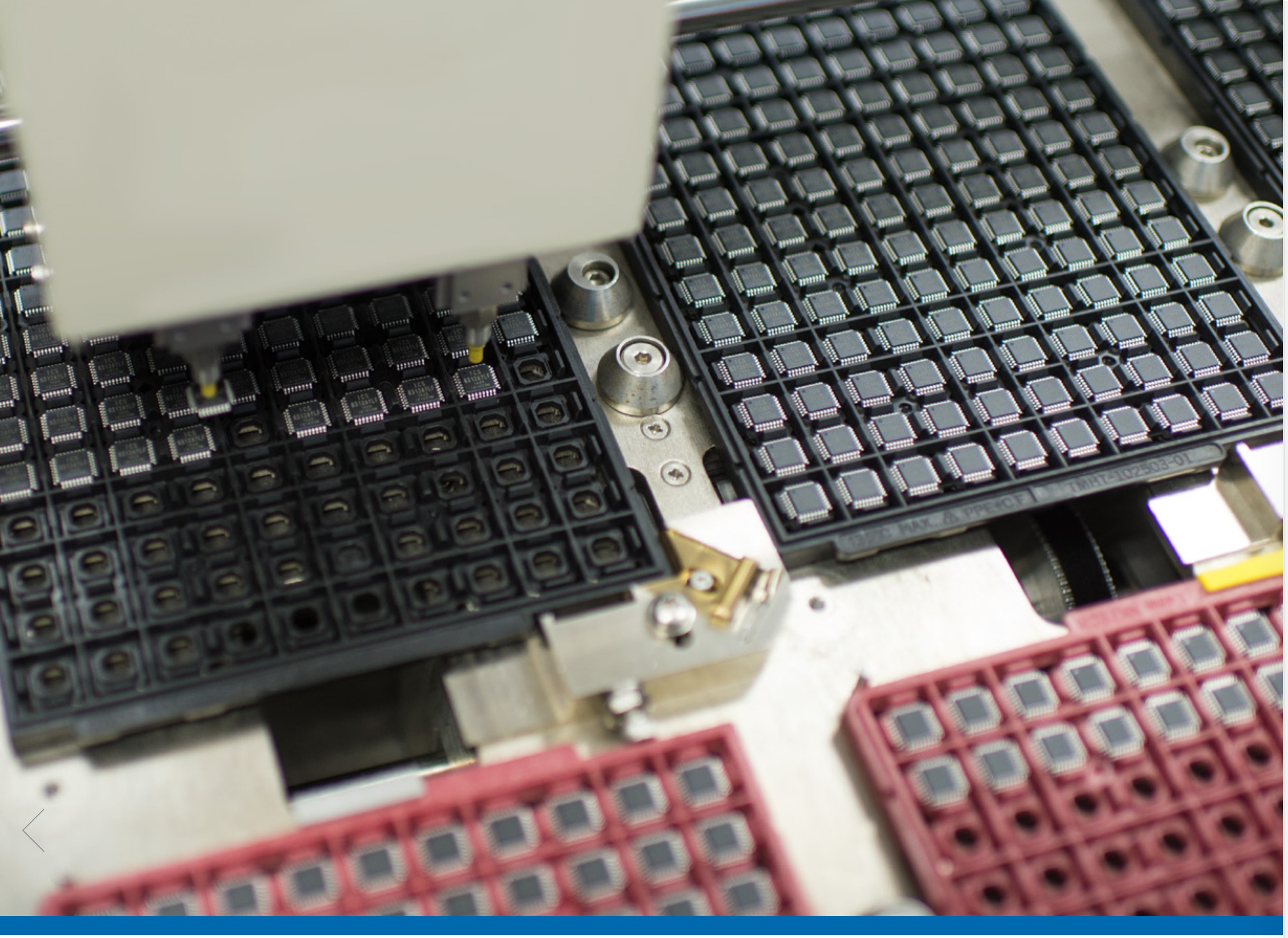
Automated Test Outlook 2015

A comprehensive view of key technologies and methodologies that impact the test and measurement industry



A Technology and Business Partner

Since 1976, companies around the world including BMW, Lockheed Martin, and Sony have relied on NI 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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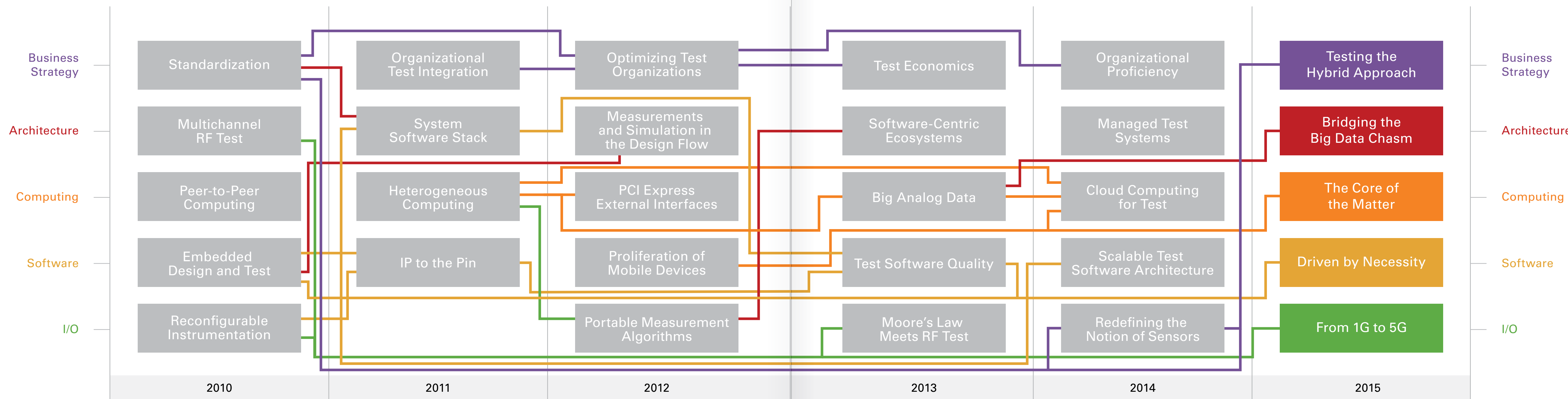


HOW WE ARRIVED AT THE TRENDS

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 15th year. We also conduct meetings, called regional advisory councils, around the world. Annually, these events include 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.

TESTING THE HYBRID APPROACH:

How COTS-Based Standardized Testers Are Reshaping Industries

Test departments are constantly looking for ways to drive down their test costs by maximizing efficiencies. One method is the continuous improvement process, which strives to improve processes, products, or services by ensuring commonality across test platforms through a standardized universal tester. But far too often, a lack of consideration for market drivers, product complexity, and long-term cost goals results in overdesigned, costly testers that are intended to meet needs but end up creating highly complex burdens.

Thankfully, recent changes in automatic test equipment (ATE) allow test managers to look beyond the limited build-versus-buy purchase model and focus on a more holistic, hybrid approach when it comes to defining overall test strategy. In this new approach, test managers can evaluate more trade-offs, match unique needs with considerations for product complexity, and contemplate how market drivers may reduce product life cycles. For the many industries typically inclined to purchase commercial ATE solutions, such as automotive, aerospace/defense, and semiconductor, this trend presents an exciting new opportunity.

This is especially true for those in the semiconductor industry, who are seeing market drivers such as the Internet of Things, tablets, smartphones, digital TVs, and smart grids. Because these trends all leverage radio frequency integrated circuits (RFICs) and microelectromechanical systems (MEMSs) that are more integrated, complex, and capable, they also have significantly shorter life cycles, and are much more difficult to test. As a result, an ATE test strategy that's not cost-efficient, flexible, and easy to support will risk capital-intensive acquisitions of entirely new equipment every few years. But with the benefits of increased throughput and high-volume production driving strong adoption of a universal test approach in the semiconductor industry, these challenges can be easily addressed.

Build-Versus-Buy Trade-Offs

Test managers now recognize that they can make their testers "universal" without completely building the testers themselves or asking a vendor to do it for them. But with enough knowledge, experience, and time, companies like Intel and Altera are building their own test solutions from the ground up because the market isn't meeting their needs.

Test managers now recognize that they can make their testers "universal" without completely building the testers themselves or asking a vendor to do it for them.

In a recent news release announcing a High Density Modular Test (HDMT) platform, Babak Sabi, Intel's vice president and director of assembly and test technology, states, "We developed the HDMT platform to enable rapid test development and unit-level process control. This proven capability significantly reduces costs compared to traditional test platforms. HDMT reduces test time to market and improves productivity as it uses a common platform from low-volume product debug up to high-volume production." Here, Intel has opted for greater upfront effort and more internal support to reap the lower capital costs instead of minimal upfront effort and internal support with higher capital costs from the vendor. Because most test departments lack either the expertise to build their own ATE or the significant amount of time required to maintain the software, they typically purchase a commercial, Big-Iron ATE solution from one of three major players in the market today. This approach appeals to those who value vendor support, but it is often overdesigned and requires a sizable capital expense, which results in an amortized product life that may exceed the shorter life of products today. The buy strategy works well in situations where the product life matches the amortization schedule and the level of flexibility is minimal to eliminate any additional augmentation investment.

Hybrid

In 2002, the Semiconductor Test Consortium (STC) was formed to create a cost-effective testing method while enabling open test solutions intended to achieve hardware and software interoperability, but the STC never met its true vision. Today, history is repeating itself as the industry demands an open architecture that meets cost and time-to-market pressures while providing a flexible solution that adapts to the growth in RFIC and MEMS technologies.

NI, Marvin Test Solutions, and other test vendors are basing the core of these testers on a modular, commercial off-the-shelf (COTS) platform that already exists as an answer to market demands. Using an existing COTS-based solution as the core of a tester has long been a successful strategy (with many companies building their own universality), but how will that play in a semiconductor industry with the limited variation provided by universal offerings from basically three major ATE vendors? And what makes this approach more likely to succeed now as opposed to back in 2002?

The answer may lie in the growing trend toward wider acceptance of modular solutions, such as the industry-standard PCI eXtensions for Instrumentation (PXI). Global consulting firm Frost & Sullivan says the test industry will see a cumulative annual growth rate of 18.1 percent in modular solutions over the next six years. This market growth has led to hardware development that meets or exceeds the I/O points required to address the RFIC and MEMS explosion that was unmet before 2002.

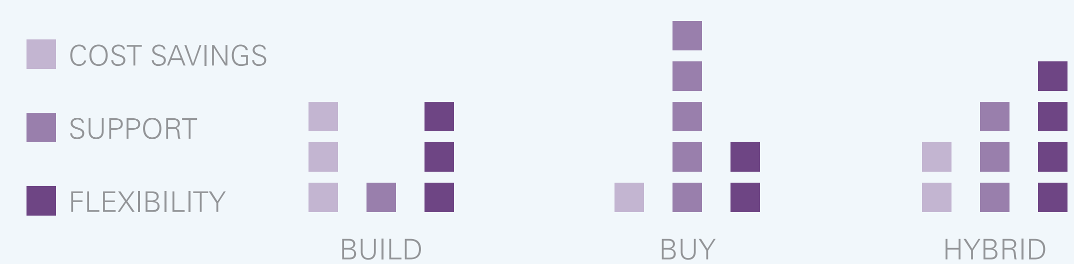
In addition, the commercial software tools that are flexible enough to handle increased ATE needs are more widely available. Because the hardware expense is only a fraction of the total cost of ownership when maintaining a tester, the availability of commercially available software solutions has significantly lowered the barrier to this approach.

Balance

Despite the variety of options test managers have to develop standardized test solutions, the prevailing trends in the modular market have enabled a hybrid model that can meet many cost and flexibility needs while achieving a strong level of standardization. This hybrid approach not only provides more options to address the difficult test challenges of modular instrument growth but also reveals how a COTS-based universal tester can significantly simplify test strategies and maximize ROI across many industries and redefine the commercial ATE market for the long term. ■

"Traditional ATE systems require major costly retooling efforts on the test floor as generations of test systems become obsolete or unable to meet new test requirements, but the nature of the open PXI architecture helps us retain our original investment and build upon it, rather than throw it away. It provides the flexibility we need to reconfigure and grow our test platforms in parallel with our growing performance needs."

–Glen Peer
Director of Test Engineering
IDT



The hybrid approach for developing ATE systems offers the ideal amount of trade-offs when balancing cost savings, support, and flexibility.

BRIDGING THE BIG DATA CHASM:

How Engineering and IT Can Work Together to Leverage Test Data

Competition, market forces, and new innovations require companies to evaluate the people, processes, and technologies used to develop products and services. For test and measurement companies, that evaluation is being driven by the emergence of the Big Analog Data problem, which includes collecting and analyzing the raw data from the physical world around us.

Unlike the big data typically associated with traditional IT data sources such as social media and enterprise applications, Big Analog Data solutions represent a vastly untapped well of information and insight that test and measurement companies can use to identify and create competitive advantages in data-centric engineering. This is no small feat considering the IDC estimates that only 5 percent of the data collected today is even being analyzed.

In this push to better acquire, store, and leverage Big Analog Data solutions, specifically for test data, as it is known in automated test, engineers must start by recognizing the role that IT plays in managing it. At present, the sheer amount of data being generated by engineering departments is causing a chasm between IT and engineering. Unless these groups work together to develop tools and methods to better use the data, this chasm will grow deeper.

> *The companies that choose to make the shift to data-centric organizations will be market leaders with access to up to 95 percent more data than competitors.*

The first step to cohesion is understanding how big data is classified: structured, unstructured, or semistructured. Historically, most big data solutions have focused on structured data. Defined by the user, structured data embodies a distinct relationship to the user, who inputs numerous values (name, birthday, address) as raw data. Unstructured data contains no metadata, schema, or other preassigned, established organization.

The third category, semistructured, is influenced by the dramatic increase in the amount of test data being collected. As more test systems are deployed for 24/7 test data collection, the volume of test data will soon surpass that of human-generated data. Because test data yields so much information, assigning structured value to each and every byte is difficult. Creating hierarchies of data provides structure and makes mining the data after capture easier. This semistructured test data is typically marked with a timestamp and then analyzed across a set time period or for a set stimulus/response event.

Most companies suboptimally implement their solutions for test data because they haven't anticipated how valuable the correlation of the information gleaned from this stimulus/response data might be at the time of implementation. The most effective methods to combat this issue combine test data analytics with traditional IT tools, but this architecture requires new approaches to data integration and management. This includes new infrastructures and skills to store, mine, and analyze the information-rich data collected. These solutions need to be designed to analyze new data sources and integrate with existing data stores.

Though IT departments haven't traditionally included test data from engineers and scientists in their overall objectives, they now see the compelling business value to applying analytics and algorithms for exploiting this mountain of data and driving new business opportunities. But making this challenging transition requires asking the following questions:

- Is more than half of your analysis manual?
- Does your team spend more than five hours a week searching for data trends?
- How much data are you actually analyzing? Is it less than 80 percent of the data you're collecting?
- Do you have a streamlined process across departments? Or are different teams using different tools?

Form a Cross-Functional Data Management Team

To effectively transform into a test data-centric organization, a cross-functional team should jointly test solutions and ensure compatibility. This team should include a representative from IT, an engineer tasked with data collection, a data scientist, and a manager with a high-level view of how new solutions will roll out to other departments. Additionally, an executive should have a vested interest in the outcome of the inclusion of test data analytics to ensure key members of the cross-functional team are held accountable for progress.

Don't Expect Results Immediately

Many companies make the mistake of expecting a full data analytics solution in an unreasonable amount of time. Underestimating the effort required to align multiple teams while trying to overhaul existing workflow processes usually leads teams into proposing solutions without understanding their true data needs. This results in an unusable solution that end users don't adopt.

A full data analytics solution for test data involves smaller, incremental steps and builds momentum for end users, IT professionals, business leaders, and so on. Best-in-class companies often run an internal pilot within a single department before documenting data analytics requirements. This pilot typically includes integrating a data storage mechanism specifically for test data into existing IT infrastructure, testing multiple data analytics software packages, and defining a process to analyze data from start to finish.

This allows key stakeholders to understand the flow of the collected data and identify data bottlenecks. It also gives the IT department time to learn the differences between traditional big data and test data and to pinpoint strategies for adopting the different tools required for the successful implementation of test data solutions. Addressing bottlenecks also improves yield, quality, and time to market as well as prevents sending inadequate products to market by catching more errors or tests out of specification. These benefits will increase the company's overall profit.

Architect for Expansion

Companies need to keep the big picture in mind when starting pilot programs in test automation. They need to remember that solutions architected for certain groups won't scale when rolling out test data analytics solutions to different departments. In addition, companies can send their engineering and design teams weekly reports to identify key trends for avoiding failures or tightening margins. This can jump-start a redesign process that addresses all possible scenarios.

By prioritizing a long-term vision when designing a test data analytics solution architecture, companies can set tangible goals for expansion and IT can plan accordingly and add more servers as the solution is implemented across multiple departments.

Invest Now for Enormous Payoffs

Implementing a test data solution can add tremendous value to an organization by enabling a more productive workforce while lowering costs and increasing profit. The companies that choose to make the shift to data-centric organizations will be market leaders with access to up to 95 percent more data than competitors, which can make them 20 percent more cost-efficient. Forming a strong relationship between IT and engineering to meet these test data challenges is critical for extracting not only the analytics but also the knowledge in large test data sets. ■

"At Caterpillar Inc., we are strongly accentuating on utilizing data from physical tests in simulated environments to further improve product development velocity and product quality. Since we're a vertical integration company, we are constantly producing rich sets of heterogeneous data from different types and different levels of testing. Managing this data is not a trivial task. In fact it vigorously demands not only a proper data management system, analytical tools, and IT infrastructure but also a long-term strategic partnership between our company and NI."

–Tien D. Doan
Senior Engineering Project Team Leader, Validation Information and Data Management Dept., Product Development and Global Technology Business Unit, Caterpillar Inc.

Combining IT and engineering teams holds transformational possibilities in analytics for asset-intensive industries and automated test.

THE CORE OF THE MATTER:

Evolving From Multi-Core to Many-Core Processors

In the test and measurement industry, faster processor clock rates have traditionally reduced test time and cost. Though many companies, especially those in semiconductor and consumer electronics, have benefited from upgrading the PCs that control test hardware, the days of depending on faster clock rates for computational performance gains are numbered.

Faster clock rates have an inverse correlation to processor thermal dissipation and power efficiency. Therefore over the last decade, the computing industry has focused on integrating multiple parallel processing elements or cores instead of increasing clock rates for increasing the computing performance of CPUs. Moore's law states that transistor counts double every two years, and processor vendors use those additional transistors to fabricate more cores. Today, dual- and quad-core processors are common in desktop, mobile, and ultra-mobile computing segments, and servers typically have 10 or more cores.

Processors are becoming "many-core" as core counts soar higher than the 10 cores common in server-class processors today.

Traditionally, the test and measurement industry has relied on computers with a desktop and/or server class of processor for higher performance. As recent sales trends indicate, the desktop segment of the computing industry is shrinking. From Q3 2013 to Q3 2014, Intel saw a 21 percent increase in notebook platform volumes but only a 6 percent increase in desktop volumes. This trend reveals that casual consumers are moving toward more portable yet powerful platforms such as ultrabooks, tablets, and all-in-ones. For better addressing the demands of the faster growing market segment, the computing industry is focusing on improving the graphics performance and power efficiency of the ultra-mobile, mobile, and desktop classes of processors. Increasing computational performance for these processor categories is generally a tertiary consideration. High-end mobile and desktop processors will continue to offer adequate computational performance for test and measurement applications. However, limited improvements in their raw processing capabilities between newer generations of these processors should be expected.

For the server class of processors, the main applications for the computing industry are IT systems, data centers, cloud computing, and high-performance computing for commercial and academic research. These applications are significantly more computationally intensive and are pushing the computing industry to continue to invest in increasing the raw computational capabilities of this server class of processors. These applications are inherently parallel, and they typically spawn numerous virtual machines or software processes based on user demand. Their usage model along with processor power efficiency concerns is driving the computing industry to add more processing cores rather than focus on increasing core frequencies. As an example, in late 2014 Intel released its Xeon E5-2699 v3 processor with 18 general-purpose processing cores.

Over the last five years, single-threaded applications have achieved performance gains when moving to the next generation of processor by leveraging innovations such as Intel Turbo Boost Technology. But as evident from computing industry trends, it's highly unlikely these applications will continue to see these benefits. Applications designed to take advantage of parallel computing can leverage the benefit of added cores to realize impressive performance gains. Engineers who use NI PXI embedded controllers, which are modular PCs, have become accustomed to a 15 to 40 percent computing performance increase by modifying their applications to be multithreaded and upgrading to the next generation of processor. But without the proper care in creating an application with parallelism, these gains will be minimal.

Many-Core

More cores are being pushed into smaller, lower power footprints. Processors are becoming "many-core" as core counts soar higher than the 10 cores common in server-class processors today. Super computers provide an idea of what the processors of tomorrow will look like. The last five years of the TOP500, which lists computers ranked by their performance on the LINPACK Benchmark, show that the world's fastest computers are built with millions of cores. Though these multimegawatt beasts aren't well-suited to run a test station on the production floor, the idea that more functionality will be packed into smaller and smaller spaces means many-core processors will be able to scale down to other processor classes as the power footprint is reduced. An example of this trend is the Intel Xeon Phi class of coprocessors, which offers up to 61 cores and provides the ability to concurrently execute 244 threads.

Clearly, some cores are being devoted to special functions instead of solely to general computing. Graphics processing engines are a good example, with video displays at high resolutions showing more realistic 3D rendering. Other special-purpose cores include security engines that perform root-of-trust and encryption/decryption operations and manageability engines that allow for out-of-band management if the processor is hung, in reset, or otherwise unreachable. However, for these many-core processors, the majority of cores will be available for general computing.

Leveraging Many-Core

With the relative plateauing of the general-purpose computing capabilities of high-end mobile and desktop processors, engineers who want their test applications to maximize performance, lower test times, and hence reduce the overall cost of ownership will need to start adopting server-class processors with many-core architectures.

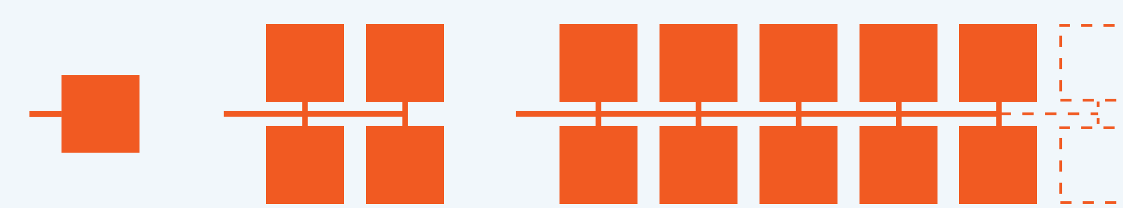
Software architectures that divide computing work and can scale to leverage more than 10 processor cores will be required. Consider which tasks can be implemented in parallel from the beginning when designing new applications. For example, in an end-of-line test scenario, measure and analyze multiple units at once and, for each unit, perform more than one test at a time. Thinking further ahead, split data analysis into multiple parallel tasks by processing chunks of data at a time or reordering parts of the algorithm to make more tasks available for computation at once. Though completing more work in parallel means measurements and analyses will have to be carefully correlated and collected to achieve a coherent overall test result, the reward is worth the effort.

When considering implementation, choose tools that allow a user to maximize the parallelism in an application. Selecting an optimizing compiler, multithreaded analysis routines, and thread-safe drivers is a good starting point. Also make sure that implementation languages offer strong support for threading and an appropriate level of abstraction so that the increased software complexity does not negatively affect developer efficiency.

Ignoring parallelism, at best, will result in tepid performance gains as processors evolve. The market is pushing for graphics improvements and higher core counts. Though test and measurement applications most likely won't use the graphics features, newer processors with higher core counts offer valuable performance gains to test applications designed to benefit from the upward trend in core count.

"The growth of parallelized distributed workloads such as search, big data analytics, and high availability directly drives the need for many cores. Processor designers and manufacturers tend to hit performance ceilings with architectural and silicon process enhancements, hence adding cores continues to be an effective alternative for higher availability and performance."

–Dr. Tom Bradicich
VP, Server Engineering
Hewlett-Packard



The migration from single-, multi-, and now many-core processors is pervasive in high-performance computing areas and will continue to be leveraged in more general applications as the wider benefits of parallel processing are realized.

DRIVEN BY NECESSITY:

How Safety Regulations and Software Are Pushing HIL Testing to the Forefront of Transportation Manufacturing

We live in an increasingly software-driven world, but the growth of embedded software in modern automobiles and airplanes presents significant challenges for manufacturers trying to eliminate software bugs and make products as safe as possible.

In the aerospace and defense industry, reducing release cycles and preventing program delays have become increasingly difficult. In automotive, consumer demands are driving up test complexity and introducing new costs in areas like infotainment. In response, test managers must find affordable ways to incorporate RF testing for wireless signals and machine vision testing for assisted parking to meet the widening I/O spread of test coverage.

Though industry regulations provide a guide to ensure safety in embedded electronics, compliance with these regulations requires the thorough testing of embedded software across an exhaustive range of real-world scenarios. Developing and testing embedded software with an emphasis on quality can strain the balance of business needs such as short time to market, low test cost, and the ability to meet the technical requirements driven by customer demand for new features and product differentiation. All embedded system manufacturers face similar demands, but they cannot sacrifice quality when it comes to safety-critical applications. Organizations that can evolve their development strategies to incorporate advanced hardware-in-the-loop (HIL) testing can reduce spending on quality-related problems, improve their market perception, and, most importantly, ensure customer safety.

HIL test becomes even more valuable as the need to offload test time in the field or the test cell intensifies with the addition of functionalities to controllers and the increase in test cases.

HIL Test Helps Meet Safety and Business Needs

Complying with safety standards requires an understanding of all potential health risks and hazards as well as the capability to rigorously test those scenarios. HIL testing meets many of these growing test needs at a lower cost and in a shorter time frame than physical tests and field tests. With this method, companies dynamically simulate real-world environments using mathematical models to provide closed-loop feedback to the controller being tested. HIL test becomes even more valuable as the need to offload test time in the field or the test cell intensifies with the addition of functionalities to controllers and the increase in test cases.

Hybrid electric vehicle motor controllers are establishing new levels of functionality by managing safe power control between an internal combustion engine and an electric motor. While designing Subaru's first hybrid electric vehicle, the Subaru XV Crosstrek, engineers at Fuji Heavy Industries needed to deliver complete test coverage of their innovative powertrain technology.

Subaru Uses FPGAs for Greater Safety and Reliability

Testing the hybrid motor controller required advanced test tools and new methodologies to provide high-quality software within the engineers' timeline. Subaru chose to use FPGA technology to meet its high-performance needs and verify a wide range of tests. For instance, when the vehicle slipped on ice, the controller had to recognize the loss of traction and provide the appropriate response to the hybrid powertrain. Re-creating these conditions on the proving grounds inconsistently yielded accurate data, and traditional processors for HIL could not accurately simulate the fidelity and speed required of an electric motor model.

Using open and flexible FPGA modules, which significantly reduced communication time by collocating the processing node and I/O node, Subaru engineers offloaded taxing calculations and performed HIL tests on their system for corner cases such as traction loss on ice to provide greater safety and reliability. With the open architecture, they programmed their system to use a high-fidelity JMAG-RT model and achieve the 1.2 µs simulation rate required to accurately simulate the safety handling of an electric motor. The ability to move more field tests into the lab resulted in a 20X reduction in test time, so the engineers did not have to compromise innovative technology, shorter time to market, and lower test cost to achieve high-quality software. Subaru's HIL testing platform provided cheaper, more comprehensive, and faster testing than physical testing.

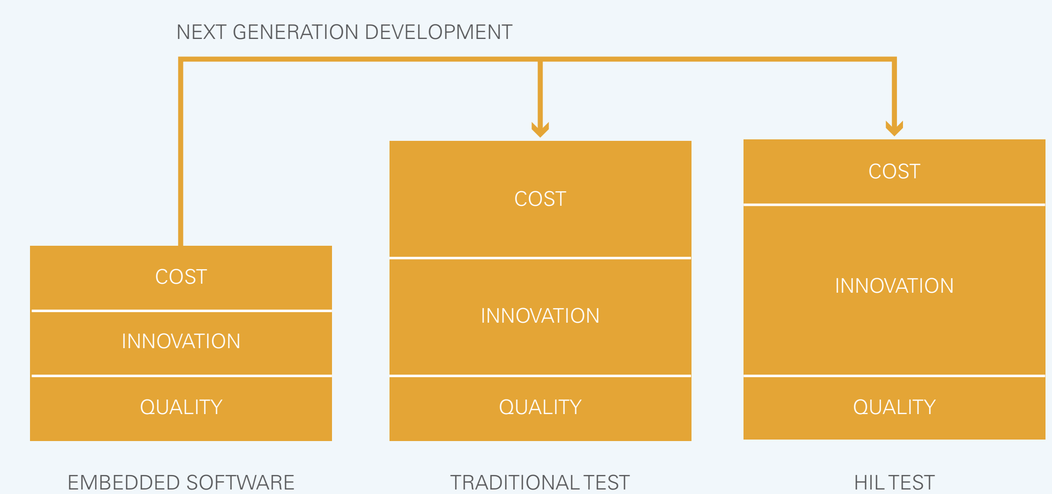
Scalable Test Platforms Offer Affordability While Ensuring Safety

Embedded software design and test teams must continue to find new ways to use this practice to ensure quality and make consumer safety a priority without sacrificing release schedules. HIL testing is mostly entrusted to only a specific test team, but developers have also been performing manual stimulus testing known as knob-box testing for quick functionality checks. This restricted form of testing allows them to spoof the controller by manually changing a limited number of channels. However, many functionality defects are still found in the later stages of HIL testing, or even in the field, which cost developers more resolution time. With higher levels of automation and easily repeatable test scenarios, developers can discover more of these functionality defects so that test engineers can focus on identifying performance and integration-based defects. Full-rack HIL test systems are not necessary for this application. Instead organizations must build scalable test platforms to provide an affordable solution across varying capabilities.

As increasing embedded controller capability drives further innovation, safety regulations will be honed to ensure even greater user safety. To keep up with future demand while preserving the quality of the overall system, test capabilities will need to grow accordingly. Simply adding more test bandwidth will not scale with overhead; test managers need to adopt advanced HIL test technology and new techniques. This ensures that as industry regulations help guide system engineering teams toward higher levels of safety for more advanced products, test platforms can still meet critical cost and time requirements. ■

"By adopting FPGA-based HIL simulation, we achieved the simulation speed and model fidelity required for verification of an electric motor ECU. We reduced test time to 1/20 of the estimated time for equivalent testing on a dynamometer."

–Tomohiro Morita
Senior Engineer,
HEV Design Dept.
Subaru - Fuji Heavy
Industries Ltd.



HIL solutions help drive down test costs without sacrificing the growing quality requirements inherent with new innovations.

FROM 1G TO 5G:

How Moore's Law is Advancing Instrumentation in the 5G Era

From the late 1980s to the early 2000s, the rule of microwave instrumentation was simple: those who make the best microwave transistors win. Throughout this era, test vendors released instrumentation that pushed the envelope on characteristics like frequency range, noise floor, and linearity performance. Advances in hybrid microcircuit technology, synthesizer tuning time, and phase noise were some of the most critical innovations during this period.

Today, the continued evolution of wider instantaneous bandwidth represents a significant area of improvement for RF signal generator and analyzer technology. And this isn't bandwidth improvement of just a few megahertz. This article is a look back and a look ahead, from a decade ago when signal analyzers with 20 MHz of instantaneous bandwidth were considered fairly wideband to 10 years from now when a signal analyzer with no less than 2 GHz of bandwidth will be considered entry-level.

This trend of signal analyzers supporting wider instantaneous bandwidth is primarily being driven by the evolution of off-the-shelf analog-to-digital converter (ADC) technology and wireless standards, but the benefits of faster ADCs reach far beyond the wireless industry. Improvements in off-the-shelf ADC technology now allow test equipment manufacturers to address the needs of customers across a broad spectrum of industries, especially aerospace and defense.

Based on the current rate of development, 12-bit converter technology will soon be able to drive RF instruments to multigigahertz of instantaneous bandwidth.

From 1G to 5G

To understand how the wireless communications industry has helped drive improvements in signal analyzer technology, it's important to recognize the rapid increase of channel bandwidth across today's modern wireless standards. For example, an AMPS communication channel (1G cellular) consumes around 30 kHz of bandwidth for one-way communication (60 kHz for full duplex), a GSM channel (2G) consumes 200 kHz, and a UMTS channel (3G) consumes 5 MHz.

An even more telling evolution in wireless technology was the widespread development of 802.11ac devices that began several years ago. At the time, the wireless industry had created a widely adopted standard that was ahead of the capabilities of RF signal generators and analyzers. As a result, many test and measurement vendors accelerated their development of wider bandwidth instruments just to support the bandwidth requirements of 802.11ac in a timely manner.

Looking ahead, the next major milestone for RF test equipment is the ability to test the fifth generation of cellular devices. And as researchers use advanced software defined radio tools to actively prototype 5G candidate technologies such as massive MIMO, GFDM, and millimeter wave communications, the potential use of wideband millimeter wave signals most likely will require RF test equipment to offer 2 GHz of bandwidth by 2017 or 2018 to support a 2020 deployment.

By any standard, achieving 2 GHz of instantaneous bandwidth in an RF signal analyzer would be a major landmark in the test and measurement industry. If such an instrument existed, it would be an incredibly useful tool for bandwidth-hungry applications such as radar pulse measurements and spectrum monitoring.

Making It All Possible

If you're wondering how the industry is going to get to 2 GHz of bandwidth, a good place to start is Moore's law, which theorizes that transistor density on an integrated circuit doubles every two years. And for those in the computing industry, Moore's law remains a strong indicator of the ever-increasing capability of computing technology today.

CPUs and FPGAs are not the only technologies that have benefitted from exponential improvements in transistor density on an IC. ADC sample rates are following a similar trend. Consider the maximum available sample rate of 12-bit ADC technology versus time. Because 12-bit ADCs provide increasing dynamic range to analyze frequency domain signals, they are an effective proxy for the bandwidth capabilities of RF signal analyzers.

In 1975, a 12-bit ADC with 2 µs settling time (approximately 500 kS/s, though not an exact corollary) was considered state of the art. Today, the fastest sampling 12-bit ADCs are hitting rates of greater than 2 GS/s—a feat that's powering some of the widest bandwidth signal analyzers in the industry.

Based on the current rate of development, 12-bit converter technology will soon be able to drive RF instruments to multigigahertz of instantaneous bandwidth and boost today's gigahertz-bandwidth oscilloscopes to even higher resolutions.

Next-Generation RF Instruments

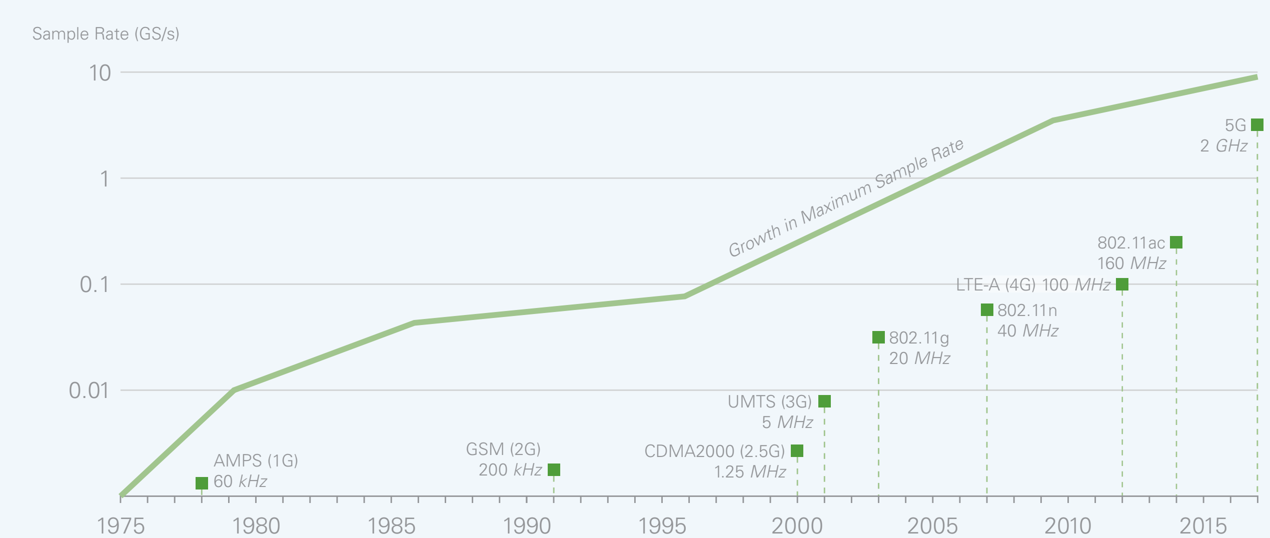
For engineers in the wireless industry, the next generation of extremely wideband instruments is poised to help drive 5G products to market. But with a broader view of the benefits to come, engineers will soon be using exciting new measurement approaches and techniques ushered in by next-generation RF signal analyzers (and even oscilloscopes).

In radar design and development, for instance, the growing bandwidth and signal-processing capabilities of instrumentation should soon yield more advanced radar prototypes. In high-volume manufacturing test, the ability to acquire ultra-wideband signals in a single shot will help test engineers easily capture data from multiple wireless devices in parallel for faster multisite test configurations.

In many respects, the bandwidth limitations of yesterday's RF signal analyzers now drive some of the test techniques we use today. Now that we're in the middle of a bandwidth revolution, we need to consider how wider bandwidth is going to empower the test techniques of tomorrow. ■

"We can see 12-bit ADCs pushing to 10 GS/s over the next two to three years, and 14-bit ADCs pushing to 2.5 GS/s in that same time frame. Fourteen to 16 bits at 10 GS/s is certainly on the horizon, though we will need to realize some technical breakthroughs to see these converters come to fruition."

–David Robertson
Vice President,
Analog Technology
Analog Devices Inc.



ADC sample rate and wireless communications system bandwidth continue to grow at an exceptional rate.

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