Research and development

Vossloh is a technological leader in the rail infrastructure segments in which it operates. Innovation is a crucial component of the company's technological competitiveness. Vossloh's products and services are subject to detailed technical specifications and standards that must be met in order to ensure safety. Before products and services for railway infrastructure are ready for the market, they usually undergo several years of (further) development and testing, in addition to complex approval procedures by independent testing institutions. Research and development projects at Vossloh are, therefore, usually scheduled to run for several years.

In order to permanently meet the specific expectations of customers in the individual market regions and to further strengthen its own competitive position, Vossloh is constantly investing in the further development and optimization of its products and services with structured innovation management. The group-wide innovation guidelines (Innovation Playbook) adopted in 2021 define principles and procedures. Vossloh intends to increase collaboration across business units to develop new products, services and business models and ensure that customers and suppliers – with their specific expertise – are involved more closely in research and development processes. After reviewing its production processes over recent years, the company is now implementing a range of measures which will provide ongoing efficiency gains, including modernization, increased automation and specialization.

One focus of innovation at Vossloh is digitalization as the link between hardware and services. The company uses specialized sensor systems to compile data on track condition and the loads within the track as well as on the condition of rail vehicles. Among other things, this data can be used to gain knowledge about the degree of wear and damage to track components. This knowledge can be used to determine which maintenance strategies are most appropriate to use and when. Artificial intelligence also plays an important role in this context. It makes wear patterns visible, allowing failures of track components to be anticipated and avoided through planned maintenance measures. Vossloh uses its systemic understanding of the track to meet the core customer requirement – increasing the availability of the rail track – and develops holistic solutions in cooperation with all business units. Under the guiding principle of "enabling green mobility", these ensure that the rail infrastructure is more robust and resilient and that track availability is increased, even though the demands on the rail network are constantly increasing.

At the same time, sustainability criteria such as low material usage and energy consumption, the use of secondary raw materials and recycling or avoiding emissions play an important role in Vossloh's research and development activities. Vossloh is increasingly developing energy-efficient, recyclable products that reduce the environmental impact and promote a sustainable circular economy. Based on life cycle analyses, all business units are working on solutions that reduce the ecological footprint of Vossloh products and services. Detailed information on this can be found in the Group Sustainability Statement on pages 69 et seqq.

A significant proportion of Vossloh's research and development efforts relate to specific customer contracts. Accordingly, these expenses are reported under cost of sales in the income statement and not under research and development (R&D). Expenses incurred in the development of market-ready products are only capitalized if they meet the relevant criteria defined in IAS 38. Development costs that cannot be capitalized are shown as research and development costs if they are not reported under cost of sales.

In 2025, research and development expenses – including capitalized own work – totaled €19 million (previous year: €16.6 million). This corresponds to a share of around 1.4 % of group sales (previous year: 1.4 %). At €5.7 million (previous year: €4.4 million), R&D expenses in the Core Components division were largely attributable to the Fastening Systems business unit. R&D expenses in the Customized Modules division amounted to €7.6 million (previous year: €7.0 million). The amount of €4.3 million (previous year: €4.0 million) was attributable to the Lifecycle Solutions division, while €1.0 million (previous year: €1.2 million) was attributable to Vossloh AG and Vossloh RailWatch GmbH.

Capitalized additions from own work and from third-party deliveries or services in the 2025 fiscal year in the amount of €1.8 million (previous year: €2.3 million) mainly related to the Core Components division.

Vossloh Group – Research and development costs

€ mill.	2025	2024
Research and development costs	19.0	16.6
of which capitalized	1.8	2.3
Research and development expenses (income statement)	**17.2**	**14.3**
Amortization (of capitalized development costs)	0.9	0.9

Vossloh's research and development efforts in 2025 continued to focus on creating new products and services that provide solutions to the major challenges currently facing the rail sector. One goal is to increase the availability of rail lines and enable their more efficient use. At the same time, solutions are to be developed to address the impact of the resulting increased track loads, such as wear and tear or noise emissions. Vossloh also conducts research that focuses on extending the service life of infrastructure and infrastructure components in order to reduce lifecycle costs. The focus is on both optimized maintenance and predictive care of the rail network, and the development of increasingly durable and low-maintenance infrastructure components that can be manufactured in a way that conserves resources as much as possible.

Vossloh possesses comprehensive expertise in the complex rail track system. The company is able to leverage this expertise to significantly improve the efficiency of rail network maintenance processes. Digitalization plays a key role in this. The focus is on intelligent rail systems and digital track monitoring. This promotes uninterrupted operation and paves the way for increased rail traffic. Thanks to its expertise in the areas of sensor technology, computer vision, and cloud computing, Vossloh contributes to a more efficient rail infrastructure. This is necessary to ensure that people and goods can be transported in an environmentally friendly manner that does not unduly impair the quality of life of the general public, including those living in areas close to railways.

The company is using Vossloh connect to focus on advanced digitalized applications in the rail infrastructure business. The cloud-based one-stop shop platform for customers from the entire rail network offers a range of state-of-the-art solutions that optimize the management and maintenance of rail infrastructure, thus contributing to greater safety, lower life cycle costs and improved overall performance. All digital solutions – mainly in-house developments by Vossloh, with additional complementary products from selected external partners – are integrated into a singular, user-friendly system. The platform provides a convenient, comprehensive overview of rail infrastructure and operations. It also includes advanced analytics and alerting systems that reduce the risk of accidents and incidents. This is crucial for railbound traffic safety and helps to reduce the cost of emergency repairs and extend the service life of railroad systems.

Vossloh connect gives customers real-time access to data on the condition of their rail infrastructure. Measurement data and analyses that contribute to improving the maintenance of the rail network can be viewed in a protected area. By using advanced algorithms, the efficiency of maintenance work is increased and downtimes can be reduced.

The information on the condition of the rail infrastructure is delivered, among other things, by configurable IoT sensors located directly in the track, which measure vibration conditions near turnouts to identify atypical track behavior. In addition, Vossloh rail processing machines, equipped with a series of sensors, as well as laser or eddy current instruments, serve as diagnostic vehicles. They measure the condition of the rails during the train schedule. The data is transferred to an asset management system, for example, in-house developed applications mapl-e or MR.pro. In this connection, mapl-e not only displays the condition, but also assesses it and derives maintenance measures from it, and also carried out an economic evaluation of the work required. On this basis, the asset manager can draw up a plan and determine a budget for maintenance.

The condition of the track over time is also significantly influenced by the wheel-rail contact. Vossloh RailWatch monitoring technology uses optical and acoustic sensors to identify the technical condition of freight and passenger cars, multiple units and locomotives as they pass by. A supplementary measuring system, which is installed in the track, enables further data to be recorded, including various parameters of the wheel profile, weight information and the distribution of axle loads. This information is also processed in the cloud using artificial intelligence. This allows wear or damage to be detected early on, enabling maintenance measures to be planned and implemented with pinpoint accuracy.

Turnouts are the most critical elements of the rail track, and also the components which require the most maintenance. Turnout disruptions are one of the main reasons for track unavailability and unplanned mainte-nance. Turnouts are also the ideal starting point for the continuous collection of condition data using sensors. In addition to tracks, a number of signaling and control systems cross each other at turnouts; as a result, the data collected at turnouts is particularly useful. Various digital solutions are now available for turnout manage-ment. In urban regional transportation, for example, Vossloh's compact electrohydraulic Easydrive point machine can be equipped with smart sensor technology for remote monitoring. The PM-DiagBox can be added to conventional analog point machines to make them smart. Vossloh offers the innovative Easyswitch MIM-H point machine for mainline routes – a modular plug-and- play solution with excellent reliability. The in-house development SMV (Smart Monitoring Vossloh) is already being used to prevent turnout component failures, proactively identify the need for tamping work on the ballast in the turnout area and check its effectiveness.

Vossloh's wayside monitoring system based on artificial intelligence (AI) is used in ports and on industrial sites, among others. The pulsar installed in the track is equipped with high-resolution camera technology, among other things, and records process and status data such as UIC wagon numbers and brake block conditions. The continuous monitoring of incoming and outgoing trains helps to optimize operating processes and reduce downtimes.

Digitalization accelerates development work

Digitalization also presents direct opportunities for Vossloh's R&D activities. Research and development work in all divisions is increasingly based on data processing technologies – a trend that continued in 2025. One example of successful development using digital tools is the new M-Generation of tension clamps from Vossloh, which took the company significantly less time to develop than comparable products in the past. Thanks to a higher natural frequency and improved torsional rigidity, the tension clamps are more robust than their predecessors. At the same time, their compact design results in lower transportation costs and less potential for conflict on the track.

Contributions to a "quiet rail"

Vossloh's innovations also focus on quiet rails because noise and vibrations can impact people, especially in urban areas. Examples of products in this field include cellentic components and rail fastening systems containing a high plastic content that reduce structure-borne noise, sleeper pads to reduce vibrations in the track, and whisper turnout, which significantly reduces noise when passing over the turnout. Improvements were made to a number of solutions in this field in 2025. A production facility for sleeper pads is currently being put into operation. In addition, Vossloh has rail processing technologies (grinding, milling) for restoring a smooth and thus quiet surface; the company's maintenance services demonstrably reduce noise emissions. Vossloh uses sensor technology to monitor noise and, thanks to targeted track grinding, can permanently keep the noise level of rail infrastructure permanently low. The company is using the opportunities offered by digitalization to improve the quality of life in urban areas by reducing noise pollution.

Cooperation efforts and partnerships

When it comes to some of its development tasks, Vossloh has long relied on the specific expertise of external specialists. The Group has access to an extensive network of experts. Vossloh works closely with well-known universities and research institutes around the world, for example, in Germany, France, Sweden, China, Australia and the USA, as part of long-term partnerships at different levels and in various configurations. Vossloh focuses on partnerships with technology companies and startups working in digitalization and big data analysis. The joint venture established with Rhomberg Sersa represents a crucial partnership that offers a wide range of monitoring and maintenance services for turnouts and rails. The MR.pro software provides the joint venture with a set of open-system digital tools for evaluating and visualizing the condition and material of track infrastructure.

As part of a strategic partnership with the Swedish digitalization specialist Predge, work is underway on a prediction model that provides accurate defect forecasts and valuable insights into impending malfunctions, particularly in turnout point machines. Vossloh developed the SoniQ Rail Explorer together with its specialist French partner UltraRS. The manually guided ultrasonic testing system can detect and locate irregularities inside the rail – even in a manganese-cast crossing at a depth of up to 60 millimeters beneath the track surface. A partnership between Vossloh and the British Cordel Group has been in place since the beginning of 2025. Its flagship platform uses artificial intelligence to provide an automated analysis of transport corridors based on video and LiDAR (Light Detection and Ranging) data. In November 2025, Vossloh entered into an extensive partnership with the Canadian company Athena Industrial Services. Its patented ARCD system (Advanced Rail Condition Detection) is designed to autonomously detect rail breaks and train presence – even in areas without conventional signaling systems, known as dark territories. The technology helps to reduce the risk of accidents, particularly on routes without signaling, and to avoid costly repairs or breakdowns.

Several selected partners, in addition to Vossloh, offer innovative digital solutions on the Vossloh connect platform. The Swedish company Strainlabs contributes its expertise in the field of intelligent screws. Cervello, a company based in Israel, specializes in cybersecurity solutions for the rail industry. The most recent addition to the predictive maintenance and asset monitoring ecosystem is the ARCD technology mentioned above.

In 2025, the R&D experts in the Fastening Systems business unit of the Core Components division focused, among other things, on developing the new M-generation of tension clamps. The focus was on performance (for use on heavily stressed lines), service life, and sustainability. Sustainability aspects were at the forefront of the new development and further development of plastic components, in particular, the reduction of CO_2 and material efficiency. An additional focus involved developing a sustainable material mix for a sleeper pad with a low ecological footprint, also in terms of the manufacturing process, which increases track stability, thereby helping to optimize the life-cycle costs (LCC) of the track system. In the Tie Technologies business unit, during the reporting year, the R&D departments continued to work on changes to the composition of concrete for railroad ties that reduce material and energy consumption. In Australia, Vossloh launched its first product with a significantly improved carbon footprint. In North America, a railway operator has installed test ties that contain devices for monitoring the condition of the ties. The objective is to tamp the track bed according to demand rather than according to predetermined deadlines. Thanks to Sateba, the division is also strengthening its innovative capabilities in the field of low-carbon concrete ties and continuing to advance the process of decarbonizing the rail network. In addition, the ECOTRACK system helps conserve resources over the entire life cycle by reusing and recycling components.

In the Customized Modules division, R&D specialists focused on life cycle cost analyses and recycling and reusing turnout components. There were premieres in both areas in 2025: Using this approach, Vossloh has created a life cycle model for a complete tram network for the first time and can now offer a wide range of products that have an Environmental Product Declaration (EPD). The first customer to commit to a fully circular economy for turnout procurement from 2026 onwards has been secured: All dismantled turnout crossings are recycled, and Vossloh supplies manganese crossings that consist of up to 90 % recycled material. The company is aligning its manufacturing processes more strongly with the circular economy for this purpose. The existing methods and models for inspecting and monitoring turnouts on the track have been improved with the help of new software. In general, advancing digitalization was an important R&D topic throughout the division. It is for this reason that Building Information Modeling (BIM), which integrates energy efficiency, CO_2 balance and operating costs into the development models, is playing an increasingly important role, both in internal processes and in collaboration with customers.

In the Lifecycle Solutions division, (further) development work focuses on machines for both rail processing and onboard measuring systems for even more comprehensive condition monitoring of rail lines and software for evaluating and displaying the overall data (smart maintenance). In 2025, the control, sensor and measurement technology of various grinding and milling vehicles was also adapted in line with customer requirements. At HSG-next, the improved version of the successful high-speed grinding train, the

focus is on both optimizing the grinding units, and making changes to the design to achieve a significant weight reduction in the future. The adaptation of the HSG-city to other track gauges is intended to expand the range of applications of the urban rail grinding machine. The engineers have developed an inspection head carrier vehicle that can be attached to trains and records data on the condition of the rails while the train is moving. In the welding plant, a safety system was successfully tested that protects employees from falling off rail stacks. A patent application has been filed.

Streamlined processes and digital data flows along the entire value chain are becoming an increasingly important part of Vossloh's internal processes. The cross-business-unit exchange of knowledge in the context of international development projects with the help of modern communication and collaboration solutions is growing. Accordingly, the IT structure was further expanded and standardized in 2025. In addition to the scheduled rollout of the standardized enterprise resource planning (ERP) system, which will enable the unrestricted cross-border cooperation of all employees, the focus was on cybersecurity. The information security management system was further refined to protect against all kinds of cyber threats. Detailed information on this can be found in the Group Sustainability Statement on pages 136 et seqq.

Optimization of production and administration