Connecting Laboratories with Data-Driven Automation Software

Automation, both digital and physical is becoming an integral part of laboratory processes and workflows. Advanced tools, instrumentation, and robotics have replaced manual, error-prone steps with automated processes requiring minimal human intervention. These developments have greatly increased laboratory throughput, allowing researchers to focus on more meaningful tasks.

Though useful, these advanced tools and new technologies can increase complexity and disrupt existing workflows. Connectivity is also a challenge for laboratories — the software in various instruments may not support a standardized, bidirectional flow of information.[1] This may prevent users from acquiring/consuming data to drive their workflow and hamper their ability to seamlessly connect physically automated systems/devices with a laboratory information management system (LIMS).

Powerful automation software can overcome these challenges and deliver the desired results by facilitating data format harmonization across different devices and systems and streamlining the communication process. The bidirectional flow of information between the various systems and instruments, supports the users in their workflows and increases data accessibility.

Thermo Scientific™ Momentum™ Workflow Scheduling Software is a software platform that enables users to efficiently define, execute, and monitor scientific processes and workflows on their physically integrated robot & instrument(s) systems.[2] The easy-to-use software possesses intelligent decision-making capabilities, powerful scheduling control, unrivalled connectivity, and flexibility — all of which contribute to its superior performance. Momentum software covers a wide range of applications and is especially suited for drug discovery and development (both large and small molecule).[3]

This guide will discuss the importance of incorporating automation software into laboratory workflows to improve the quality and efficiency of operations. We will also highlight the key features of the latest automated software available to simplify laboratory workflows.

Choosing the Right Software Solution for Your Laboratory

It is important that new additions to a laboratory increase the efficiency and throughput of workflows. Apart from superior design, it is important that the software has connectivity capabilities to support human interaction and usability. Momentum software enables higher levels of performance and reliability in a powerful yet easy-to-use visual environment. Using an array of built-in tools, the software enables autono-

mous data integration to laboratory workflows in real-time.[3]

Design

Two separate user interfaces (Dashboard and General), make Momentum software easy-to-use for both new and experienced users. The software also supports plug-in architecture, allowing quick and efficient integration of third-party tools such as data analysis and management. Plugins enable the easy integration and simple upgrade path to the most advanced laboratory automation platform on the market.[3,4]

Key Features

Software connectivity tools allow for real-time, flexible, autonomous data integration. Momentum can both receive requests from an external service and initiate requests to external services (3rd party applications). Momentum Software RESTful API receives requests from external services (e.g., LIMS, ELNs, CDS, etc) and responds accordingly (e.g., status of system, work queue progress, adding work, etc). Momentum's Unite Module initiates requests to external services (e.g., LIMS and ELNs) so the requested data (e.g., plate map containing both plate and well level data matched to specific plate's barcode) is sent to the automated system where it can be consumed, used, duplicated, manipulated, formated, and stored within Momentum for use during work execution.[2,4]

Another user-friendly feature of the Momentum software is the flowchart style of process building which makes available twelve different flow controls, which help to manage the flow of a process, ensuring maximum control of the system. Users can readily see and understand their scientific processes plus how work will be executed within the system. These flow controls can be used in conjunction with scripting action blocks also. Flow controls allow users to co-ordinate operations in parallel, set time constraints, repeat processes, and even add work to a running batch, loop, update variables in real-time, move data between wells, etc. The software assists users throughout the entire workflow to reduce rework and errors.[2]

Momentum software is equipped with various modes – normal/simulation, attended/unattended for users to develop and test protocols ahead of committing samples and use built-in error handling during production run-time. Momentum Integrated Security provides three levels of access; operator (able to run predefined workflows), expert (enables users to create workflows and edit various elements within the software) and administrators (provides user management and full access to all software features), providing maximum tiered flexibility. In addition to secure accounts, data features such as variables, expression builders, and attributes allow total control over the workflows.[4]

Momentum software can be used with other hardware solutions such as Thermo Scientific™ inSPIRE™ Collaborative Laboratory Automation Platform and the Thermo Scientific™ Vanquish™ UHPLC Loader.[5,6] The inSPIRE platform is a collaborative laboratory automation system that integrates everything required for the automated workflow in a configurable, touch-enabled, and versatile platform. The Vanquish UHPLC Loader is a dedicated device that is an intermediary robotic transferring mechanism between the Vanquish HPLC and a Momentum controlled robotic sample preparation system. End-to-end analytics workflows are realized between upstream sample preparation and downstream analysis, with little-to-no human intervention.[5,6]

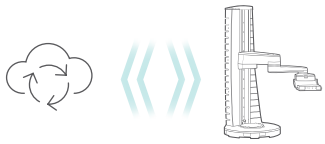
Applications

Thermo Fisher Scientific has worked with many companies, over a range of applications including:[7]

- Large molecule (antibody) upstream, downstream, formulation, and quality assessment workflows
- High throughput screening, closed-loop/secondary screening, target identification
- Automated analytical workflows incorporating HPLC & MS instruments
- Proteomics workflows
- Functional genomics
- Synthetic biology
- High content imaging
- Cell & tissue (including organoids) culture
- Enzyme-linked immunosorbent assay (ELISA)
- Next-generation sequencing (NGS) can also be supported with such advanced automation software

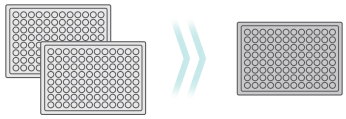
You can read an in-depth case study based on the real-life application of the Momentum software in the last section of this guide.

How it works: An example workflow where the Unite Module handles simple through multi-part/form-data

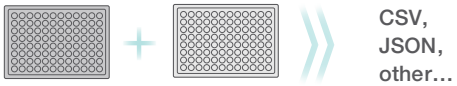


1. Unite Module requests information from external source (e.g., LIMS) via that sources API (e.g., REST, SOAP, .net, etc)

2. Transfer external information to a container



3. Copy information from one container to another



4. Data Builder formats information for Momentum or external destination compability

5. Unite Module uploads formatted information to external destination

Figure 1: A workflow of the Unite Module and how it handles simple through multi-part/form data

Optimizing the Workflow

With its advanced, flexible and user-friendly features, the Momentum software enables researchers to optimize their workflow and overcome the challenges associated with the traditional workflow.[4]

Superior Connectivity

Connecting automation systems into the data ecosystem is critical in today's modern laboratory. Connectivity also enables the synchronization of work amongst the various laboratory sites. These remarkable data capabilities of the Momentum software are facilitated through its built-in RESTful API and Unite module.

In addition to REST API, the Momentum software supports a wide variety of technologies, such as SOAP, .net binaries, SQL, and other implementations.

Advanced Functionality

In addition to its superior connectivity, the Momentum software comes with advanced functionality and flexibility. Its open instrument design enables users to integrate a variety of tracks, robots, and other movers with an ever-expanding library of over 400 different instruments. This enables researchers to create a complete system that meets the specific needs of their laboratory.[2]

Using the dynamic scheduling and intuitive process creation present in the Momentum software, users can keep track of multiple containers and individual wells throughout the entire workflow. Containers are identified using distinct attributes (such as users, date, and process step), which helps researchers select specific assay plates and pass them across to subsequent processes. In addition, the barcode feature can be used to easily locate a plate anywhere in the process.[2]

The Momentum software, with its remarkable features, supports process execution traceability and ensures data integrity to enable CFR21 Part 11 compliance. Data integrity implies that the data records are complete, intact, and maintained within their original context. Ensuring data integrity is essential for reliable and trustworthy records that can withstand scrutiny during regulatory inspections.[2]

The Momentum software also enables exceptional sample and inventory management. Inventory or "persistent" containers can be used within and across multiple workflows.

Users can attach user-defined information to containers at both the container and well level allowing for real-time process control and decision-making based on machine logic evaluation. Inventory containers can be used in all workflows – especially those which require full traceability of the sample across more than one plate (e.g., nucleic acid extraction, cell growth and treatment, etc).[4]

Ease-of-use

The simplified and streamlined dashboard display, equipped with touchscreen controls, makes the software easy to use for beginners as well as experienced users. The display contains three sections – one to monitor the system, another to simply add work, and a third to monitor the status of the run.[4]

Users can easily build workflows using the graphical drag-and-drop process editor – the process is as simple as creating a flow chart. The logic of a process can be easily managed using flow controls, which may be nested and/or used in combination to create the desired behavior. Flow controls also enable researchers to coordinate operations in parallel, set time constraints, repeat processes, and add work to an ongoing batch, with ease.[2]

The integrated system enables better instrument control and maintenance, increasing productivity. Additionally, the user-friendly interface enables instruments to be easily switched from online to offline and vice versa. Instruments can be brought offline, for manual use, maintenance, or to change instruments in the system. Laboratory staff can still access and use equipment present on the integrated system for maximum productivity. If the offline device is needed again, Momentum provides a readable, actionable prompt to bring the device back online.

Momentum software's unique design guides the user throughout process creation to maximize efficiency and uptime and reduce errors. For example, the built-in PARS (Prevent, Anticipate, React, and Solve problems) error-handling approach combines intelligent guidance during process creation, robot self-healing, runtime error mitigation, with easy and intuitive error recovery.[2]

Applying Momentum Software to Real-life Applications

The COVID-19 pandemic caused major economic and social disruptions. Laboratories across the world played a pivotal role in controlling the deadly virus and were hugely

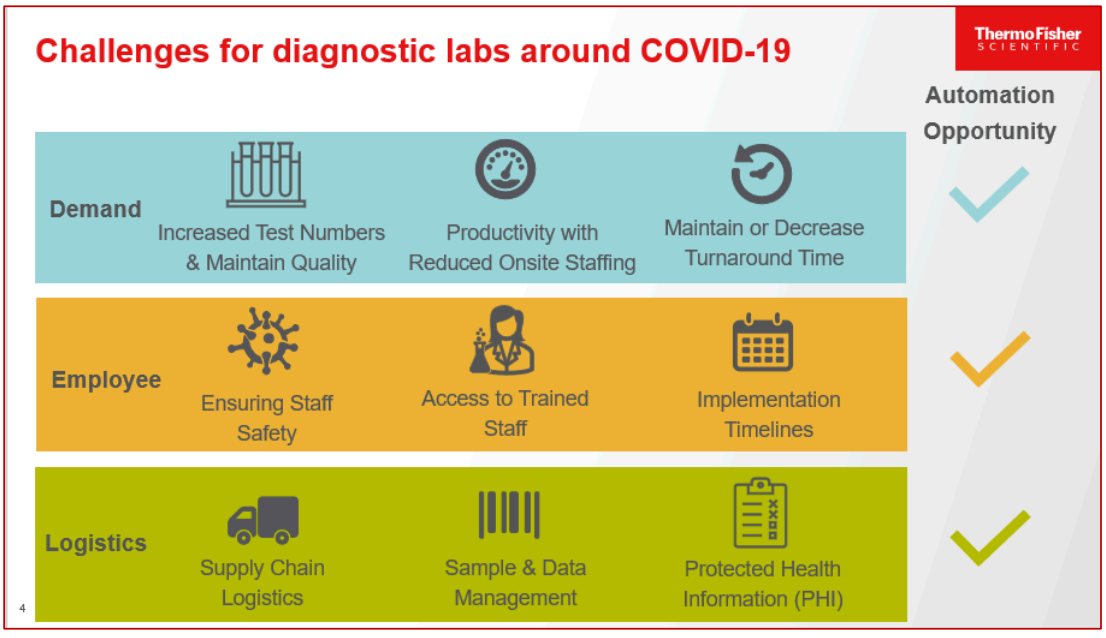


Figure 2: Challenges for diagnostic laboratories around COVID-19

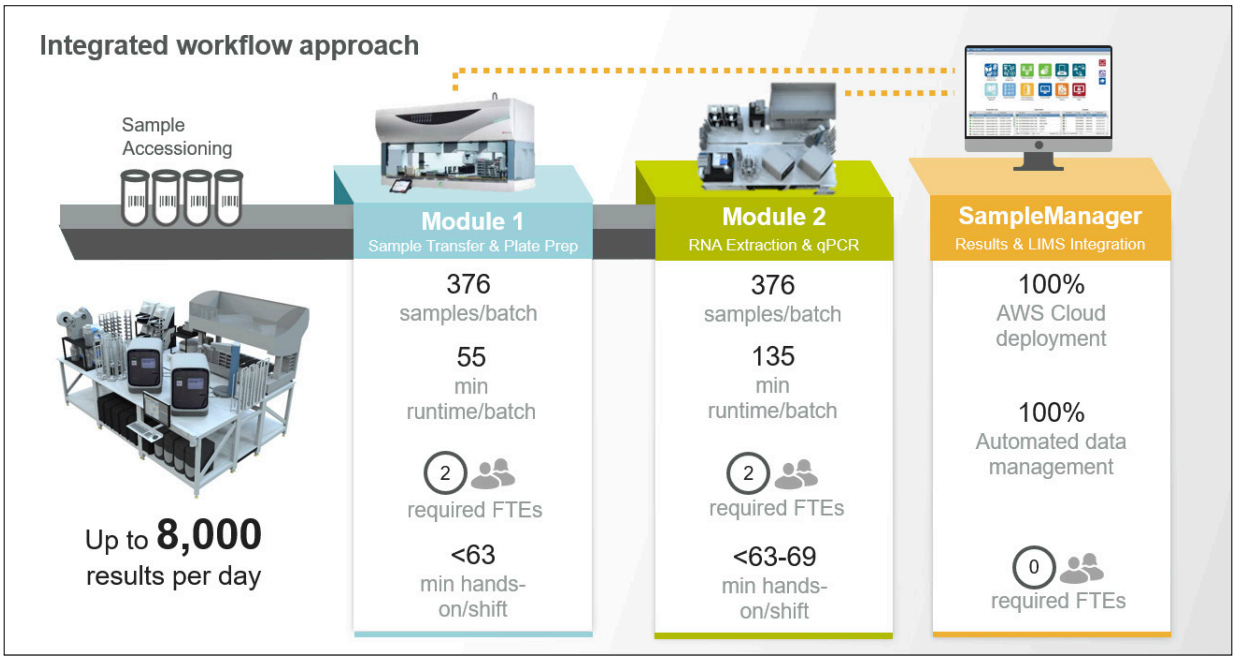


Figure 3: The Thermo Fisher Scientific Amplitude™ solution

impacted; they were required to quickly scale their existing workflow while ensuring the quality and reproducibility of their results. Laboratories faced several challenges (see figure 2) during the pandemic, including increased test demand, access to trained staff and logistics issues.

Thermo Fisher Scientific's Amplitude Solution is a new automated molecular diagnostic solution that offers maximum throughput with minimal hands-on time, equipment, and manpower. Capable of analyzing up to 8,000 COVID-19 specimens in 24 hours, this technology enabled laboratories to quickly scale up COVID-19 testing to control the spread of the virus and help communities return to work and school.

In addition to the Momentum workflow software and TaqPath COVID-10 HT kit, the Amplitude solution consists of two hardware modules connected by Thermo Scientific™ SampleManager™ LIMS Software. The SampleManager LIMS is connected to the user's Laboratory Information System (LIS), where the raw samples are received and accessioned as per the user's standardized procedure.

Module 1 – Tube to Plate transfer

Module 1 is equipped with a Tecan Fluent 1080 Liquid handler system that transfers samples from tubes to plates prepares samples for extraction on the second module. The runtime for module 1 is 55 minutes for a batch consisting of 376 samples and it can be run with just two employees (a total hands-on time less than one hour per eight-hour shift). Upon completion of its run, module one yields four 96 deep-well plates containing patient specimen, along with the reagents required to perform sample extraction. A laboratory technician will then transfer the four deep well "extraction" blocks to Module 2.

Module 2 – Extraction to result

In Module 2, the Momentum software system performs RNA extraction, qPCR, and analysis of qPCR data to evaluate whether sample tests positive, negative or needs to be retested for the presence of COVID-19 viral material.

Momentum workflow scheduling software is used to control the instruments and software devices in Module 2 and execute the associated testing workflow. The Unite module provides real-time bi-directional communication with SampleManager throughout the workflow.

Since its launch, the Amplitude Solution has been deployed in more than 100 systems worldwide. Themo Fisher Scientific has also delivered 14+ custom systems, since the pandemic, to support customers working on COVID-19

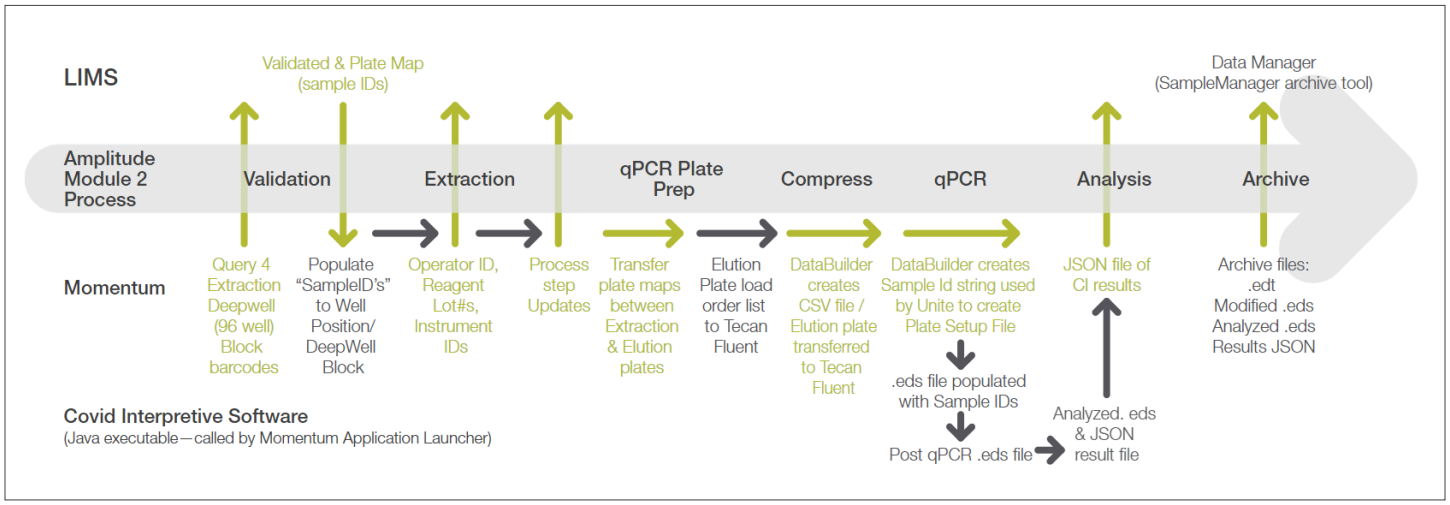


Figure 4: The workflow of module 2

across the globe. However its use extends beyond just COVID-19 research; it has also been used in other research fields such as drug discovery, drug development, and biotechnology.

Automation Is Changing Laboratory Work

Thermo Scientific's Momentum workflow scheduling software can help laboratories embrace digital transformation and streamline their scientific processes. Its unique features and intelligent data-driven decision-making capabilities facilitate dynamic connectivity allowing users to adapt easily to complex real-time conditions, revolutionizing their workflows while maintaining superior performance.

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