff offers in this field are unique; no other vendor offers this level of completeness.”

Fitra Systems & Software GmbH & Co. KG

Since the company’s foundation in 1992, Hoka GmbH has focused on the development of highly specialized measurement and control solutions for processing and energy technology applications. In order to embark on a new field of business – the development of fire simulation systems – the company set up Fitra Systems and Software GmbH & Co. KG as an affiliate. Its core business is the planning, production, maintenance and improvement of fire simulation systems for training firefighters, emergency technicians and disaster relief workers.