ARC WHITE PAPER

By ARC Advisory Group

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Automation Controllers that Reduce Deployment Risk in Machine Design and Improve Performance

ARC Advisory Group

Aerotech A3200 Offers Key Advantages in Motion-Centric Machine Design

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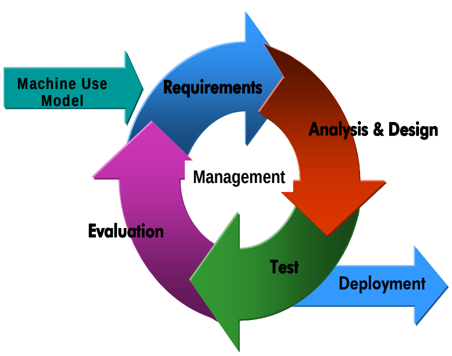
Executive Overview

Facing new challenges through globalization, machine builders are investing in new technologies and skills to maintain competitiveness and penetrate emerging markets. In today's technologically mature markets, the highest gains can be achieved with software. Automation platforms will help design engineers make gains in productivity and efficiency that will be comparable to the the benefits achieved in the IT world.

Streamlining the design, development, and the final integration of industrial machinery is one of the foremost concerns of engineering managers. What many are facing is the increased complexity of integrating mechanical, electrical, automation software and other subsystems. This complexity continues to impede time-to-market and creates uncertainty in project development cycles. These challenges are making it a business imperative to seek out efficient internal development practices that are not an impediment to conceptual design through detailed design and delivery.

Automation Platforms Streamline Engineering

The biggest challenge for machine builders is reducing risks throughout the product development cycle. From concept design through detailed analysis there are thousands of opportunities for projects to incur a delay due to the numerous engineering design decisions. The most onerous part of the component selection process is the automation platform, as evaluation can often take months, particularly if the engineering staff chooses a multivendor approach to automation. For many machine builders the decision is to use what worked in a previous application. It is a difficult decision to switch the automation system supplier as there are often many years invested in training and application development; however, the cost of not evaluating can be measured as a lost opportunity.



Automation Platforms are Critical to Managing Development Cycles.

Aerotech, a specialist in motion-centric machine control, has developed an integrated automation solution that blends concepts from Information Technology with the world of open automation. This is a comprehensive development environment that is designed to meet the demands of each specialist in machine control. Moreover, the approach has applied methods standardized in the IT world to enable development tools to share information in a single engineering environment.

Machine Design and Development Risks Affecting Deployment Time

An automation platform can play a significant role in reducing risks associated with many of the development issues confronted in machine design. Furthermore, an automation solution that improves engineering efficiencies provides an opportunity to increase the value of the finished product as compromises are not made. Engineering organizations are forever confronted with uncertainties during final integration. Unanticipated problems force compromises as time to market, engineering budgets, and final machine cost converge:

1. Monolithic software development leading to integration challenges
2. Integration of third-party software modules
3. Mechanical system performance issues (resonances, instability)
4. Machine cycle-time performance
5. Feature and specification creep in the system
6. Operator interface requirements expand
7. Critical design engineer leaves without documentation trail

Final Integration is a Defining Point for Projects

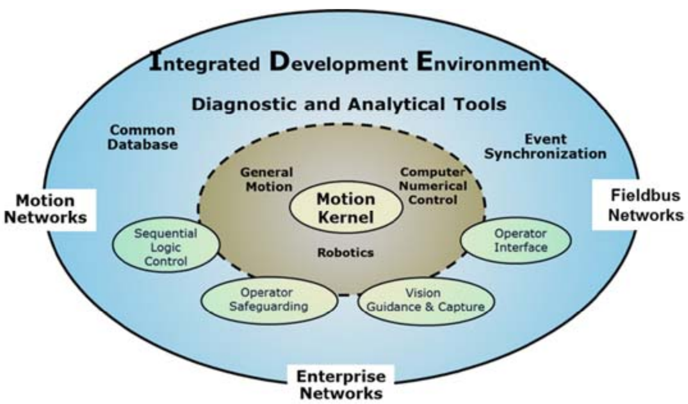
Physical prototyping at various stages throughout the development cycle is widely employed to validate independent modules. This does not eliminate all integration issues. In complex machine designs, unexpected constraints encountered in downstream design activities inhibit the ability of the designer to meet the overall performance requirements for accuracy, dynamic response, and production throughput.

Interdisciplinary Design Tools Streamline Final Integration

Problems in an interdisciplinary design context occur when the engineering disciplines interface near the end of the design process: "final integration". 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 have consistently been primary causes of lengthy machine system development and the associated costs. According to the 10x rule, the propagation of errors at each integration stage costs 10 times the cost of original project estimates.

Innovative Automation Platforms That Minimize Risk

Today, integrated automation platforms that include motion, logic, and operator interface are widely available. These automation solutions are reducing risk and improving deployment times for machine builders. While many machine control platforms offer the advantages of a single supplier and simplified hardware integration, the value of a comprehensive engineering platform is often overlooked. Many integrated solutions are only incremental improvements as innovation cycles in the automation market are notoriously slow. Many vendors are locked into legacy product lines dating back to the 1980s and need to support legacy products.



Integrated Automation Machine Controller

Innovation is thriving amongst a breed of automation suppliers that are modeling their solutions after modern computing systems where networking, graphical interfaces, embedded knowledge, open interfaces, database, and advanced diagnostics are integrated as a unified control platform. These automation solutions have made the once complex, perplexing machine control integration problem simpler by eliminating the barriers across automation domains, but also by adding diagnostic tools that are unsurpassed.

Automation Platform Leading to Development Efficiency

At the automation level, disparate functions like PLC programming, operator panel design, and device configuration are being merged into a single, comprehensive engineering framework, helping engineers to design, build, and commission machinery more efficiently and effectively than ever before. Automation platforms based on an Integrated Development Environment (IDE) are now emerging to harmonize the engineering tasks required throughout the machine design stages.

Specifically, complex automation tasks that require a motion-centric control hierarchy require an Integrated Development Environment to support a multitude of application programming languages and services. These languages and services are part of an automation control architecture that spans business integration, operator interface, machine control, and motion control aspects of the system. The engineering skills at each layer of development are often uniquely different and a development environment must be aware of these unique skill sets. Thus, automation platforms today need to be an embodiment of Information Technology development tools along with Industrial Automation development tools that create a bridge between domains.

Marriage of IT Development Tools & Industrial Automation

The commercial software market advanced by leaps and bounds as multiple business functions consolidated into "office productivity suites". These suites applied accepted standards for deploying common user interfaces amongst applications that allowed the first practical sharing of objects between applications, creating true efficiencies. Now, with some time delay to the commercial world, industrial software is moving to the application suite model, driven by the need to improve productivity and shorten engineering cycles.

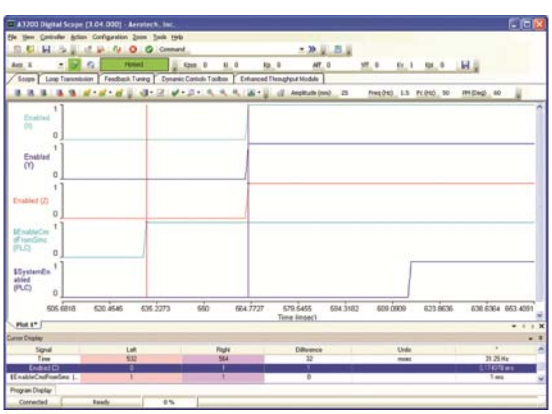
> Designing controllers for production machinery often involves many different elements of closed-loop control and signal analysis. Pressure control, heater control, servomotor control, image processing, and vibration analysis are all examples of relatively sophisticated algorithmic implementations.

In the "business world" the office suite of products is combined in a way to allow users to tackle business problems using the most appropriate tool. Similarly, the notion of office productivity suites is now being leveraged in automation solutions to allow design engineers to use the most appropriate tool for each task. In production machinery design a wide range of tasks spanning closed-loop control, sequencing, and signal processing & analysis requires a broad array of application design tools. Pressure control, heater control, multi-axis servomotor control, image processing, and vibration analysis are all examples of relatively sophisticated machine capabilities that require specialized algorithms and control strategies.

The adoption of IT methods and concepts has the benefit of creating an open environment for third-party applications. Third-party analytical and design tools such as Simulink® from The MathWorks or LabVIEW® from National Instruments are widely used by engineers to evaluate control strategies. Simulation tools are an integral part of the design process. However, there is also a trend toward using these analytical tools to employ a model-based design approach. Model-based design tools provide the ability to model the dynamics of the machine and implement advanced control algorithms in a common development environment. Innovative automation solutions are providing this bridge between traditional industrial development tools and model-based design tools. This represents a tremendous opportunity for machine builders to reduce training costs while also reducing the deployment time of projects.

Diagnostic and Analytical Tools Addressing Integration Issues

Perhaps the most compelling issue facing machine builders today is to improve performance, minimize initial investment in design & development, and ensure that the machine performs according to the original design goals. Designing and building a new line of machinery always encompasses a certain amount of risk to the machine builder. In fact, many machine builders would prefer to stay in their comfort zone with new machinery designs to avoid uncertainties in actuator selection, mechanical configurations, and final integration. It is rare for all of these design decisions to come together flawlessly when developing a new generation of machinery.



Integrated Diagnostic & Analytical Tools

Accuracy, precision, cycle time, energy efficiency, and throughput are all key performance indicators (KPI) and how machine builders are being measured.

Diagnostic tools are essential for machine builders to achieve these KPIs. To enable engineers to get the most out of the equipment, improving performance requires visualization of the problem using diagnostic tools that are familiar to the engineering community. Whether it is a digital oscilloscope, spectrum analyzer, logic analyzer, or software debugger, the integrated development environment has led to a broad range of diagnostic engineering tools that function seamlessly when a system is operating dynamically or statically. Diagnostic tools are critical to rapid problem solving during the final integration phases of a machine design. Often a problem crosses the boundaries between electrical, mechanical, and software implementation; however, isolating the source of a problem can be merely hypothesis without diagnostics that provide empirical data for problem isolation.

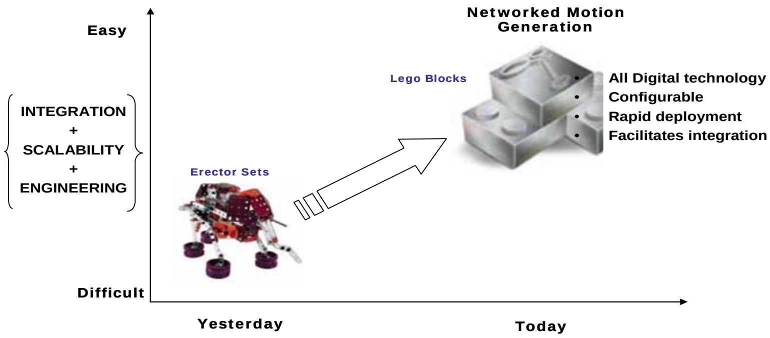
Diagnostic tools are critical to rapid problem solving during the final integration phases of a machine design.

Once problems are isolated there may be a number of viable options that would result in a resolution. For example, software algorithms can be employed to compensate for mechanical resonances and nonlinear perturbations that were not modeled accurately on the design board. In many instances, the location of a feedback device, the effect of a coupling, stiction force to decouple masses, or the effects of temperature variation on the mechanics cannot be accurately predicted. These unanticipated effects commonly result in system resonances, causing inaccuracies and underperforming movements. The ability to cancel-out unanticipated ringing in a system without redesigning the mechanical system is not a new concept. However, diagnostic tools in conjunction with analytical tools that are part of the integrated development environment provide a unique ability to streamline engineering.

Object-Oriented Design for Tracking Development Progress

More machine builders are becoming custom design houses. To manage the cost of designing custom machines there has been extensive use of modularity for both mechanical and electrical subsystems. However, in software design many machine builders continue to use monolithic concepts, controlling widely dispersed machine functions from a single, centralized program structure. Some are simply not aware that modular software can lower development costs and shorten commissioning time.

Modular design approaches to programming go hand in hand with mechanical and electrical subsystem design strategies because each takes an object-oriented view of machine sub-systems. The modular approach allows machine builders to divide their machine designs into functional units, and then program and configure each unit as if it were a stand-alone system. The goal is to build up a library of software objects that are pre-validated so that ensuing designs can be assembled like Lego® blocks rather than starting each project from the ground up.



Component Solutions Give Way to Mechatronic Subsystems

Many engineering tools now have libraries for user-created objects, but not all allow the user to manage them efficiently and track changes as objects are developed. While the costs of automation control platforms and hardware continue to decline, the hidden cost of software development is escalating rapidly, thereby negating many of these cost reductions. In effect, software development is rapidly garnering a greater percentage of the overall engineering effort, so efficiency gains won in engineering productivity are amplified.

Using an object-oriented approach is an important shift that will have a long-lasting impact on the machine building market. The object-oriented approach relies upon 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 divide into independent modules. Machine builders who combine modular machine architectures along with object-oriented software design methods benefit from deployment costs and have a distinct competitive advantage.

Real-Time Database Spanning Automation Domains & IT Domains

One of the most difficult problems of working with automation systems has traditionally been the management of the automation controller data. Most automation controllers based on PLC architectures typically offered only simple data structures such as linear lists of bit, byte, and word data with more modern systems providing a wider array of data types such as floating point and integers. Even many motion control solutions remain difficult to use as they do not work in the units of the mechanical system, many times forcing developers to use the units of the feedback device.

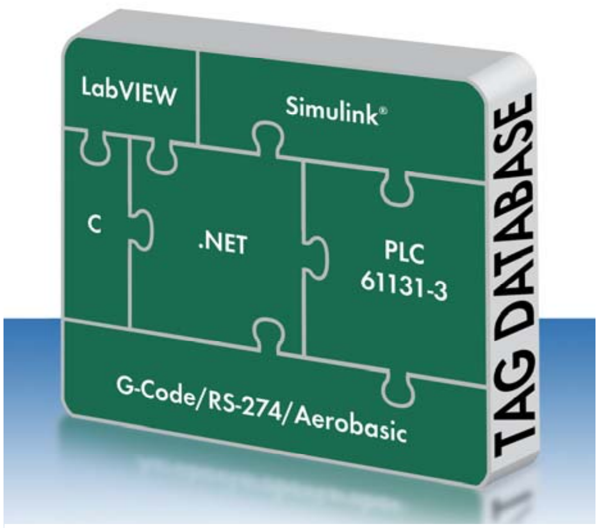
> The challenge for modern engineering tools is to unite all system data in a single common database that is accessible by all devices.

Many of the data reference issues were addressed by visualization software vendors who gradually replaced dedicated displays. The database was moved to operator panels or industrial PCs where data could be manipulated in a freer, more PC-like environment. “Tags”, or virtual data that point to fixed PLC register addresses, were created to allow users to process data in a wide variety of data formats, or group dissimilar data types together in logical object-oriented structures. Data management problems were caused by the fact that data “lived” in multiple locations, often distributed among several devices in an automation system including PLCs, motion controllers, operator panels, IPCs, and even smart field devices. Creating a new data point in one system necessitated the creation of corresponding tags in the other systems if this information was to be shared.

One of the greatest achievements for modern engineering tools is to unify all system data in a single common database that is accessible by all devices. Furthermore, the use of symbolic references to data has enabled automation systems to dynamically allocate the physical memory location of data without burdening the design engineer. Relieving the engineering group from the concerns of physical memory allocation eliminates a whole host of integration problems when system software and hardware components are brought together. These database features have the potential to dramatically increase the efficiency with which automation systems are engineered and deployed.

Aerotech A3200: An Automation Platform Streamlining Development Processes

Aerotech, an innovative machine control company, subscribes to the philosophy of "Integrated Automation Solutions". The A3200 automation platform embraces the concept of integrated automation by combining the best of the IT world with the most widely adopted standards for network interfaces and programming in industrial automation. Thus, the A3200 has been developed by motion control experts that understand the integration challenges, also recognizing that the challenges in machine development encompass a broad range of tasks. This is critical to helping customers lower their engineering costs. This platform facilitates integration with development tools optimized for each task at hand.



A3200 Facilitates Data Sharing Between Programming Environments

The A3200 is an engineering framework that embraces Microsoft Windows® and the PC platform for both development and real-time automation execution. Development tools and application programming environments are based upon the same desktop tools that engineers are working with today. The A3200 connects Microsoft Visual Studio®, an Automation Integrated Development Environment (IDE), and a PLC IDE together through the Tag Database and runtime machine state information. In this environment, application programs written in different languages (IEC61131-3, C#, and G-code) work together seamlessly. The real-time machine state information is shared through the .NET Common Interface Language (CIL) that runs in the real-time motion kernel. The .NET framework is the glue that facilitates data sharing between all the disparate programming environments.

The standard IEC61131-3 industrial PLC programming environment also conforms to the .NET framework. IEC61131-3 applications employed for machine control sequencing and other auxiliary functions have been augmented with specialized motion function blocks. More advanced design engineers are able to work directly in a motion language, AeroBasic™. This positions the A3200 as an ideal solution for both complex and standard motion-centric machine control. By providing a library of widely used motion functions along with robot kinematic transformations and standard CNC capabilities built into the system, this relieves engineering groups from implementing more common complex motion control functions.

Machine Tag Database

Regardless of which language is used for development purposes, the real-time variable and static data is all accessible in a central machine tag database. Engineering groups working in parallel developing application software can reference variable data that is published by each application. Tags created in any development tool for any device are automatically and immediately accessible to other devices. If, for example, a user creates a new tag in the PLC to measure a temperature, that tag is automatically created in the operator panel at the same time. This saves valuable engineering time compared to conventional methods that require the tag to be created in each device. Data is universally accessible. Thus, network communication, graphical Human Machine Interfaces, sequential machine control, and motion control applications all have simultaneous access to data for reading and writing.

Simultaneous Access to Tag Database

Diagnostics and Analysis

The most obvious advantage of the A3200 for development engineers is the rich set of diagnostic tools. Digital oscilloscopes, logic analyzers, and code debuggers can all be utilized simultaneously to solve many integration issues. These tools are not solving problems, but are giving the development group the information needed to analyze issues so that problems can be solved collaboratively. It is often the case where the application programmer is not intimately familiar with some of the subtle dynamics in the machine electromechanical section. With the use of application program analyzers and motion analyzers, problems can be resolved by working in tandem.

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Acronym Reference: For a complete list of industry acronyms, refer to our web page at http://www.arcweb.com/research/pages/industry-terms-and-abbreviations.aspx

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

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