



# Bridging the Gap: The Emerging Middle Ground Between Manual Pipetting and Laboratory Automation

## Accelerated Workflow Without Robotic Complexity

A Strategic Whitepaper by Axon, Craig Funnell

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For laboratory managers, molecular diagnostics professionals, NGS workflow specialists, and scientific distributors navigating the operational realities of modern laboratory environments.

*"Innovation is not always about replacing the human hand. Sometimes it is about empowering it with greater speed, consistency, and control."*

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### Executive Summary

Modern laboratories are caught between two inadequate extremes. Manual pipetting — the bedrock of laboratory technique for decades — is increasingly insufficient for the throughput demands, consistency requirements, and staffing realities of today's life sciences environment. Yet full robotic automation, often positioned as the natural solution, carries a complexity, cost, and rigidity burden that places it out of reach for the vast majority of working laboratories.

This whitepaper argues that there is a third path — one that has been underarticulated and underserved. Between fully manual and fully automated lies a growing category of **hybrid, guided liquid handling**: a model in which intelligent, semi-automated tools accelerate human workflows without replacing them. This is not a compromise. It is an architectural choice — one that delivers real throughput gains, measurable consistency improvements, and meaningful operational benefits while remaining accessible to the labs where most of the world's scientific work actually happens.

The following pages define this emerging model, examine why it is becoming the operational norm for forward-thinking laboratories, and explain how Axon PlateWizard™ platform represents its most practical implementation.

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# 1. The Laboratory Throughput Challenge

## A Profession Under Pressure

The modern laboratory operates under a set of compounding pressures that did not exist in the same configuration even a decade ago. Sample volumes are rising. Testing panels are expanding in complexity. Turnaround time expectations — driven by clinical urgency, regulatory timelines, and competitive contracting — have compressed considerably. And yet the human workforce available to absorb these demands is not growing proportionally.

The global liquid handling system market was valued at \$5.1 billion in 2025, growing at approximately 8% annually — a figure that reflects both the scale of the underlying problem and the urgency with which laboratories are seeking solutions. The demand for automation in laboratories to enhance efficiency, accuracy, and throughput has become one of the primary drivers of this expansion, as laboratories must process hundreds or thousands of samples per day with consistent precision.

## The Staffing Reality

Laboratory staffing shortages represent one of the most persistent structural challenges in the life sciences sector. The problem predates recent disruptions: a decades-long shortage of qualified medical technologists and licensed technicians has left many institutions chronically understaffed, with experienced personnel managing workloads originally designed for larger teams. Frequent sick calls due to mental fatigue, retirements of seasoned staff, and an inability to attract qualified technologists to meet the demands of increasing test-ordering patterns have been widely documented.

The implications for pipetting-intensive workflows are direct. When a single technician is responsible for processing plates of 96 or 384 samples across multiple assay steps, the cognitive and physical burden is substantial. Research indicates that over 300 hours of pipetting per year — which corresponds to just one to two hours a day — significantly increases the risk of musculoskeletal disorders and repetitive strain injuries. A single person may perform pipetting motions thousands of times in a single working day, and if pipetting for more than four hours a day, the risk of repetitive strain injury becomes clinically significant.

## Where Efficiency Breaks Down

The compounding effect of throughput pressure and staffing constraints is predictable: workflow inconsistency. When fatigued operators perform repetitive liquid transfer tasks at the limits of their capacity, pipetting technique degrades. Volume accuracy drifts. Step-timing errors accumulate. The result is not merely inefficiency — it is variability that affects assay

outcomes, creates downstream rework, and ultimately undermines the reliability that laboratories are built to deliver.

These are not edge-case scenarios. They are the operational reality of a significant proportion of molecular diagnostics labs, NGS facilities, HLA typing centres, and mid-throughput research institutions operating today. The question facing laboratory leaders is not whether to address this reality, but how.

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## 2. Why Full Automation Is Not Always the Answer

### The Promise and the Gap

Full robotic laboratory automation carries an undeniable appeal. The promise of hands-free sample processing, consistent execution across unlimited volumes, and theoretically unlimited scalability addresses the throughput challenge in a compelling theoretical frame. For very-high-volume facilities — reference laboratories, major pharmaceutical screening operations, large clinical core labs — total laboratory automation (TLA) can deliver meaningful returns.

However, academic analysis of TLA implementation consistently finds that the capital investment is substantial, and that payback periods depend heavily on volume assumptions that most laboratories cannot confidently sustain. A financial analysis found that considering only staff cost reduction, it was anticipated that 4.75 years would be needed to pay back the initial investment in total laboratory automation — and that figure assumed stable high-volume throughput. For mid-throughput or variable-demand environments, the economics deteriorate further.

### The Five Barriers to Robotic Adoption

For the majority of laboratories operating in the real world, full automation encounters five structural barriers that are rarely resolved by vendor roadmaps:

#### 1. Capital Cost

Full robotic liquid handling systems represent a significant upfront commitment. Beyond the instrument itself, integration requires infrastructure upgrades, software licensing, validation costs, and often physical laboratory redesign. For smaller labs and scaling research facilities, high initial capital investment remains a defining restraint, and integrating new automation systems with legacy instruments and laboratory information systems adds layers of complexity and expense.

## 2. Implementation Timeline

Robotic platforms do not become operational on delivery. Workflow redesign, validation requirements, and protocol development add weeks or months to the deployment timeline. For laboratories already operating under throughput pressure, the transition period creates a capacity paradox: the system purchased to solve a throughput problem temporarily worsens it.

## 3. Training and Expertise Requirements

Operating, maintaining, and programming robotic liquid handlers requires specialised technical competency that most laboratory teams do not have at hire. Implementing automation requires retraining laboratory personnel, and resistance to change and concerns about role redefinition can affect institutional adoption. When the trained operator is absent — through illness, turnover, or reassignment — the system's utility is often entirely lost.

## 4. Operational Rigidity

Robotic platforms are optimised for defined, repeatable workflows at scale. The real-world laboratory, however, operates with frequent protocol variations, kit changes, and adaptive assay modifications. The flexibility required to manage this variability is precisely what rigid automation architectures are least equipped to provide. Automation solutions must be ultra-flexible to handle the vast variation encountered in specialised labs on a daily basis — a requirement that standard robotic platforms often struggle to fulfil cost-effectively.

## 5. Space and Infrastructure Constraints

Modern laboratory space is at a premium. Many facilities operating in hospital systems, research institutions, or diagnostic settings were not designed with large robotic workstations in mind. The physical footprint of a full liquid handling system — including access zones, ventilation requirements, and safety clearances — is a practical barrier that rarely features in vendor demonstrations but consistently emerges in real-world procurement decisions.

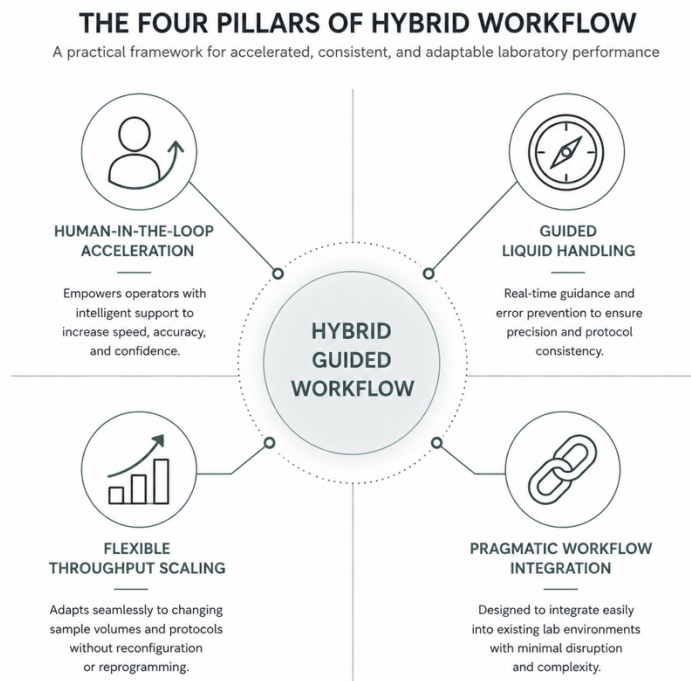
## A Structural Mismatch

The most important point is not that full automation is inferior. For the right volume, the right setting, and the right institutional context, it remains the appropriate solution. The structural problem is that full automation was designed for a laboratory profile that describes a minority of the world's active labs. The majority operate at mid-throughput, with variable demand, lean staffing, and constrained resources. For this majority, the conventional automation narrative does not fit — and a different framework is needed.

### 3. The Emerging Hybrid Workflow Model

#### Naming a New Category

There is a conceptual space between manual pipetting and full robotic automation that has long existed in practice without being clearly named. Laboratory professionals have always developed informal strategies to accelerate their workflows: structured plate templates, colour-coded positioning aids, workflow checklists, multi-channel optimisations. These are instinctive attempts to achieve what might be called **guided liquid handling** — the application of structured support to human-executed tasks in order to reduce error, increase speed, and lower cognitive burden.



What is new is the emergence of dedicated technology architectures built specifically to operationalise this concept. Rather than replacing the human operator, these systems function as an intelligent partner: providing real-time visual guidance, step-by-step workflow orchestration, and error-prevention mechanisms that extend the operator's capabilities without requiring robotic infrastructure.

This emerging model can be defined by four core characteristics:

#### The Four Pillars of Hybrid Workflow Acceleration

##### Human-in-the-Loop Acceleration

The operator remains central to the workflow — not as a limitation to be engineered around, but as the primary executor. The system's role is to augment the operator's speed, accuracy, and confidence through guided instruction, removing the cognitive overhead of protocol memorisation and position tracking. The result is a workflow that is faster, more consistent, and less mentally fatiguing — without any of the infrastructure complexity of robotics.

##### Guided Liquid Handling

At the core of the hybrid model is real-time positional and procedural guidance. Rather than requiring the operator to mentally track their location within a complex plate layout, the

system provides clear, step-by-step visual instruction. This reduces the primary sources of manual pipetting error: position mistakes, volume confusion, and step omissions. It transforms an inherently variable human process into a semi-structured one.

#### Flexible Throughput Scaling

Unlike robotic systems, which are economically justified primarily at high, stable throughput, guided liquid handling platforms operate efficiently across a wide range of sample volumes. A laboratory processing 48 samples today and 192 samples next month can use the same platform without protocol reprogramming, infrastructure adjustment, or revalidation cycles. This scalability is operational flexibility in its most practical form.

#### Pragmatic Workflow Integration

Hybrid workflow tools are designed to enter existing laboratory environments rather than to redesign them. They work alongside existing instruments, require no dedicated IT infrastructure, and impose no laboratory redesign. For laboratory managers already managing complex operational environments, this frictionless integration model represents a fundamentally different adoption calculus: low barrier, fast deployment, near-immediate impact.

### Why This Model Is the Right Response to the Moment

The hybrid workflow model is not a transitional step on the road to full automation. For a significant and growing proportion of laboratories, it is the destination. It matches the operational profile of the modern mid-throughput laboratory — variable demand, lean staffing, limited capital, and a need for both consistency and adaptability — in a way that neither manual pipetting nor full robotics can.

The market data supports this directional shift. The global liquid handling market is projected to grow from \$5.1 billion in 2025 to over \$7.4 billion by 2030, with a meaningful portion of that growth driven not by full automation deployments but by accessible, scalable, operator-supporting technologies. As laboratories increasingly recognise that robotic complexity is not the only path forward, the hybrid model represents the most strategically coherent position for the majority of working labs.

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## 4. Real Workflow Impact

### From Concept to Measurable Outcome

The value of the hybrid workflow model is not theoretical. Its benefits translate directly into the operational metrics that matter to laboratory managers, procurement decision-makers, and clinical directors.

## Throughput and Speed

The most immediate impact of guided liquid handling is cycle-time reduction. When operators no longer need to pause and verify their position in a plate layout, recheck protocol steps, or mentally track which wells have been processed, the pace of the workflow increases naturally and sustainably. This is not speed through pressure — it is speed through removal of friction. For a laboratory running multiple 96-well plates per day, this translates into meaningful cumulative time savings that compound across the working week.

## Consistency and Error Reduction

The structural cause of most manual pipetting errors is not incompetence — it is cognitive overload during repetitive, complex tasks. Guided workflows address this at the source. By externalising the protocol tracking and positional confirmation that operators would otherwise carry mentally, guided liquid handling systems reduce the principal sources of within-run variability. The result is improved consistency that supports downstream assay integrity without requiring robotic precision mechanisms.

The following table illustrates the practical workflow profile across the three approaches:

| Dimension                   | Manual Pipetting             | Hybrid Guided Handling    | Full Robotic Automation |
|-----------------------------|------------------------------|---------------------------|-------------------------|
| <i>Setup time</i>           | Minimal                      | Low                       | High (days to weeks)    |
| <i>Throughput</i>           | Limited by operator fatigue  | Significantly accelerated | Maximum, but fixed      |
| <i>Error rate</i>           | Variable (fatigue-dependent) | Low (guided, structured)  | Very low (mechanical)   |
| <i>Flexibility</i>          | High                         | High                      | Low to moderate         |
| <i>Capital investment</i>   | Low                          | Moderate                  | High                    |
| <i>Training requirement</i> | Basic                        | Minimal                   | Extensive               |
| <i>Space footprint</i>      | None                         | Minimal                   | Significant             |
| <i>ROI horizon</i>          | Immediate                    | Short                     | Long (3–5+ years)       |

## Operator Wellbeing and Retention

The human cost of repetitive pipetting is a dimension that is often absent from automation procurement discussions but is increasingly relevant to laboratory workforce strategy.

Research confirms that over 300 hours of pipetting per year meaningfully increases the risk of musculoskeletal disorders, with pipetting tip mounting identified as the highest-force activity and therefore the greatest injury risk. Guided liquid handling — by reducing the total number of unguided, unverified pipetting actions per session — distributes cognitive and physical load more evenly across the workflow, contributing to reduced operator fatigue.

In a labour market characterised by persistent staffing shortages and documented burnout, protecting operator wellbeing is not a soft benefit. It is a strategic operational priority that affects retention, absence rates, and the quality of the work performed.

## Reduced Training Burden

Manual pipetting mastery takes time to develop and is difficult to standardise across a team. Full robotic systems require specialist training that takes longer still and does not transfer easily to new hires. Guided liquid handling platforms occupy a distinct position: the guidance infrastructure itself is the training scaffold. New operators can follow complex protocols accurately without extensive prior experience, reducing the time-to-competency curve and enabling more flexible staffing deployment.

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## 5. The PlateWizard™ Approach

### The Natural Expression of Hybrid Workflow Thinking

Axon PlateWizard™ product family represents the most fully realised implementation of guided liquid handling principles available today. Rather than replicating robotic architecture at smaller scale, PlateWizard™ was built from the ground up around the hybrid workflow model: placing intelligent guidance in the hands of the human operator, and making that operator measurably more capable at every step.

### mPlateWizard™ Guided Precision for Manual Workflows

The **mPlateWizard™** is designed for laboratories that require real improvements in accuracy and throughput without any increase in infrastructure complexity. Providing real-time visual step-by-step guidance through complex plate-based workflows, mPlateWizard™ eliminates the positional uncertainty and protocol tracking burden that drives manual error and slows manual execution. For laboratories running NGS library preparation, HLA typing workflows, molecular diagnostic panels, or any multi-step plate-based protocol, mPlateWizard™ delivers immediate, measurable improvement in operator performance without requiring a single change to the existing instrument environment.

The value proposition is direct: same operator, same pipette, meaningfully better outcome. Faster cycle times, fewer errors, reduced cognitive fatigue, and protocols that are reproducible regardless of which team member is running them.

## ePlateWizard™ Semi-Automated Acceleration

The **ePlateWizard™** extends the hybrid model into the semi-automated domain, incorporating electronic pipetting capability with guided workflow orchestration. For laboratories processing higher sample volumes or managing particularly complex multi-step protocols, ePlateWizard™ provides the throughput acceleration and consistency assurance of a more advanced system while retaining the operational simplicity, flexibility, and human-in-the-loop character of the hybrid model.

ePlateWizard™ is the solution for laboratories that have reached the ceiling of what guided manual handling can deliver but are not candidates — financially, operationally, or physically — for full robotic deployment. It represents the highest expression of the hybrid workflow concept: maximum practical capability without robotic complexity.



## How PlateWizard™ Operationalises the Framework

Both PlateWizard™ platforms share a set of design principles that directly reflect the hybrid workflow model:

- **Rapid deployment** — operational within hours, not weeks, with no infrastructure requirement.
- **Protocol flexibility** — adaptable to a wide range of assay types without specialist reprogramming.
- **Minimal footprint** — designed for real laboratory environments, not purpose-built automation suites.
- **Low training barrier** — intuitive guidance systems that reduce time-to-competency for new operators.

- **Scalable throughput** — equally effective at 48 samples, 96 or 384, without system reconfiguration PlateWizard™ is not a scaled-down robot. It is a fundamentally different kind of instrument — one that makes the human operator the source of quality rather than the potential source of error.

## 6. Who This Is For

### The Hybrid Workflow Laboratory Profile

The guided liquid handling model serves a specific and identifiable laboratory profile. Understanding this profile is important both for laboratory decision-makers evaluating solutions and for distribution partners positioning these technologies within their markets.

#### Molecular Diagnostics Laboratories

Mid-throughput molecular diagnostics operations running plate-based panels for infectious disease, oncology, or genetic testing face consistent pressure on turnaround time and result consistency. These labs need throughput improvement without the infrastructure burden that full automation implies. Guided liquid handling addresses this directly.

#### NGS Workflow Environments

Next-generation sequencing library preparation is among the most error-sensitive, multi-step, plate-based workflows in the modern laboratory. The complexity and precision requirements of NGS sample preparation — particularly for clinical applications — make it an ideal candidate for guided workflow support. Consistent, reproducible library preparation is a fundamental quality requirement for reliable sequencing outcomes.

#### HLA Typing Laboratories

HLA labs operate at the intersection of high complexity, regulatory scrutiny, and clinical consequence. The workflow variation encountered in HLA testing — diverse sample types, evolving panels, and strict result quality requirements — demands exactly the kind of flexible, guided approach that the hybrid model provides. NGS-based HLA typing has expanded the

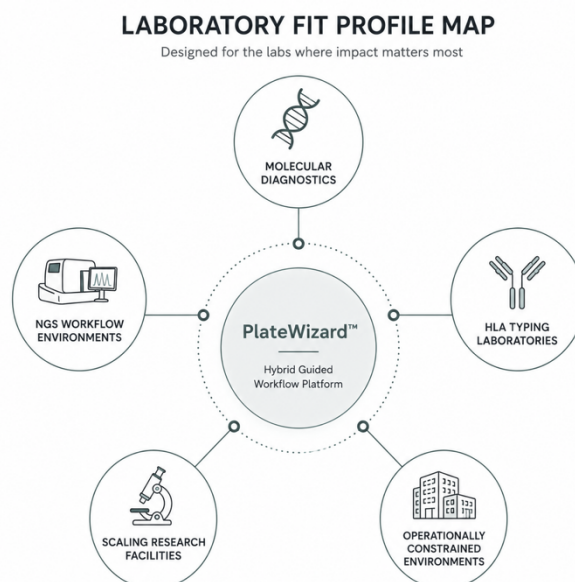


plate-based workflow burden in these settings considerably, making guided liquid handling support increasingly relevant.

#### Scaling Research Facilities

Academic and contract research organisations moving from low-throughput experimental work toward higher-volume sample processing face a classic scaling challenge: throughput needs are growing faster than staffing and capital budgets. Guided liquid handling provides a practical on-ramp to higher-throughput operation without a full automation investment.

#### Operationally Constrained Environments

Hospital-based laboratories, satellite facilities, and point-of-care adjacent settings that operate within space, budget, or staffing constraints that preclude robotic infrastructure represent one of the largest and most underserved segments of the liquid handling market. For these environments, the hybrid model is not a compromise — it is the only viable path to meaningful workflow improvement.

### For Distribution Partners

The laboratories described above share a common purchasing profile: they are budget-conscious, operationally pragmatic, and actively seeking solutions that deliver measurable impact without disruptive implementation. They have typically encountered full automation proposals and found them prohibitive. They represent a large, commercially attractive, and currently under-addressed segment.

PlateWizard™ products are designed to convert this unmet need into accessible, high-confidence purchasing decisions. The combination of demonstrable throughput benefit, low implementation complexity, and accessible price point creates a compelling commercial case for distribution partners seeking differentiated laboratory technology solutions with clear customer relevance.

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## Conclusion

The laboratory of the next decade will not be defined by a binary choice between manual pipetting and full robotic automation. It will be defined by the intelligence of the workflow architecture that connects the two — and by the degree to which that architecture respects the operational reality of working laboratories rather than the theoretical ideals of system designers.

The hybrid guided liquid handling model represents a mature, commercially coherent, and operationally validated response to the throughput pressures, staffing realities, and resource constraints that characterise the majority of the world's active laboratories. It delivers genuine improvement — faster workflows, more consistent results, reduced operator fatigue, lower training burden — without the capital commitment, implementation complexity, or operational rigidity of robotic automation.

Axon PlateWizard™ platform is the embodiment of this model. Built for the laboratory as it actually operates, not as it might ideally be resourced, PlateWizard™ defines what guided liquid handling looks like in practice: accessible, flexible, and immediately impactful.

The gap between manual and automated has always existed. What is new is the availability of technology that fills it intelligently.

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## About Axon

For over 37 years, Axon has developed laboratory instrumentation, consumables, and workflow solutions for life science laboratories worldwide, with particular expertise in molecular biology applications. Combining precision engineering with practical laboratory insight, Axon delivers reliable technologies and ongoing laboratory supply solutions designed to improve accuracy, efficiency, and workflow performance across research, diagnostics, and genomics.

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This whitepaper is intended for laboratory managers, workflow specialists, scientific decision-makers, and distribution partners evaluating liquid handling workflow strategy. The views expressed represent the strategic perspective of Axon and are based on industry observation, published market research, and operational experience in laboratory workflow design.

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For more information about Axon PlateWizard™ platform, to request a demonstration, please contact your regional Axon distributor, or visit our websites:

[axon-labortechnik.de](http://axon-labortechnik.de) | [platewizard.eu](http://platewizard.eu)

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