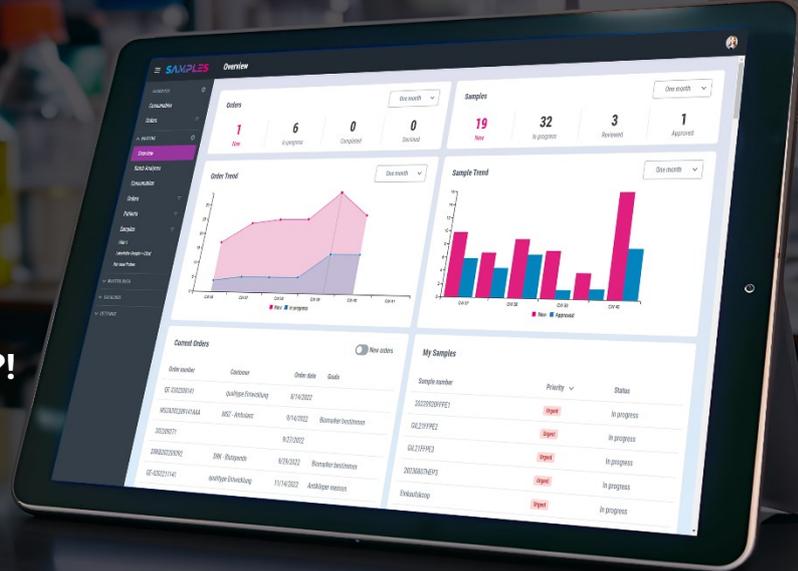


Whitepaper
**Can There Be a Future-Proof
 Laboratory Without a Modern LIMS?!**

Requirements and Opportunities on
 the Road to Lab 4.0



We are convinced that many laboratories are at a crucial crossroads. Looking at other industries – such as industrial manufacturing – we see that they set a new course years ago with developments around *Industry 4.0*, *digital twins*, and *machine learning*. At their core, such concepts and strategies are about enhancing efficiency through digitalization. Laboratories face similar challenges, as demands placed on them continue to grow. The key to the laboratory of the future also lies in digitalization: it is all about maximum performance and connectivity.

Current challenges

Based on experiences from the COVID-19 pandemic and in light of current developments and regulatory changes, we have identified the most pressing challenges in the laboratory environment and developed potential solutions. This was done in collaboration with our partners medicalvalues GmbH and Consileon Business Consultancy GmbH, as well as the internationally leading healthcare cluster Medical Valley EMN e. V. The focus is on untapped innovation potential and the resulting impulses for new structures and workflows on the path to the laboratory of the future.

Since laboratories generally operate in a rapidly changing environment with increasing cost pressure, continuous adjustments are necessary to maintain competitiveness. These range from the fundamental service portfolio to ongoing internal process optimization and innovations in the system landscape. In response to similar challenges, approaches such as cross-laboratory collaboration or, where applicable, the use of site-spanning planning and control mechanisms can also be considered. However, both require at least a minimum level of shared standards.

At the same time, laboratories must meet the expectations of a diverse range of customer groups whose needs and requirements have in some cases changed significantly in recent years. Patients, for example, increasingly expect access to digital data with low entry barriers and a high level of transparency. For physicians, seamless data exchange with existing applications is becoming ever more important. And although often underestimated: user experience plays an increasingly crucial role for everyone – especially when it comes to the acceptance of digital solutions.

And this aspect is a crucial factor when it comes to addressing the widespread shortage of skilled workers in this industry as well. Requiring urgently needed specialists to perform monotonous routine tasks — rather than automating them — can become a long-term obstacle. There is a growing expectation for attractive workplaces with a clear focus on professionally challenging tasks.

But even in laboratories that have already digitalized a large part of their processes and rely on device integration and automation, two fundamental challenges come into focus in the ongoing optimization of process control: data availability and data sovereignty. Both are crucial — especially when it comes to the use of modern technologies and methods for forward-looking solutions involving, for example, artificial intelligence, process mining, or DataOps.

Key Innovation Potentials

The challenges mentioned also represent innovation potentials on the path to a competitive and resilient laboratory of the future. The most obvious potential lies in the process optimization described above: a high degree of automation reduces costs, frees up skilled staff from tedious routine tasks, and enables proactive planning and scheduling of workflows. However, it is crucial to ensure the greatest possible independence from manufacturers and to rely on standardized protocols and interfaces in order to guarantee long-term data availability and data sovereignty.

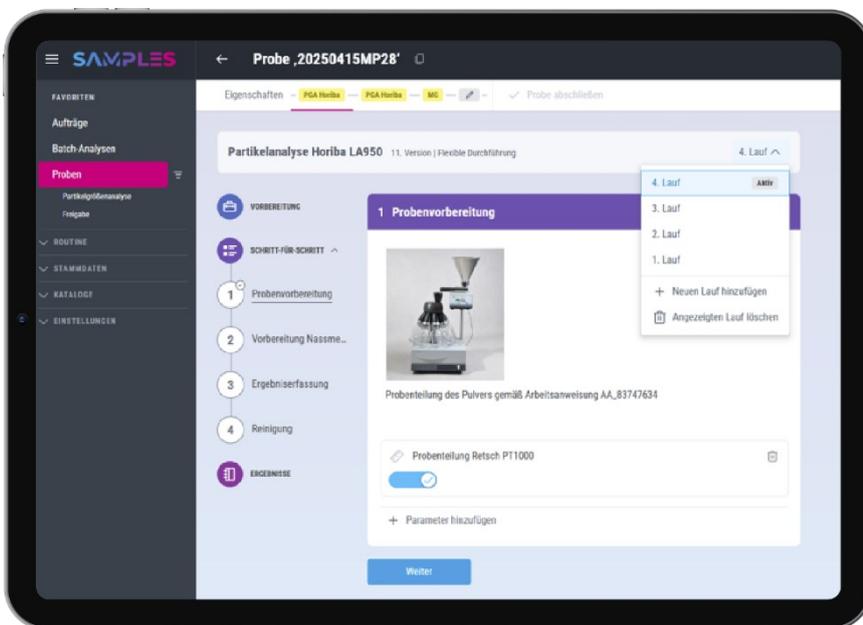


Fig. 1: SAMPLES is highly flexible and customizable, allowing the implementation of individual workflows for maximum performance.

The second major innovation potential follows seamlessly from the one just mentioned: to ensure the essential adaptability and responsiveness of laboratories, the modularity and agility of the system landscape are of critical importance. Instead of large-scale projects and comprehensive all-in-one solutions, implementations in manageable steps and a system architecture composed of many smaller, well-networked specialized systems prove to be more effective. This enables laboratories to respond appropriately to current developments and to adopt the best available solution in each case.

The third identified innovation potential lies in internal organizational development and employee retention. Laboratories with a high degree of digitalization and automation can position themselves much more effectively as attractive employers — provided that employees are adequately supported throughout the transformation processes. In light of the changing demands of customer groups, the business model of a "healthcare service provider" for private individuals, including the provision of appropriately processed digital data, has also been identified.

The Modern LIMS as an Enabler

What role do Laboratory Information Management Systems (LIMS) play on the path to Laboratory 4.0? This question is best answered by looking at the definition: A LIMS is generally understood as an IT application that supports laboratory operations in sample processing and management, as well as the associated workflows. In short, this means that the LIMS—and its structure—is of central importance to this discussion, as it impacts the entire laboratory operation and virtually all potential process optimizations: from order entry and sample organization to analysis and data capture, all the way through to evaluation and preparation of results.

In light of the identified innovation potentials, specific requirements for a LIMS also emerge. First, let us focus on the topics of usability and user experience — namely, the acceptance of digital solutions by laboratory staff and the attractiveness of the laboratory as an employer. Each of us uses mobile applications almost daily and increasingly expects a comparable “feel” from the software we use professionally — especially when speaking with younger employees. A modern LIMS should meet these requirements for usability and user experience, while also offering extensive configuration and customization options — ideally manageable by the users themselves.

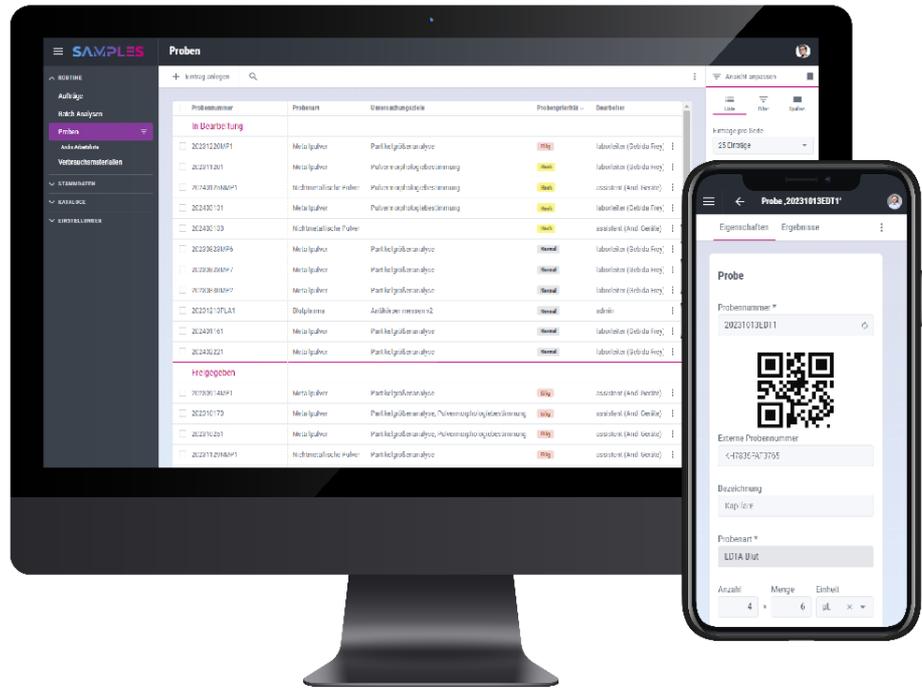


Fig. 2: SAMPLES offers a modern, attractive user interface and intuitive operation for maximum acceptance.

With regard to the system landscape, the LIMS should align with the principles of the preferred architecture — actively supporting integration, accessibility, interoperability, and expandability with other components, and certainly not hindering them. In conjunction with middleware that functions centrally as a “mediator” or “translator,” the LIMS should be embedded as an integral part of the overall architecture alongside distributed components (such as DMS, SDMS, schedulers, organizational software, etc.). The prerequisite for this is an open software architecture that enables the implementation of open, high-performance interfaces — for example, for device integration, connection of external tools, and comprehensive automation. Ideally, the LIMS should support modern interface standards such as LADS, SiLA-2, AnIML, PAC-ID, T-REX, ADF, HL7, MTP, or SDC, as these ensure interoperability, secure data transmission, and traceability—and, not least, enable easy interchangeability of devices and software components used in the laboratory. Under these conditions, the LIMS serves as a central link in the laboratory

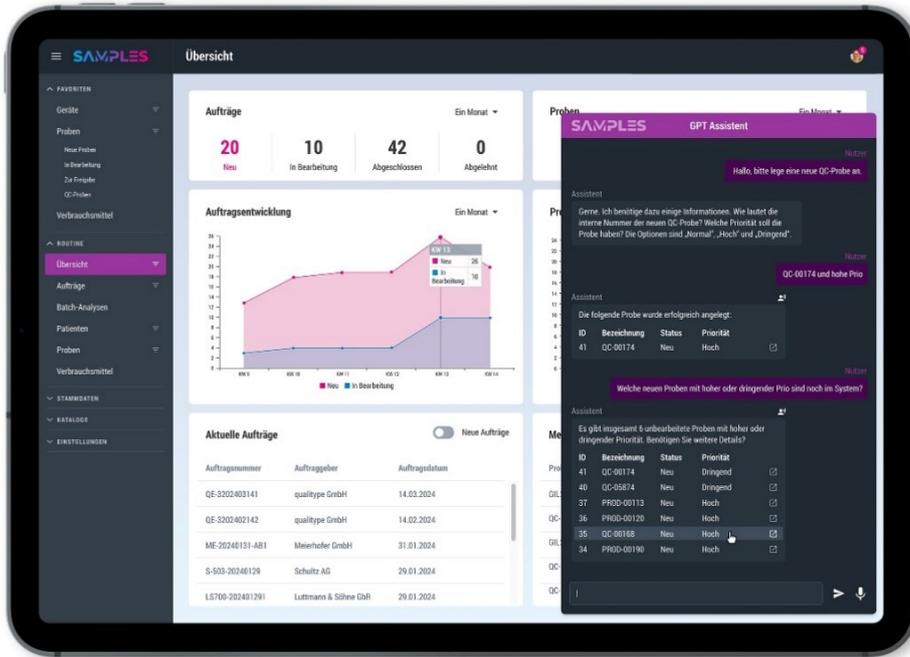


Fig. 3: SAMPLES enables the implementation of AI-based solutions – shown here is the prototype integration of an AI chat.

of the future, enabling users to manage, orchestrate, and control a wide range of processes. Such a LIMS ensures future-proof maximum performance and connectivity – even enabling the use of artificial intelligence solutions. In addition to AI applications such as pattern recognition and image processing, the integration of an AI-based chat within the LIMS is also feasible. This expands user interaction capabilities with the system, accelerates the search for relevant content, and increases overall efficiency. Desired information can then be retrieved from the LIMS via the interface

through the AI chat – or even actions can be performed directly via the application, such as creating new samples in the LIMS (Fig. 3).

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Do you have any questions or would you like to learn more about SAMPLES?



Dr. Isabell Hilger
Product Owner SAMPLES

i.hilger@qualitype.de
+49 162 7488 273

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