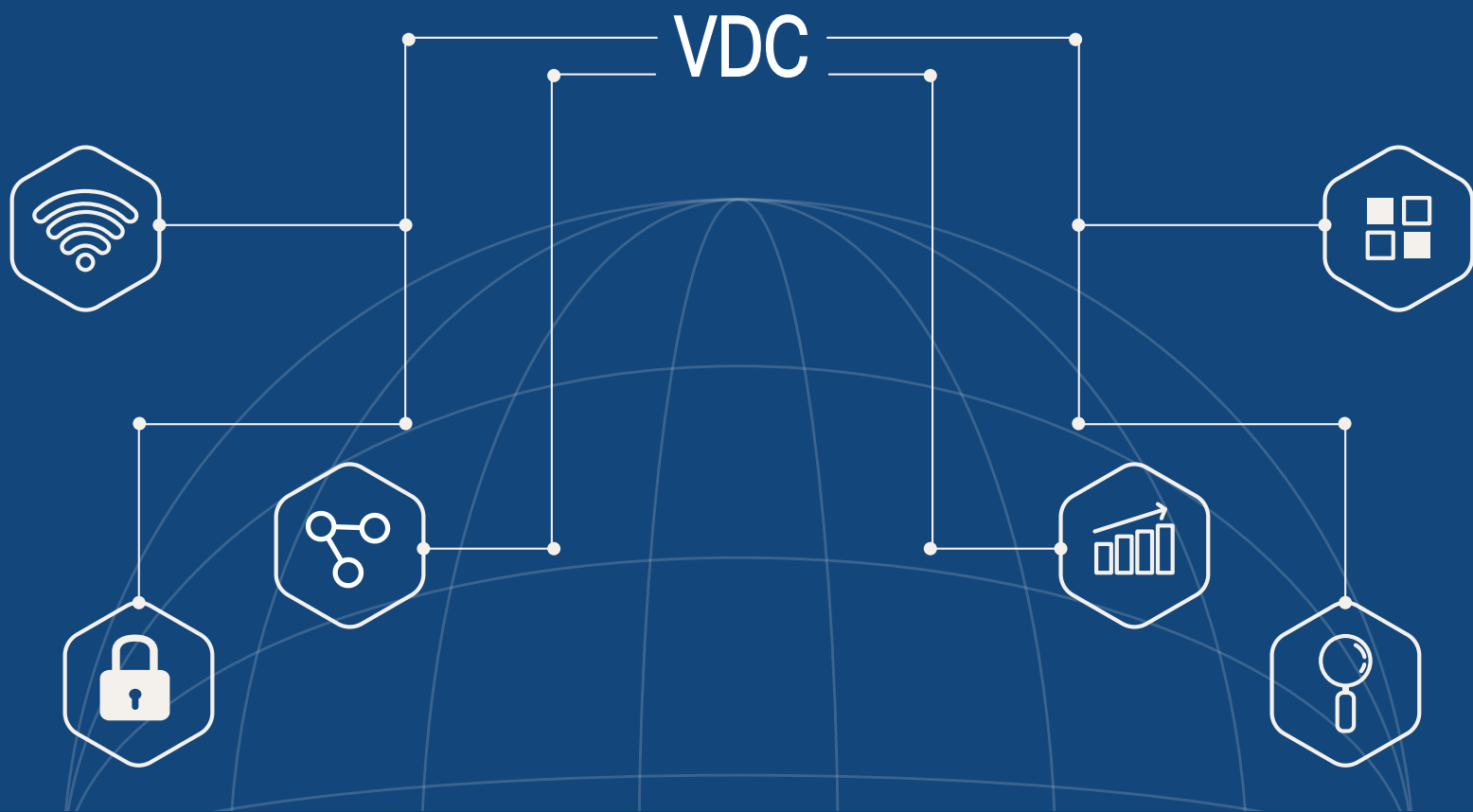


Automate without Compromise

Accelerating Factory & Logistics Automation Solutions



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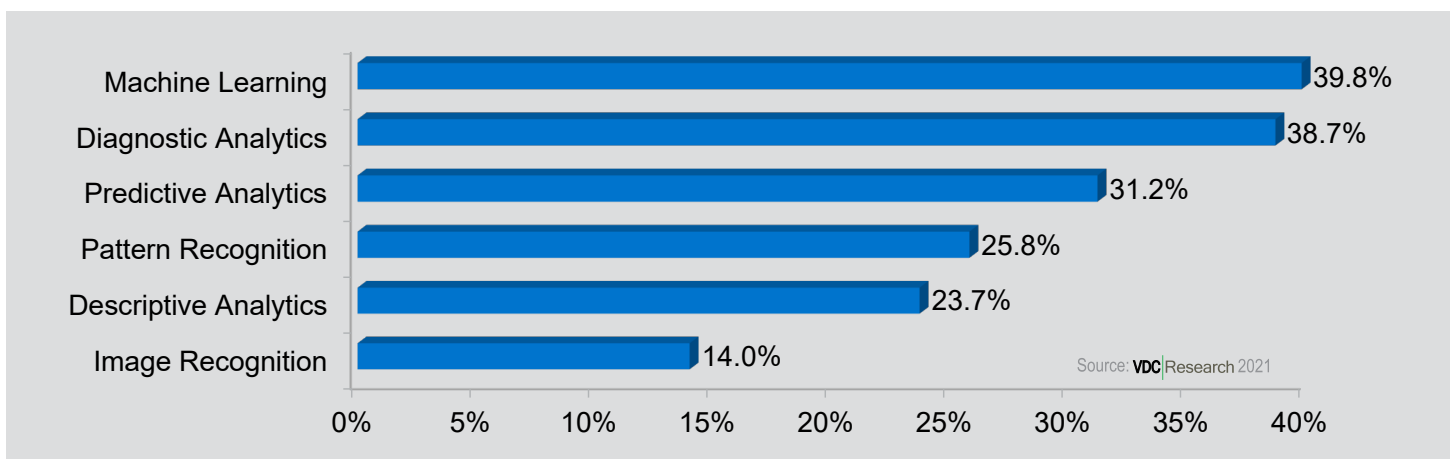
Overview

Automation is Changing Industries

Smart factories are rapidly emerging around the world, leveraging advanced automation applications such as augmented reality, autonomous mobile robots, cobots, and industrial sensors. Even beyond the traditional factory floor, automation is accelerating in areas like warehouse automation and logistics by using similar applications. These new features and functionality are now more practical because of hardware improvements enabling real-time networking, high-performance processing, high reliability, low power consumption, and interface flexibility.

Keeping factories alive and profitable today requires optimizing performance and uptime by deploying connected automation and predictive maintenance solutions, which can translate into immense savings and value for end users. Demanding 7x24 operation in industrial and logistics environments increases stress on devices, especially in systems with active drives and motors (e.g., bearings, electronics), and a single motor failure can halt operations or production. Newer computing solutions for automation, such as integrated edge AI engines, can identify these irregularities and predict failures well in advance so that operators can be alerted, parts can be pre-ordered, maintenance scheduled, and overall operational efficiency increased. In addition, local onsite processing reduces network transmission costs, storage costs, and reduces datacenter processing costs all while valuable data is protected by eliminating transmission to remote sites. Leading implementers are now embracing a wide range of different (and often multiple) types of analytics to process IIoT data and produce impactful insights (see Exhibit A) that are fueling further automation innovation.

Exhibit A: Types of Cloud Analytics Used to Analyze IIoT Data in Current Projects



Enabling Intelligent Automation is Not Trivial

While intelligent automation has the potential to produce critical value and insights within operational environments, designing, developing, and integrating an automation solution is complex, with many different considerations. Factory and logistics floors are increasingly dense with more intelligent and connected deployments combining programmable logic controllers, industrial networking, functional safety, and robotics. These systems-of-systems combine with increasingly sophisticated analytics to provide enhanced system-wide integration and situational awareness, establishing a foundation for future capability additions. Automated mobility brings further requirements for collision avoidance with complex sensor fusion processing and sensor bridging. Growing demand for increasing efficiency with autonomous robotics/machines is accelerating advancement in motors, sensing and/or vision processing, and more edge analytics throughout the landscape.

¹ All survey data sourced from VDC's IIoT & Embedded Technology Survey of more than 770 developers, engineers, and product/project managers worldwide across industries.

Next Generation Automation Demands the Right Mix of Technology

Increasingly sophisticated automation solutions require the support of leading silicon technology providers throughout the hardware and software stack. The demands for edge AI and computer vision only exacerbate this need for sound solution partner selection. A flexible hardware architecture, at the lowest level, is critical for maintaining the pace of innovation for industrial and logistics automation solutions. Today, software development comprises the bulk of development cost and labor in industrial projects, placing great value on supporting libraries, toolsets, and ecosystem support from automation technology providers. Development must be accelerated from the onset of new technology launches by silicon providers themselves, while more non-core development from automation OEMs needs to be outsourced to focus internal resources.

Flexible Hardware is an Essential Foundation

Automation Workloads are Evolving

The choice of hardware architecture is critical for everyone including automation solution builders/providers. It dictates not just the semiconductors that will be used at the core of the system, but also the availability and support of different development resources required across embedded software, security, other IP, and design services. FPGAs with integrated processors combine flexibility, performance, and programmability to support the rapid adoption and deployment of new technologies to meet the evolving needs of Industrial Automation.

FPGAs, in particular, feature unique flexibility to support a range of dynamic automation computing profiles and requirements. Today's FPGAs feature very low power consumption and efficient energy usage, enabling them to be designed in smaller form factors with simplified cooling (i.e., passive) compared to alternatives, which is critical at the network edge. FPGAs are also completely customizable, with a range of benefits over software-based solutions, such as lower latency. In addition, FPGAs support high-performance control loops, PWM, and more connected control motors per unit than comparable high-end MCUs. Lattice Semiconductor offers FPGAs with extremely low soft error rates for improved reliability, which is optimal for applications requiring high availability and functional safety.

Adapt to the Changing Connectivity Landscape

Factory floor automation environments continue to migrate from traditional fieldbus towards more open and capable industrial networking technologies like Ethernet TSN and OPC-UA, among others. Growing requirements around interoperability, latency, and data standardization are accelerating the use of newer field protocols and connectivity types. Interconnects between industrial/automation nodes and main application processors (e.g., Ethernet bus, LVDS) are another layer of consideration, particularly when building protected systems. In addition to a diverse mix of industrial protocols and field networks vying for influence, automation solutions are supporting a range of real-time requirements. There is often a mix of soft and hard real-time requirements for automation systems that can greatly complicate development when navigating the challenges in other domains like application performance, security, and/or functional safety.

Security Starts with the Silicon

Hardware security is paramount for protection from an evolving threat landscape and ensuring uptime. Traditional factory and logistics automation deployments were often isolated from the Internet/cloud and even between subsystems therein. Now, increasingly connected automation systems must be protected from hackers, who can shut down systems, blackmail operators, steal sensitive data, or engage in a host of other malicious behavior and otherwise create undue financial risk. MCU and/or software-based solutions are unable to match the real-time protection that alternatives like FPGAs provide with instant detection, high-performance coverage of multiple subsystems, and the ability to roll back to a known good state to recover from attacks, which is critical. FPGAs can be highly secure and resilient with monitors at the lowest level (beneath the operating system) — protecting firmware before/during/after boot, securing/validating code itself, and providing a root-of-trust.

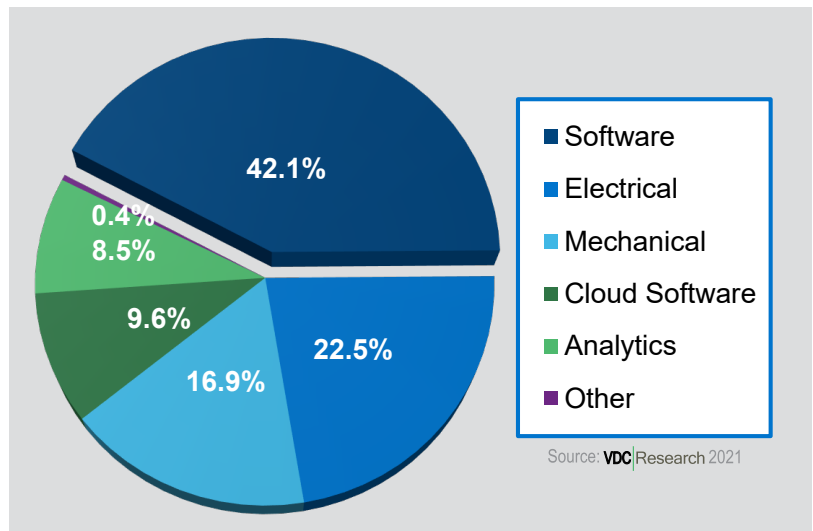
Automation Software Must be Simple & Portable

Leverage Silicon Technology Providers for Optimized Libraries

A flexible hardware foundation is useless without strong software support from semiconductor providers and their partnership ecosystem, particularly for automation solutions. Software development already comprises the vast majority of development costs in industrial automation and control projects (see Exhibit B), so high-quality support in that realm is crucial to project success. Lattice Semiconductor, for example, provides a base platform of lightweight protocols for real-time sense and control using Ethernet for networking (e.g., enabling multi-axis motor control over Industrial Ethernet while daisy-chained to multiple monitors). In addition, high performance FPGAs are becoming more software-friendly, offering software programming tools and graphical design environments like the [Lattice Propel™](#) design environment. In short, today's premium solutions and mature ecosystems allow OEMs to focus on differentiation and accelerate time-to-market.

Automation often incorporates several functional domains with special software requirements, including edge AI, embedded vision, and security stacked on top of lower-level software like operating systems and firmware. Access to more sophisticated software libraries and IP from semiconductor providers in these domains is particularly important for optimizing performance and power efficiency with on-chip accelerators and hardware resources. For example, in the edge AI domain, it is now table stakes to enable development with common frameworks such as TensorFlow, Caffe, and Keras for implementation of CNNs supporting popular use cases like human presence detection, key phrase detection, face tracking, and object counting. For vision applications, solution designers often need flexible interface connectivity (e.g., MIPI CSI-2, LVDS, PCIe, GigE).

Exhibit B: Percent of Industrial Automation & Control Engineering Development Costs Spent on Specific Domains/Tasks



Software Programmability Compliments Programmable Hardware

While programmable hardware supporting low power, high performance compute with low latency is highly beneficial, some workloads are better controlled or implemented in software. For example, software programmability is optimal for predictive maintenance applications, and also enables development with more prevalent developer skillsets (e.g., programming in C). The combination of FPGAs with traditional processor types in heterogeneous system-on-chips, modules/boards, and integrated computing systems enables hardware-software co-processing and advanced system flexibility.

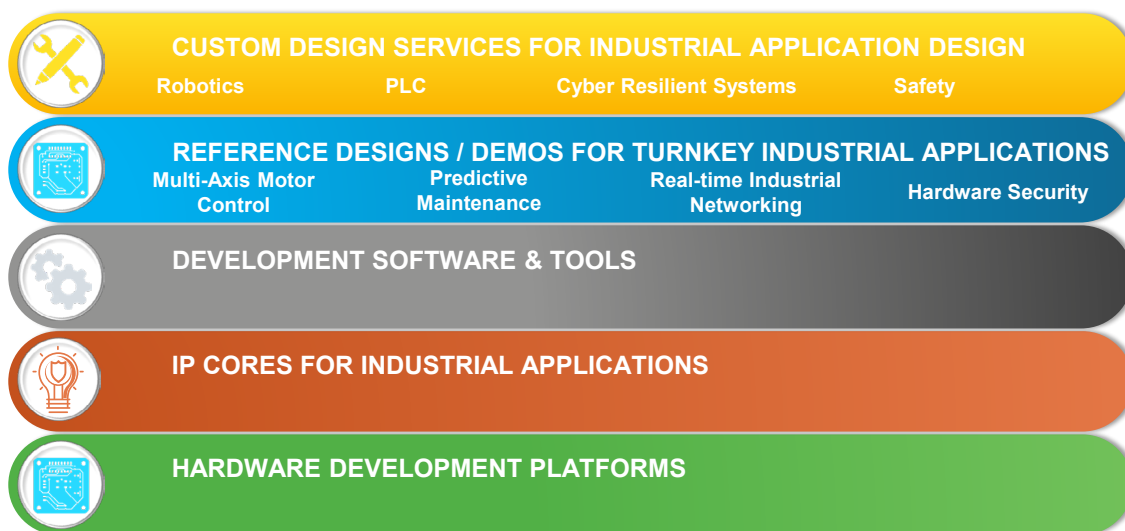
Check for More Automation Building Blocks

IP is Critical to the Automation Roadmap

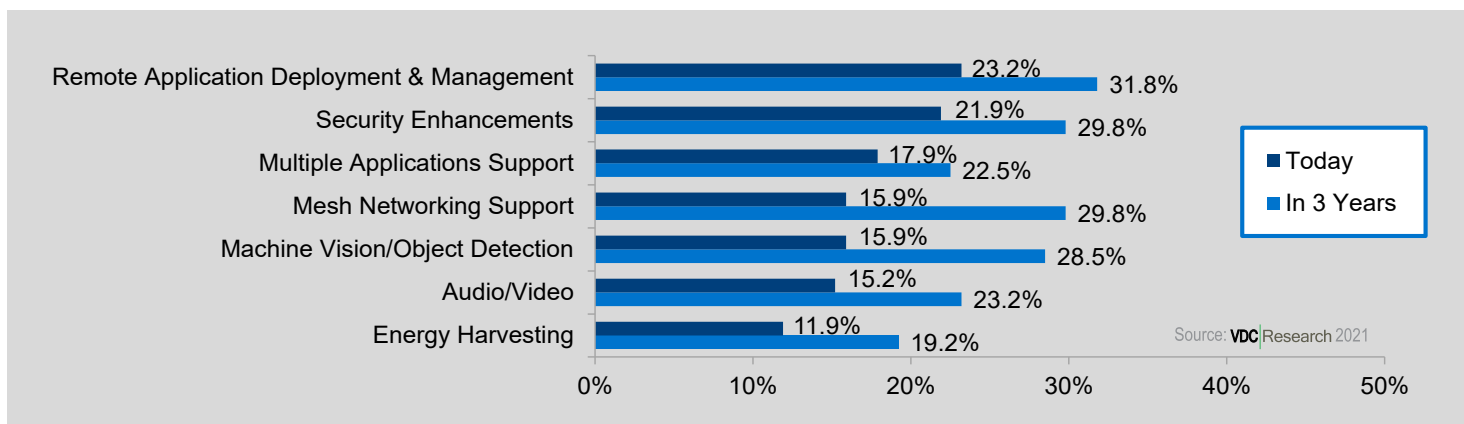
Automation solutions today feature many dynamic components and subsystems that must be developed in harmony to be competitive in the market. Support for motor control, edge AI, sensor fusion, functional safety, computer vision, and security all must tie neatly together in an end-to-end automation solution to accelerate adoption and commercial rollouts. A range of challenges face automation OEMs, systems integrators, and solution builders today that has driven silicon suppliers over the past decade to offer new ways to accelerate innovation. Overall, the most significant causes of delays to current projects are technical in nature and arise most with the use of static hardware architectures with limited software support that cannot evolve with industry workloads.

To help their customers navigate these challenges, leading silicon technology providers are offering more vertical-/application-specific support to accelerate development of new workloads, such as predictive maintenance proof of concepts, experimentation with new co-processing architectures, and prototyping to new specifications/integrations (see Exhibit C). Real-life implementations of new processor technology offerings compliant with popular safety requirements such as SIL-2 or safety co-processing (e.g., reference designs, project examples, etc.) are powerful demonstrations of redundancy/safety that can be better evaluated than theoretically through datasheets or simulation.

Exhibit C: A Solution Stack for Industrial Automation



The automation stack is often built on a variety of IP that is crucial to the application and automation silicon supplier (ecosystem) consideration. Industrial automation and control systems already feature a broad range of functionality, from ranging graphical interfaces, real-time response, wired/wireless networking, and local events analytics to rugged form factors. However, these systems are quickly becoming more sophisticated to support new capabilities that are critical to automation solutions, like machine vision/object detection and security enhancements, among others (see Exhibit D). Providing these features/capabilities with a roadmap for deeper or more advanced support is critical for automation silicon and future-proofing a solution.

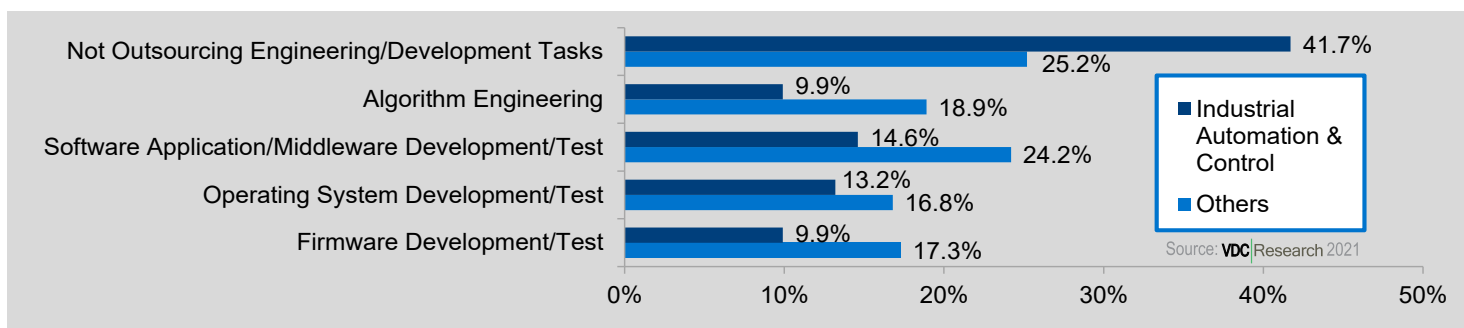


Outsource Non-Differentiating Development

Growing Complexity Is Driving the Value of Offloading Tasks

Designing and building modern automation systems is increasingly too complicated and costly to be done completely in-house. As with the broader embedded and edge computing market, customization and specialized designs are commonplace to fill in any gaps for system/application requirements. The industrial automation and control domain currently has the lowest use of outsourcing for any engineering/development tasks compared to other industries (see Exhibit E). With the modernization of existing factory and logistics environments as well as new greenfield deployments, it will be critical for industrial OEMs to embrace outsourcing best practices seen in more agile industries.

Exhibit E: Engineering and Development Work Outsourced to Third-Party Engineering Services



Software development, in particular, is an area where industrial automation and control are lagging, opening up an opportunity for creating new efficiencies. Finding, hiring, and retaining talent for lower-level software development is increasingly difficult, and their work often adds no application value to the end product. Even in other areas like edge AI, the enterprise/cloud space had a jumpstart in acquiring human resources, and now those organizations have large pocketbooks to continue attracting many of the emerging AI experts. Automation solution providers need to reevaluate their development strategy and outsource more software development to focus more of their limited resources on creating differentiation.

Leverage the Growing Services of Silicon Providers and Their Partners

Leading silicon technology providers over the past several years have greatly expanded their own internal capabilities to support OEMs and others with specialized design services. For example, Lattice Semiconductor features an internal design group for all application segments, enabling the customization and integration of its solution stacks for AI/ML, vision, security, and automation, in addition to a product services group offering manufacturing and production support. The company also has a partner network of organizations that have been trained and qualified with its tools to ensure quality service from third parties. A high-quality design services partner ecosystem is key to fostering greater silicon technology support closer to the application level with dedicated support for the fragmented supplier/technology space for robotics, PLCs, safety, and secure systems.

We are in a New Era of Automation

Automation is now more practical because of hardware advances in real-time networking, high-performance processing, system reliability, power consumption, and interface flexibility. Further, a growing list of sensory inputs including vibration, ultrasonic, temperature, infrared, voltage, acoustics, and LIDAR/radar are feeding edge AI, analytics, and, ultimately, automation solutions. Exposing those data streams is increasingly important to end users. Automation data is often stored and processed locally on-premise and not in the cloud, which places new considerations on edge computing requirements and architectures for new deployments. Processing and storing on site reduces latency, while protecting valuable data and minimizing network and/or data center costs. Even mature silicon families that have been pre-certified for safety compliance are now reaching into new domains/functionality to add value and support for sophisticated applications such as automation.

Enabling Automation Requires a Full Stack Approach

Factory and logistics environments are in a period of rapid change that requires a new engineering and development mindset and planning for creating automation solutions. As spotlighted earlier, software development is an increasing burden on industrial automation and control projects, yet the industry is still taking on too much of the lift internally. FPGAs from vendors like Lattice Semiconductor, which stands out in the market for low power consumption and small footprint devices, are uniquely positioned to support a range of automation applications with growing requirements for high-performance processing, mixed-criticality, low latency, and security. Silicon providers must offer support throughout the stack for precision motor control, real-time networking, functional safety, predictive maintenance, and cybersecurity in tandem to best support/enable automation applications. The [Lattice Automate™](#) solution stack is an example of this full stack approach to automation system design.

The Right Technology Partner will Accelerate Automation Innovation

Silicon technology providers have an increasing influence over the system stack and are a critical consideration when creating new automation solutions. There are many supplier and silicon criteria to consider spanning hardware, software, services, and ecosystem for jumpstarting development and ensuring automation solution lifecycle support, which can span decades. Software development support, in particular, is of crucial importance to mitigate the largest pain points and risks with creating automation solutions and supporting them over time. From a security standpoint, the silicon provider is the most critical piece of the system as it underlies all other forms of monitoring and control. They must guarantee supply chain security that protects IP and devices from manufacturing through shipping – controlled with private keys to put devices into a known state from their firmware. Automation is built on top of a wide variety of hardware and software elements but having the right silicon partner with established tools, IP, and resources across the different underlying foundational domains is imperative to future solution success.

About The Authors



Dan Mandell

Dan Mandell supports a variety of syndicated market research programs and custom consulting engagements in the IoT and Embedded Technology practice. He leads VDC's annual research services for embedded processors, boards, integrated systems, IoT gateways, and other computing hardware. Dan's insights help leading technology providers align their go-to-market planning and competitive strategies with the dynamic embedded landscape and its constantly evolving buyer behaviors, technology adoption, and application requirements. His working relationship with VDC dates back to 2005 and includes time supporting Business Development as well as the AutoID practice. Dan holds a B.S. in Information Systems Management from Bridgewater State University.

Contact Dan:

dmandell@vdcresearch.com



Chris Rommel

Chris Rommel leads VDC's syndicated research programs and consulting engagements focused on development and deployment solutions for intelligent systems. He has helped a wide variety of clients respond to and capitalize on the leading trends impacting next-generation industrial and device markets, such as security, the IoT, and engineering lifecycle management solutions. Chris has also led a range of proprietary consulting projects, including competitive analyses, strategic marketing initiative support, ecosystem development strategies, and vertical market opportunity assessments. Chris holds a B.A. in Business Economics and a B.A. in Public and Private Sector Organization from Brown University.

Contact Chris:

crommel@vdcresearch.com

About VDC Research

VDC has been covering the product development technology market since 1994. The analysis and supporting discussions in this paper are based on VDC's ongoing research in this market and by findings from a survey of over 700 OEM product decision-makers and engineers. This global survey offers insight into leading business and technical trends impacting product development organizations as well as the best practices implemented to address them. The respondents are based across a range of industries including automotive, aerospace and defense, healthcare, industrial automation, and transportation, among others.



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