White paper
Maximizing capacity and throughput with continuous flow
Continuous flow brings enhanced flexibility and productivity to histology

Research shows Anatomic Pathology (AP) labs can achieve maximum capacity, protocol flexibility and throughput by adopting technology with continuous flow capabilities that facilitate the elimination of batch processing. However, most automated staining instruments do not support continuous flow – many require batching in drawers of five, ten or more, which may limit protocol flexibility, loading and unloading, and overall capacity. Only the VENTANA BenchMark ULTRA IHC/ISH platform allows labs to process slides individually using “drawers of one” for continuous loading and enhanced productivity. For that reason, it provides a key illustration on the importance of continuous flow in automated IHC/ISH staining.

To quantify the benefits, Lean workflow experts from Ventana studied the metrics of several labs representing a mix of advanced staining technologies and manufacturers, including the BenchMark ULTRA platform and its leading competitors.* This paper summarizes the results of their research and provides insight into how labs can maximize flexibility and throughput using continuous flow (also known as single piece flow) for IHC/ISH staining.

* Data for this analysis is aggregated from six laboratories. Among them, one lab uses only Ventana instruments; one lab uses only Leica instruments; one lab uses both Ventana and Leica instruments; one lab uses Ventana instruments in conjunction with Leica and Dako instruments; and the remaining labs use a combination of Leica and Dako instruments only. Because the Leica and Dako instruments included in this analysis require batching in drawers of ten and five respectively, data comparisons in this study focus on those batch sizes, though it is worth noting that some advanced staining instruments require even larger batch sizes.
Individual slide drawers enable maximum drawer utilization throughout the day

When instruments allow technicians to stain slides individually – one slide per drawer, each with its own temperature control and full protocol options – the lab has the opportunity to achieve and maintain maximum capacity for every slide drawer. Each time a slide is ready to come off, another slide can replace it immediately while the run continues for all other slides as needed. This ability to reach 100% drawer capacity with only one slide eliminates the need to choose between running the instrument at suboptimal capacity or delaying the run until more slides are ready.

By contrast, instruments that require batches of five, ten or more slides per drawer often offer decreased capacity in many real-world applications. All slides in the drawer must run a similar protocol or have other restrictions, and often these protocol flexibility issues necessitate runs with drawers operating at less than full capacity. For example, a single STAT sample will require the use of an entire drawer if its protocol does not match that of other slides to be batched. With one slide per drawer (as with the BenchMark ULTRA platform), a single slide is all that is required to reach 100% drawer capacity. With a five-slide drawer (such as the Dako Omnis instrument), a single slide translates to 20% drawer capacity; with ten slides per drawer (such as the Leica BOND instrument), one slide translates to 10% drawer capacity (see Figure 1). When drawers are not filled to capacity, the result is suboptimal instrument utilization, which leads to suboptimal throughput. In instruments where the drawer is designed to hold multiple slides, the use of a single slide in a drawer negatively affects capacity.

**Individual slide drawers deliver optimal capacity**

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<thead>
<tr>
<th>Number of Slides</th>
<th>BenchMark ULTRA drawers of one</th>
<th>Dako Omnis drawers of five</th>
<th>Leica BOND drawers of ten</th>
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<tr>
<td>1</td>
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Figure 1: Individual slide drawers enable maximum drawer and instrument capacity with every slide, allowing continuous loading and unloading of single slides throughout the day.

The continuous loading capability of the BenchMark ULTRA platform enables technicians to operate the instrument at maximum capacity by adding and removing slides without impacting workflow – no delays or disruptions to in-process slides, even for urgent, unexpected, or late arriving samples. Individual slide protocol flexibility also enables ISH samples to run alongside IHC, resulting in the ability to change out IHC while simultaneously continuing the ISH stains, which take 3-7 hours longer than IHC. In this situation, individual heater pads and protocol flexibility enable technicians to put any slide in any available drawer without compromising in-process slides and still enable protocol optimization for each slide being added.
Individual slide drawers deliver up to five to ten times greater protocol flexibility per run

Because the individual slide drawers of the BenchMark ULTRA platform enable technicians to select a different protocol and temperatures for each slide, protocol flexibility is also maximized. With one slide per drawer, labs have the flexibility to select as many as 30 different protocols at once – one per drawer – compared to batching instruments and processes that can lead to protocol restrictions within each drawer. The more slides it takes to reach maximum drawer capacity, the more likely there will be fewer protocol options available per run. In other words, protocol flexibility increases as the number of slides needed to reach maximum drawer capacity decreases.

Instrumentation drives process improvement for optimized workflow and throughput

Of the labs participating in this study, only those using the BenchMark ULTRA platform with continuous flow processes can consistently achieve full capacity for each slide drawer and instrument throughout the workday, filling every slide drawer in the morning and staying full all day. Labs that batch fall short in this regard; the actual capacity used with batching ranged from 54-83%, with a combined average of 74%. Furthermore, these suboptimal actual capacity rates may still come with tradeoffs in the form of decreased protocol optimization, as efforts to increase drawer utilization could lead to suboptimal protocol flexibility and quality. Differences in each lab's internal processes account for variations in actual capacity used, but Figure 2 illustrates the averages observed across the sample of labs that participated in this study.

Continuous flow helps labs achieve maximum instrument capacity

![Figure 2: Aggregate data shows labs using the BenchMark ULTRA instrument with continuous flow processes can achieve maximum capacity; by comparison, labs using batch processes on Leica and Dako instruments leave, on average, 26% remaining capacity unused.](image)

It should also be noted that laboratory process improvement is critical to facilitating the gains made possible through continuous flow technology. Single slide drawers combine with continuous flow processes to help labs perform IHC/ISH staining at 100% capacity at all times, compared to the leading competing instruments which do not support continuous flow and therefore return an average actual capacity used of only 74%.
Of the labs participating in this study, those using the BenchMark ULTRA platform reported faster slide sorting and loading times – a savings of 15 minutes compared to labs that batch for staining. The reason is simple: with individual slide drawers and protocol flexibility, technicians no longer needed to spend time figuring out which slides can and can't be batched with others. This reduced the total time for slide sorting, loading and unloading to one hour – compared to 1.25 hours with batch processes – which translates to increased productivity and higher throughput. Labs with multiple instruments sometimes have internal processes that require technicians to sort, not per batch, but per instrument to manage workflow across instruments designated for certain assays and reagents.

One lab in particular (“Lab A”) shed the most light on throughput capabilities of continuous flow versus batching. At an average volume of 54,000 slides per year (SPY) with no overnight shift, Lab A uses continuous flow processes with its four BenchMark ULTRA instruments to complete an average of 225 slides each day. They also use two Leica BOND instruments to batch slides together in three trays with 10 possible slides on each tray, resulting in additional throughput of only 59 slides per day, on average. When dividing these throughput totals by the number of instruments used to achieve them, the results show that Lab A processes an average of 56.25 IHC/ISH stains on each BenchMark ULTRA instrument per day, compared to an average of 29.5 IHC/ISH stains per day on each Leica BOND instrument. That represents a 91% increase in throughput when using continuous flow processes and instrumentation compared to batching.

Maximum capacity results in maximum throughput

20% less time spent sorting and loading

91% higher throughput with continuous flow
To accommodate STAT requests as expeditiously as possible, some labs want to “hold” a drawer for urgent requests only. With the 30 individual slide drawers of the BenchMark ULTRA platform, labs can do exactly that with only a very modest impact on overall productivity. Even with one drawer not in use except on STAT orders, 29 other slides can be run at all times with full continuous flow capabilities. With batch processing instruments, the impact on throughput is much greater because one drawer equals five, ten or more slides (depending on the instrument design), so holding a drawer would essentially decrease the run to a 20 or 25 slide maximum, or fewer where batching exceeds ten slides.

This loss to throughput makes it impractical for labs that batch to reserve space for STAT orders. Therefore, technicians cannot move ahead with STAT requests until a drawer built for a new batch becomes available. With drawers of one, on the other hand, labs can place STAT slides in drawers immediately or as soon as the next slide in the run is complete.

Further conclusions on throughput can be drawn by comparing Lab A to another lab in this study (“Lab B”), where batch processes are used with ten Leica BOND instruments and two Dako Autostainer instruments to run 89,000 SPY. Batching predominately in drawers of ten, Lab B completes an average of 275 slides per day (including a third shift for overnight runs) across all twelve instruments. Compared to Lab A’s achievement of nearly 225 slides on average using only four BenchMark ULTRA instruments, the impact of continuous flow on throughput is clear: one BenchMark ULTRA instrument with continuous flow can deliver slide throughput roughly equal to that of two batching-based instruments (see Figure 3).

Continuous flow helps labs maximize throughput per instrument

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Continuous flow allows labs to reserve a STAT drawer with minimal impact on throughput

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With lab capital expenditures falling and lab consolidation rising, today’s innovative labs are seeking technologies that support Lean processes and provide the necessary flexibility to do more with less. Many of these labs employ single piece flow processes elsewhere in the lab but are forced by their instrumentation to batch at the point of IHC/ISH staining. Building on the concept of single piece flow as a tenet of Lean lab operations, the BenchMark ULTRA platform drives and supports continuous flow with individual slide controls, unlike the leading competitors. In reviewing the details of this analysis, it is clear that with the BenchMark ULTRA platform, labs need fewer instruments to reach daily throughput goals. For a lab to truly be successful in maximizing throughput, it is necessary to adopt internal processes that support the continuous flow capabilities made possible through instrument design.

In general, lab personnel express greater satisfaction with instruments that allow higher productivity and protocol flexibility through individual slide staining. They appreciate the ability to mix and match assays, the sensors that facilitate URA, flexible protocol optimization, and the many ways continuous flow supports the overarching mission in cancer diagnostics and anatomic pathology.

Conclusion

Sharing reagents between instruments complements continuous flow. When asked about other benefits of the BenchMark ULTRA platform, labs participating in this study cited efficiency gains from another innovative feature: Ultimate Reagent Access (URA). URA enables access to reagents at frequent intervals, alerting technicians to needed reagents and allowing the changing of reagents as needed. This helps keep workflow on track.