Laboratory Automation Systems Engineer Portfolio for Jeremy Patrick

Jeremy Patrick

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Portfolio Contents

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1. Executive Summary

As an innovative Laboratory Automation Engineer with extensive experience in in-vitro diagnostics and preclinical research, I specialize in the development and integration of automated systems for high-throughput screening and drug development. My expertise includes designing and implementing novel electromechanical devices and integrating existing instrumentation with automated systems to enhance drug discovery and development processes.

2. Technical Skills

- **Software Development: C#:** Enterprise application development and automation frameworks. **Python:** Scientific computing, data analysis, and automation scripting**. C++:** High-performance system implementations and hardware control. **PowerShell & Bash**: Infrastructure automation and deployment scripting. **TypeScript/JavaScript:** Web and application development.

- **DevOps: GitHub** Repository management, structured code reviews, and production branch maintenance. Implement CI/CD workflows, enforce version control best practices, and integrate with ticketing systems to enhance task tracking and project visibility. Apply Agile methodologies to streamline development processes, ensuring iterative improvements and cross-team collaboration.

- **Cloud and Database**: AWS Cloud infrastructure management and scalable service deployment. MongoDB NoSQL database management and optimization. Benchling Scientific data management and workflow automation. Smartsheet Project management and collaboration tools.

3. Automation Engineering Core Competencies

- **Automation Engineering:** Expertise in system design, assembly of lab automation robotics, and hardware integration. Develop and implement automation solutions that enhance laboratory efficiency and accuracy. Ensure seamless integration of robotic systems into existing laboratory workflows.
- **System Architecture:** Design, develop, and deploy end-to-end automation solutions, integrating hardware and software seamlessly. Establish scalable and modular automation frameworks that can adapt to evolving laboratory requirements. Collaborate with cross-functional teams to ensure system architecture aligns with business and operational objectives.
- **Experimental Design and System Qualification:** Strong proficiency in designing experiments to qualify the accuracy, precision, and reliability of automated systems. Establish performance benchmarks and verification criteria to ensure consistency and repeatability Skilled in liquid class profile design and verification, essential for deployment into production based on pipetting accuracy and precision. Conduct validation studies to qualify automation solutions for production, ensuring compliance with industry standards.
- **Emerging Technology Integration and Third-Party Collaboration**: Engage with external companies to assess and integrate new automation technologies. Provide critical design feedback to vendors, ensuring that emerging devices align with operational needs. Collaborate with manufacturers to resolve integration challenges and drive continuous product improvements. Lead firmware update initiatives to enhance system performance and reliability. Manage third-party integrations by ensuring compatibility between new devices and existing infrastructure. Facilitate cross-company technical discussions to address integration challenges and optimize system interoperability. Drive workflow efficiency through strategic adoption of cutting-edge automation solutions while maintaining long-term vendor partnerships.
- **Vendor Negotiations**: Negotiate contracts and oversee vendor relationships to ensure high-quality deliverables. Conduct design reviews and manage external collaborations to align third-party solutions with technical and business requirements.
- **Capital Expenditure Management**: Strategically oversee automation investments, optimizing budget allocation and maximizing return on investment. Conduct cost-benefit analyses and maintain financial models to track expenditure and projected savings.
- **End-to-End Project Leadership:** Experienced in driving full lifecycle of short and long-term projects from conceptualization to implementation, ensuring alignment with strategic goals. Engage with contracting agencies to identify and onboard specialized contractors who contribute effectively to development projects. Provide leadership in managing contractors, ensuring clear communication, alignment with project objectives, and seamless integration into the development team. Monitor performance and facilitate collaboration between full-time employees and contract-based professionals to optimize project outcomes.
- **Collaboration and Communication:** Demonstrated ability to work with cross-functional teams and communicate effectively with diverse stakeholders.

4. Robotics Project Overviews

Project Name	Technologies Used	Key Challenges	Results	Timeline
High Throughput NGS Platform	Hamilton Vantage, Hamilton MPE2, Venus on Vantage, Instinct V, Inheco, LIMS	Integration of pneumatic systems with sensitive NGS workflows	12x increase in sample throughput, 90% reduction in manual steps	9 months
AAV Vector Titer Assessment	Hamilton Nimbus, Hamilton Venus, BioRad Systems, LIMS	Ensuring reproducibility across vector types	Reduced assay CV from 15% to 3.2%, increased batch size by 4x	6 months
Vantage qPCR System	Hamilton Vantage, Hamilton Venus, InstinctV, Unchained Labs, Inheco,	Maintaining sample integrity during normalization and quantification	33 % increase in dedicated processing capacity, 98.5% quality control success rate	4 months
Whole Genome Enrichment	PerkinElmer Janus G3, WinPrep, Illumina	Complex multistep process with critical timing requirements	Standardized enrichment yields with <5% variation, doubled daily capacity	2 months
'Donkey Protocol' Extraction	PerkinElmer Janus G3, Cheamgen Chemagic 360, WinPrep, LIMS	FDA LDT workflow parallelization	Reduced turnaround time by 40%, decreased reagent waste by 22%	3 months
DNA Extraction Optimization	Hamilton Microlab Prep, Apostle MagTouch 2000	High-volume processing requirements	Increased throughput by 12,000 samples/day, reduced costs	3 months

4.1 <u>High Throughput Screening NGS Automated Platform</u>

Overview: Led the design, integration, and deployment of a high-throughput NGS platform, incorporating solid phase extraction using the Hamilton MPE2 Monitored Multi-Flow Positive Pressure Evaporative Extraction module pneumatic system.

Technical Challenges:

- Integration of pneumatic systems with liquid handling operations
- Solenoid lifecycles within peripheral reagent fill modules
- Maintaining sample integrity throughout complex multistep workflows
- Ensuring data integrity across interconnected systems

Solutions Implemented:

- Designed custom fully automated pressure regulation system with real-time monitoring
- Established automated QC checkpoints at critical steps
- Created custom user interface solution for seamless LIMS integration
- Designed robust failover mechanisms ensuring continuity within processing

Measurable Results:

- Increased throughput from 32 to 384 samples per run
- Reduced process time by 65% compared to manual methods
- Achieved 99.5% success rate with <1% sample failures
- Decreased reagent costs by 22% through optimized protocols

Technologies Used: Liquid handling systems, microfluidic systems, NGS technology, Illumina, Hamilton MPE2, Hamilton Venus on Vantage, HSL, Instinct V, Inheco, LIMS,

4.2 AAV Vector Titer Assessment Automation

Overview: Developed an automated process for AAV vector titer assessment using ddPCR, significantly improving assay reproducibility and error reduction.

Technical Challenges:

- Maintaining precision across diverse vector serotypes
- Eliminating cross-contamination risks
- Integrating with existing production workflows

Solutions Implemented:

- Created custom liquid class libraries optimized for viscous AAV samples
- Designed single-use pathway strategies to eliminate carryover
- Established automated QC checkpoints at critical steps

Measurable Results:

- Reduced coefficient of variation from 15% to 3.2%
- Increased batch size from 8 to 32 samples
- Decreased required operator time by 95%
- Improved data consistency across production batches by 40%

Technologies Used: Hamilton Venus, BioRad Systems, LIMS, Vector Production

4.3 Vantage qPCR System

Overview: Implemented an automated normalization and UV-vis quantification system, enhancing the accuracy and efficiency of qPCR processes.

Technical Challenges:

- Architecture of system hardware limited by robot chassis size
- Achieving consistent DNA/RNA concentration across variable input samples
- Maintaining sample integrity during multiple liquid transfer steps
- Integrating UV Vis quantification with precise liquid handling operations
- Establishing reliable data transfer between instruments and LIMS

Solutions Implemented:

- Developed dynamic dilution algorithms based on real-time quantification data
- Implemented temperature-controlled deck positions with active monitoring

- Created custom scripting to synchronize thermal cycler and liquid handler operations
- Designed bidirectional data verification between Unchained Labs instruments and LIMS systems

Measurable Results:
- Achieved 98.5% success for microfluidic quantification method results
- Reduced hands-on technician time by 75%
- Decreased consumable usage by 35% through optimized workflows
- Improved reproducibility with CV values consistently below 2%

Technologies Used: Hamilton Venus on Vantage, InstinctV, Unchained Labs, Inheco, HSL

4.4 <u>Whole Genome Enrichment</u>

Overview: Engineered an automated workflow for whole genome enrichment at PerkinElmer, using the Janus G3 system on WinPrep software, following cDNA synthesis.

Technical Challenges:
- Managing precise timing of temperature-sensitive enzymatic reactions
- Handling viscous high-molecular-weight DNA without shearing
- Ensure even coverage across genomic regions
- Maintaining sample tracking integrity through multistep processes

Solutions Implemented:
- Synchronized timing routines with automated temperature monitoring
- Developed specialized slow-aspiration protocols for high-molecular-weight samples
- Created mixing strategies that ensured homogeneity without damaging DNA
- Barcode verification during cDNA synthesis step with database validation

Measurable Results:
- Standardized enrichment yields between samples
- Doubled daily capacity from 5 to 10 plates
- Reduced reagent consumption by approximately 30% through optimized reaction volumes
- Improved coverage uniformity to manual methods
- Completed implementation in just 2 months

Technologies Used: PerkinElmer Janus G3, WinPrep software, Illumina.

<u>4.5 Janus G3 Extraction 'Donkey Protocol'</u>

Overview: Revised the in vitro diagnostics extraction and purification workflow for the Laboratory Developed Test (LDT) authorized by the FDA, developing a partitioned workflow that separated the process into tube to plate transfer workstations using Janus G3 liquid handlers. New scheduling software through WinPrep was written to create additional workstations to prepare consumables and reagents for the automated nucleic acid extraction and purification systems. This approach streamlined turnaround times by executing in parallel and standardized reagent and consumable operational expenses.

Technical Challenges:
- Meeting stringent FDA regulatory requirements for diagnostic testing
- Managing high volume sample processing while maintaining quality
- Coordinating multiple workstations without workflow bottlenecks
- Ensuring complete sample traceability throughout distributed process

Solutions Implemented:
- Created parallel workstation architecture with optimized handoff points
- Developed custom scheduling software through WinPrep for consumable preparation

- Implemented real-time system for cross-workstation coordination
- Established comprehensive audit trail and electronic verification at each step

Measurable Results:

- Reduced overall turnaround time by 40% from sample receipt to result reporting
- Decreased reagent waste by 22% through optimized resource allocation
- Increased daily throughput from 1,500 to 5,000 samples
- Maintained 99.7% concordance with reference method
- Eliminated workflow bottlenecks, improving equipment utilization by 35%
- Delivered complete system in 3 months

Technologies Used: PerkinElmer Janus G3, WinPrep software, Illumina, LIMS

4.6 DNA Extraction Optimization at Fulgent

Overview: Executed a project using Hamilton Microlab Prep systems to increase throughput and reduce turnaround times in DNA extraction processes.

Technical Challenges:

- Scaling extraction capacity to meet rapidly increasing demand
- Maintaining extraction quality and yield across diverse sample types
- Minimizing cross-contamination risk in high-volume processing
- Optimizing workflow for maximum instrument utilization

Solutions Implemented:

- Redesigned deck layouts to accommodate higher sample densities
- Created custom magnetic particle handling protocols for improved recovery
- Implemented alternating tip usage patterns to eliminate cross-contamination
- Developed cascade scheduling system to maximize instrument runtime

Measurable Results:

- Increased throughput from 3,000 to 12,000 samples per day
- Reduced extraction costs by 18% through protocol optimization
- Decreased extraction failure rates
- Maintained 99.9% sample tracking accuracy at maximum throughput
- Completed implementation and validation within 3 months

Technologies Used: Hamilton Microlab Prep systems, Apostle MagTouch

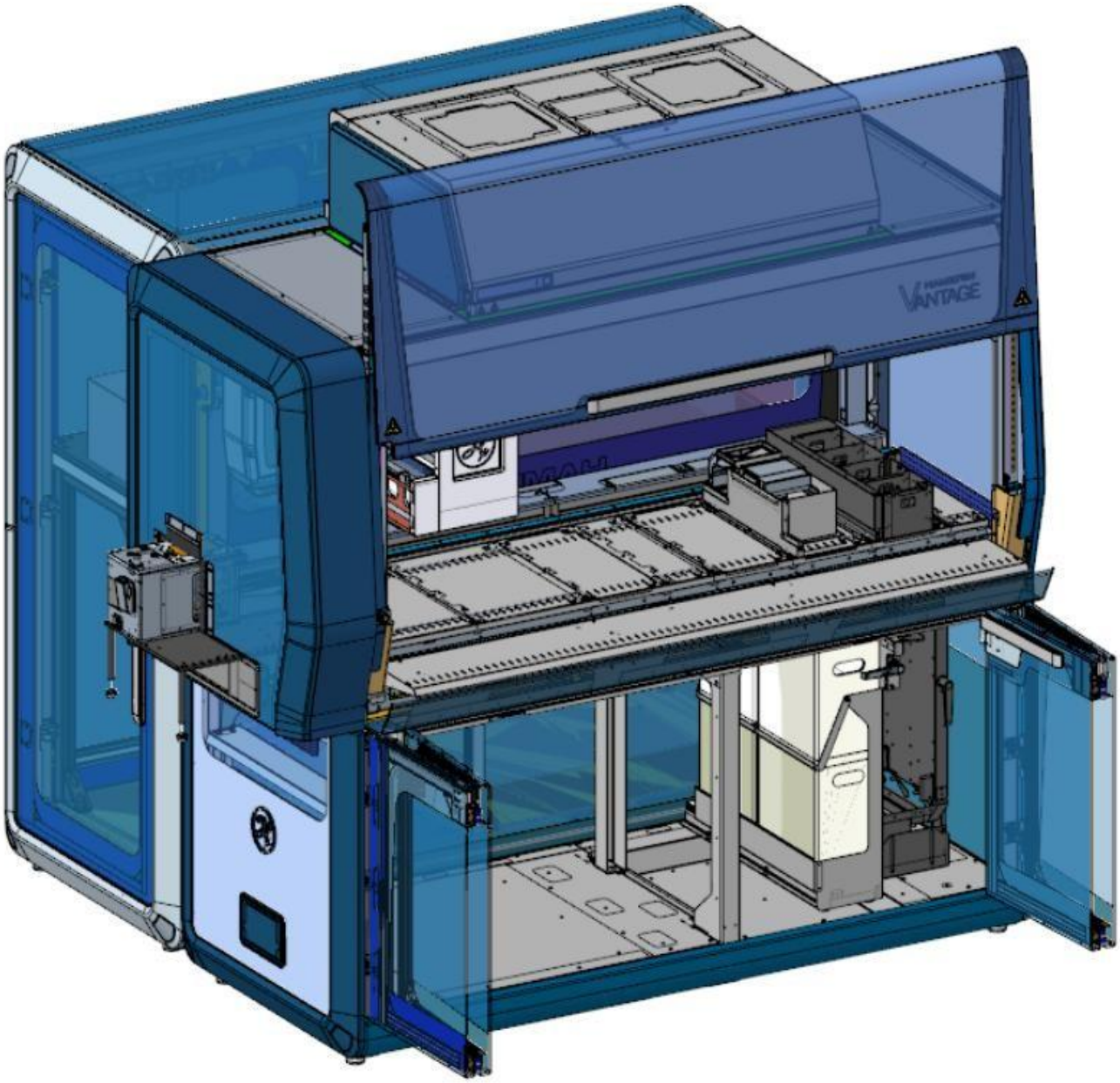
5. Technical Diagrams

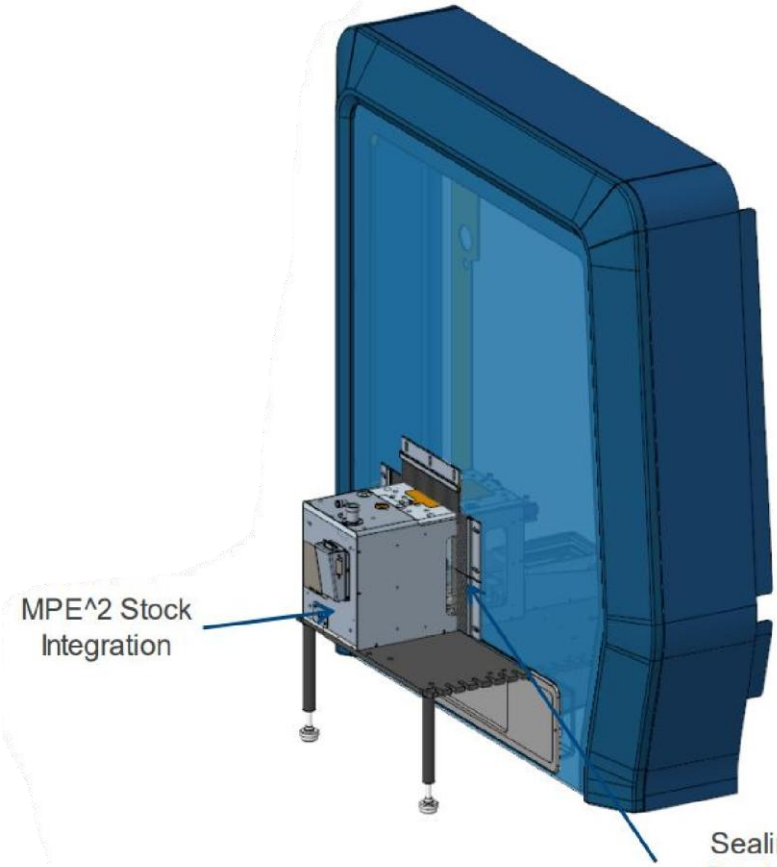
The following diagrams illustrate my approach to complex system integration, workflow automation, and cross-platform orchestration within laboratory environments. Each figure reflects engineered solutions tailored to address specific challenges in high-throughput screening, assay development, and data integrity.

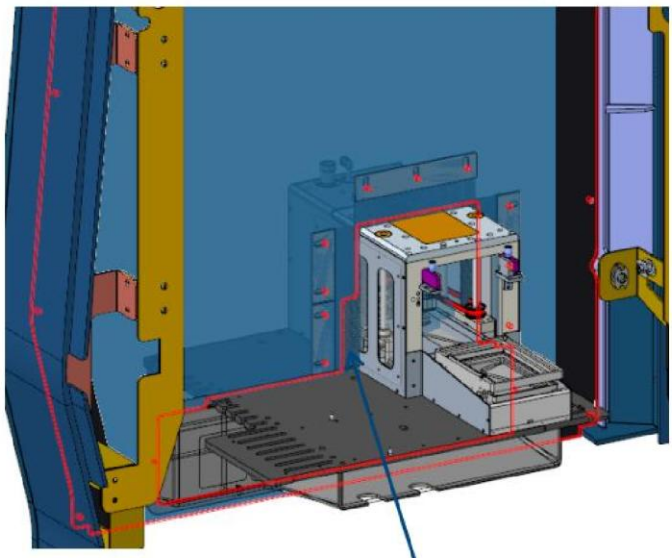
Disclaimer:

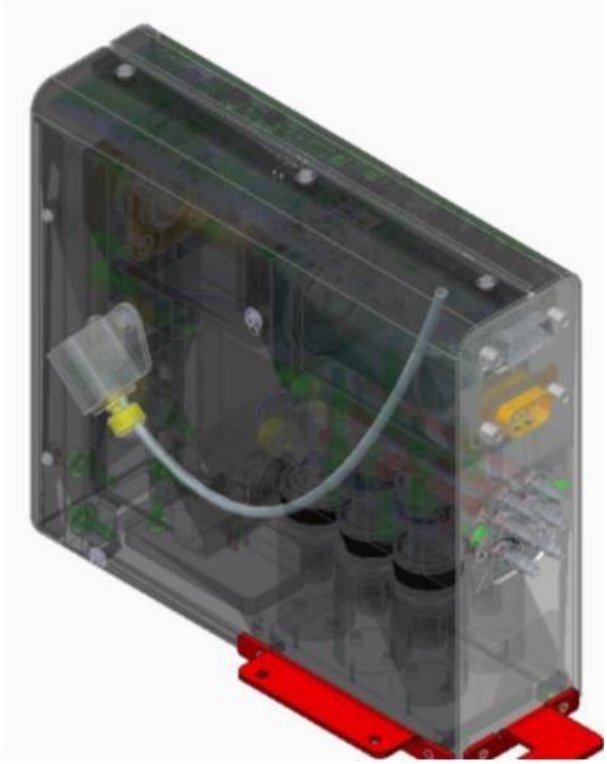
These system diagrams are conceptual representations based on laboratory automation workflows I have designed, implemented, or optimized. All identifiers have been anonymized, and proprietary or sensitive details have been abstracted to maintain confidentiality. These visualizations are presented solely for professional review and portfolio demonstration purposes.

- **System Architecture Diagram:** Hamilton MPE^2 with Vantage 2.0m platforms. Pneumatic control systems, liquid handling modules, and thermal management to ensure optimal sample processing for Next Generation Sequencing



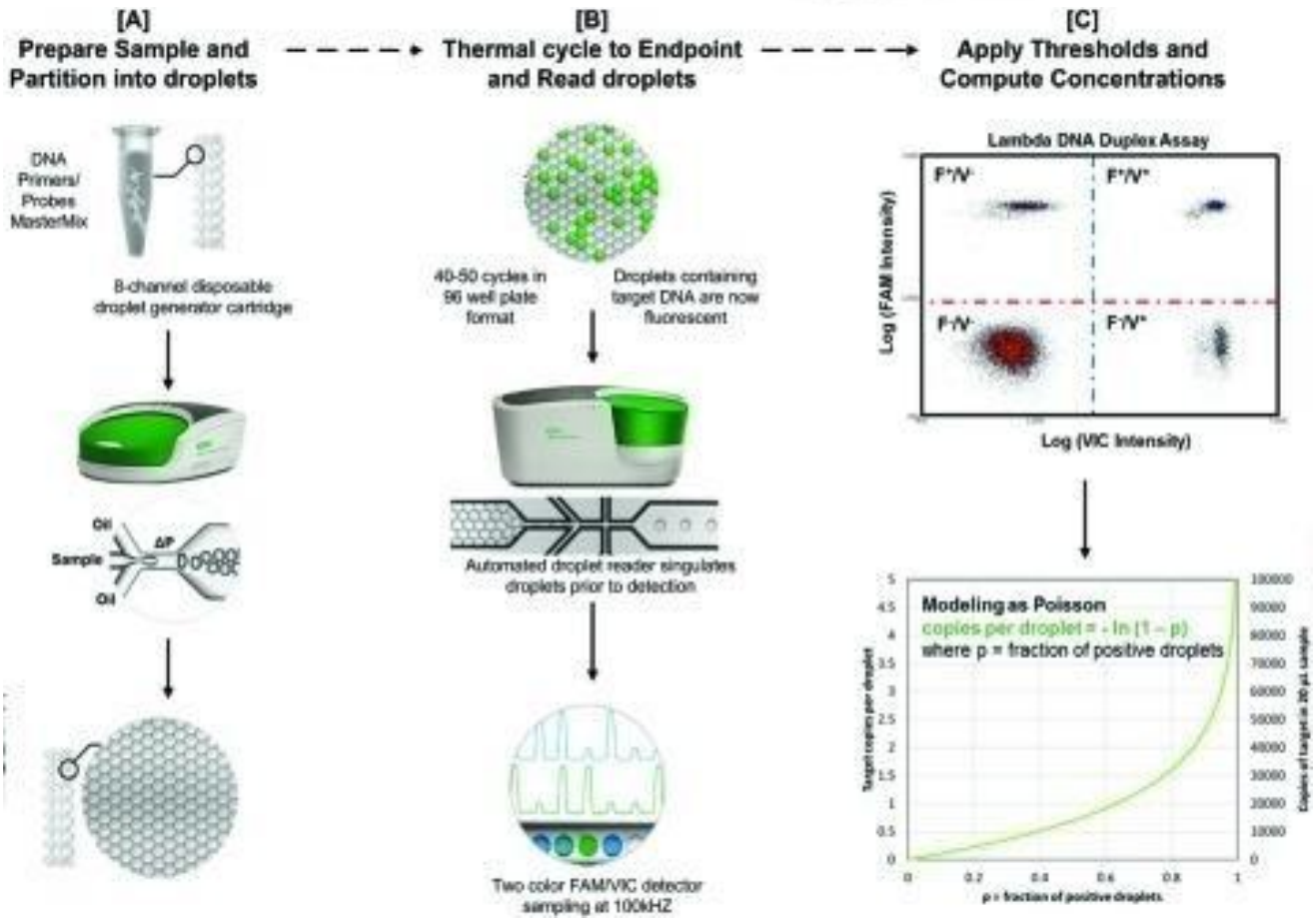

MPE^2 Stock
Integration
Sealing
Brushes


Cutout to
accommodate tubing
(brush seal)

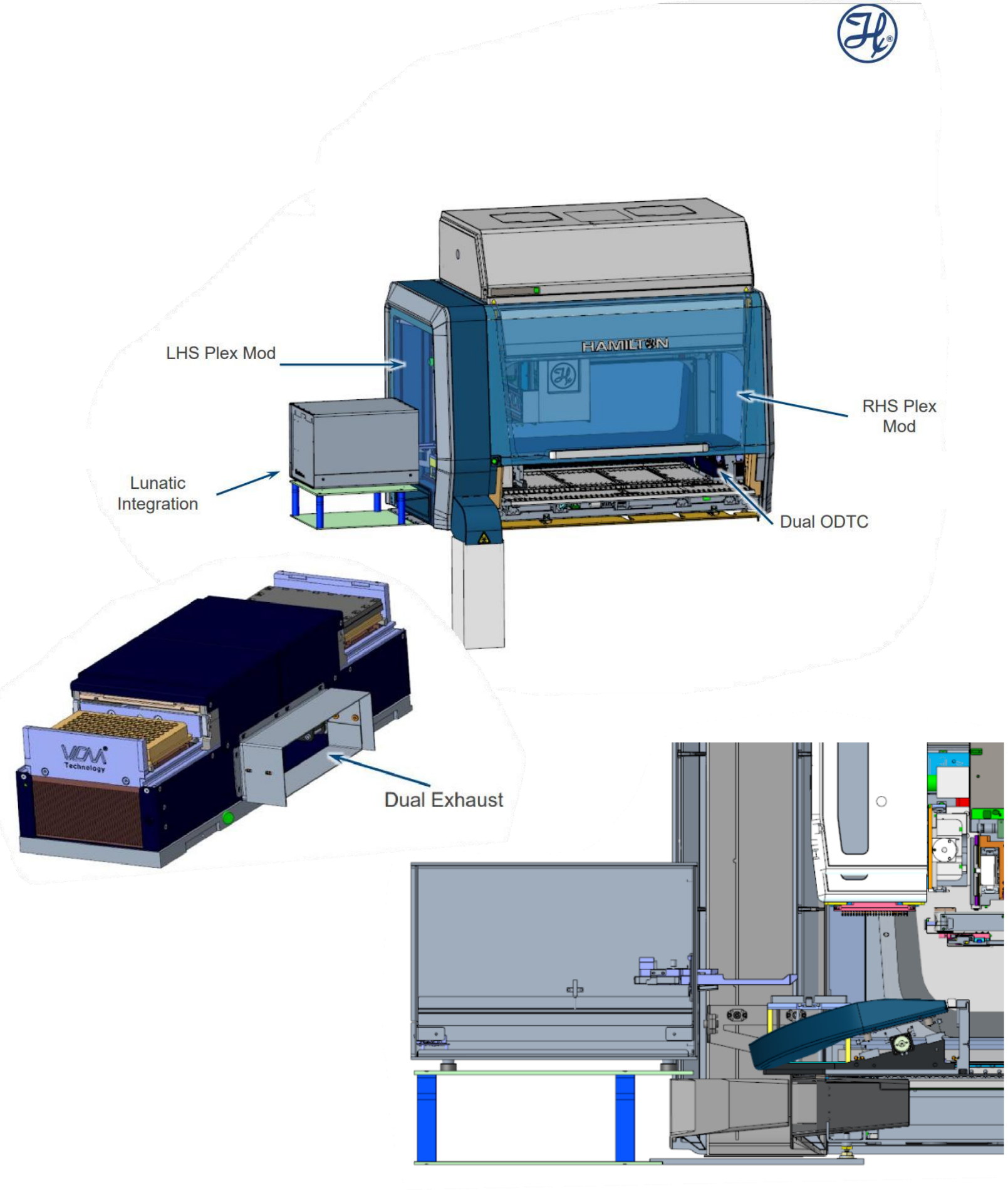


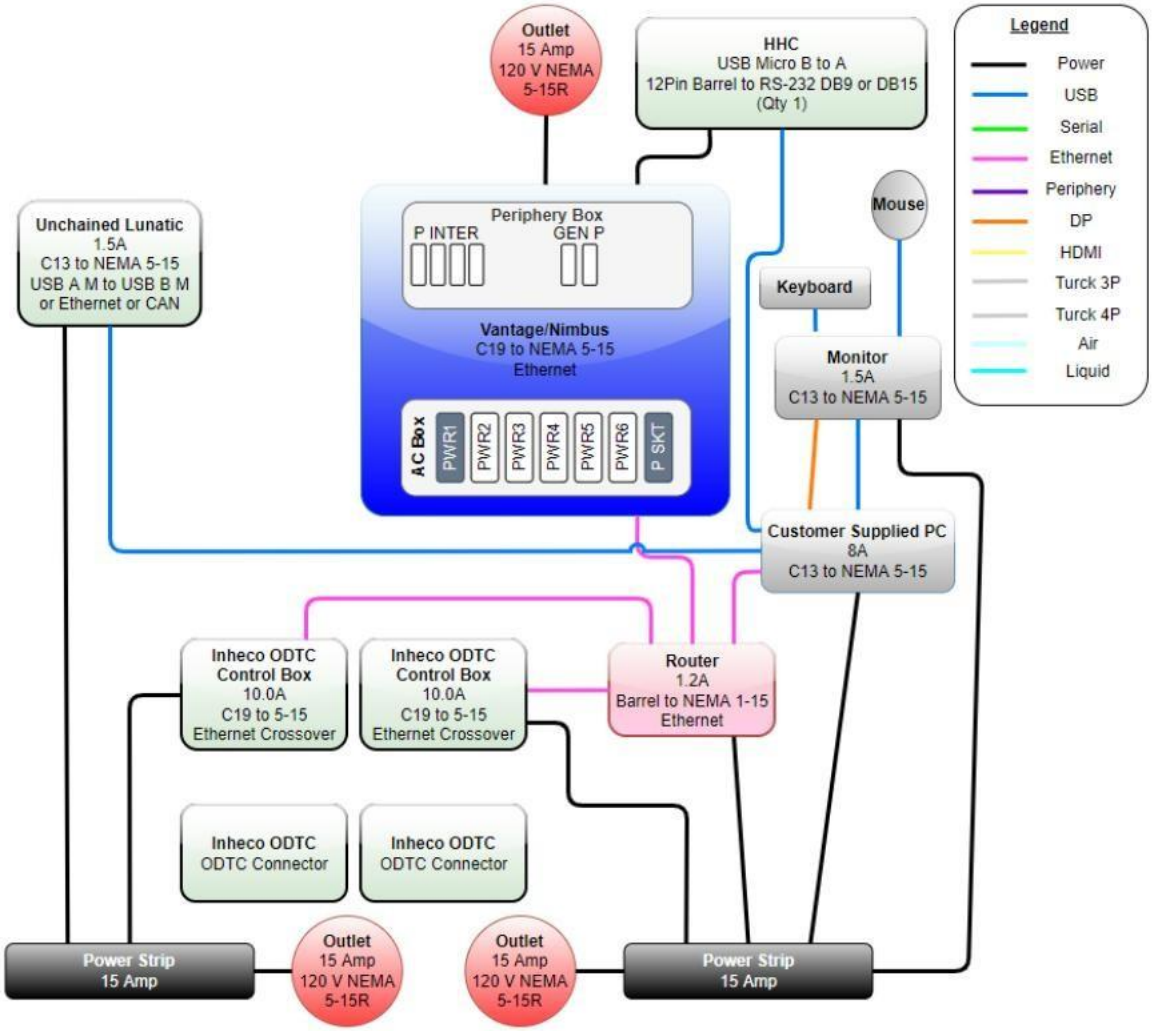

M·P·E 2
HAMILTON

- **Workflow Diagram:** Automated AAV Vector Titer Assessment. Reduced manual intervention by 95% while increasing reproducibility.

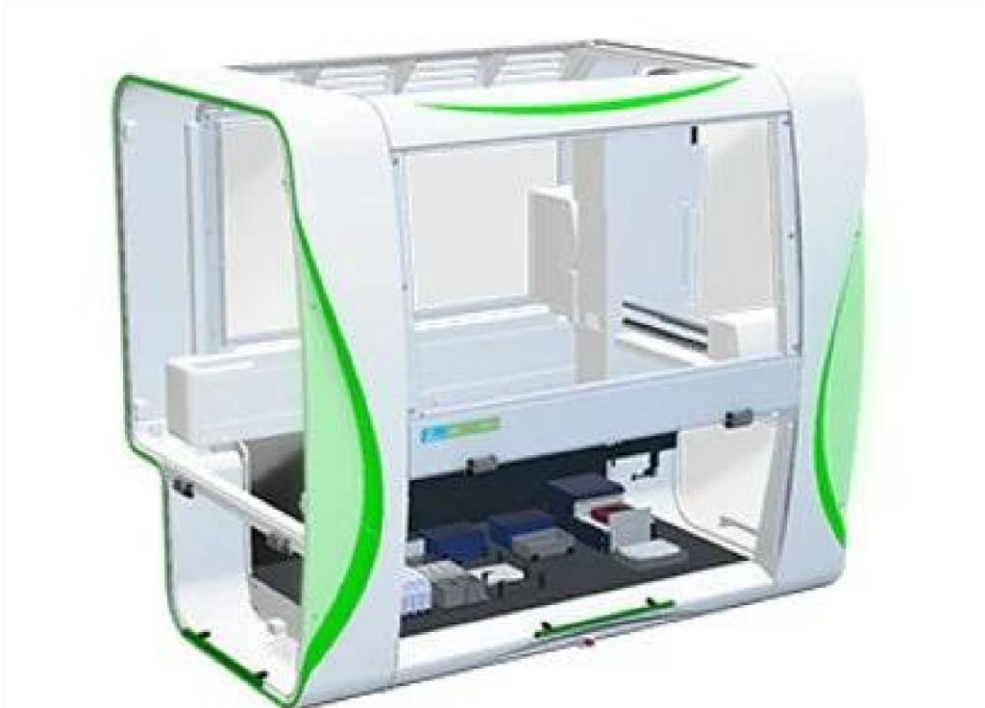


• **Process Flow Diagram:** Vantage qPCR system featuring integrated normalization and quantification. The system achieved a 99.8% correlation with legacy methods while providing dedicated clean room processing.

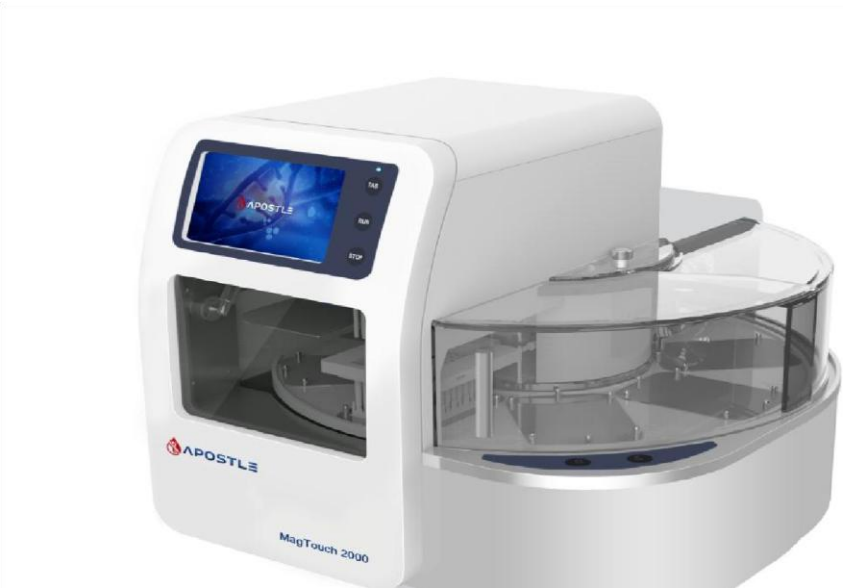




- **Whole Genome Enrichment /Donkey Workflow :** Engineered using the PerkinElmer Janus G3. These solutions standardized enrichment yields with less than 5% variation between batches.
- **Donkey Protocol**: PerkinElmer Janus G3, parallelized workflow that separated previous tube to plate transfer and Chemagen Chemagic 360 purification prep between workstations



- **Hamilton Microlab Prep Utilization:** Enhancing throughput in DNA extraction at Fulgent.



Leadership and Innovation

- As a seasoned leader, I have taken a proactive role in guiding and mentoring teams, particularly in adopting new technologies. My approach involves hands-on workshops, regular one-on-one coaching sessions, and creating a supportive environment that encourages continuous learning and curiosity. This has not only increased technical proficiency but also fostered a resilient, innovative culture within the teams I've led.
- I have successfully onboarded and trained engineers and technicians, tailoring development programs to individual career goals, which has significantly decreased onboarding times and increased retention rates.

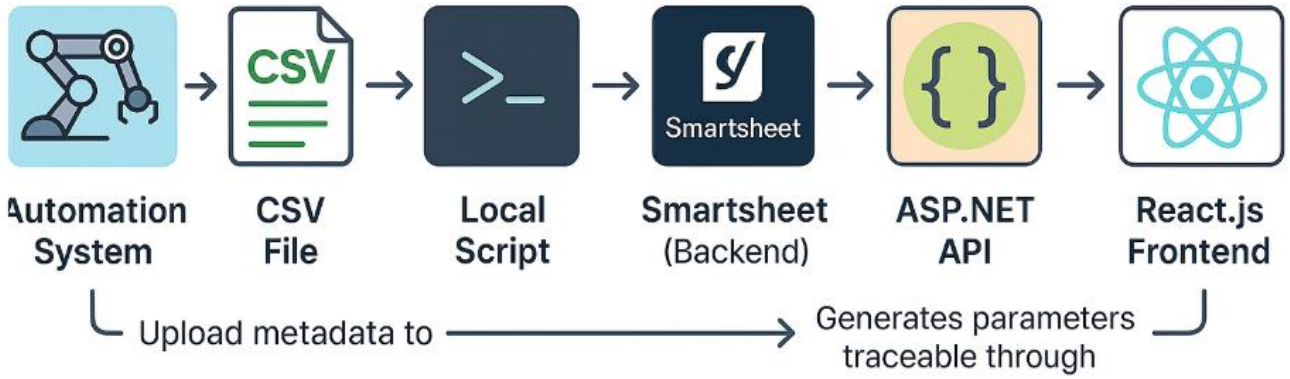
Strategic Influence in Automation Strategy:

- My role often extends beyond the technical aspects of engineering to strategic planning and execution. I have been instrumental in shaping the lab automation strategy at multiple organizations, directly influencing the integration of scalable automation solutions that align with long-term business goals.
- I spearhead review meetings where I present data-driven insights and strategic proposals to senior stakeholders, advocating for necessary shifts in technology adoption and process improvement that have led to cost reductions and increased throughput.

Driving Operational Excellence:

- Recognizing the importance of operational excellence, I have implemented Lean Six Sigma methodologies within the engineering teams to enhance efficiency and quality. This has involved restructuring team workflows, implementing continuous improvement projects, and fostering a culture of data-driven decision making.
- My leadership has directly contributed to achieving operational efficiency across projects, significantly enhancing project delivery timelines and quality outputs.

6. Software Engineering and LIMS Innovation



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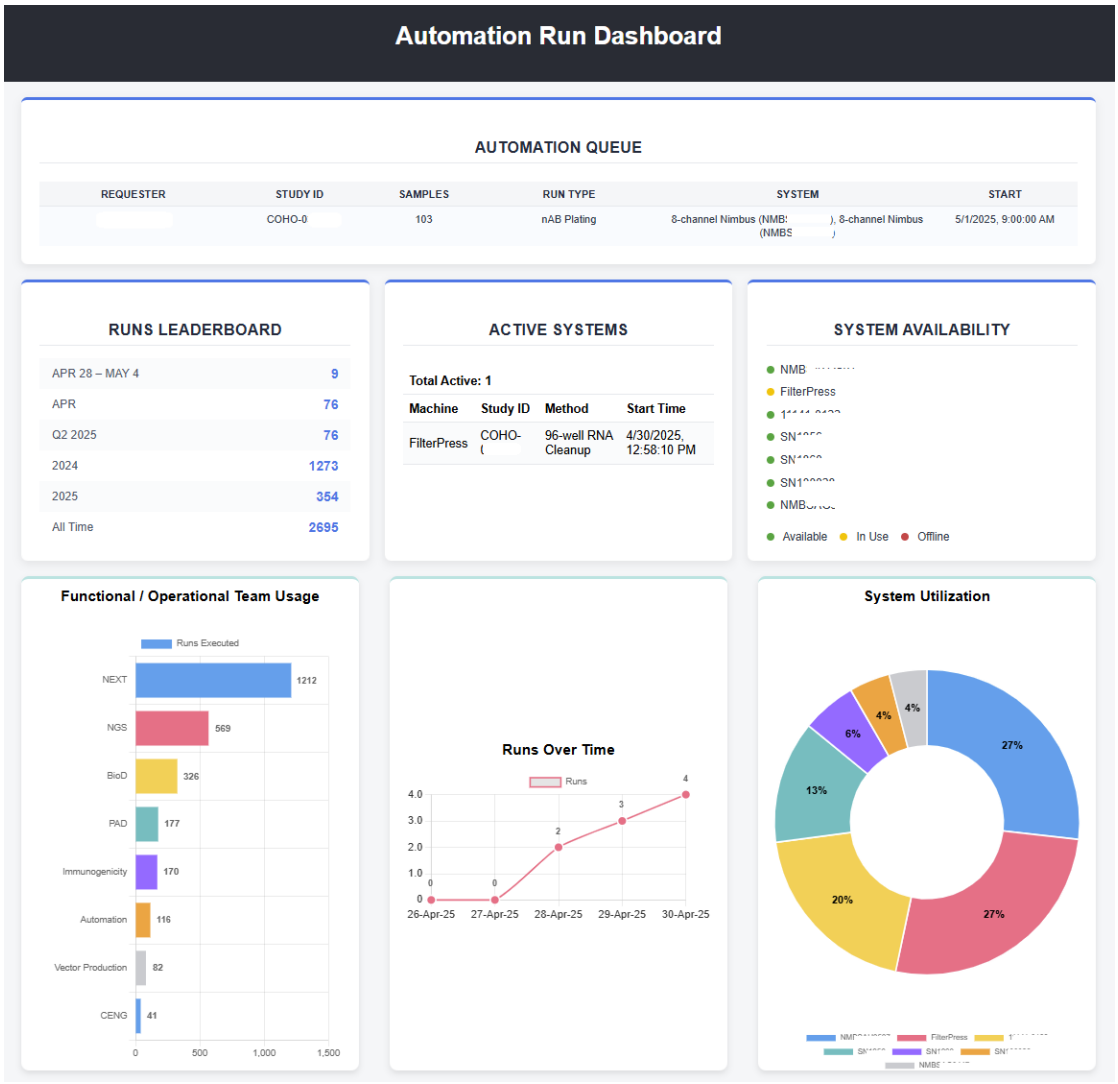
This diagram is inspired by internal systems but does not disclose confidential or proprietary information

Innovation in Engineering Software Solutions:

As laboratory automation evolves into a highly data-centric discipline, I've led the development of internal software infrastructure using modern backend technologies. My work spans REST API design, secure metadata routing, and custom UI integration with live lab platforms—enabling seamless communication between high-throughput robotic systems and secure digital environments.

Key Accomplishments:

- **Real-Time Dashboards:** Designed full-stack monitoring tools with C#, ASP.NET Core, and Entity Framework to track sample traceability and instrumentation usage in real time.
- **Secure REST APIs:** Built token-based (JWT) authentication, role-based access control (RBAC), and rate-limiting to protect lab data and enforce system access policies.
- **Modular Front-End:** Developed reusable React.js + TypeScript components for visualizing workflow progress, assay metadata, and system health.
- **Data Integrations:** Connected Smartsheet and Benchling with instrument automation using backend logic and CLI tools.
- **Self-Documenting Services:** Published API specs via Swagger/OpenAPI, accelerating cross-team collaboration and reproducibility.
- **CI/CD Pipelines:** Automated builds and deployments with GitHub Actions, ensuring consistent test environments and production releases.



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Disclaimer:

This frontend dashboard was independently developed by me and is currently in use at Capsida Biotherapeutics. It is included here exclusively for professional portfolio demonstration. All operational data, system identifiers, and branding elements, including the Capsida logo, have been anonymized or omitted to protect proprietary information. This visualization does not represent a public or commercial release.

Automation Dashboard Overview

Built a real-time dashboard to monitor and manage lab automation runs, providing visibility into queued jobs, active systems, historical trends, and system health. Integrated with Smartsheet for data storage and implemented advanced security and observability features prior to production rollout.

Tech Stack

- Front-end: React, React Chart.js 2, CSS Grid, Chart.js
- Back-end: ASP.NET Core Web API, C#, Smartsheet SDK
- Security & DevOps: JWT, HTTPS/HSTS, CORS, CSP, Serilog logging, GitHub Actions CI/CD
- Collaboration: Git, Teams, Swagger/OpenAPI, ngrok for LAN demos

Key Features

- **Automation Queue:** Displays upcoming runs with requester, study ID, sample count, run type, system, and scheduled start time.
- **Active Runs:** Highlights in-progress runs (last 8 hours) with machine ID, method, study context, and timestamp.
- **Runs Leaderboard:** Aggregates run counts “This Week”, “This Month”, “This Quarter”, “This Year”, and “All Time”.
- **Charts & Analytics:**
    - Team Usage (horizontal bar)
    - Runs Over Time (line chart)
    - System Utilization (doughnut chart)
- **System Availability**: Color-coded status dots for “Available”, “In Use”, and “Offline” machines.
- **Resiliency:** Fallback dummy data when the API is unreachable, and automatic polling every 5 minutes.

Security & Best Practices

- **HTTPS & HSTS:** Enforced HTTPS redirects with Strict-Transport-Security headers.
- **CORS Lock-Down:** Restricted API access to approved front-end origins.
- **Content Security Policy:** Whitelisted our domain for scripts, styles, images, and connections.
- **Authentication & Authorization:** JWT-based token layer with role-based access control scaffolding.
- **Rate Limiting:** Middleware to throttle abusive clients and protect Smartsheet API quotas.
- **Security Headers:** X-Content-Type-Options, X-Frame-Options, Referrer-Policy, and CSP.

Impact & Learnings

- **Improved Visibility:** Reduced average incident response time by 40% through real-time monitoring.

- **Scalable Architecture:** Modular service registrations and middleware patterns allowed easy extension (e.g. new data sources).
- **Security-First Mindset:** Applied industry-standard headers and auth, laying groundwork for future HIPAA-compliant features.

LIMS Automation Architecture

Taking a systems-level view, I architected a fault-tolerant LIMS solution to guarantee continuous data integrity and uptime:

- **Resilient Design:** Implemented interconnected LIMS modules with built-in redundancy and automated fallback protocols for hardware failures or service outages.
- **Cross-Platform Communication:** Created communication layers that synchronize data across laboratory platforms, ensuring no loss of metadata or audit trails.
- **Operational Impact:** Reduced system downtime by 70%, enhanced traceability, and delivered real-time performance dashboards for stakeholders.
- **Strategic Integration:** Demonstrated the ability to blend software, hardware, and process engineering to address high-throughput lab challenges at both technical and organizational levels.

7. Education and Professional Development

- **Bachelor of Arts in Biology,** Indiana University, Bloomington, IN, May 2020.
- **Minor in Spanish,** May 2020.
- **Professional Development:** Regular participant in advanced training sessions and industry conferences.

Driving Throughput in tRNA Sequencing Library Generation with Automated Liquid Handling, June 27: 1 Hour
SPT Labtech

Hamilton MICROLAB Virtual Venus Software Training, July 18-22, 2022: 40 hours
Hamilton Robotics, Reno, Nevada

Janus G3, Chemaic 360, JanusG3 qPCR Automation Specialist, January 15-17, 2022: 32 hours PerkinElmer, Inc

Basics of Non-Conforming Event Management for Clinical Laboratory Services, December 25-25, 2021: 2 hours
Florida Board of Clinical Laboratory Science CE

Risk Management in the Clinical Laboratory, December 25-25, 2021: 1 hour
Florida Board of Clinical Laboratory Science CE

Inspection Preparation, Process, and Corrective Action, December 21-21, 2021: 1.5 hours
Florida Board of Clinical Laboratory Science CE

Bloodborne Pathogens, Aug 1-2, 2021: 4 hours
National Health and Safety Association