ferrous systems

Delivering high accuracy, certifiable neonatal brain oxygen monitoring with Rust and Ferrocene

Case study: OxyPrem

Executive summary

OxyPrem is a Zurich-based medical device manufacturer specializing in near-infrared technology. The product is NOAH, a next-generation neonatal tissue oximetry system that continuously monitors cerebral oxygenation to support clinicians during oxygenation changes. The system includes a sensor that non-invasively measures oxygenation in real-time and a monitor that notifies medical teams about relevant changes in oxygenation. To meet IEC 62304 Safety Class B standards under a strict deadline, OxyPrem chose to develop critical parts of the software for both components in Rust.

To accelerate progress, OxyPrem selected Rust expert Ferrous Systems, along with its qualified open-source toolchain Ferrocene, to build a robust, safety-critical software platform capable of meeting certification timelines and scaling with evolving regulatory expectations.

Customer
OxyPrem (medical device; neonatal care)

Challenge
Accelerate the delivery of its life-critical neonatal monitoring system (NOAH) to prepare for CE marking (MDR), FDA approval and clinical adoption

Solution
Contracted Ferrous Systems to develop NOAH's Rust-based sensor firmware with Ferrocene to ensure certifiable, real-time monitoring

Result
IEC 62304 Safety Class B certifiable, non-invasive, real-time brain oxygen monitoring system ready for CE marking and FDA approval

The Challenge:
Meeting medical device safety and certification requirements

Premature infants are among the most fragile patient populations in modern medicine. Even brief lapses in oxygenation—sometimes as little as five minutes—can lead to permanent brain damage. Despite this critical risk, historically there have been few monitoring systems designed specifically for newborn physiology.

OxyPrem faced the combined challenge of delivering high-accuracy tissue oxygen monitoring while meeting stringent safety and regulatory requirements. The solution had to support advanced signal processing with multiple wavelengths and dynamic calibration, perform accurately under strict real-time and variable physiological conditions, and remain clinically usable with a gentle, reusable, non-adhesive sensor suitable for fragile neonatal skin.

The system, composed of a sensor as an embedded device and a monitor as a graphical user interface, had to balance regulatory compliance with tight development deadlines. The sensor, operating under strict real-time constraints, had to take measurements periodically with only microseconds of jitter while remaining certifiable under IEC 62304 Safety Class B. The monitor handles critical calculations and communication with the sensor, which requires a safe and performant language, while its noncritical visualization components can leverage frontend-focused languages, enabling efficient development within time and budget constraints.

Meeting these real-time, clinical, and regulatory requirements on an accelerated schedule posed a high-stakes engineering challenge.

As the team at OxyPrem prepared NOAH for CE marking under the EU Medical Device Regulation (MDR) and intending to proceed to future FDA approval, they realized that they needed to refine their development approach to better balance regulatory rigor with execution speed.

The Solution:
Safety-critical neonatal software, powered by Rust and Ferrocene

NOAH was developed from the ground up with clinical needs in mind, combining advanced optical technology and robust validation to ensure accurate, reproducible measurements across neonatal conditions.

OxyPrem specifically chose Rust for its suitability to target both high-assurance embedded and backend systems without compromising safety or development speed, offering the balance needed for NOAH. It also selected the Ferrocene qualified open source toolchain and related artifacts to improve audit readiness.

To meet its own aggressive deadlines, OxyPrem contracted Ferrous Systems to lead development of the NOAH sensor firmware, with KDAB serving as a key development partner.

Work included development of a custom hardware abstraction layer (HAL) to reduce risk and limit external code size, and the implementation of time-critical tasks based on the RTIC v1 real-time interrupt-driven concurrency framework to provide strict real-time guarantees at a certifiable runtime size. The team also helped implement the custom sensor–monitor communication protocol and refine requirements and design decisions to meet timelines while maintaining regulatory-quality standards.

A detailed requirements traceability process was established based on an open source tool developed at Ferrous Systems, linking requirements to implementation, ensuring test coverage, and verifying non-code or timing-critical requirements manually. Continuous integration infrastructure was also provided, including Ferrocene's Facade targets, offering the ability to test business logic on the emulated target architecture, a hardware-in-the-loop setup to test sensor–monitor interactions and low-level peripheral controls, and automated detection of changes to requirements traceability. Finally, Ferrous Systems provided a build process for safety-critical certification using Ferrocene and provided all necessary documentation to satisfy certification needs.

This approach strengthened OxyPrem's ability to demonstrate safety-related software properties to regulators and notified bodies while enabling ongoing development velocity.

"Already at an early stage, we decided to rely on Rust to build our solution. Ferrous Systems has delivered the experience as well as the development and implementation force to make this happen," said Alexander Nitsch, Co-Founder, OxyPrem.

> "Already at an early stage, we decided to rely on Rust to build our solution. Ferrous Systems has delivered the experience as well as the development and implementation force to make this happen."
>
> **Alexander Nitsch,** Co-Founder, OxyPrem

Results and outlook

With comprehensive engineering and certification support from Ferrous Systems and KDAB, NOAH is now progressing toward CE marking under MDR, with FDA clearance planned to follow.

Looking ahead, OxyPrem plans to extend its technology beyond neonatal care to include adult clinical care, broader medical applications, and simultaneous monitoring of multiple vital parameters. By pairing high-accuracy hardware with a safety-oriented software foundation written in Rust and built with Ferrocene, OxyPrem is positioning NOAH as a tissue oximetry solution for critical care worldwide.