Nabla Engineering

speedgoat
real-time simulation and testing

Nabla Engineering created a digital twin of a tunnel to automate the testing processes of its ventilation, lighting, and fire-alarm control systems, as well as training tunnel workers and monitoring staff.

Leveraging a Speedgoat real-time target machine in their setup, the digital twin of the tunnel simulates the sensors and actuators, communicates with the tunnel control system, and provides real-time information needed for further processing.

Safe Passage for Vehicles and Trains

Nabla Engineering (hereinafter Nabla) is a company operating in Switzerland (Basel) and Germany (Auggen). They created a real-time simulation of a safe tunnel passage for vehicles and trains with the usage of Speedgoat and MathWorks products in their latest mandate. They specialize in conducting security validations of traffic routes and infrastructure facilities as well as designing and implementing ventilation systems for various infrastructure-related projects utilizing their expertise in tunnel safety topics; protection from fires and explosives, ventilation, control, and simulation technologies.

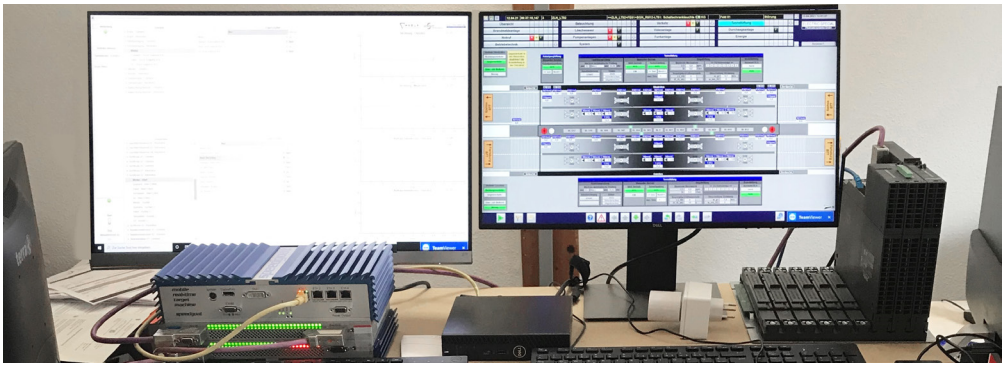
Nabla used Simulink to create a digital representation of a road tunnel to automate the testing processes for its ventilation, lighting, and fire-alarm control systems. A Speedgoat target computer runs the tunnel model in real-time and communicates with the supervisory system under test by simulating the communication interfaces of all sensors and actuators.

Minimizing Efforts for Commissioning Time and Operator Training

Nabla was faced with the complex challenge of finding the best way to test the control system of a road tunnel under realistic conditions while the tunnel was still under active construction. Due to tight deadlines and constraints posed by the construction, running lengthy and tedious full-scale tests proved to be inefficient and difficult. In addition, reproducing accurate testing conditions was problematic due to the variables associated with real traffic and ventilation conditions. Therefore, Nabla opted for developing a digital simulator of the real-life tunnel to reduce their testing efforts, while also benefiting from using it as a training platform for the tunnel workers.

The Tunnel Digital Twin

The tunnel simulation model, designed in Simulink, runs in real-time on a Speedgoat target computer which is connected to a Siemens PLC via the PROFIBUS



Nabla testing setup with an integrated Mobile real-time target machine

communication protocol. This setup allows data to be exchanged at a rate of up to 12 Mbit/s.

The entire control logic contains around 60 PROFIBUS devices representing more than 660 data points of sensors and actuators. Among the exchanged signals are data readings of the flow rate or luminance sensors, including triggers for actuators such as ventilators or lighting.

The Simulink model is structured as follows:

- **Fluid dynamics model:** CFD model of tunnel's internal aerodynamics, including traffic and ventilation
- **Fire-alarm controls system:** Model of the tunnel's fire alarm equipment, including smoke and fire detection systems
- **Lighting system:** Model of the relation between lighting sensors and actuators

The field devices are simulated using the IO642-32 multi-node simulator, capable of emulating up to 32 PROFIBUS devices. Parallel use of several IO642-32 modules allows the emulation of up to 128 devices. In addition, the IO642 Simulink driver blocks simplify the configuration steps of devices using GSD-Import and automated baud-rate detection.

Thanks to the customized user interface developed with this setup, around 100 testing scenarios related to fire incidents and malfunctions of the lighting system could be implemented virtually and used for staff training purposes.

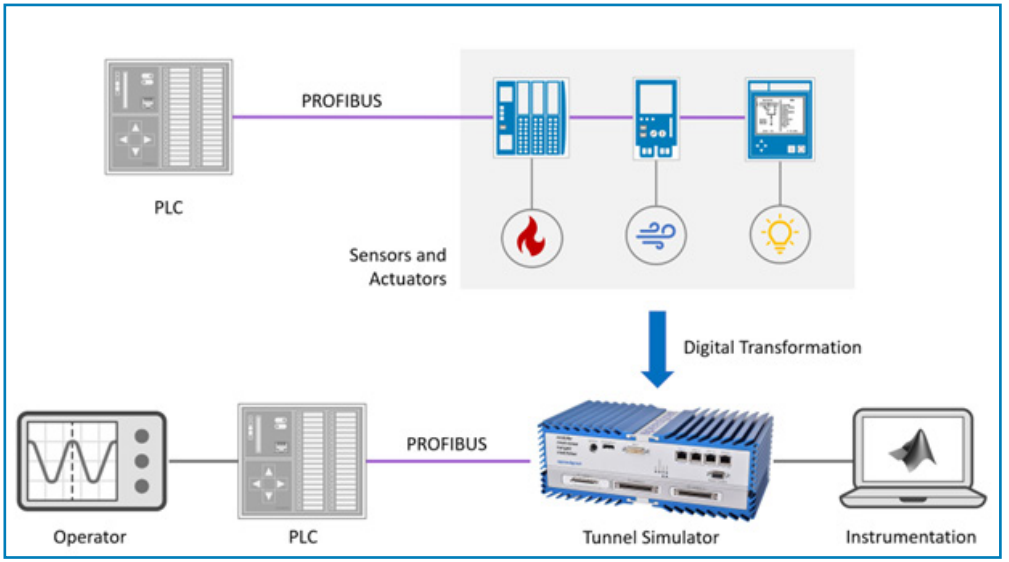
"A digital twin of a tunnel can serve as a reference for future tunnels."

"This gives us the unique opportunity to show to our customers how systems will behave before final approval."

Axel Bassler, CEO of Nabla Engineering

Key Benefits of Tunnel Simulation and Automated Testing

1. Full-scale lab testing including edge cases for safety-critical systems, minimizes realization risks on the tunnel construction site and increases the quality of the tunnel automation system
2. Efficient and early testing of supervisory control algorithms reduces time, energy, equipment, and manpower efforts to commission the tunnel
3. Leveraging the digital twin as a comprehensive training platform speeds up the training of tunnel workers and staff members independent from the actual physical tunnel



Utilized Speedgoat products:
» Mobile real-time target machine
» IO642-32 PROFIBUS Slave multi-node I/O module

Utilized MathWorks products:
» MATLAB®
» Simulink®
» MATLAB Coder™
» Simulink Coder™
» MATLAB Compiler
» Simulink Real-Time™

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