Case Study:
350 Years, 19,008 Positions—Monitoring Bulgaria's National Radioactive Waste Repository

How an incomplete design spec gave a systems integrator the chance to restart

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CASE STUDY: 350 YEARS, 19,008 POSITIONS—MONITORING BULGARIA'S NATIONAL RADIOACTIVE WASTE REPOSITORY

How an incomplete design spec gave a systems integrator the chance to restart

The new National Repository for Medium and Low Radioactive Waste in Bulgaria is where radioactive waste packages must be tracked for the next 350 years.

Every radioactive waste package that enters Bulgaria's new National Repository for Medium and Low Radioactive Waste must be tracked by position, nuclide composition, specific activity, and various other acceptance criteria, for the next 350 years, under the oversight of the Bulgarian Nuclear Regulatory Agency and the International Atomic Energy Agency.

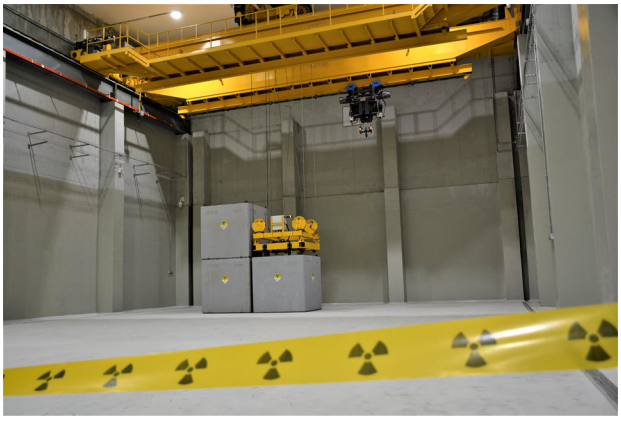
That means 19,008 cell positions across the 66 permanent storage cells, plus 122 in a temporary storage building. Every move recorded, every position confirmed.

The €120 million ($139 million) EU-funded facility adjacent to the Kozloduy Nuclear Power Plant in northwest Bulgaria spans 12 buildings: three storage buildings with cranes, a liquid radioactive waste management system, three 20 kV substations with five transformers, seven HVAC subsystems, fire and water supply systems, a 440 kW diesel generator, central UPS, cooling and heating centers, external site lighting, and a radiation monitoring system that runs continuously inside the perimeter and on a public information display outside it.

A massive project like this required a lot of coordination and a working specification.

A PIONEER PROJECT WITH NO WORKING SPECIFICATION

The original design specified Siemens® PLCs, Profibus/Profinet® networks, and WinCC® SCADA. But as a first-of-its-kind facility in Bulgaria, construction was parceled out to multiple subcontractors, and each chose their own hardware, protocols, and control methodologies.



A bridge crane operates inside the repository's engineered storage facility.

"The facility design had minimal technical detail and no functional specifications for automation," said Boris Karakushev, who led the SCADA integration for TUVI & Co. Ltd., a Bulgarian engineering firm with deep roots in radiation monitoring. "In some cases, the wires didn't end up in the rooms the drawings said they would."

When the brand new cranes arrived, they were outfitted with Omron® PLCs already configured by their own subcontractor. Various Siemens PLCs were installed by another subcontractor, while others chose Modbus®-enabled devices.

"There was almost no compliance with the original technical design, nor was there any consistent approach to the equipment used within individual subsystems," says Karakushev. "Often it was required to manage important systems without being able to receive feedback."

"We convinced the main contractor, the end user, and the designer to let us evaluate what it would take to unify all of the site's systems under a single control platform."

- Boris Karakushev, TUVI & Co. Ltd.

FROM RADIATION MONITORING TO THE ENTIRE SCADA

TUVI had been hired to do the radiation monitoring. They have over 30 years experience in radiation protection and measurement, and they also build their own gamma dose rate probe—an OPC UA®-enabled Intelligent Gamma Probe registered as a utility model in the Bulgarian Patent Office and at WIPO (World Intellectual Property Organization).

But as construction progressed, TUVI realized the radiation monitoring system was only one piece of a much larger challenge. The site was becoming a patchwork of control systems. Ultimately, a future-ready system would need to bring all of it together in a unified interface. So TUVI proposed a broader approach.

"We convinced the main contractor, the end user, and the designer to let us evaluate what it would take to unify all of the site's systems under a single control platform," Karakushev said.

THE MOVE TO *groov*

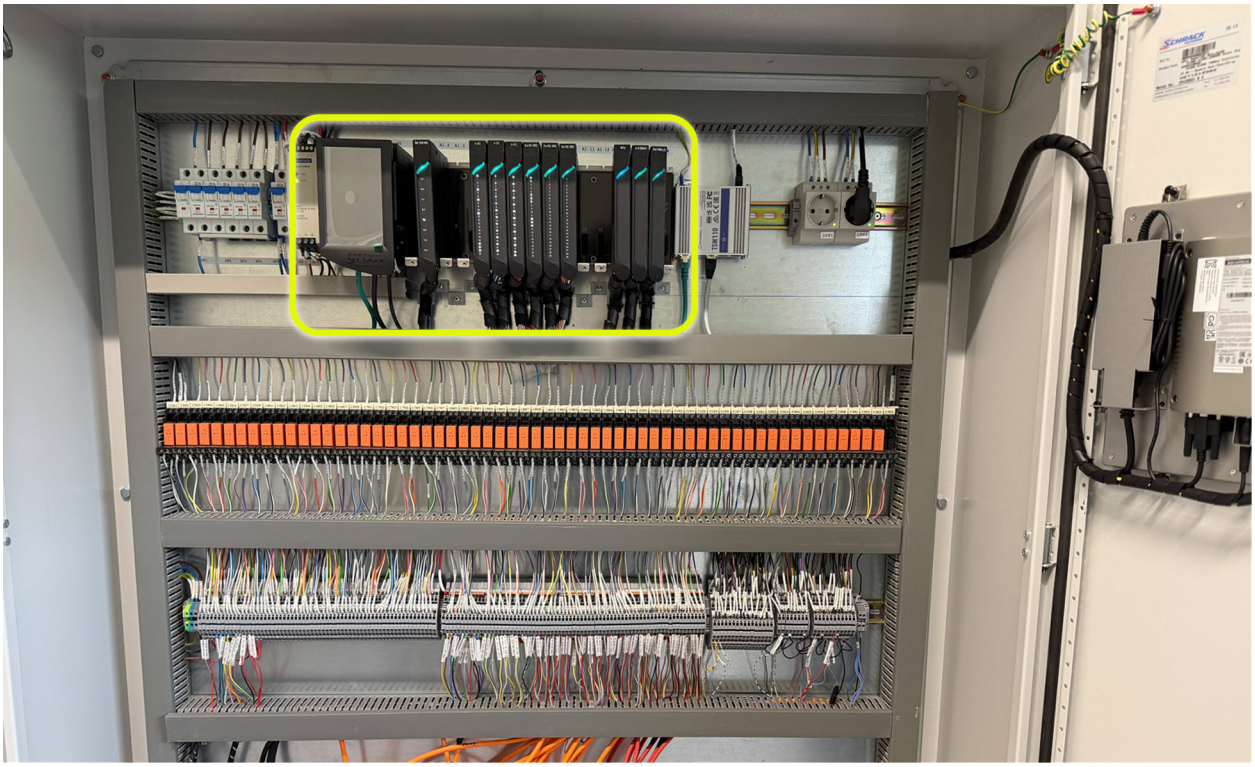
TUVI knew what the facility needed. The harder question was how to build it.

The original architecture was already moving along, so replacing everything was not an option. Whatever platform they chose would need to integrate with existing equipment from multiple vendors, adapt to changing field conditions, and scale as construction continued.

"We discovered the Opto 22® *groov* platform via Google® search," Karakushev said.

What caught his attention was not a specific feature, but the platform's flexibility. TUVI needed a controller that could handle various industrial protocols, serial communications, and traditional I/O from a single platform while remaining independent of any one vendor's ecosystem. Just as importantly, it needed to accommodate

Specialized storage containers are used to safely isolate and manage radioactive waste within the national repository.



Opto 22's *groov* EPIC system provides the foundation for a unified control system.

the uncertainty of a project where equipment selections, wiring, and subsystem requirements were still evolving.

As the evaluation progressed, TUVI became convinced that the *groov* EPIC® system could provide the foundation for a unified control system.

A MISSION TOWARDS IGNITION

By the time TUVI finished evaluating the facility, it had become clear that unifying the hardware was only half the challenge.

The repository was no longer the Siemens-centric project described in the original design documents: it was a mix of Omron PLCs installed on the crane systems, various subsystems relying on Modbus devices, serial communications, and other standalone equipment from multiple vendors. Each system could be monitored individually, but operators needed a single view of the entire facility.

Karakushev ruled out treating the project as a traditional PLC-to-SCADA deployment. The repository needed a platform that could connect to virtually anything, accommodate changes as construction continued, and remain maintainable long after the project was commissioned. This made not locking the facility into a single vendor's solution that much more critical.

As TUVI evaluated options, Inductive Automation®'s Ignition® software emerged as a strong fit. Its vendor-neutral architecture, support for open standards such as OPC UA, MQTT, and Modbus (both TCP and RTU), and ability to connect to diverse industrial protocols through a single platform aligned with the realities of the project. So TUVI made their second case: replace WinCC with Ignition.

HARDWARE AND SOFTWARE UNITE

The final system combined 16 control cabinets built around *groov* EPIC processors (GRV-EPIC-PR1) and a centralized Ignition SCADA platform. Each cabinet was equipped with the mix of I/O actually required in the field using the following *groov* I/O modules:

- GRV-IDC-24—discrete input module
- GRV-ODCSRC-24—discrete output module

- GRV-IMAI-8—analog input module
- GRV-CSERI-4—serial communication module
- GRV-OVMALC-8—analog output module
- GRV-IRTD-8—analog input temperature module
- GRV-ODCIS-12—discrete output module

For the radiation monitoring system, nine of TUVI's Intelligent Gamma Probes connect to nine *groov* EPIC processors distributed throughout the site. A tenth probe, paired with a weather station, feeds a public radiation display mounted outside the facility perimeter using another *groov* EPIC.

At the center of the architecture sits Ignition, running on Linux® with a redundant PostgreSQL® historian. The platform brings together radiation monitoring, HVAC, electrical distribution, substations, crane management, diesel generation, fire protection, water systems, heating and cooling infrastructure, IP telephones, technical video surveillance, and weather monitoring into a single operational view.

Rather than replacing existing equipment, TUVI integrated it. Omron PLCs and Siemens controllers remained in service. Modbus devices, analog instrumentation, RTDs, motorized valves, and dry-contact signals were connected through *groov* EPIC processors. For serial equipment, Node-RED, a flowchart-based IIoT program tool built into every *groov* device, facilitated data flows that moved raw serial data into data tags. Data tags from all of the devices are exposed through the *groov* EPIC's data service, a common interface that provides an OPC UA server connection.

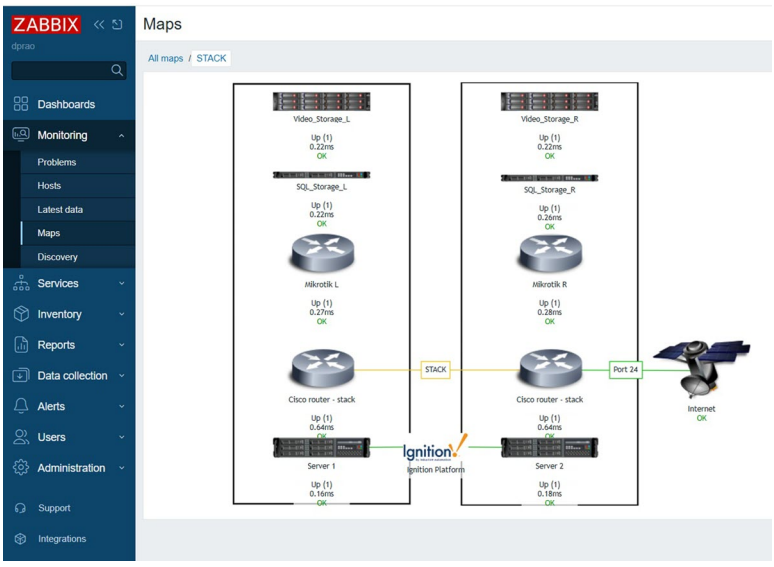
"Equipment substitutions, late additions, and wiring discrepancies were absorbed through *groov* EPIC and Ignition without requiring additional control hardware."

- Boris Karakushev, TUVI & Co. Ltd.

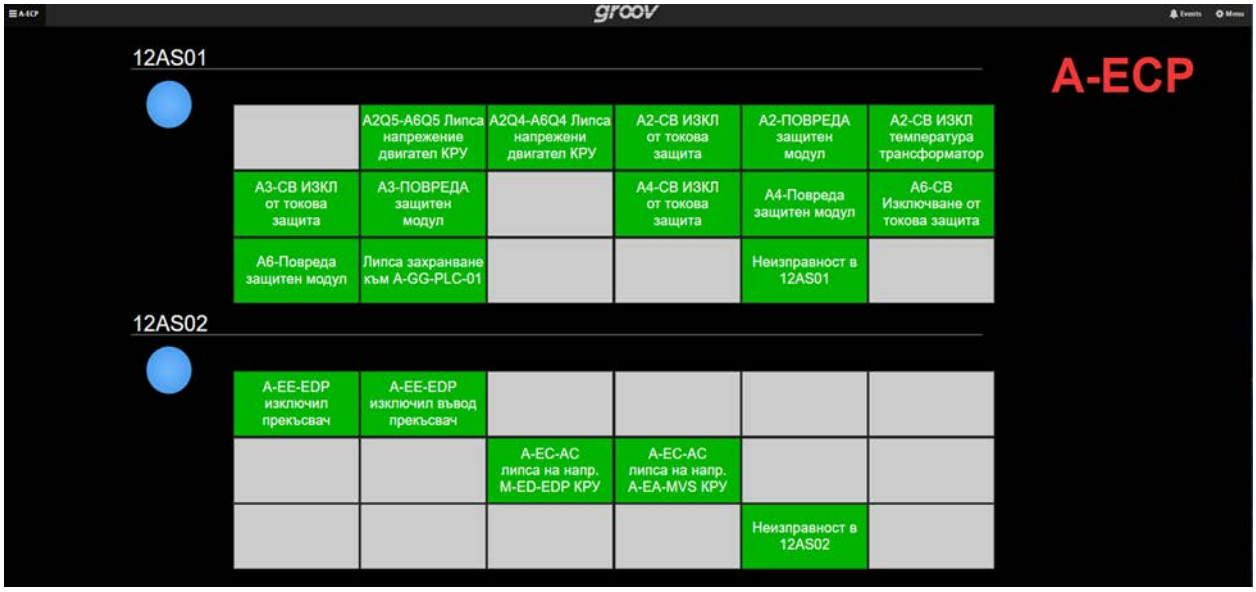
The resulting architecture also allowed systems to share information in ways the original design never anticipated. Weather data used for the public radiation display also supports HVAC freeze protection. Fire alarm events can trigger operational responses and voice notifications. Site-wide lighting and utility systems can be coordinated across multiple controllers. Ignition became the common layer that connected systems originally designed to operate independently.

As construction continued and field conditions changed, TUVI adapted the system in software rather than hardware:

"Equipment substitutions, late additions, and wiring discrepancies were absorbed through *groov* EPIC and Ignition without requiring additional control hardware.



Ignition provides centralized monitoring and visualization across the repository's distributed infrastructure systems.



***groov* View provides operators with real-time visibility into electrical systems, equipment status, and alarms across the repository.**

Every issue was resolved using the software functionalities of the *groov* products and without additional cost," Karakushev said.

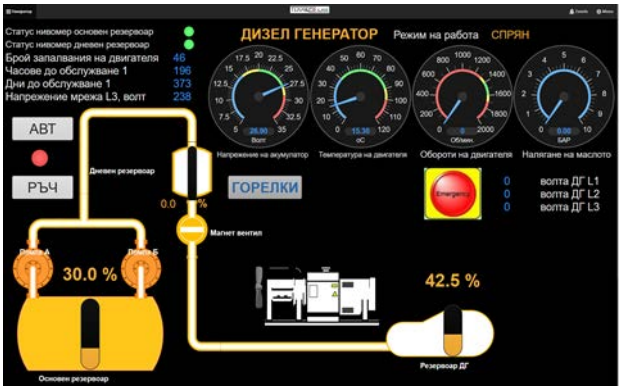
THE 19,008-POSITION TRACKING PROBLEM

The hardest software job was waste package tracking, which must have retrievable data for the next 350 years. The temporary storage building holds 122 positions: 60 packages per row across two rows, plus an inspection bay and a repair bay. The two permanent storage buildings hold 66 cells each containing 72 positions per row across four rows—288 packages per cell, 19,008 packages across both buildings. At any moment the SCADA has to know which package is in which position (with the full data record for that package), which positions are free, which are occupied, and which positions are allowed or forbidden for any specific package under the loading algorithm.

TUVI built it on top of Ignition. "We have created 19,130 tags for each position that stores the data for the packages," Karakushev said. Python scripting moves and stores the data. Pop-up windows handle operator interaction. The system walks the cranes to the correct position for each package, gates further steps until all required data is filled in, and won't accept a placement until the crane confirms the release. Any potential mistake can be reversed under access-controlled supervisor override.

RESULTS: HALF THE OPERATORS, SIX MAN-MONTHS SAVED

TUVI's estimate is that the project would have consumed a lot more time on any other platform—the change orders, substitutions, and field surprises would have meant repeated hardware purchases and re-engineering instead of software changes.



Operators use *groov* View dashboards to monitor backup power generation and fuel systems that support repository operations.

Operators can access *groov* View dashboards from their mobile devices.

The operators were able to efficiently address any issues with the monitoring and system management interfaces built with *groov* View, an HMI solution provided with the *groov* EPIC. With *groov* View, the operators could access system dashboards on their computers or mobile devices for the entire repository.

"Any changes or updates saved at least six man-months compared with other alternative solutions," Karakushev said.

The bigger result was on the operations side. The end user reduced operational staff by half once the facility went live.

"Representatives of the end user have said they have never seen such a good SCADA in their professional career," Karakushev said.

WHAT'S NEXT

TUVI has already signed its next contract—design, delivery, installation, and commissioning of the radiation monitoring system for the Radioactive Waste Disposal Facility at Ignalina Nuclear Power Plant in Lithuania, using *groov* EPIC controllers and *groov* RIO, Opto 22's industrial-grade intelligent edge device. Not only did the products exceed project expectations, but the ongoing support TUVI has received from Opto 22's Gerhard Kreiling has been invaluable.

"The key lesson was that everything is possible. Don't say no. Find the solution—use Opto 22 products."

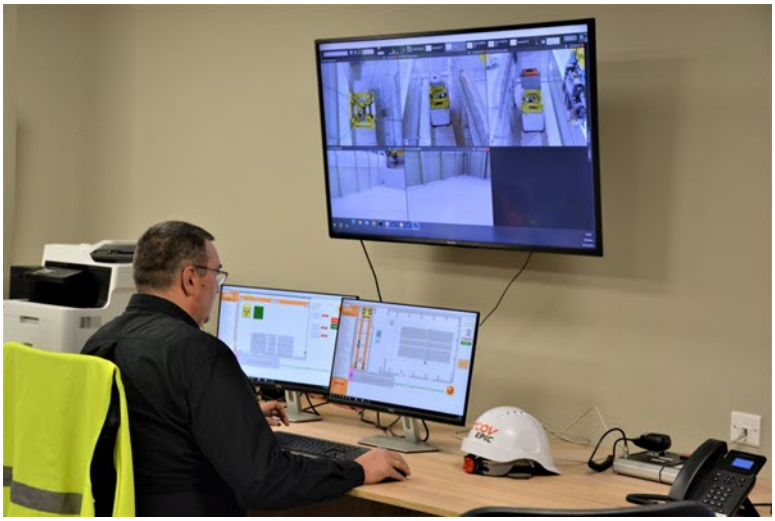
- Boris Karakushev, TUVI & Co. Ltd.

"We see great potential," Karakushev said. "It is already a proven integrated solution. We are now in the process of using the same approach for another project, and it was easier to convince the new end user."

For Bulgaria's waste repository, the result is the kind of integration nobody asked for in the original specification but everyone needed by the time the facility was operational. One platform, one place to look, one record of every package, for the next three and a half centuries.

Looking ahead, the repository plans to continue standardizing on *groov* EPIC as future modernization projects are undertaken. As existing systems reach the end of their lifecycle, their functionality can be incorporated into the repository's new unified architecture.

"The key lesson was that everything is possible," Karakushev said. "Don't say no. Find the solution—use Opto 22 products."



Operators can monitor and control the repository from a main control room.

ABOUT TUVI & CO. LTD.

TUVI & Co. Ltd. is a Bulgarian engineering firm with more than 30 years of experience in radiation protection, radiation measurement, maintenance, project preparation and implementation, project management, engineering research, and technological support, serving Bulgaria and the European Union (EU).

For more information, please visit: https://tuvi-bg.com

ABOUT OPTO 22

Opto 22 was started in 1974 by a co-inventor of the solid-state relay (SSR), who discovered a way to make SSRs more reliable.

Opto 22 has consistently built products on open standards rather than on proprietary technologies. The company developed the red-white-yellow-black color-coding system for input/output (I/O) modules and the open Optomux® protocol, and pioneered Ethernet-based I/O.

Famous worldwide for its reliable industrial I/O, the company in 2018 introduced *groov* EPIC® (edge programmable industrial controller). EPIC has an open-source Linux® OS and provides connectivity to PLCs, software, and online services, plus data handling and visualization, in addition to real-time control.

groov RIO Ethernet-based edge I/O modules, introduced in 2020, include I/O and IIoT software in a compact industrial package that goes anywhere.

All Opto 22 products are manufactured and supported in the U.S.A. Most solid-state SSRs and I/O modules are guaranteed for life.

The company is especially trusted for its continuing policy of providing free product support, free online training, and free pre-sales engineering assistance.

For more information, visit opto22.com or contact **Opto 22 Pre-Sales Engineering**:

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