**ARC WHITE PAPER**

By ARC Advisory Group

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# Tailored Automation Solutions for Performance-Driven Machinery


## Aerotech Offers Key Advantages in Motion-Centric Machine Design

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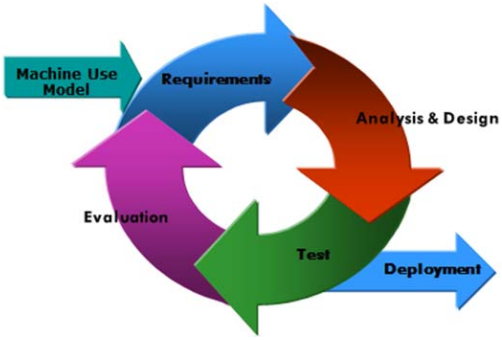
# Executive Overview

Today's machine builders confront a new era of risks, as globalization increases competition and the Internet rapidly disseminates information about products and markets. The highest priority for designers of performance-driven machinery is to reduce the various risks confronted across the machine design, development, and maintenance lifecycle. Astute business managers seek out organizational improvements that help mitigate these risks.




**Machinery Development Lifecycle**

High-performance machine design exacerbates the challenges of managing the design and development process across an interdisciplinary engineering staff of mechanical, electrical, and automation software designers. Every decision during the machine design and development cycle is critical to achieving performance goals. However, machine builders often have limited resources in their engineering organizations, making it challenging to stay on the forefront of modern engineering design tools, advanced algorithms, and automation. Training time often lengthens design and development lifecycles. An alternative is to utilize an automation specialist with a strong track record in high-performance machine design.

Aerotech, a specialist in high-performance motion-centric machine control, now provides a comprehensive service for machine builders that spans from initial concept through end of life. This service, an extension of a machine builder's own electromechanical and software development staff, utilizes Aerotech's extensive application experience to enable the machine builder to complete its designs in a time-efficient manner. Collaborating with a specialist such as Aerotech can provide the competitive edge that allows machine builders to respond to unique industry or customer requirements, while maintaining profitability. Aerotech has proven expertise in machine architectural design across mechanical, electrical, and automation software disciplines. By employing a systems engineering-based methodology, the team evaluates requirements to determine ideal design alternatives. Using advanced mathematical modeling tools, simulation, and virtual validation of the complete machine, Aerotech's engineering team can help ensure that all functionality and physical behavior requirements are achieved economically.

# Business Case for External Collaboration

Machine builders face enormous pressure to improve their business performance. Factors such as declining machinery prices, cyclical capital expenditures, and a regional shift on the demand side make the business more challenging. Machine builders must now reassess the business value chain to determine where the greatest competitive advantage is to be found. It is not simply a matter of eliminating costs here and there, but of "leaning out" the business by eliminating waste across the organization.

Meeting customer requirements and remaining competitive in a market that demands constant product improvements and the inclusion of the latest technology is a tremendous challenge. Perhaps the most daunting challenge is dealing with the complexity of building machinery that must not only integrate the latest advances in mechanical and electrical design, but also incorporate the more complex automation software that will differentiate products from competitors' products.

## Training and Design Assistance Cement Automation Relations

Today's machine builders need support services from automation suppliers more than ever. In a survey conducted by ARC Advisory Group, the participants ranked the type of services they sought from automation suppliers to support integrating actuator technology on a machine. "Design assistance" and "technical training" received a relatively strong response of 43 percent and 38 percent, respectively. As many machine builders lean out their engineering organizations, they face increased pressure to outsource non-core elements of the business. Increasingly, machine builders recognize that by strategically aligning their own organizations with an automation supplier, they can minimize a wide range of business costs.

| Suppliers Services | Percent |
|---|---|
| Automation Design Assistance | 43% |
| Automation Technical Training | 38% |

Some machine builders have learned that they can improve product functionality and reduce up-front integration costs for modular drives, control-reliable drives, and combined motion and I/O networking by working with an automation supplier's services organization. Many machine builders have relied on these services for application programming, to custom engineer components, or even to support their field service organizations. However, in most cases, high-performance machine design demands project services that encompass the entire life cycle of the machinery.

### Shorter Innovation Cycles

Today, manufacturers seek significantly shorter delivery times for each new generation of machinery they order, since they know that their competition is not standing still. Based on ARC research, the lifecycle of high-performance machinery is now five years or less. For machine builders, this means that once the current generation of machinery is built, they need to immediately start looking ahead at the next generation of improvements. To confront these challenges, design engineers need training with leading-edge design and development tools to achieve the performance goals for the next generation of machinery.

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To achieve high-performance design goals in packaging, semiconductor equipment, electronics, injection molding, metal cutting, or robotic machinery an automation solution must be tailored to the application. Integrated development tools, modern software methods, and model-based design tools are available in the automation market to address these challenges. However, a majority of engineering organizations do not take advantage of modern automation tools due to limited budgets and/or a culture of reacting to problems after they surface in the field.

### Late-Stage Design Alternatives Increase Project Risk

As innovation cycles become shorter, there is simply no room for development delays. Problems in machine design often directly relate to organizational and budgetary business issues. The organizational aspect is that engineering disciplines continue to function as silos. Secondly, budgets are insufficient to bring the latest in technological advances for managing software and analyzing complex systems. The result is that engineering organizations have a limited capability to take a high-level perspective of the functional aspects of the machine until most of the detailed design has been completed. This means that problems in machine design only surface when the engineering disciplines interface near the end of the design process. This results in further iterations in the late stages of the development process, leading to project extensions and cost overruns.

Often, these problems emerge due to incomplete or inexact connected interfaces between the detailed design disciplines of mechanical, electrical, and automation software. Late consolidation and difficulties with system integration has consistently been one of the primary causes of lengthy machine

The propagation of errors at each integration stage can drive the original project cost estimates up by ten times.

system development and the associated costs. Rework at each stage of integration can drive up the cost for each stage by ten times the original budget.

### Minimizing Number of Vendors Can Help Optimize Machine Design

One approach to optimizing overall machine design is to minimize the number of different vendors involved. It's likely that a single vendor that fully understands the system's design goals and requirements and has the appropriate capabilities will be in a better position to create a successful machine design than if multiple vendors are involved. This is because with multivendor solutions, the individual vendors are often reluctant to share intellectual property, with the machine builder forced to take on the role as an intermediary when critical design issues arise. Also reducing the number of suppliers can reduce the likelihood of after-the-fact finger-pointing.

In any machine design, individual components should be evaluated in advance via a well-articulated process to ensure their appropriateness for a given machine application. Here, deep knowledge of the fundamental physics of the application is critical.

In high-performance machine design, customizing components such as a motor, gearbox, coupling, or other elements of the power train may have to be considered. A systems engineering approach provides options for design engineers to improve on the overall machine performance and minimize custom components by evaluating alternatives from a system-level perspective and determining the ideal criteria for each component. To this end, machine builders should consider partnering with an automation supplier with extensive experience in system-level design approaches.

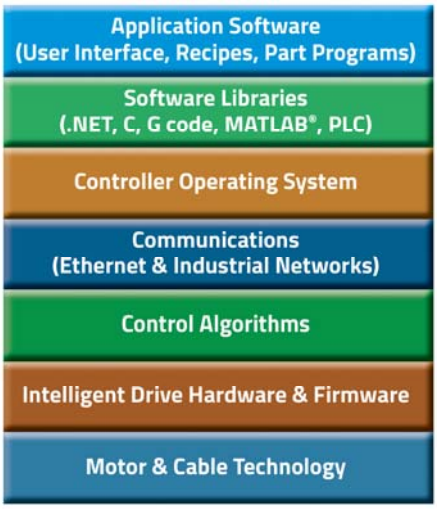
## Tailoring the Automation Platform

Since automation is not a core competency for most machine builders, it often makes sense to outsource all or part of this key element to an appropriate automation supplier. However, before evaluating any suppliers, it's a good practice to first identify the specific automation platform characteristics required. ARC Advisory Group believes that, for modern machine design, it's essential to employ an automation platform that is flexible

enough to accommodate all application requirements without requiring modifications to the core product hardware, firmware, or software.

### Tailoring Standard Machines

Manufacturers are expanding operations globally to capture market share in emerging markets. These manufacturers seek machine builders that are able to customize machinery for local regulatory requirements and adapt the machinery to the particular skills of the local labor pool.




**Flexible Machine Architecture can be Tailored at Any Layer**

These market accommodations lead to increasing variations in software and electronics on each production machine. The standard machine is slowly becoming an anachronism; every machine requires customization to meet the specific needs of the manufacturer. However, the required customization should be achievable without affecting or disrupting the core machine automation capabilities. This is particularly important in highly regulated industries such as aerospace and pharmaceutical manufacturing where validating and certifying machinery for these markets is extremely costly and time consuming.

These highly regulated industries have spurred a best practice of validating the core functionality of a machine design in a manner that enables a certain degree of customization without requiring the entire design to be retested or revalidated for each iteration. This reduces development costs and time-to-market, while helping maintain the quality and reliability of the base product. An automation partner with appropriate expertise developing flexible automation platforms can often help machine builders achieve this.

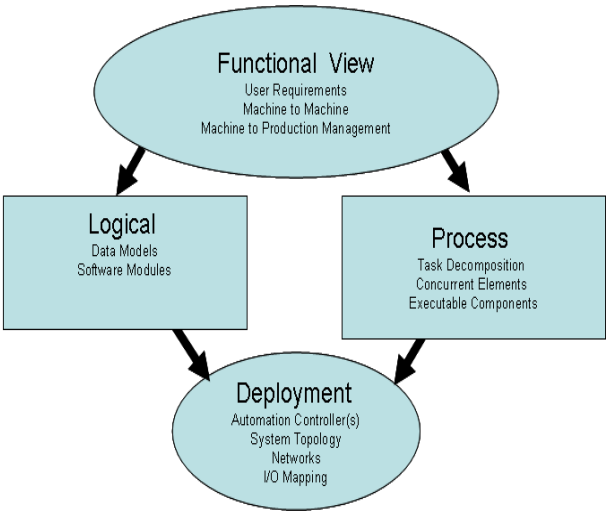
Automation platforms that support interdisciplinary engineering tools reduce the need for design changes that affect the core machine. By developing a conceptual functional model that captures all engineering discipline interfaces, added features that disrupt the core elements of the system can be avoided.

Added functionality often involves developing software modules. Here, an object-oriented approach can provide tremendous value to automation systems. The object-oriented approach involves defining messaging interfaces,

behavior, and state information associated with a specific element of the machine. These software design techniques rely on reusability and extensibility of the underlying machinery components, allowing designers to build application software that mirrors the mechanical implementation. This plays a significant role in lowering the cost of developing additional functionality in machinery and enabling machinery to be divided into independent modules. Machine builders that combine modular machine architectures with object-oriented software design methods benefit from lower deployment costs and have a distinct competitive advantage.

## Maintenance and Documentation

To help improve software development productivity, Aerotech's engineering services group can apply the lessons learned over the last several decades. This could provide tremendous benefits for machine builders that have been slow to adopt these methods themselves. One approach to improve software development productivity is to first define a Functional View of the system and then map these requirements into Logical, Process, and Deployment Views. This leads to the development of modular code that helps reduce development time and cost while building-in consistency across a product line.




**Delineate the Key Elements of the Design Process**

This approach requires a commitment to developing documentation that can be used throughout the project development cycle and that can support maintenance once the machine is deployed in the field. In many instances, machine builders fail to recognize the importance of developing a clear set of documentation that unambiguously specifies the functional operation of the machinery before initiating any software design.

In many machine building organizations, defining an external view is generally not a formalized process. Instead, it is generally left up to the project engineer responsible for delivering a working machine. Writing a set of functional specifications to define the operational view is often not factored

into the project development plans. However, instituting Functional Views into the project plan leads to consistent deployment from machine to machine and facilitates the final test and validation of the machine operation.

Easily maintainable machine control solutions demand the use of modern development practices. These include employing a software management approach that strives to reuse and extend a baseline of software components to deploy on every machine. A large element of the software development strategy needs to embrace a continuous improvement approach that relies upon iterative design methods, well-documented interfaces, and a maintainable code base.

### Practices for Maintainable Systems

By decomposing the design requirements of the system into subsystems and components using a systems approach, the engineering team can develop the functional specifications. This enables the various engineering design disciplines to define integration interfaces early in the design cycle.

This process lends itself to concurrent development within each engineering discipline involved in the overall system design and validation. The systems engineering method is the reference point for each design discipline and how they will interface. This allows machine builders to validate concurrently the basic subsystems requirements and functionality for mechanical, electrical, and automation software design. Furthermore, design tradeoffs between engineering disciplines are evaluated during an early validation process.

There is a significant difference between just hiring a software contractor to develop the machine control software versus working with a full-service automation partner. The ideal automation partner will have developed processes and software guidelines that allow a machine builder to reduce time to market, allow for incremental improvements, and minimize software maintenance costs over the lifetime of the machinery.

# Automation Generalist vs. Boutique Automation Supplier

The value proposition offered by any full-service automation supplier is the support and services available throughout the selection and integration process. Leveraging an automation supplier to become an extension of a machine builder's own engineering organization is a partnership that requires serious consideration. Depending upon a machine builder's strategy, it can decide to partner with an automation generalist or a boutique automation supplier.

The automation generalist is the right choice when the strategy is simply to minimize the number of equipment vendors. The broad line of components provides an ideal opportunity to source from a single supplier; however, be wary that individual products are generally not intended to optimize any specific application.

In contrast, the boutique automation supplier that understands a machine builder's application problems while having sufficient resources to support its development cycle may be more valuable. The ability to offer an automation platform with open interfaces that allow for extensibility through standard interfaces can often provide the most value going forward. Machine builders need to seek-out a partner that can help them reduce the overall automation complexity by becoming an extension of their engineering staffs.

## Aerotech as an Extension of a Machine Builder's Engineering Staff

Automation suppliers that can speak the language of the mechanical, electrical and software engineering groups are a rare breed. Aerotech believes that it has this capability, enabling it to serve as an effective extension of a machine builder's own engineering staff.

By assigning a dedicated consultant to provide a single point of contact for the engineering services it provides to its machine builder clients, supported by a team of highly experienced automation engineers familiar with system design approaches, the company is in an excellent position to help minimize risk and ensure a successful automation solution; one that is easy to implement and maintain and has the flexibility to meet varying customer requirements without requiring customization of core design elements.

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**Acronym Reference:** For a complete list of industry acronyms, refer to our web page at www.arcweb.com/Research/IndustryTerms/

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| **API** | Application Program Interface | **IT** | Information Technology |
| **CIL** | Common Interface Language | **KPI** | Key Performance Indicator |
| **HMI** | Human Machine Interface | **PLC** | Programmable Logic Controller |
| **IDE** | Integrated Development Environment | **PC** | Personal Computer |



*This paper was written by ARC Advisory Group on behalf of Aerotech. The opinions and observations stated are those of ARC Advisory Group. For further information or to provide feedback on this paper, please contact the author at sspada@arcweb.com.*


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