

# CONSECUTIVE SAMPLE WEIGHING FOR SOLUTION FORMULATION AND ANALYTICAL CHEMISTRY

## BENEFITS OF DIGITAL WORKFLOW IMPLEMENTATION OVER TRADITIONAL PEN-AND-PAPER RECORDING

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### EXECUTIVE SUMMARY

Consecutive sample weighing is a common preparatory step in many downstream analytical processes, but pen-and-paper documentation remains prevalent despite being time-consuming and prone to errors. Digital alternatives like **Laboperator** by Labforward offer a streamlined approach with **process guidance**, **automated data transfer**, and **improved workflow management**. In this application note, we compared pen-and-paper recording to a digital Laboperator workflow, and found Laboperator to be 50% more efficient. Overall, adopting digital solutions can help laboratories save time, reduce errors, and increase efficiency in executing processes.

### KEYWORDS

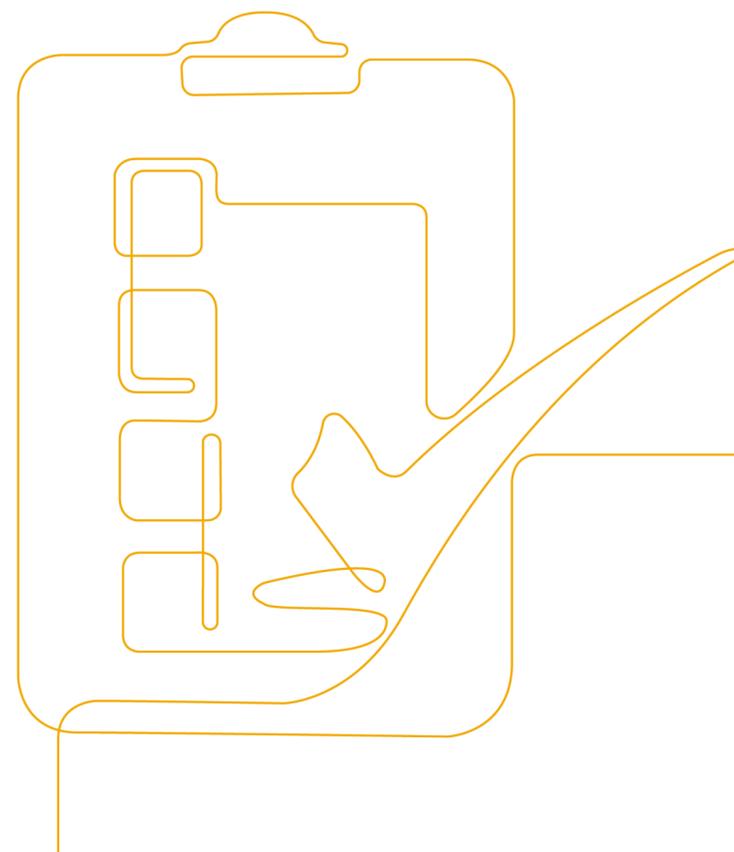
process guidance, digital workflow, automatic data transfer, data integrity, protocol automation, workflow management, laboratory execution system

Pen-and-Paper Workflow		Digital Laboperator Workflow	
+	-	+	-
<ul style="list-style-type: none"> <li>&gt; Simplicity</li> <li>&gt; Low technological requirements</li> <li>&gt; Familiarity</li> <li>&gt; Less prone to technical difficulties</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Increased risk of errors</li> <li>&gt; Limited traceability</li> <li>&gt; More time-consuming and labor-intensive</li> <li>&gt; Limited data analytics</li> <li>&gt; Reduced flexibility</li> <li>&gt; Lack of connectivity between data and devices</li> <li>&gt; Data must be manually transferred</li> <li>&gt; Poor compatibility with digital tools</li> <li>&gt; Difficulties achieving GxP compliance</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Central and traceable data storage</li> <li>&gt; Automatic and secure data transfer</li> <li>&gt; Increased accuracy and efficiency</li> <li>&gt; Improved data management</li> <li>&gt; Integration with other digital tools (ELN, LIMS)</li> <li>&gt; Cost-effective</li> <li>&gt; Vendor-agnostic: Provides connectivity to your existing equipment</li> <li>&gt; Increased adherence to GxP standards</li> </ul>	<ul style="list-style-type: none"> <li>&gt; Installation &amp; infrastructure setup</li> <li>&gt; Training effort</li> <li>&gt; More prone to technical difficulties</li> </ul>

## SCOPE

Whether you are a laboratory manager or group leader in a (1) **Quality Control (QC) or Quality Assurance (QA) Laboratory**, (2) **Pharmaceutical Company** (R&D, Production), or (3) **Industrial, Organic, or Analytical Chemistry Laboratory**; preparatory steps such as sample description, registration, weighing, and other types of characterization are necessary for a wide variety of downstream processes such as:

- > Capsule filling or tablet preparation
- > USP methods like Content Uniformity, Conformity of Mass, Dissolution Testing, etc.
- > Determination of moisture content (Loss on Drying - LoD, Loss on Ignition - LoI)
- > Formulation of recipes for Research & Development
- > Solution preparation for media, titration, reference standards, etc.
- > Chromatography and spectroscopy techniques:
  - > HPLC, GC
  - > MS, NMR, UV-Vis/IR Spectroscopy
- > And many more...



## COMMON PROBLEM

Despite the high frequency with which scientists must carry out these preparatory steps, many laboratories still rely on arduously recording data by pen-and-paper. Data is then manually transferred from a paper document (a batch record, for example) to a digital format for downstream calculations and analyses. Not only is this process **time-consuming** but it is also prone to **transcription errors** which can negatively **impact data integrity**. Furthermore, as laboratory personnel face intense pressure to produce results, synthesize products, and decrease time to market, any time that can be saved or inefficiencies that can be eliminated from experimental workflows, via a digital alternative, is worth considering.

Therefore, to provide a concrete comparison between a typical pen-and-paper workflow and a digital alternative, we've compared both processes in terms of accuracy, efficiency, and data management and discussed the pros and cons of each practice. Here, we focus on consecutive sample weighing, keeping in mind that many of the discussed advantages and disadvantages extend to a variety of other protocols.

## USE CASE DESCRIPTION

Consecutive sample weighing is a commonly used technique in laboratories where **precise** and **accurate** measurements of small quantities of substances are required. Particularly in the analysis of **active pharmaceutical ingredients** or other **small molecule compounds**, repetitive sample weighing is used to ensure that the mass of each sample is determined correctly, without the introduction of errors or contamination between samples. Additionally, as weighing is the first step in many downstream protocols, any errors made at this point can propagate through the rest of the process and have a profound impact on experimental outcome or product quality. With this in consideration, utmost care must be taken to ensure the integrity of multi-sample weighing procedures.

The current status of many multi-sample weighing protocols includes manual registration of the sample, manual recording of the sample's mass (often by pen-and-paper), followed by manual entry of each sample's mass with the corresponding sample ID to an electronic format. Not only are these manual tasks **prone to human error**, but they also reveal room for improvement, particularly in regard to their **lack of efficiency**. As an alternative, digital solutions should be considered, as they can provide a more **error-resistant**, **time-efficient**, and **streamlined** approach.

Particularly, it is only once analog data is transferred to a digital format, that it can be used for calculations and downstream analysis. This task becomes particularly burdensome as sample batches scale in size. Therefore, one distinct benefit that digitalized workflows offer is the ability to **automatically record data**, and **transfer it from an instrument to a digital platform** (such as an electronic laboratory notebook (ELN) or laboratory information management system (LIMS)), all while keeping the mass measurement together with the associated meta-data of the sample (i.e. sample ID, batch number, synthesis information, etc.). Not only do digital approaches save the user time, via automatic data transfer, but they also reduce human error by minimizing the number of manual steps and increase traceability.



**Figure 1:** A sequential weighing workflow carried out via the Laboperator interface.

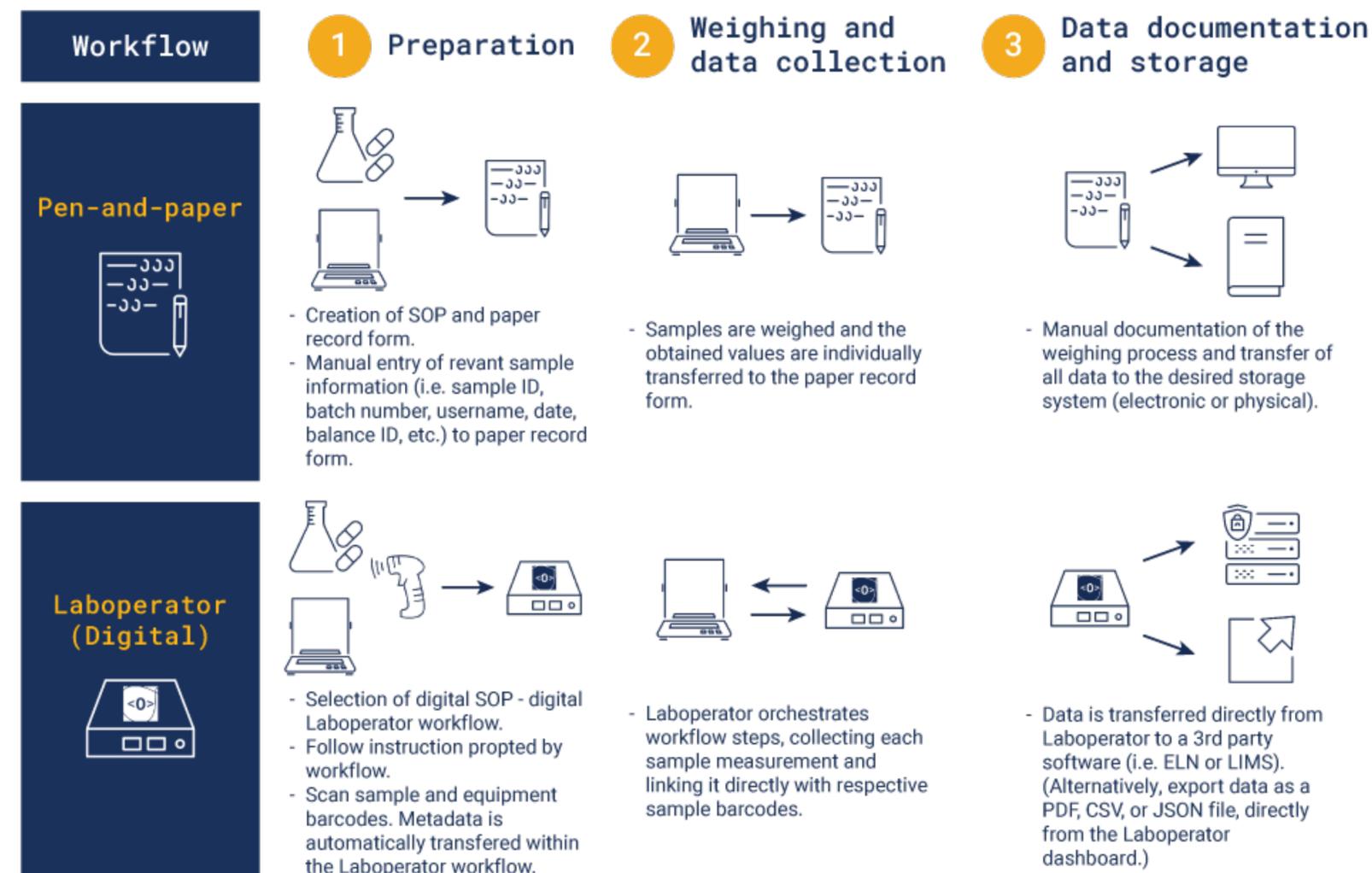
## LABFORWARD'S DIGITAL SOLUTION

One such digital solution is our Laboratory Execution System (LES), **Laboperator**. Laboperator is a digital solution consisting of a web application, a hardware component – the Connector Box, and a companion app – the Workflow Editor. The Laboperator Connector Box allows its users to connect their laboratory equipment in a vendor-agnostic manner. The Laboperator Workflow Editor allows users to build customizable laboratory workflows specific to their own experimental needs. The Laboperator web application allows users to control laboratory devices remotely, display and analyze output from several instruments, and seamlessly export data to other software in a tamper-proof manner (i.e. to an ELN or LIMS).

## WORKFLOW SUMMARIES

In general, whether documented by pen-and-paper or digitally, a conventional consecutive sample weighing workflow can be divided into three major steps (**Figure 2**):

- 1. Preparation:** Corresponds to the preparatory substeps necessary before the actual weighing process takes place. This may include the creation of an entry or protocol template to be followed, and selection and registration of the required samples and equipment.
- 2. Weighing and data collection:** The iterative process of weighing samples and recording data.
- 3. Data documentation and storage:** Completion of process documentation, transfer of data to storage destination (physical or digital), and/or further processing and analysis.



**Figure 2:** Procedure summaries for pen-and-paper and digital Laboperator sequential weighing workflows.

## WORKFLOW COMPARISON

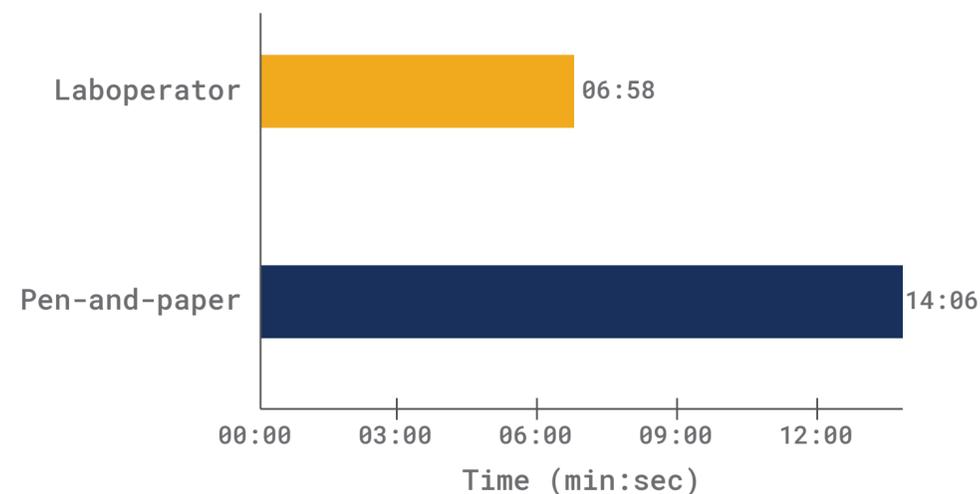
To provide a more precise comparison between a typical pen-and-paper workflow and our digital Laboperator workflow, the processes were tested side-by-side in a real-case scenario. A detailed description of the procedures and workflow steps can be found in Figure 2.

Briefly, each workflow consisted of consecutively weighing 20 samples (tablets of ~1g), utilizing the same balance. To quantitatively compare the efficiency of pen-and-paper and digital workflows, the total time spent to complete each procedure (including all preparatory, data collection, and documentation steps) was measured. For this purpose, one person performed the workflow steps while another timed each process. Additional measures, such as accuracy, traceability, flexibility, ability to transfer meta-data, and presence of an audit trail, were also examined for qualitative comparison.

## RESULTS

### Efficiency:

The digital Laboperator workflow was completed in 6 minutes 58 seconds, while the pen-and-paper workflow took 14 minutes 6 seconds (Figure 3). **The Laboperator workflow, therefore, improved overall efficiency by around 50% in comparison to the conventional pen-and-paper workflow.**



**Figure 3:** Efficiency comparison between pen-and-paper and digital Laboperator workflows.

### Productivity:

To provide an outlook regarding how this increase in efficiency could translate to increases in productivity and cost-savings, we estimated how many tablets employees could weigh per (8-hour) workday with the pen-and-paper protocol and with the digital Laboperator protocol, and determined the following:

- > **Pen-and-paper Workflow:** 680 tablets/day
- > **Digital Laboperator Workflow:** 1,378 tablets/day

Next, if we assume two equally skilled and equally compensated (\$20/hour) employees are each given batches of 500 tablets to weigh, we would discover the following:

- > **Employee using Pen-and-paper Workflow:** ~6 hours/batch (\$118)
- > **Employee using Digital Laboperator Workflow:** ~3 hours/batch (\$58)

Lastly, assuming the employees are asked to repeat this sample batch weighing protocol once per week for an entire year, the following cost savings would be achieved via the digital Laboperator Workflow:

- > **Annual compensation for Pen-and-paper Workflow runs:** \$6,136/year
- > **Annual compensation for Digital Laboperator Workflow runs:** \$3,016/year

Clearly, the impact of these time and cost savings, particularly once scaled across all of a laboratory's personnel and processes, are manifold.

### Accuracy:

The pen-and-paper workflow relies heavily on manual data entry, which increases the risk of errors due to illegible handwriting, transcription mistakes, and data transfer or calculation errors. On the contrary, digital Laboperator workflows reduce the risk of human errors, since data is retrieved, processed, and stored automatically. This can help improve the accuracy and reproducibility of laboratory data and reduce (and in some cases eliminate) the risk of mistakes that could lead to invalid or incorrect results.

**Traceability:**

The digital Laboperator workflow provides better traceability of samples, materials, and data throughout laboratory processes, which facilitates quality control, auditing, and promotes regulatory compliance. Moreover, the Laboperator’s **audit trail feature** provides a complete record of all data entries, changes, and deletions, which helps ensure the integrity and authenticity of data (i.e. when and which actions were performed, by whom, and on which equipment). In comparison, traceability is not ensured in the pen-and-paper workflow since paper-based records are prone to loss, damage, or tampering.

**Metadata transfer:**

In the digital Laboperator workflow, metadata from your sample is automatically transferred and stored, eliminating the need for time-consuming and labor-intensive manual data entry present in the pen-and-paper workflow. Furthermore, this simplifies management and analysis of large amounts of data. Automated metadata transfer can also facilitate better collaboration and data sharing between different teams or departments within a laboratory or across different organizations.

**Flexibility:**

The pen-and-paper workflow is limited in terms of adaptability, scalability, and data sharing. Conversely, the digital Laboperator workflow is more flexible and adaptable to changing laboratory needs and processes, allowing for easier modification and optimization of laboratory workflows.

METRIC	PEN & PAPER	DIGITAL
 <b>Efficiency</b>	Low (~14 min turnaround time)	High (~7 min turnaround time)
 <b>Productivity</b>	Low - Excess time spent on process documentation efforts	High - Streamlines and automates process documentation efforts
 <b>Accuracy</b>	Low - Prone to human error	High - Greatly reduces transcription and data transfer errors
 <b>Traceability</b>	Not ensured	Ensured
 <b>Audit Trail</b>	No	Yes
 <b>Metadata Transfer</b>	Limited - must be manually entered on paper record form	Automatically transferred and stored
 <b>Flexibility</b>	Limited	Highly customizable

**Figure 4:** Comparison of success metrics between pen-and-paper and Laboperator workflows.

## CONCLUSION

Here we have demonstrated the key advantages of a digital Laboperator workflow over typical pen-and-paper recording, by testing the performance of both approaches in a consecutive sample weighing use case. In particular, we have shown the capacity of Laboperator to enhance process efficiency (up to 50%) and increase productivity while reducing error risk, due to automated data transfer and storage, which simultaneously ensures high data integrity. Moreover, due to its flexibility, Laboperator can be tailored to meet the specific needs of the laboratory, allowing for greater control and oversight of processes.

Overall, the advantages of adopting digital workflows outweigh those of pen-and-paper workflows. However, a comprehensive evaluation of the pros and cons of each process must be conducted to make an informed final decision. If you're interested in digitalizing your laboratory's workflows, reach out to our team for a discovery call.

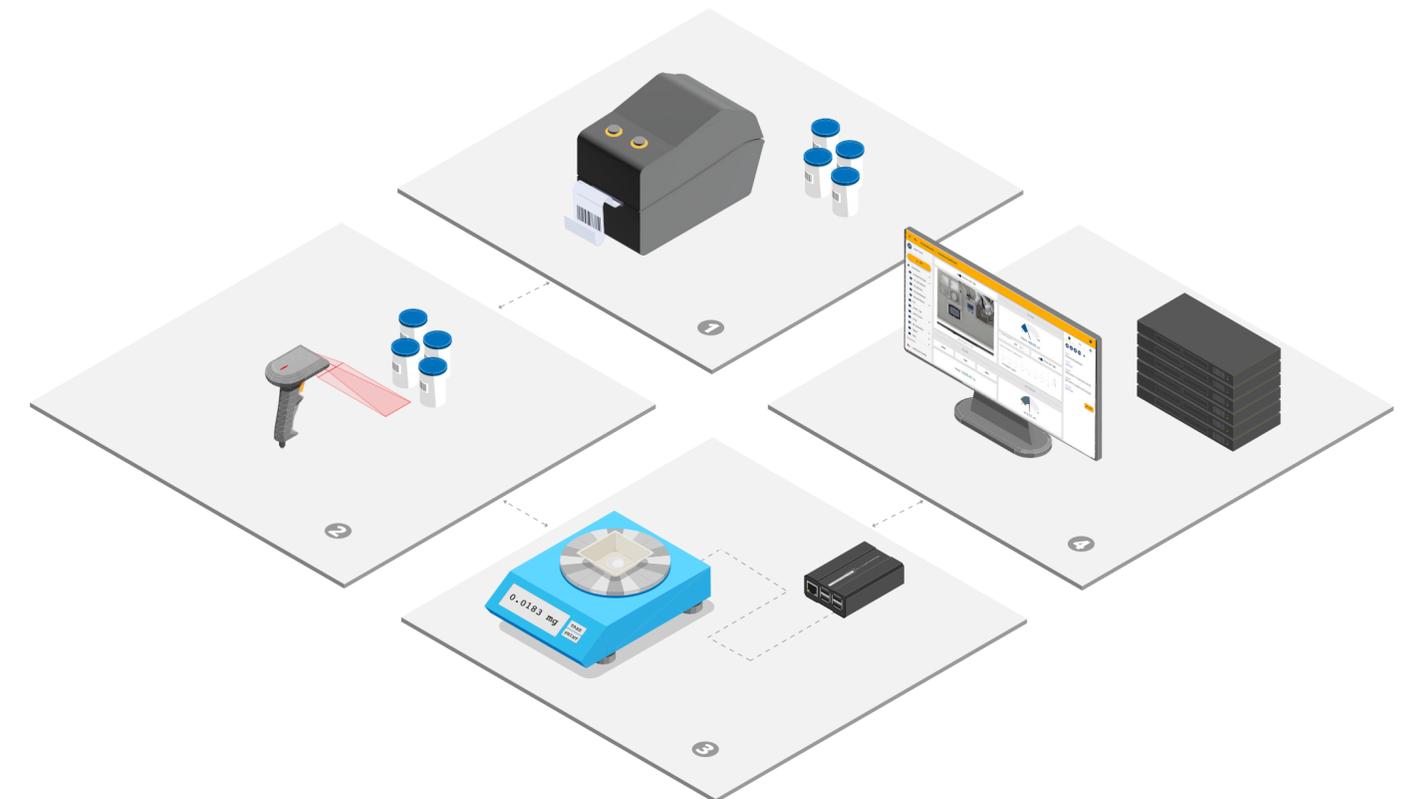


Figure 5: Modular steps utilized in Laboperator's consecutive weighing workflow.