

# The Smart Lab: *IoT and the data-driven lab manager*

Lab managers have “always-on” roles, serving as both strategic managers and the tactical glue that holds operations together. With the movement to Smart Labs and Internet of Things (IoT) technologies, a variety of new tools have emerged to support their increasingly complex mission.

In this paper, we will explore the opportunities for lab managers to take full advantage of these technologies to meet their continuous improvement goals while expanding their strategic impact on the organization as a whole.

## Managing the flow of data

Whether it's tracking, recording, analyzing or storage, managing the flow of data is a fundamental task in science. In addition to primary experimental data, the modern lab data sphere has expanded to include employee training records, instrument calibration records, inventory data, environmental data, test protocols, and most frustratingly, test results from various instruments that do not connect with each other.

The challenges of data management are numerous – from acquisition and storage to access – because **laboratory data lives on many islands**. This virtual archipelago is comprised of some assets that are manually gathered and stored in notebooks with handwritten signatures to other streams that are completely digital. Navigating (and ultimately connecting) these islands is one of the biggest challenges organizations of all sizes face. The challenges and costs are simultaneously obvious and obscured.

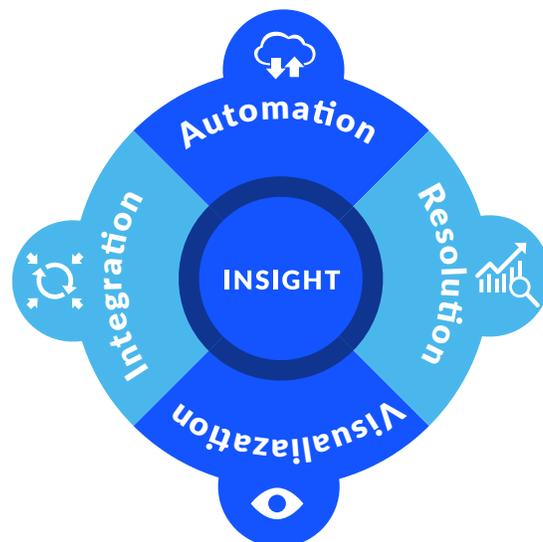
Without complete access to lab data across the

enterprise, the full value of the data isn't available to the organization. That access is hampered by two critical issues:

- **Gaps:** Whether due to lack of technology or resources, there are often massive data gaps, either in the granularity of data gathered, or an absence of other data, altogether.
- **Integration:** Lab data isn't always integrated into traditional management information systems. Whether associating training information with HR records, correlating the costs of experimental runs with finance reports, or ensuring that proper information is stored in the enterprise resource planning system - laboratory data is often segmented and not connected.

## Change is on the horizon

The concept of the Smart Lab, populated with connected, data-generating systems that range from smart instruments to intelligent sensors to analytics software, promises to exponentially increase the volume of lab-generated data by



lowering the barriers to data collection. For lab managers who bring a broad view of how to harness this new paradigm to improve operations, there is a strategic shift in how they perform their roles. If success in implementing this approach, they will need to build a framework that will further enhance operational efficiency, make more insightful and meaningful decisions, and deliver even greater strategic value to their organizations.

## Tapping the power of the Smart Lab

From the Smart Building to the Smart Home to the Quantified Self movement, IoT has brought the latest innovations in sensors, networking, and computing power to improve the places we all work and live in, as well as our overall health and fitness. The same underlying technologies are now coming to the lab, with the promise that new data from new sources will help improve and accelerate science.

*Smart Lab solutions share these capabilities:*

- **Automated Data Gathering:** Ensuring that teams have access to all the data required to optimize their work
- **High-resolution Data:** Large data sets require tools to manage, integrate and analyze effectively, and create opportunities for enhanced analysis and deeper insights
- **Visualization:** To quickly deliver visibility into large data sets
- **Integration:** To ensure that all data can be shared across systems
- **Continuous:** Round-the-clock surveillance of equipment, instrumentation, processes and environmental variables eliminates data gaps, and creates enormous new data assets
- **Comprehensive:** All equipment, environment, and processes can now be tracked and monitored without gaps
- **Centralized:** Data from various systems, equipment and workflows can be integrated and cross referenced, streamlining analysis

*Smart systems specifically optimized for the lab mean that:*

- **Valuable assets** can be monitored and protected with customized alert triggers
- **Instrument data** can now be acquired automatically and sent directly to the cloud for analysis, sharing, and storage
- **Experimental data** can be remotely monitored and more tightly controlled with instant access from anywhere
- **Deeper analysis** is facilitated and accelerated as data from multiple sources can be synthesized and scrutinized for deeper insights into patterns and relationships
- **Reproducibility** is improved when experimental results can be tracked and documented, including both experimental processes and precise environmental conditions in the research environment, which also optimizes the scale-up process
- **Reports and documentation** to support GLP and GMP accreditation are much easier to gather and maintain
- **Consumables utilization data** can be directly shared with purchasing systems, and incoming raw material data can be shared with manufacturing QA/QC teams
- **Environmental efficiency** is improved because environments and conditions can be optimized based on actual data feedback.
- **Operational efficiency** is enhanced by analyzing and optimizing actual usage and utilization patterns

## Strategic long-term value

From an investment perspective, Smart Lab systems are typically modestly priced, with the majority of the cost being in organizational planning and fore thought to fully exploit the value the systems can bring.

Rather than being viewed as overhead costs, necessary to ensure R&D or production quality, Smart Lab systems and the data they generate

enable labs should be valued for their ability to validate an organization's operational and strategic health. These systems have the power to radically transform the way science is performed, but require new thinking from lab managers and the teams they support.

### From lab manager to data strategist - Expanding the lab manager role

Smart Lab systems demand the thinking of both a data strategist and a traditional scientist, and offer the opportunity to refine both operations and experimental science. Rather than dealing with equipment or experimental failures after the fact, Smart Lab solutions can be used to predict potential failures and reduce downtime, as well as reduce labor dedicated to repetitive tasks, enabling teams to re-deploy scarce resources. With new detailed data about process execution, these same systems can provide insights to simplify laboratory processes and streamline science, altogether. The keys are to have the data and the tools to use it in powerful new ways.

## Transforming lab data management with Smart Lab technologies

A consequence of the influx of high-resolution data is a growing data management burden. This emphasizes the importance of developing strategies for acquiring, storing, tracking, accessing, integrating and safeguarding data. Not only are lab managers considering the systems and tools they need, they're creating data management strategies with an eye towards sharing critical data with key stakeholders in the lab and beyond. Both the volume and value of the data are reshaping the view of laboratory data along three vectors:

### From archival to actionable

One of the most interesting byproducts of the Smart Lab is that real-time data streams instantly transform data from an archival responsibility to an actionable asset. Real-time data means that teams know instantly if equipment is operating inside or outside of specified parameters, or if there's a situation that requires immediate attention. These insights help prevent sample loss and enable teams to schedule preventative maintenance to avoid future issues.

Real-time data changes the way teams manage data and outcomes. In the past, test results from all the steps of a workflow would simply be archived for later analysis – often because something went wrong and needed to be corrected. Constant monitoring of every step of the process, as well as the existing conditions, provides **operational metadata** about the physical environment. If leveraged strategically, this metadata can lead to actionable insights. Let's consider some real-world examples:

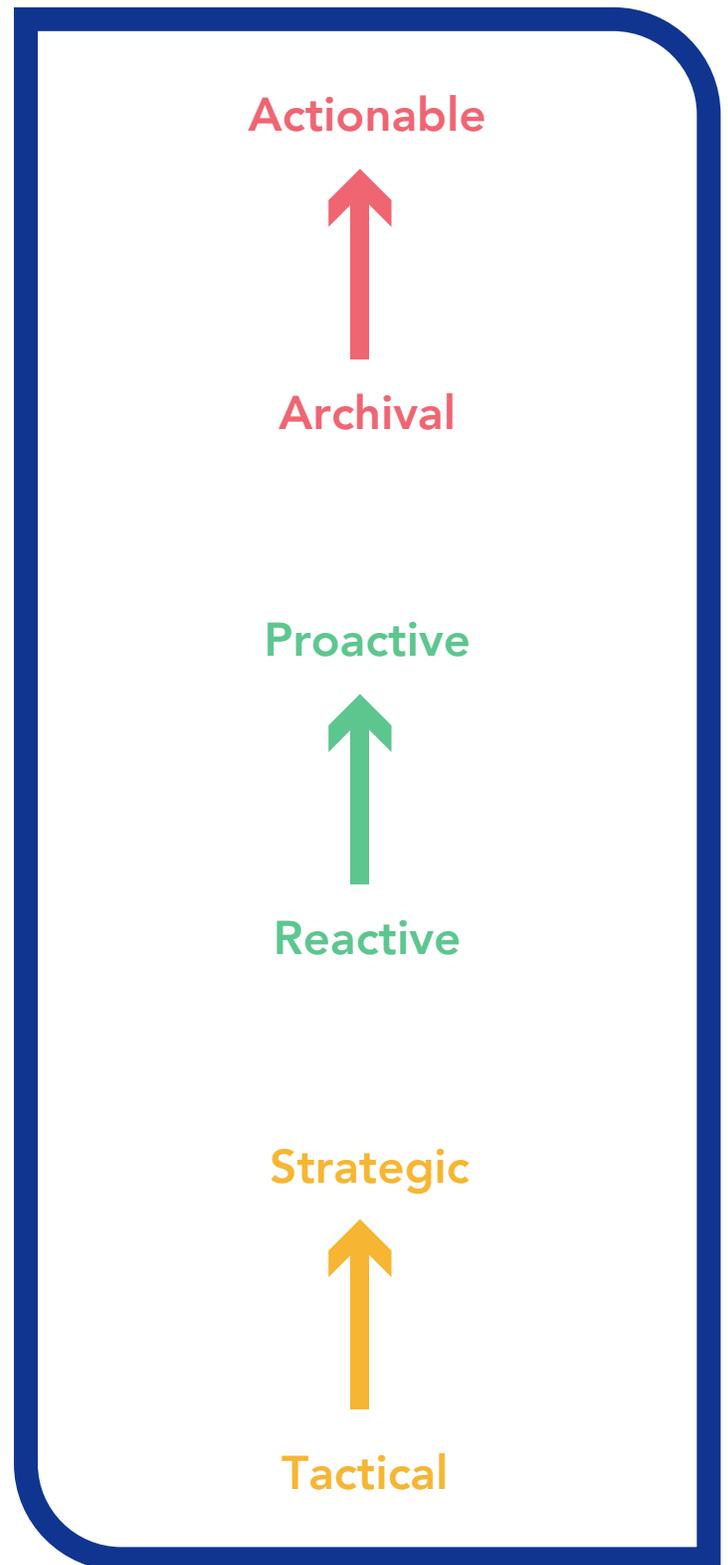
- Documenting temperature, humidity, air pressure, and light in real time enabled a materials science R&D team working on a drug-delivery coating to understand that when the ambient humidity was above 56% their process consistently failed but when it was below that threshold it would succeed
- Accessible data showing detailed equipment performance enabled a team to quickly evaluate the viability of different equipment for their GLP process, and select a cold room solution over a single freezer due to fewer deviations in room temperature
- Visualizations of -80°C freezer data over a month enabled a team to quickly assess the health of the equipment and schedule preventative maintenance

All cases illustrate the material impact of having actionable data, whether to improve efficiency or increase reproducibility.

## From reactive to proactive

Smart Labs, with data available constantly and everywhere, mean that lab managers are no longer at the mercy of events that were once beyond their control. Let's consider a few examples:

- Instruments now come with attached sensors that measure utilization, allowing the lab manager to know how much testing is being done on any given instrument
  - Forecast how much material is being consumed, how often and when the instrument should be cleaned and recalibrated, and even plan for when the instrument might need to be replaced
- Lab equipment such as ovens, freezers, and incubators can be equipped with intelligent sensor devices that continuously monitor temperature and alert designated staff when something has gone wrong
  - Enable teams to address critical situations before vital samples or materials are lost
  - Real-time visibility lets lab managers monitor ongoing equipment health, helping identify early signs of potential equipment failure by analyzing deviations from the established data patterns
- Wireless environmental sensors measure temperature, humidity, air pressure, and light conditions, giving lab managers and staff visibility into these critical variables, and helping ensure that test results are being generated consistently/not being affected by changes in these factors
- Web and mobile applications provide 24/7 access to Smart Lab data, enabling lab managers to review conditions onsite or remotely and decide whether they need to return to the lab in the middle of the night to address a potentially critical situation (i.e. power outage) or whether the situation can be resolved remotely



## From tactical to strategic

With new sources and insights, lab data is becoming even more strategic by enabling teams to make far better decisions as processes and products move into other departments in the organization.

- Continuously monitored conditions including ambient readings (temperature, humidity, pressure, light), equipment performance, instrument utilization, and resource availability allow teams to make data-driven strategic decisions around operational processes, investments in people and technologies
- QA/QC lab managers are no longer limited to providing and accepting go/no-go decisions based on a test result, but rather can start to look for patterns of failures and recommend necessary changes to mitigate/eliminate failures
- Remote access give teams from multiple locations the ability to access results collaboratively
- High-resolution data enables teams to use more sophisticated machine learning and data analysis strategies to cross-reference multiple data sources to understand more about the factors that may be influencing lab-based work

With a much broader set of tools, lab managers are poised to become **LabOps managers**, analogous to DevOps managers, using new technologies to further enhance processes and taking on a more strategic role in the organization. Like all organizational changes, these will take time, but simply taking the first steps in this direction positions teams for success going forward, and puts them far ahead of others who have yet to consider the new opportunities.

*“Smart Lab technologies give us better surveillance capabilities, enabling our team to be proactive about efficiency and continuous improvement initiatives”* reflects Lyndsey York, Lab Manager for LabCentral, a Cambridge, Massachusetts-based shared laboratory space designed as a launchpad for high-potential life sciences and biotech startups, offering fully permitted laboratory and office space comprising approximately 125 scientists and entrepreneurs. *“Having access to both real-time and historical data helps shape decisions, and is helpful in fact-checking intuition about what may be going on.”*

## About Elemental Machines

Elemental Machines is revolutionizing science-based industries with powerful, data-driven insights that help customers improve laboratory operations, research, development, and manufacturing outcomes. Continuously monitoring equipment and environmental variables provides new levels of clarity, transparency and consistency, and improved repeatability.



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