Automated Test Outlook 2013

A comprehensive view of key technologies and methodologies impacting the test and measurement industry.

BUSINESS STRATEGY
ARCHITECTURE
COMPUTING
SOFTWARE
I/O

NATIONAL INSTRUMENTS™

A Technology and Business Partner

Since 1976, companies around the world including BMW, Lockheed Martin, and Sony have relied on National Instruments products and services to build sophisticated automated test and measurement systems.

Test delivers value to your organization by catching defects and collecting the data to improve a design or process. Driving innovation within test through technology insertion and best-practice methodologies can generate large efficiency gains and cost reductions. The goal of the Automated Test Outlook is to both broaden and deepen the scope of these existing efforts and provide information you need to make key technical and business decisions.

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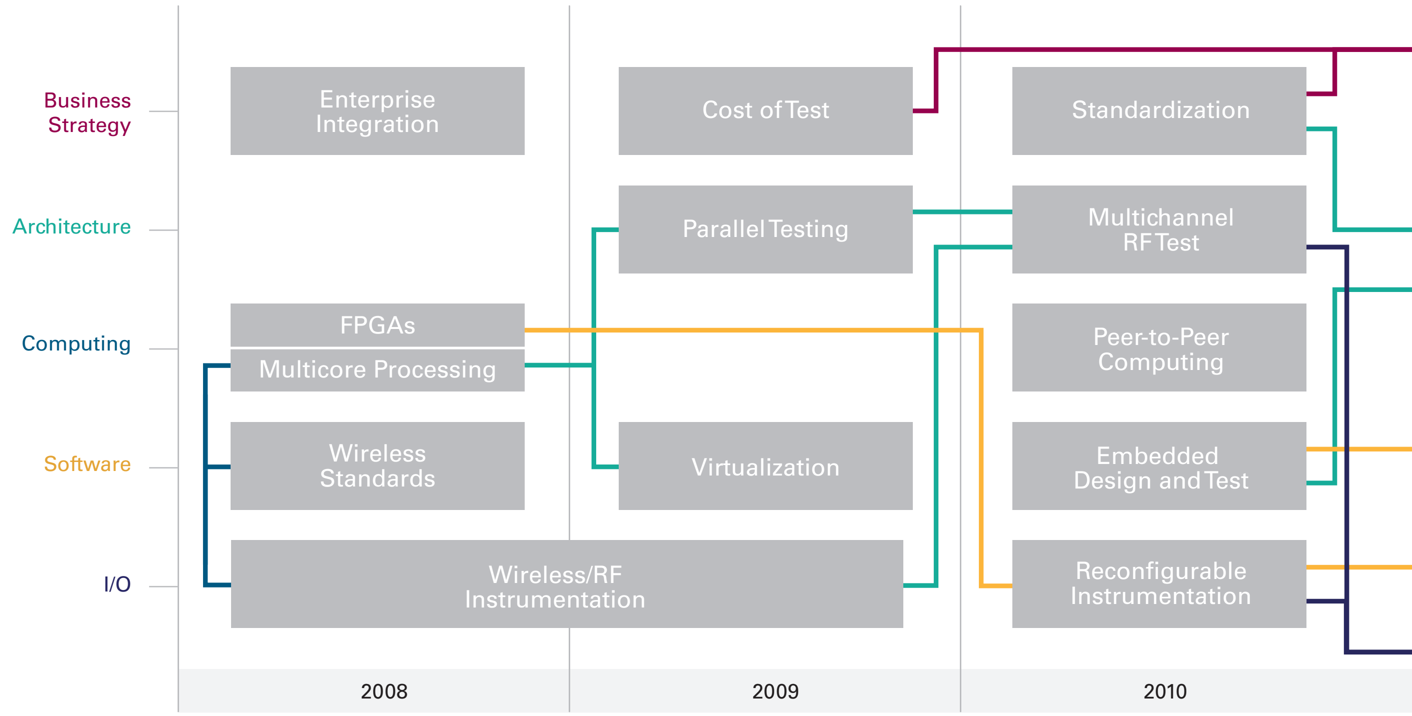
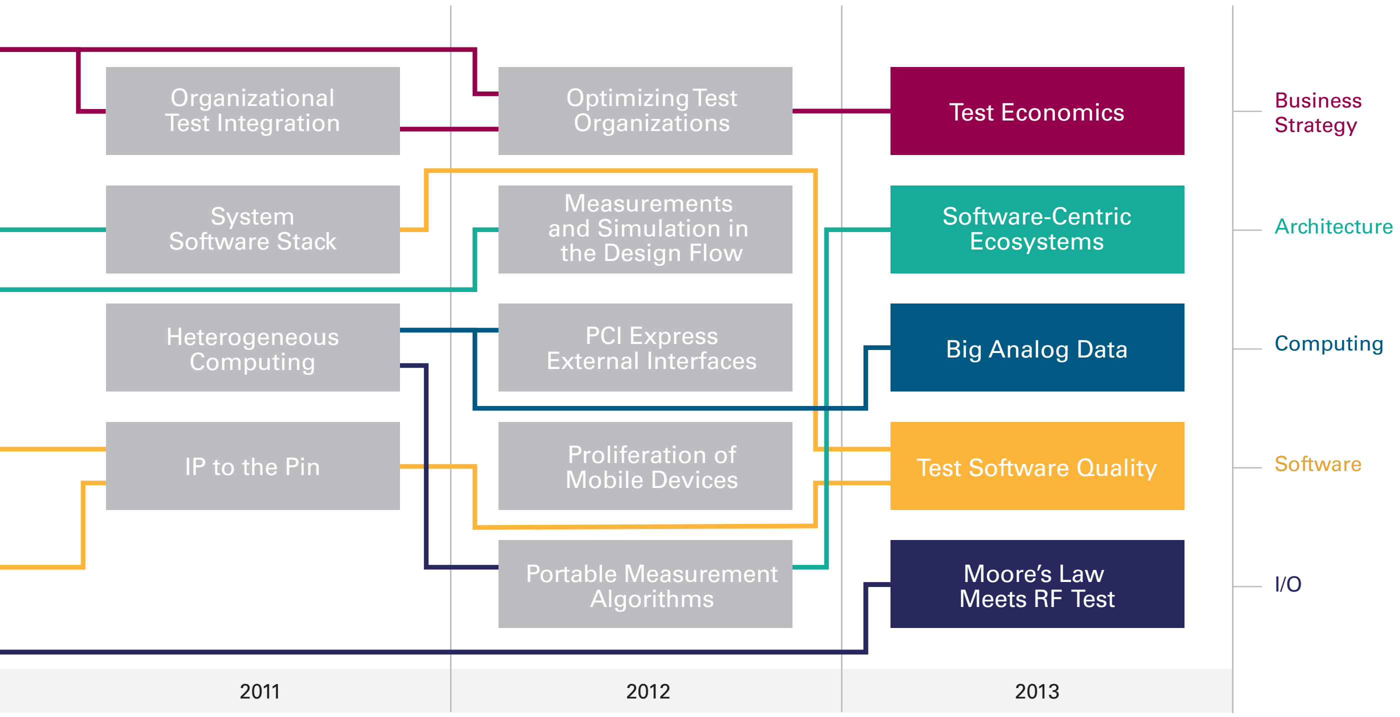


How We Arrived at the Trends

As a supplier of test technology to more than 35,000 companies worldwide each year, we receive a broad range of feedback across industries and geographies. This broad base creates a wealth of quantitative and qualitative data to draw on.

We stay up to date on technology trends through our internal research and development activities. As a technology-driven company, we invest more than 16 percent of our annual revenue in R&D. But as a company that focuses on moving commercial technology into the test and measurement industry, our R&D investment is leveraged many times over in the commercial technologies we adopt. Thus, we maintain close, strategic relationships with our suppliers. We conduct biannual technology exchanges with key suppliers that build PC technologies, data converters, and software components to get their outlook on upcoming technologies and the ways these suppliers are investing their research dollars. Then we integrate this with our own outlook. We also have an aggressive academic program that includes sponsored research across all engineering disciplines at universities around the world. These projects offer further insight into technology directions often far ahead of commercialization.

And, finally, we facilitate advisory councils each year for which we bring together leaders from test engineering



departments to discuss trends and share best practices. These councils include representatives from every major industry and application area—from fighter jets to the latest smartphone to implantable medical devices. The first of these forums, the Automated Test Customer Advisory Board, has a global focus and is in its 13th year. We also conduct regional meetings, called regional advisory councils, around the world. Annually, these events include well over 300 of the top thought leaders developing automated test systems.

We've organized this outlook into five categories (see above figure). In each of these categories, we highlight a major trend that we believe will significantly influence automated test in the coming one to three years. We update the trends in these categories each year to reflect changes in technology or other market dynamics. We will even switch categories if the changes happening are significant enough to warrant it.

As with our face-to-face conversations on these trends, we hope that the Automated Test Outlook will be a two-way discussion. We'd like to hear your thoughts on the industry's technology changes so we can continue to integrate your feedback into this outlook as it evolves each year. Email ato@ni.com or visit ni.com/test-trends to discuss these trends with your peers.

Test Economics

Executives rely on engineering and manufacturing operations to maintain marketplace advantage. They measure financial and business metrics such as return on invested capital (ROIC), return on assets (ROA), time to market, profit margin, and product quality to drive improvements in product development. However, methods used to measure test organizations are less standardized.

The reality is that many companies have test organizations with reactive approaches that lack a long-term strategy or financial impact metrics, as described in the "Optimizing Test Organizations" business trend of NI Automated Test Outlook 2012. This forces executives to ask the wrong question of test functions; it is not just "How do I reduce my cost of test?" but rather "Which test investments (people, process, and technology) do I need to improve business metrics?"

According to the 2012 NI test leadership survey, approximately 66 percent of an organization's test budget is spent on maintaining the current environment with only 34 percent dedicated to providing new business capabilities to the business. This means organizations can make only incremental improvements to test operations. By contrast, design engineering teams are developing new products with step function increases in capability and lower price points.

To meet this challenge and justify strategic investment in test, test organizations are proposing initiatives backed by financial metrics such as return on investment (ROI), cost per unit tested, annual test costs and savings, payback periods on investments, and the breakdown of capital versus noncapital costs. Proper modeling uncovers all lifetime costs of certain test assets and provides a financial framework for justifying future investments.

TOTAL COST OF OWNERSHIP

A fundamental way to assess the business impact of a test organization is to determine total cost of ownership (TCO). TCO is emphasized because test cost is often attributed to capital-equipment costs of test systems. While capital cost is a key component, there are other elements such as upfront development cost, deployment test cost, and operational/labor cost. The combination of these components represents total cost of test for a product and/or company.

Upfront development cost elements are typically one-time costs such as strategy development, hardware and software tools, non-recurring engineering (NRE), and internal training. It is important to note that an organization may have additional development test costs not represented in these common elements. Deployment costs are costs incurred every time a tester is deployed. They are the easiest to determine since most include the cost of capital equipment along with software deployment costs. There are additional deployment test costs for test organizations, such as shipping, so it is important to carefully examine deployment costs to ensure consistency.

Operational test costs are a combination of personnel, maintenance, and facility costs to keep testers running. More specifically, personnel costs reflect man-hours, while capital costs encompass the cost of maintaining spares to prevent downtime in the event of a failure or instrument removal for calibration.

Knowing TCO at the project, department, and company levels helps test leaders represent the actual added value of a test strategy and justify future investments.

STRATEGIC TEST SCENARIOS

Accurate TCO models are invaluable when determining where to invest for maximum ROI and where to reallocate resources. It can pinpoint process improvements and increase efficiency while lowering design and manufacturing costs affected by test. However, financial metrics are not always the same. The following case studies examine transformation initiatives executed by organizations that affected different financial metrics (reducing operational cost, minimizing true cost of test, and improving cost/defect), but each measured ROI and payback on initial investment.

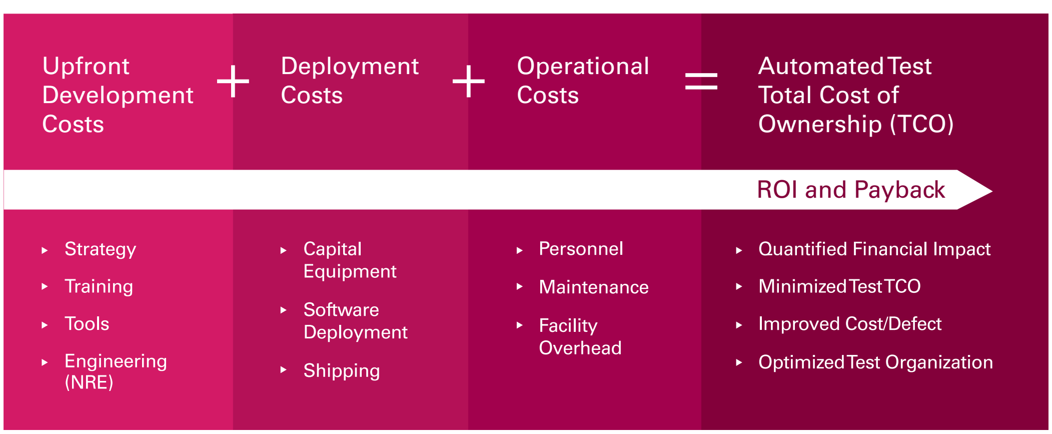
Production Test Standardization. Large organizations segmented by business units (BUs) or product lines typically have their own P&Ls. Each BU usually owns its product development and manufacturing process and resources. This leads to each BU developing testers specific to product(s), which leads to a heterogeneous mix of test equipment based on individual product lines. Developing a common test platform across multiple test platforms not only reduces capital costs by leveraging economies of scale but also decreases operating and maintenance personnel costs by eliminating operators and technicians. Hella KGaA Hueck & Co. executed this strategy by aligning multiple product lines and standardizing common hardware and software. Hella realized a 46 percent reduction in operational test costs while increasing test throughput by 57 percent, resulting in a 37 percent ROI and a payback period of just eight months.

Scaling Test Throughput. As product demand increases, companies need to reevaluate testing methodologies and develop systems that can test growing volumes of product at lower margins while maintaining product quality. Investing in a next-generation multi-unit parallel test strategy has a significant impact on test throughput and test TCO per unit. Harris Corporation reduced its cost of test by 74 percent while scaling the test solution to meet increased demand. The project had an ROI of 185 percent and a payback of just 2.8 months.

> Our mission is to develop innovative high-quality products that simplify our customers' lives. By investing in our test platform team, who leveraged NI technology for automation and reuse, we reduced our cost of quality by 81 percent while maintaining full compliance with international regulatory standards, saving us $4.5 million USD annually.
>
> ▸ *Katherine dePadua, Vice President of Quality and Regulatory Affairs, Philips HHS*

Engineering Test Reuse. While the definition of quality varies by company, it is universally a high priority. Results based on the analysis of 63 software development projects at companies such as IBM, GTE, and TRW Automotive show the cost of finding a product defect during production was 21 to 78 times more expensive than during design. Engineers at companies seeking to differentiate products by adhering to the highest quality standards focus on investing more in test systems that reuse test components to capture defects earlier. Philips Healthcare is saving $4.5 million annually with a test strategy that reduces cost of quality by 81 percent. This strategy identifies defects earlier in the design process, resulting in a 316 percent ROI and three-month payback period.

Measuring and tracking financial metrics are necessary complements to any test vision and strategy. Justification for investment in test relies on proving long-term ROI as well as metrics to measure success. The test TCO approach evaluates investment alternatives and makes a proactive impact on business metrics.



▸ Proper modeling of total cost of ownership uncovers all of the lifetime costs of certain test assets and provides a financial framework for justifying future strategic investments.

Software-Centric Ecosystems

The transition under way in mobile devices offers insight into an important trend for test and measurement: the power of a software-centric ecosystem. Early-model mobile telephones were built to make calls first and later send text messages, but the capabilities were almost completely defined by the vendor. Once the software on these devices was opened up to the user, capability ranging from music players to cameras to email quickly followed. But the effectiveness of the transition was more than just an open software experience. Apple, and later Google, built robust ecosystems around their products and created a community of developers for "apps" that accelerated usefulness.

The inherent openness and community concept for mobile phones arguably could have been fostered by mobile phone providers themselves, but in this case it was Apple and Google that worked on software environments first and deployed hardware second. By exposing an appropriate level of customization to users or third-party developers, they succeeded in changing the way consumers view their mobile phones.

This same concept is making an impact on the test and measurement industry. Communities of developers and integrators, building on standard software platforms, are using commercial off-the-shelf technology to extend the functionality of complex hardware into applications previously impossible. The level of productivity and collaboration delivered by software-centric ecosystems will have a profound effect on test system design over the next three to five years.

In the past, your test system was only as valuable as the investment of time and money that you made in it. Going forward, your system will benefit from the entire community of third-party suppliers, integrators, consultants, and derived standards supporting the software ecosystem at its core. This is a crucial element in meeting the demands of next-generation device test.

▸ *Jessy Cavazos, Industry Director, Test & Measurement, Frost & Sullivan*

ECOSYSTEMS DEFINED

In his book *The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems*, James F. Moore defines a business ecosystem in the following way: *"An economic community supported by a foundation of interacting organizations and individuals—the organisms of the business world. The economic community produces goods and services of value to customers, who are themselves members of the ecosystem. The member organisms also include suppliers, lead producers, competitors, and other stakeholders. Over time, they coevolve their capabilities and roles, and tend to align themselves with the directions set by one or more central companies."*

For test and measurement, cross-industry collaboration is nothing new. Active industry groups such as the IVI Foundation, PXI Systems Alliance, and LXI Consortium have been bringing industry players together for decades but often with key gaps as outlined in Moore's description. With active participation in these groups now including software-specific, hardware-specific, and joint hardware/software vendors, the focus on enabling interoperability for proprietary architectures and ease of use for open architectures is fostering business ecosystems.

The most successful examples of current ecosystems in this industry, though, are rooted in software. NI LabVIEW is an example of application software made more valuable through its ecosystem. Significant numbers of engineers have been trained on LabVIEW and developed add-ons suitable for private application needs as well as others through commercial vehicles like the LabVIEW Tools Network. System integrators in the NI Alliance Partner Network as well as LabVIEW Consultants work to deploy this ecosystem. With every additional supplier, producer, competitor, or other stakeholder, the value of the software to each user grows.

ECOSYSTEMS IN OPEN AND PROPRIETARY SOFTWARE/HARDWARE ARCHITECTURES

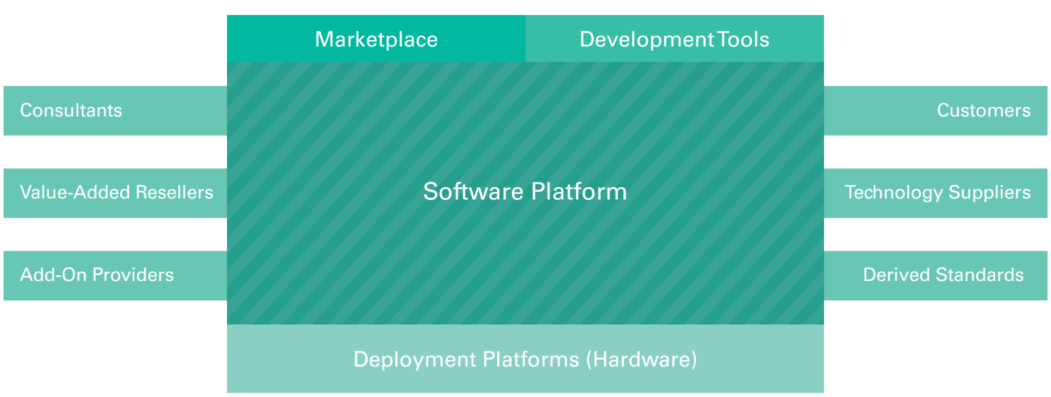
An extremely useful ecosystem standardizes the way we communicate with instruments—Interchangeable Virtual Instrument (IVI) drivers. By developing a common means of communicating to similar instruments across multiple vendors at the application programming interface level, the IVI Foundation reduced the learning curve for users and the development cycle for vendors. This opened the door for third parties to create drivers, aggregation websites to house them (like IDNet on ni.com), and abstraction layers to be created on top of them. With well-architected hardware abstraction layers, technology insertion for systems designed to last decades became not only possible but routine. The ecosystem fostered by standardization was crucial in achieving this, and it continues to grow with the recent ratification of native Microsoft .NET implementations for IVI in the past few years.

When programming FPGAs in applications like inline signal processing or device under test (DUT) control, hardware and software from a single vendor are practically required to achieve the abstraction necessary to meet the skill level of most test engineers. When these solutions are delivered in the context of a software-centric business ecosystem, the platform can retain as much user flexibility as a disparate or interchangeable hardware/software approach. For example, the FPGA programming capability of the LabVIEW reconfigurable I/O (RIO) architecture can incorporate third-party VHDL or Xilinx CORE Generator IP inside the LabVIEW system design toolchain. The LabVIEW Tools Network helps users exchange sample projects and compiled code to support different application spaces among users and vendors in automated test. This ecosystem opens the doors of FPGA programming to nontraditional automated test spaces and offers the IP necessary to be successful.

Without a software-centric ecosystem, many viable open platforms have struggled. The xTCA platforms have seen adoption in telecommunication infrastructures and interest from the high-energy physics community, but they have failed to develop a strong ecosystem in automated test. The multiple form factor, communication bus, and software options presented by the platform have delayed or complicated adoption by leading vendors. While efforts to rein in those options and improve them for automated test are under way in the AXIe Consortium, success or failure will be dictated by the use of a software-centric ecosystem.

THE FUTURE OF ECOSYSTEMS IN AUTOMATED TEST

Over the next three to five years, automated test systems will become more software-centric and ecosystems will have more impact on the value users derive from these platforms. The previous examples of instrument communication and abstracted FPGA programming are just the beginning for automated test ecosystems. As software vendors take greater advantage of their ecosystems and leverage commercialization models for third-party IP, the scenario unfolding for mobile devices will have a transformative effect on the test and measurement industry.



As software platforms engender ecosystems that grow with each additional customer, supplier, add-on provider, and so on, they become more valuable to each user. Software-centric ecosystems will make a large impact on the value that engineers derive from software-based test platforms.

Big Analog Data

In test and measurement applications, engineers and scientists can collect vast amounts of data every second of every day. For every second that the Large Hadron Collider at CERN runs an experiment, the instrument can generate 40 terabytes (1E12 bytes) of data. For every 30 minutes that a Boeing jet engine runs, the system creates 10 terabytes of operations information. For a single journey across the Atlantic Ocean, a four-engine jumbo jet can create 640 terabytes of data. Multiply that by the more than 25,000 flights flown each day, and you get an understanding of the enormous amount of data being generated, as noted by John Gantz and David Reinsel in their November 2011 article "Extracting Value from Chaos." That's "big data."

Drawing accurate and meaningful conclusions from such large amounts of data is a growing problem, and the term big data describes this phenomenon. Big data brings new challenges to data analysis, search, data integration, reporting, and system maintenance that must be met to keep pace with the exponential growth of data. The technology research firm IDC recently performed a study on digital data, which includes measurement files, video, music files, and so on. This study estimates that the amount of data available is doubling every two years. In 2011 alone, 1.8 zettabytes (1E21 bytes) of data was created, according to Adam Hadhazy in his May 2010 *Live Science* article "Zettabytes Now Needed to Describe Global Data Overload." To get a sense of the size of that number, consider this: If all 7 billion people on Earth joined Twitter and continually tweeted for one century, they would generate 1 zettabyte of data. Almost double that amount was generated in 2011, according to Shawn Rogers in the September 2011 *Information Management* article "Big Data is Scaling BI and Analytics."

The fact that data production is doubling every two years mimics one of electronics' most famous laws: Moore's law. In 1965, Gordon Moore stated that the number of transistors on an IC doubled approximately every two years and he expected the trend to continue "for at least 10 years." Forty-five years later, Moore's law still influences many aspects of IT and electronics. As a consequence of this law, technology is more affordable, and the latest innovations help engineers and scientists capture, analyze, and store data at rates faster than ever before. Consider that in 1995, 20 petabytes (1E15 bytes) of total hard drive space was manufactured. Today, Google processes more than 24 petabytes of information every single day. Similarly, the cost of storage space for all of this data has decreased exponentially from $228/gigabyte (1E9 bytes) in 1998 to $0.06/gigabyte in 2010. Changes like this combined with the advances in technology resulting from Moore's law are fueling the big data phenomenon.

THE VALUE OF BIG DATA

Small data sets often limit the accuracy of conclusions and predictions. Consider a gold mine where only 20 percent of the gold is visible. The remaining 80 percent is in the dirt where you can't see it. Mining is required to realize the full value of the contents of the mine. This leads to the term "digital dirt," meaning digitized data can have concealed value. Hence, big data analytics and data mining are required to achieve new insights that have never before been seen.

BIG ANALOG DATA AND THE ENGINEER AND SCIENTIST

The sources of big data are many; however, among the most interesting to the engineer and scientist is data derived from the physical world. This analog data that is captured and digitized can be called "Big Analog Data"—derived from measurements of vibration, RF signals, temperature, pressure, sound, image, light, magnetism, voltage, and so on.

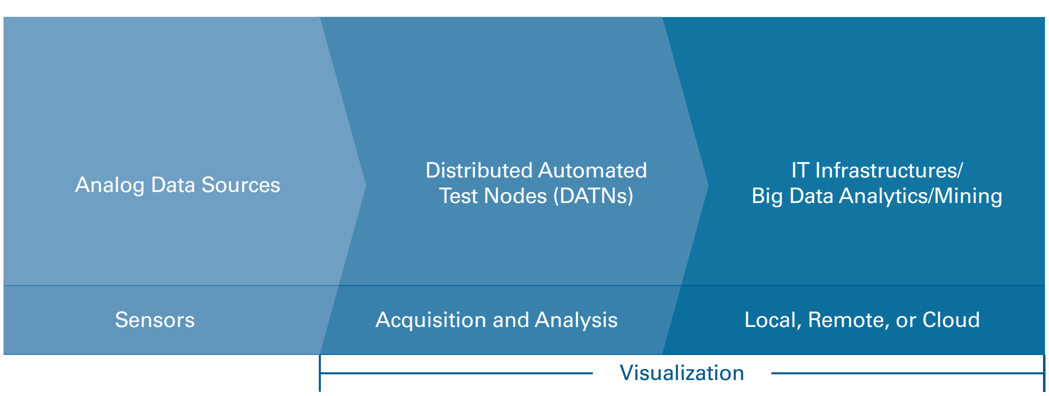
In the test and measurement field, data can be acquired at rates as high as many terabytes per day. Big Analog Data issues are becoming challenges for automated test and analysis systems. In the case where there are many devices under test, many distributed automated test nodes (DATNs) are needed, which are often connected to computer networks in parallel. Since DATNs are effectively computer systems with software drivers and images, the need arises for remote network-based systems management tools to automate their configurations, maintenance, and upgrades. The volume of test and measurement data is fueling a growing need in global companies to offer access to this data to many more engineers than in the past. This requires network gear and data management systems that can accommodate multiuser access, which in turn drives the need to geographically distribute the data and its access. A popular approach to providing this distributed data access is cloud technologies.

Big Analog Data applications create a strong dependency on IT equipment such as servers, storage, and networking. In addition, software is needed to manage, organize, and analyze the data. Thus traditional IT technologies are part of the user total solution post data capture to ensure the

> Engineers and scientists are publishing test and measurement data more voluminously, in a variety of forms, and many times at high velocities. Immediately after this data acquisition, a "Big Analog Data" problem exists, and advanced tools and techniques are required for data transfer and management, as well as systems management for the many automated test systems.
>
> ▸ *Dr. Tom Bradicich, Research & Development Fellow, National Instruments*

efficient data movement, archiving, and execution of analytics and visualization for both in-motion and at-rest data. Vendors such as Averna, National Instruments, OptimalTest, and Virinco already offer products to help manage Big Analog Data solutions. To analyze and manage billions of data points from millions of files, engineers and scientists can use National Instruments DIAdem to mine, inspect, and generate reports on measurements data. They can also use DIAdem to interface with existing IT solutions or create new servers that can be accessed globally to make decisions faster from their data. For manufacturing, Proligent from Averna and WATS from Virinco deliver solutions that provide visibility and control over product quality, test equipment, processes, and operations. Qualcomm successfully leveraged tools from OptimalTest to optimize its test process, which involves the accumulation of 4 terabytes of data per quarter (*Evaluation Engineering, October 24, 2011*). Visibility into actionable test data can help engineers identify emerging trends and proactively make decisions.

As it becomes both necessary and easier to capture large amounts of data at high speeds, engineers will face challenges with creating end-to-end solutions that require a close relationship between the automated test and IT equipment. This is driving demand for test and measurement system providers who work with IT providers to offer integrated and bundled solutions for automated test applications.



▸ A generalized three-tiered solution to Big Analog Data challenges includes sensors or actuators, distributed automated test nodes, and IT infrastructure or big data analytics/mining.

Test Software Quality

Automated test software has increased rapidly over the last decade due to the need for highly customizable, flexible, and capable measurement systems. Software-centric test solutions are the only viable approach for delivering complex technologies under aggressive timelines, limited resources, and constant product churn.

The trend toward increased product complexity and capability has made a direct impact on test software and the importance of test system reliability, performance, and accuracy. Test software has prompted an increased focus on ensuring the quality and reliability of test software through life-cycle management and development practices formerly reserved for embedded systems. Some organizations are voluntarily applying these development practices to improve test software and build more feature-rich and defect-free test solutions, but a growing number of industries will be required to use similar practices to comply with regulatory standards.

Products developed for regulated industries such as automotive, aerospace, and medical must comply with rigorous development standards and certifications. Revisions to these standards place increased scrutiny on the quality and accuracy of test tools which creates an increased burden of proof to demonstrate testers have been qualified for use. Though businesses outside these industries will not feel an immediate impact from these trends, they can benefit from detecting defects earlier in the life cycle and drive down product development cost.

For example, ISO 26262, an automotive standard for safety-critical electrical and electronic systems, was developed in response to the growing reliance on embedded control systems. It strives to standardize development and test processes across vendors to decrease defect risk, find defects earlier, and ensure safety as a critical consideration. ISO 26262, one of several standards that recognize the importance of software-based test solutions, enumerates specific requirements for test tool qualification. These requirements include creating a risk mitigation plan that assesses the impact and criticality of test tools and documenting the steps and processes used to address high-risk areas. The overall goal is to ensure that a testing tool can be used with confidence to accurately validate embedded software without introducing defects.

ISO 26262 is derived from IEC 61508, making it one of a family of standards that spans industries including nuclear, rail, and medical. While these standards vary based on industry, they are derived from the same philosophies regarding identification and mitigation of risk through validation processes.

As an industry familiar with the need for reliability and safety, avionics has long been a bellwether for other industries. As with automotive, the increased complexity of embedded avionics control systems has given rise to new standards including DO-254 and revision C of DO-178. These standards illustrate an increased focus on test systems because they enumerate requirements for test tool qualification. In particular, DO-178C has a new section titled “Software Tools Qualification Considerations” that examines tool development life cycle and documentation artifacts. The rigor of the process and the granularity of the documentation are based on the tool qualification level, which is defined by the criticality of test tools.

While the terminology and implementation of these standards are different, they prescribe recommended practices to document test requirements and prove requirements have been satisfied through iterative testing, reviews, and requirements traceability. Example guidelines and processes include:

- Test requirements
- Coding standards and stylistic guidelines
- Software documentation and traceability
- Software unit tests
- Build and deploy processes

These processes and the relationship between them are depicted using the V-model, which illustrates the progression from high-level requirements to a deployed solution as well as the corresponding test and review phases that verify that those requirements have been satisfied. The V-model is used to visualize the development process for a system, of which component testing is a part, but a similar series of steps should be followed to comply with these standards and/or ensure the quality and reliability of the test solution.

Recommended best practices for developing test software follow software engineering guidelines, which include steps to enforce regular code reviews and testing cycles. Configuration management best practices are paramount for the sake of identifying and tracking changes to source code and other artifacts throughout development. Software specifications are used to define expected system behavior under the conditions in the original risk assessment, and these are used to define unit tests integrated into continuous

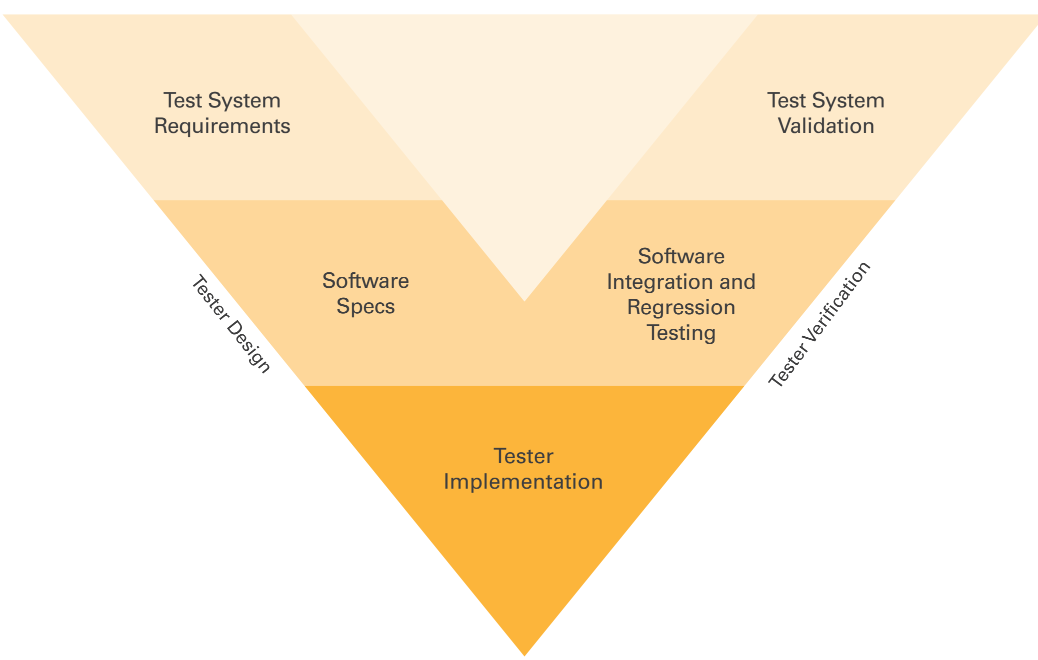
As the complexity of the systems we deliver increases, so does our test equipment; thus, a tight focus on ensuring quality and safety across all phases of development is paramount to both Lockheed Martin and our customers. As a result, many of the latest regulatory standards for the defense and aerospace industry place a greater emphasis on employing rigorous and strict software development practices to ensure reliable and accurate test results.

▸ *Sean Donner, Sr. Software Engineer, Lockheed Martin*

testing cycles for regression testing. Structured environments may go so far as to mandate that multiple unique individuals review and approve any new code incorporated into a project.

One of the primary goals of structured development approaches is to manage and mitigate the risk of introducing change. It's important to anticipate and manage the risk(s) associated with introducing changes to a system. Continuous integration addresses this by encouraging code integration and testing, which requires automated testing tools including static and dynamic code analysis. The goal is to find software defects as early as possible and minimize the cost of fixing them.

There is a correlation between increased system complexity and the need for a greater focus on test software quality. These standards set a high bar for process and quality, but software engineering best practices benefiting businesses ensure that test systems meet increasingly demanding feature and performance requirements.



▸ The steps of the V-model should be followed to ensure the quality and reliability of a test solution.

Moore’s Law Meets RF

The benefits of Moore’s law have increased performance and reduced cost for electronic products for more than half a century. The development pace and proliferation of mobile devices have leveraged Moore’s law, growing at a projected 24.9 percent CAGR for 2011–2017 (ovum.com, May 3, 2012). This trend is fueling significant silicon process developments for consumer electronics as well as pushing signal processing for features necessary to meet demand.

> The digital revolution is not driving analog signal processing to extinction. In fact, just the opposite is occurring. As the digital world continues its exponential expansion, the analog and mixed-signal functions are growing in number, performance, and diversity. As always, the challenge of providing “more” (functionality, bandwidth, dynamic range) for “less” (power, size, cost) will drive the technology forward.
>
> ▸ *David Robertson, Vice President, Analog Technology, Analog Devices, Inc.*

From a test and measurement perspective, traditional box instruments have not kept pace with this growth in an affordable, efficient manner. Because of stringent performance requirements, instrumentation has relied on more discrete design methodologies. Despite delivering accuracy and stability through these methods, box instruments are expensive, complicated to design, and often fall behind the pace of change inherent in the devices they aim to test by failing to leverage the benefits of integration.

RF instrumentation users will benefit from three trends that shift RF instrumentation to a trajectory that matches Moore’s law: advanced CMOS technology, greater FPGA use, and optimized design with modular form factors.

ADVANCES IN CMOS TECHNOLOGY

In traditional RF test equipment design, signal manipulation has been implemented predominantly in the analog domain. This means that large and complex analog systems need to be developed to amplify, filter, mix, and manipulate electric signals while dealing with the physical realities of nonlinearity, noise, coupling, interference, power dissipation, and so on. This work requires significant investment and skill on the part of the developer, which leads to expensive instrumentation.

An alternative approach is to convert signals to the digital domain with a reduced amount of analog signal processing, resulting in a less expensive and more flexible design. This requires better data converters with improved bandwidth capability, increased linearity, and reduced noise.

Analog Devices states in its *2011 Trends in Data Conversion*, “The wireless communications market will remain another key driver of data converter performance, power efficiency, and calculated integration…and it’s clear that the future of high-speed converters in this market will be defined by lower power consumption combined with faster sampling rates and more usable bandwidth at higher intermediate frequencies."

Recent RF instrumentation incorporates the latest communications infrastructure data converters and zero IF modulators and demodulators. These architectures feature several advantages over traditional architectures including lower cost, less power consumption, and high selectivity. This capability is useful in testing the latest wireless and cellular connectivity standards such as 802.11ac and LTE.

GREATER USE OF FPGAS IN INSTRUMENTATION

FPGAs are used for data manipulation and data processing as well as digital signal processing (DSP). DSP is different in the sense that analog signals are converted from the analog domain into the digital domain by data converters, and then further manipulated in the digital domain.

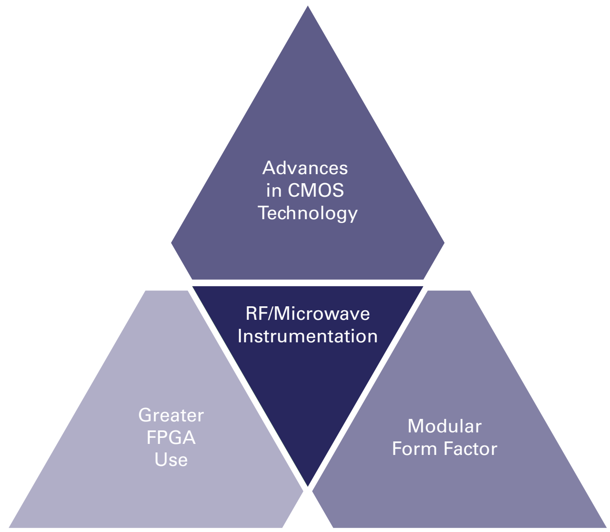
Having powerful and programmable FPGA-based digital signal processors at the center of test equipment has several advantages. First, FPGAs are parallel in nature and can therefore perform complex mathematical calculations simultaneously without involving a host processor. The digital signal processor can convert large records of data into manageable blocks of information that can then be further manipulated or stored on the network. Another advantage of DSP performed on FPGA-based test equipment is that it is reprogrammable, meaning one piece of hardware can be used for various test applications, be it current or future standards-based testing. A software-defined instrument also offers the ability to develop a custom application or update the device to the latest test applications. It thus becomes software-defined test benefitting from the rapid advances of FPGA development that is outstripping the performance of processors.

EE Journal states that FPGAs have walloped digital signal processors, conventional processors, and even graphics processors— both in terms of raw processing throughput on a single device and particularly when considering the amount of power consumed ("Supercomputing Today, Tomorrow, Whenever," November 15, 2011, eejournal.com).

The power of FPGAs has led to the reduced cost and size of RF test equipment featuring the RF performance to match the needs of high-volume RF test. An additional benefit of using FPGAs is the massive reduction in test time. By synchronizing the timing of digital control with the onboard FPGA on NI's vector signal transceiver with the RF front end of the instrument, Qualcomm Atheros decreased test times by more than 20X over previous PXI solutions and up to 200X over the original solution that used traditional instruments.

MODULAR FORM FACTOR—PXI

Building automated test systems to verify the performance and quality of the latest electronic devices requires a combination of instrumentation, data buses, processing,



► Significant CMOS and FPGA process developments, as well as the advances in modular form factors, have a disruptive effect on the cost, footprint, and test throughput of next-generation RF test solutions.

and data storage in a compact and reliable form factor. National Instruments introduced PXI in 1997 to meet these requirements and evolve with Moore's law. For example, the first PXI systems sold in 1998 offered a Pentium MMX 233 MHz processor with up to 128 MB RAM; today's PXI systems feature a quad-core Intel Core i7-3610QE 2.3 GHz processor with up to 16 GB RAM. This represents a more than 134X improvement in GFLOPS processing performance in the same form factor.

The aforementioned growth in the mobile market implies a rapid adoption of new wireless standards, such as IEEE 802.11ac and LTE. To meet the ever-growing and changing testing demands, test equipment vendors have been designing RF test solutions in the preferred form factor of PXI. Recent PXI product announcements include vector network analyzers, vector signal analyzers, and vector signal generators from vendors such as Aeroflex, Agilent, and National Instruments. Because the PXI form factor is constrained in power (~30 W per slot) and size (Eurocard formats), it is forced to adopt the latest technologies in data converters and FPGAs to remain competitive. Thus, it represents a viable commercial vehicle to ensure the delivery of these benefits to RF engineers.

MOORE'S LAW BEYOND 2013

Intel expects computing performance advancements in accordance with Moore's law to continue beyond the next 10 years. This trend is fueling not only significant CMOS and FPGA process developments for consumer electronics, but also advances in next-generation RF test equipment. We are likely to see additional uses for technology propelled by fast-growing consumer electronic devices, which can have a disruptive effect on the cost, footprint, and test throughput of next-generation RF test solutions.

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