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Fraunhofer ALUMNI

ATREUS WHITEPAPER

ROBOTICS & AI: GERMANY'S JOURNEY FROM INNOVATION LAB TO THE BENCHMARK FOR THE INDUSTRY

Robotics and AI are driving a fundamental transformation of Germany's industry. This whitepaper explains how decision-makers are translating innovative potential into lasting market success and also provides concrete insights, practical examples, and actionable recommendations.

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BETWEEN WORLD MARKET AND MANUFACTURING WORKSHOP: WHERE DOES GERMANY'S ROBOTICS SECTOR STAND?

Although Germany is regarded as the cradle of Industry 4.0, the country is still debating funding guidelines while public robotics showrooms are already opening in Beijing. Service robots are commonplace in China, but they remain comparatively rare in German hotels. However, technological nostalgia for older technologies serves us no purpose.

Many robotics experts might summarize their opinion about Germany as top-of-the-line in research, a mixed bag on the industry front, and rather modest in the area of investment. World-class research is of little value unless the renowned Mittelstand — Germany's powerhouse of small and medium-sized enterprises – actually puts it to use. This is also evident in the gap with Asia: China is taking decisive action while Germany is hesitating. There is a real danger that our key technologies will be sold, copied or simply overtaken while companies here wait for the perfect prototype.

This whitepaper examines the tensions shaping German robotics: the divide between cutting-edge research and stagnant investment and the clash between a culture of fear and a spirit of renewal. It outlines the concrete steps decision-makers in German companies can take to avoid squandering their roles as technology drivers.

We wish you inspiring reading!

DR. CHRISTIAN FRANK
Partner & Member of the Executive Board, Head of the Machinery & Plant Engineering Solution Group

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"Technology is not the problem; the need for change in people's mindsets is."

Interview with Dr. Christian Frank

"AI AND ROBOTICS ARE THE DRIVING FORCE BEHIND THE NEXT INDUSTRIAL REVOLUTION"

Dr. Christian Frank is Partner & Member of the Executive Board as well as Head of the Machinery & Plant Engineering Solution Group at Atreus.

Dr. Frank, why is the convergence of AI and robotics especially relevant for Germany's machinery and plant engineering sector right now?
German industry is at a crossroads. For decades, Germany's strength has been precision and engineering craftsmanship. Software expertise defines our competitive edge today. AI and robotics are no longer just technologies that serve as add-ons to the existing engineering, but the driving force behind the next industrial revolution. Those who intelligently combine both can achieve economies of scale, greater efficiency, and enhanced resilience all at the same time.

Where do you currently see the greatest opportunities for leveraging AI-supported robotics?
The clear answer would be in logistics, assembly, and quality assurance. Wherever processes are granular, varied, and costly, AI is capable of reimagining automation. This is particularly true for Germany's small and medium-sized enterprises, which have been cautious until now but are now beginning to embrace data-driven robotics as a survival strategy.

What challenges must companies address on the way to AI-driven production?
Technology is not the problem; the need for change in people's mindsets is. Many companies have state-of-the-art technologies at hand but lack an integrated data strategy. AI and robotics need a common language so that the sensors, software, and control systems can communicate with each other. This is primarily a cultural rather than a technical challenge, but otherwise, the same idea applies: Just do it. Get started. Don't hesitate, and don't be afraid of making mistakes.

What impact will this change have on Germany as a business location?
By harnessing AI and robotics wisely, Germany can remain a global benchmark location in mechanical engineering. However, the available timeframe is tight. Those who hesitate now forfeit not only market share but also fall behind on their own learning curve. We urgently need the courage to experiment – and leaders who foster this instead of holding it back. Only by taking this approach can we remain competitive.

"AI is not merely a technological extension – it is the driving force behind digital transformation. Its full potential is realized only when paired with robotics: machines that learn, adapt, and act autonomously are able to fundamentally transform production logic and value chains. Germany and Europe are uniquely positioned in this development, combining mechanical-engineering expertise, AI know-how, and high-quality industrial data. The key is to strategically link these strengths and translate them into marketable solutions. That's because the debate over European AI sovereignty is no longer about the future – it's being decided today."

PROF. DR. AXEL MÜLLER-GROELING,
Executive Board Member for Research Infrastructures and Digital Transformation, Fraunhofer-Gesellschaft

BETWEEN COURAGE, TRANSFORMATION, AND THE CAPACITY FOR EXECUTION: HOW COMPANIES ARE SHAPING THE FUTURE TODAY

Actionable recommendations for decision-makers

- **Design for automation:** Make processes robot-friendly – minimize variants, specify gripping and reference surfaces, and standardize containers. Plan the layout at an early stage – run a simulation or launch a pilot cell to validate the cycle time, cost, and quality.
- **Digital transformation and networking:** Define data models and IDs. Connect ERP/MES/PLM via secure APIs. Use data quality as a KPI, combine the edge and cloud, and implement security by design.
- **Experimentation:** Launch small use cases with hypotheses, a budget, and target KPIs (e.g., Overall Equipment Effectiveness/OEE). Establish a sandbox, enable iterative learning loops, and get C-level sponsorship.
- **Open standards:** Use documented interfaces, ensure interoperability, and avoid vendor lock-in. Make API governance, versioning, and testing mandatory.
- **Further training:** Role-based enablement. Leadership for digital maturity; operations/IT for automation, data, security. Academy with learning paths and coaching; reward measurable improvements.

Robotics & AI: Opportunities, risks, next steps

- AI is the catalyst for digital transformation – but only in combination with robotics does it unleash its full potential.
- Modern systems are evolving from rigid machines into autonomous systems that learn from experience and carry out complex actions independently.
- The debate over European AI sovereignty is no longer about the future – it's being decided today.

Atreus Service

Robotics and AI are no longer just technologies that serve as add-ons to the existing engineering, but the driving force behind the next industrial revolution. Decision-makers who act now can secure the pole position in global competition. Atreus walks this path with you – offering implementation expertise, wide-ranging experience, and access to a network of the industry's top minds.

DIPL.-ING. RICHARD BORMANN, M.SC.
Head of the Handling Processes and Dexterity Research Team,
Fraunhofer Institute for Manufacturing Engineering and
Automation IPA

Interview with Dipl.-Ing. Richard Bormann, M. Sc.

"NOW IS THE MOMENT TO GET CURIOUS AND BEGIN"

Richard Bormann heads the Handling Processes and Dexterity Research Team at the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA). He is recognized as a leading expert in AI-enabled robotic solutions in logistics and production.

Mr. Bormann, what is the current state of robotics in industrial logistics?
In logistics, many systems are already automated; for example, automated small-parts warehouses are now standard. However, there is a lot going on right now in both inbound and outbound processes. Robotics is moving into areas that previously required manual labor – automating palletizing and depalletizing, building mixed pallets in distribution centers, loading and unloading trucks, and picking and compactly packing goods into shipping containers.
The market is huge, with logistics accounting for roughly half of all service robotics applications. These systems could operate with greater flexibility, intelligence, and autonomy in the years ahead.

What is the current state of autonomous mobile robot development?
Companies are already deploying autonomous fleets of mobile robots. Indoor transport within halls already works quite well. By contrast, external transport between halls is still in its infancy — there are not yet any solutions that are universally ready for market launch, and most initiatives remain pilot projects.
However, we are seeing a trend toward mobile handling robots that can move autonomously while also grasping, sorting, and interacting. Such systems can be more easily integrated into existing environments without the entire warehouse needing to be reequipped.

What role do humanoid robots play in this?
Humanoids captivate us because of their presence in science fiction and their humanlike appearance, but they are not always the best solution. For example, in production environments with flat floors, wheels are far more efficient, consuming only a fraction of the energy needed for walking on two legs. However, two arms or manipulators capable of operating machines or opening doors are useful in production logistics.
There are also safety aspects to consider: A humanoid robot must continuously maintain its balance. If it goes into emergency shutdown mode, it may become unstable and cause personal injury or →

property damage. That is why concepts are being developed to enable such systems to collapse in a controlled manner. Humanoid robots also remain expensive, and even conventional industrial robots are very costly despite mass production.

What needs to happen for robotics to become widely adopted within the next few years?

First, companies should design their workflows to accommodate robots. This is called "designing for automation" – that is, planning products and workflows so they can be easily automated. Second, digitization and network connectivity are essential. Only when machines, devices, and software are connected in a network can robotics realize its full potential. We need open standards and interfaces – such as the VDA 5050 initiative – to ensure that mobile robots from different manufacturers can communicate with each other. And third, this instruction is aimed at manufacturers: Flexibility must be prioritized. Robots should be quick to commission and easy to reconfigure, ideally without requiring specialist personnel. In the future, voice control, foundation models, and a kind of "everyday intelligence" that gives machines a better understanding of processes and workflows will make this possible.

What do you foresee happening with development in the coming years, and what advances in robotics should we expect?

In the next ten years, it will be about being able to instruct robots in simple, intuitive ways. Large language models and vision-language-action models are among the AI systems that we are working on that have a deeper understanding of the world and that genuinely grasp their own actions – because a good plan does not necessarily mean that you can execute it well. The interface between digital planning and physical reality therefore remains the biggest challenge.

What advice would you give to companies that want to move in the direction of AI and robotics?

My most important piece of advice is to get started now. Europe still maintains a significant lead thanks to our process and application knowledge. We need to translate that into applications for AI and robotics. Companies that are still in the early stages should first carry out a potential analysis with external experts, test small use cases based on the findings, and thereby develop a clear sense of what's possible. You don't have to change everything at once. It is equally important to keep an eye on the big picture; otherwise, efforts will be confined to individual projects that cannot fully harness the potential of automation.

7. Innovation Lounge Digital

AI NEEDS ROBOTICS – AND ROBOTICS NEEDS AI

On July 24, 2025, the Innovation Lounge Digital event hosted by Atreus and Fraunhofer Alumni was devoted to the mutual reinforcement of artificial intelligence and robotics and their strategic benefits for business, industry, and society. Experts from the worlds of research and practice examined opportunities, risks, and future scenarios – from simulations in the "industrial metaverse" to model-free grasping to questions of social acceptance, regulation, and geopolitical dependencies.

THE DISCUSSION'S KEY FINDINGS, SUMMARIZED IN NINE THESES:

1 AI is the driving force behind digital transformation.

Fraunhofer Executive Board Member Prof. Dr. Axel Müller-Groeling stresses that AI has long been more than just an optimization tool: "It is a catalyst for digital transformation." What is crucial here is the interaction with robotics to enable applications that purely mechanical systems would not be able to achieve. Modern systems are evolving from rigid machines into autonomous systems that learn from experience and carry out complex actions independently. Germany and Europe have strong competitive advantages in mechanical engineering know-how, proprietary data, and AI expertise – but must act strategically to secure technological independence: "The debate about European AI sovereignty is not academic but current and urgent." Müller-Groeling warns that restrictions on transatlantic exchange could jeopardize the lead.

2 The key to success is flexibility, not mass automation.

Dipl.-Ing. Richard Bormann, M.Sc., describes the transformation of production and logistics processes: "Today we are facing low volumes alongside a product mix that is highly varied and flexible in its variants."

Conventional hardware solutions hit their limits here, making AI solutions absolutely indispensable. The goal is to implement processes efficiently while preserving flexible automation. Using physical simulations in the industrial metaverse, a system can be configured within the virtual model and then deployed directly to the real machine or process. This reduces downtime and makes it easier to adapt to product changes. Easy operability is also important: I want workers to be able to make the changeover as easily as possible without having to call an expert."

3 Simulations and AI accelerate development cycles.

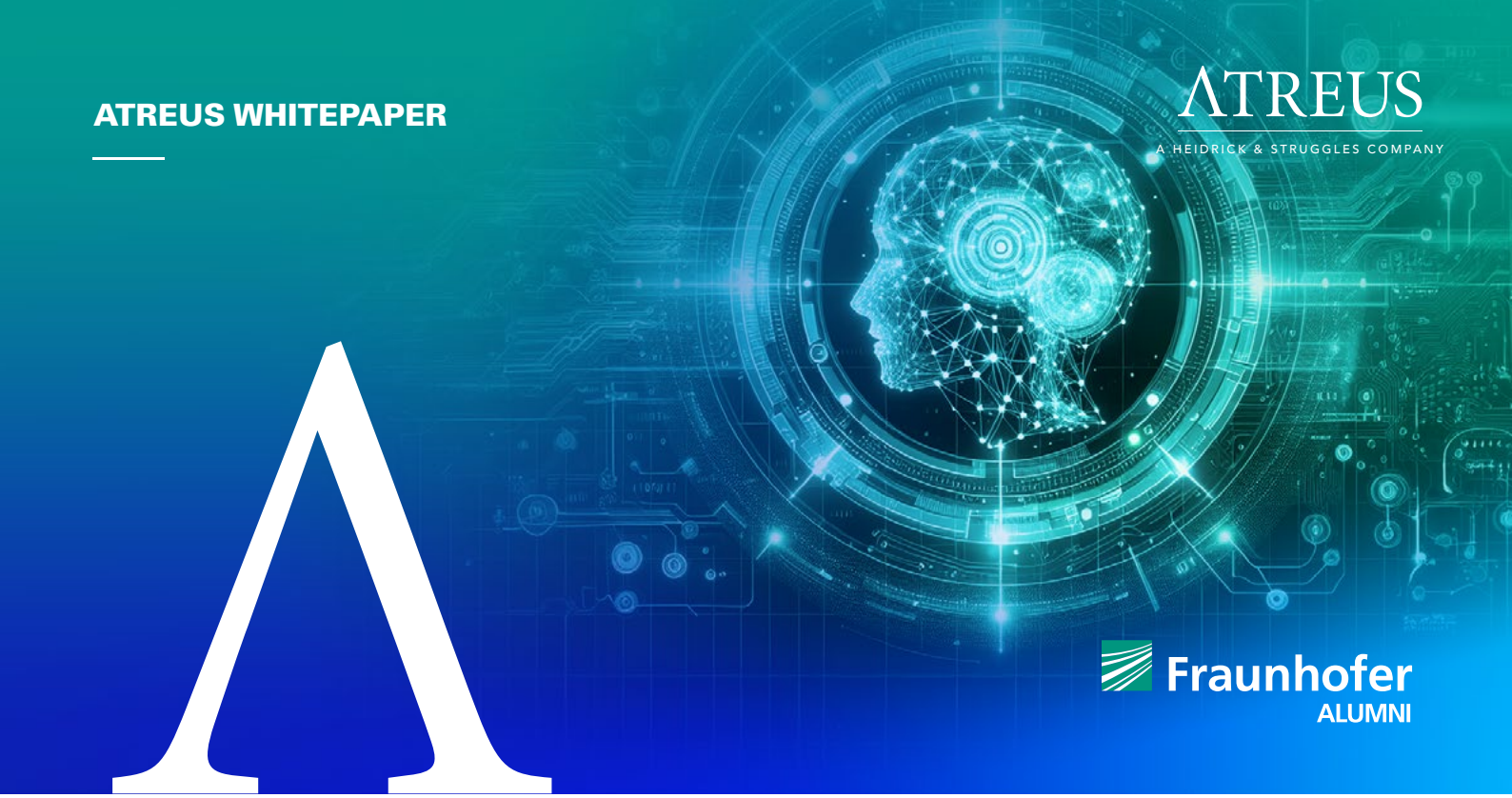
Bormann emphasizes that systems trained exclusively on simulated data "worked immediately in the real world" – even in unforeseen scenarios. Model-based grasping relies on CAD models, while model-free grasping handles unknown objects solely based on sensor data. The trend is clearly toward a "universal, multipurpose robot for commerce and production." Prof. Dr. techn. Norbert Elkmann, Head of the Robot Systems Department, Fraunhofer Institute for Factory Operation and Automation IFF, adds: "The robot must be capable of accumulating experiential knowledge." Simulations enable realistic testing without the need to build costly prototypes. "Such a simulation takes half a day with 1,000 robots, which is relatively fast." Bormann and Elkmann stress that AI-supported simulations pave the way for autonomous capabilities.

4 Human acceptance arises through bioinspiration.

Leon Valentin Siebel-Achenbach, Deputy Head of Department at the Fraunhofer Institute for Material Flow and Logistics (IML), explains why the Fraunhofer transport robot evoBOT® deliberately incorporates bio-inspired elements: "You basically can't ignore bio-inspired approaches, particularly in human interaction." For many industrial applications, humanoids with 16 degrees of freedom are considered completely over-engineered, prohibitively expensive, and effectively unusable." Instead, they rely on playful design and movement that eliminates all inhibitions and fear. The evoBOT® has "far exceeded 150 million clicks – proof that we can create cool, exciting things." International appearances have led to collaborations in Korea, for example, where regulations and legislation are being amended to foster innovation.

5 Robotics is highly complex its ultimate breakthrough can't happen overnight.

"I would dial back the predictions of hundreds of thousands of humanoid robots as soon as next year," says Professor Norbert Elkmann of Fraunhofer IFF. Many assembly tasks are "are designed for humans, and that is unlikely to change anytime soon." Wheels are often more "stable, safer, and more economical" than legs. Costs and economic viability are also frequently ignored in the excitement. Siebel-Achenbach stresses that "humanoids don't need to mimic human behavior one-to-one" – as often there are alternative, more efficient solutions. Richard Bormann also emphasizes the importance of collaboration between robotics companies and end users, noting that cleaning robotics is highly complex.



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6 Safety measures and regulations can impede innovation.

Professor Norbert Elkmann warns that safety requirements, legal issues, and liability concerns are delaying the rollout of robots in public spaces. Data protection regulations such as the General Data Protection Regulation (GDPR) create additional hurdles to implementation in Europe. Siebel-Achenbach advocates for the creation of test environments that "allow teams to start small before thinking big." He believes some risks are acceptable since robots "often operate more safely than humans – at least in part because they aren't driven by emotions." Despite regulatory constraints, small, iterative steps are essential to advancing innovation.

7 AI is a tool, not an end in itself.

Dr. Matthias Hentschel is the managing director of a company specializing in custom applications in automation technology. Hentschel Systems doesn't build its own AI but instead integrates existing models to enhance robots' perception of their environment. Rugged sensors are essential outdoors, especially if they are exposed to extreme heat, moisture, mud, or smoke. Originally developed for sports analysis, Keypoint Detection not only enables more precise navigation but also allows movements and gestures to be taught. Hentschel warned about resource constraints: "Mobile systems must always operate within tight limits – including scarce onboard resources, thermal-dissipation issues, and a limited power supply."

8 Strategic alliances are also urgently needed internationally.

The international race for robotics has begun. Richard Bormann highlights the strengths of other countries: "Denmark's strong robotics centers are exceptionally innovative." France and Spain are also well-positioned, while India represents a vast market. Leon Siebel-Achenbach likewise sees growing potential in Japan, while Elkmann points to the continued dependence on American foundational technology. Europe can no longer close the gap here either – "The die has been cast." However, Michael Hentschel also notes that initiatives like those of the Schwarz Group "do not all rely on American technology."

9 AI needs robotics – and robotics needs AI.

According to Professor Norbert Elkmann, robotics is the ultimate showcase for AI: a robot that acts is more impressive than an AI that merely analyzes legal texts or recognizes a cat in an image. Bormann adds: "If AI is to truly understand the world, it must grasp physics and be able to assimilate experiential knowledge." Hentschel provides a practical example: a sensor-equipped forklift could progressively learn through AI. Bormann also questioned whether a single end-to-end foundation model that knows everything is necessary, arguing that a combination of specialized modules often suffices. Experts agree that combining physical interaction with AI-enhanced processing will generate the greatest added value.

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ATREUS – YOUR PARTNER FOR IMPLEMENTATION AND INNOVATION

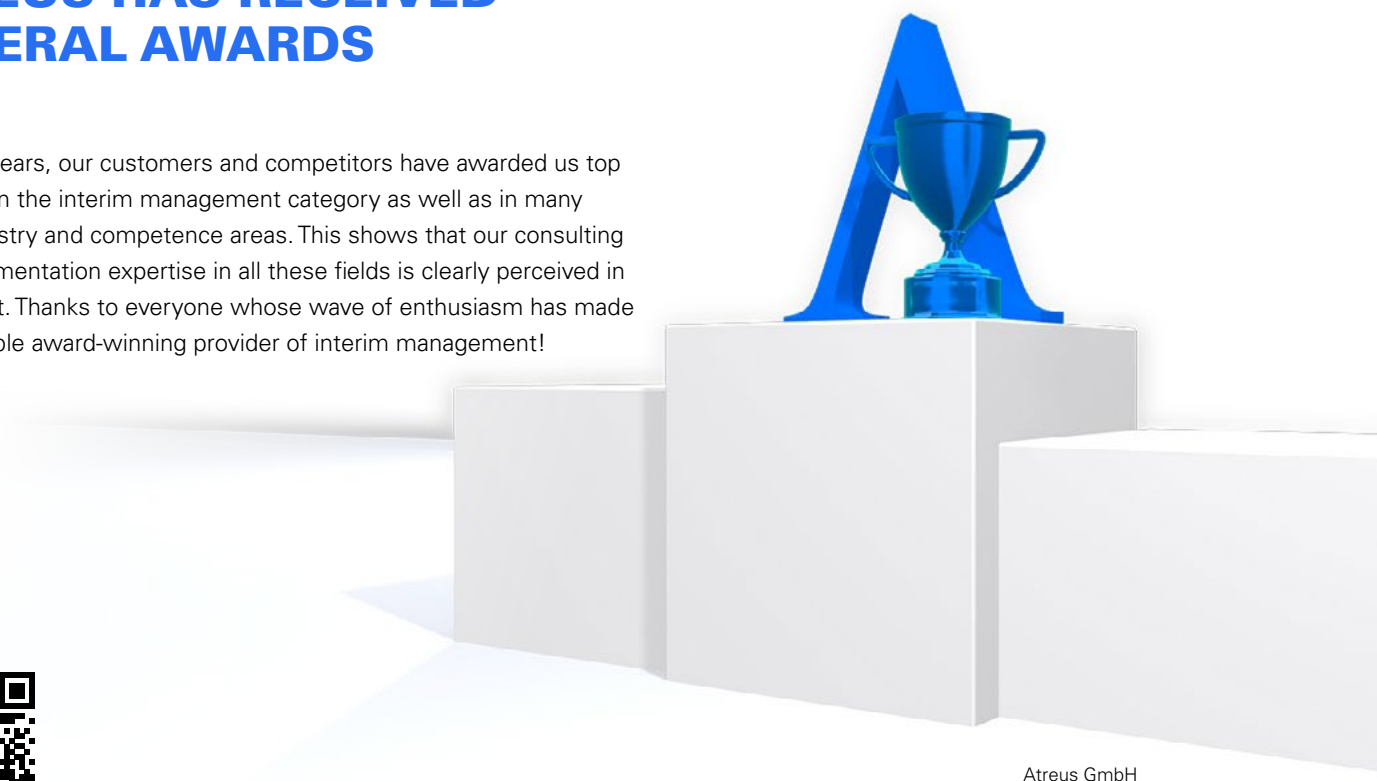
Atreus stands for consistent implementation responsibility, proven leadership in transformation and innovation initiatives, and a powerful network.

Innovative robotics solutions exhibit their added value only through professional implementation. We accompany companies from a focused opportunity scan through rigorous proofs of concept to industrial-scale implementation – with clear governance, measurable outcomes, and a common language that connects business units, IT/OT, and the shop floor. Our claim is less PowerPoint and more production performance – we create success.

With interim management, we inject speed, experience, and independence into your innovation initiatives. C-level and program excellence that enables deployments in weeks rather than months; technology-independent decision-making; and the orchestration of complex rollouts – from cobots and autonomous mobile robots (AMRs) to machine vision and digital twins for simulation and safe commissioning. We accelerate time-to-value, mitigate rollout risks (safety, compliance, and cybersecurity), and ensure lasting benefits through knowledge transfer, upskilling, and robust operations and maintenance frameworks. This is how pilot projects are transformed into productive, scalable solutions that make a tangible contribution to productivity, quality, and resilience in daily operations.

ATREUS HAS RECEIVED SEVERAL AWARDS

Over the years, our customers and competitors have awarded us top positions in the interim management category as well as in many other industry and competence areas. This shows that our consulting and implementation expertise in all these fields is clearly perceived in the market. Thanks to everyone whose wave of enthusiasm has made us a multiple award-winning provider of interim management!



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Hidden Champion, Bester Berater, German Brand Award Winner, Atreus Top Interim Service Provider Europe, Handelsblatt and many more.

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