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This Month's Feature Articles

THE DATA FACTOR(Y): Looking at the Industrial Internet

This month, *SMT Magazine* discusses how the Industrial Internet of Things (IoT), data, and analytics can help electronics assemblers take their manufacturing processes to the next level.

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ENGINEERING SOLUTIONS FOR PCB MANUFACTURING

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EDITOR'S NOTE

The New Industrial Era

by Stephen Las Marias
I-CONNECT007

We are entering a new industrial era, where new forces created by the proliferation of data, robotics, technology, and artificial intelligence are changing the dynamics, risks, and success factors for global manufacturing companies. To be successful in this new environment, manufacturers, now more than ever, should be considering a paradigm shift, focusing more on R&D, integrating new technologies, and pursuing collaborative business models.

In its 2014 Global Manufacturing Outlook report, KPMG noted numerous strategies and tactics that global manufacturing companies can deploy to capitalize on new market opportunities and stay ahead of their competition. These include predictive analytics, new OEM/supplier collaborative innovation models, technology platforms that support real-time business intelligence, and resilient and transparent supply chains that create virtual, vertically integrated manufacturing networks.

Enabling these strategies are key transformative technologies such as big data, analytics, and the Internet of Things (IoT). IoT can be classified into two categories: Consumer and Industrial. In the first category, imagine yourself going home from work. As you reach the curb in front of your home, your car will send a signal to your garage door to open. As you enter your home, your network will detect your presence and immediately turn on specific appliances, such as lights, the TV or stereo, air-conditioning unit, or whatever it is that you have programmed it to previously. That's just a simple example of how the consumer IoT can function.

On the other hand, the industrial IoT—which is more closely related to our magazine coverage—describes an integrated *system of systems* where sensors and actuators provide specific data such as measurements, timing, and equipment status, to name a few, all connected and visible throughout the enterprise. In this scenario, we'll see the convergence of operations technology (OT) in the factory floor with information technology (IT) in the enterprise,

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all working together towards a single purpose—a more-efficient, profitable and successful manufacturing operation. With industrial IoT, companies will be able to view real-time data on their manufacturing processes, and compare performance across their plants, or even shifts within their plants. With industrial IoT, they can also quickly scale their production up or down; manage their energy consumption; and even manage, troubleshoot and fix their processes and plants, even when they are located in different parts of the world.

Data plays a key role in all of these. With the forecast of 50 billion "connected" devices by 2020, it's expected that there will be a deluge of data coming from these "things," which means a mindset shift is required when it comes to deciding what to do and how to leverage these data to take your manufacturing operations to the next level.

Which leads me to our topic for this month's issue of *SMT Magazine*—"The Data Factor(y): Looking at the Industrial Internet." In our recent survey regarding data and how they are helping electronics assemblers improve their manufacturing processes, among the key challenges we found include finding the "right" data and ensuring its accuracy and integrity, and how manufacturers can derive intelligence from data.

To help you navigate your industrial IoT journey through this flood of data, in this issue we feature a great line up of articles that discuss industrial IoT, its impact on your manufacturing processes, and how you can leverage data to help you further improve production operations and efficiency.

For starters, Michael Ford of Mentor Graphics discusses the core issue within SMT assembly industry that needs fixing for the SMT Internet of Things to become viable.

Krishnan Ramanathan, a senior research analyst at Frost & Sullivan, writes about Industry 4.0 and its impact on the production line. He also talks about opportunities, challenges, and the elements needed to successfully transition into an Industry 4.0 environment.

Next, we have I-Connect007's Barry Matties' interview with Portus CEO Bill Moradkhan regarding the benefits of upgrading a manufacturer's data intelligence to help transform that data into actionable business intelligence and improve business.

I interviewed Rockwell Automation's Mike Hannah, who discussed the evolution of manufacturing in the era of Industrial IoT and the biggest changes to expect in the production line. He also talked about the importance of investing in the right equipment, systems and technologies to take advantage of the value that the IoT will bring.

In the age of big data, hardware is evidently no longer the limiting factor in acquisition applications, but the management of acquired data is. Chandran Nair of National Instruments shares how to make sense of data, keep it secured, and future-proof it, as well as other data strategies, especially when systems evolve to become even more complex. He also discusses how to manage this explosion of data and make informed decisions faster.

Of course, we also have a line-up of other technical articles to add a different flavor to this issue. Gary Burnett Jr. of Burton Industries Inc. explains the six ways that U.S. sourcing can help manufacturers save money. Mentor Graphics' Pat McGoff, on the other hand, discusses streamlining PCB assembly and testing NPI with shared component libraries.

Dr. Jennie Hwang, in her regular bi-monthly column, investigates the theory behind tin whisker phenomena. Her third installment in this series focuses on the likely key processes engaged in tin whisker growth.

Last, but not least, Robert Voigt of DDM Novastar is starting a new series for his column, this time focusing on selecting a through-hole soldering system. In Part 1 this month, he discusses the available methods for through-hole soldering and provides a brief overview of their strengths and weaknesses.

Despite over-the-top projections for the opportunities being opened up by the IoT, challenges, of course, will remain. According to a 2014 study by The Economist Intelligence Unit, a majority, or 86% of the manufacturers they surveyed have reported major increases in the amount of production and quality-control data stored for analysis over the previous two years. But it hasn't been easy, as only 14% of those surveyed report no problems managing the data glut from real-time production sensors and associated reporting and analytical models.

I do hope you'll enjoy this issue of *SMT Magazine*. Be sure to also look out for the November issues of *The PCB Magazine* and *The PCB Design Magazine* for even more insights and perspectives regarding collecting and managing data from your factory floor.

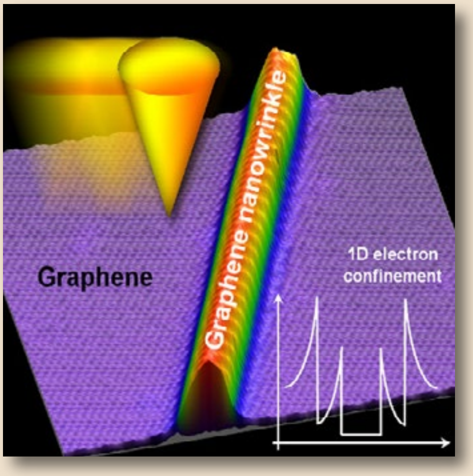
For December, we will highlight the different associations in our industry and how they are offering support and value in 2016. Stay tuned! **SMT**

Stephen Las Marias is managing editor of *SMT Magazine.* He has been a technology editor for more than 12 years covering electronics, components, and industrial automation systems.

Manipulating Wrinkles Could Lead to Graphene Semiconductors

Graphene has generally been described as a two-dimensional structure—a single sheet of carbon atoms arranged in a regular structure—but the reality is not so simple. In reality, graphene can form wrinkles which make the structure more complicated. Graphene can also interact with the substrate upon which it is laid, adding further complexity.

In research published in Nature Communications, RIKEN scientists have now discovered that wrinkles in graphene can restrict the motion of electrons to one dimension, forming a junction-like structure that changes from zero-gap conductor to semiconductor, back to zero-gap conductor. Moreover, they have used the tip of a scanning tunneling microscope to manipulate the formation of wrinkles, opening the way to the construction of graphene semiconductors not through chemical means—by adding other elements—but by manipulating the carbon structure itself in a form of "graphene engineering."



The tip of the scanning tunneling microscope (in yellow-orange) is moved over the graphene and the nanowrinkle.

"Up until now, efforts to manipulate the electronic properties of graphene have principally been done through chemical means, but the downside of this is that it can lead to degraded electronic properties due to chemical defects," said Yousoo Kim, head of the Surface and Interface Science Laboratory, who led the team. "Here we have shown that the electronic properties can be manipulated merely by changing the shape of the carbon structure. It will be exciting to see if this could lead to ways to find new uses for graphene."

SMT PROSPECTS & PERSPECTIVES

A Look at the Theory Behind Tin Whisker Phenomena, Part 3

by Dr. Jennie S. Hwang
H-TECHNOLOGIES GROUP

In this third installment of the series, we will continue discussing the likely key processes engaged in tin whisker growth.

Energy of Free Surface

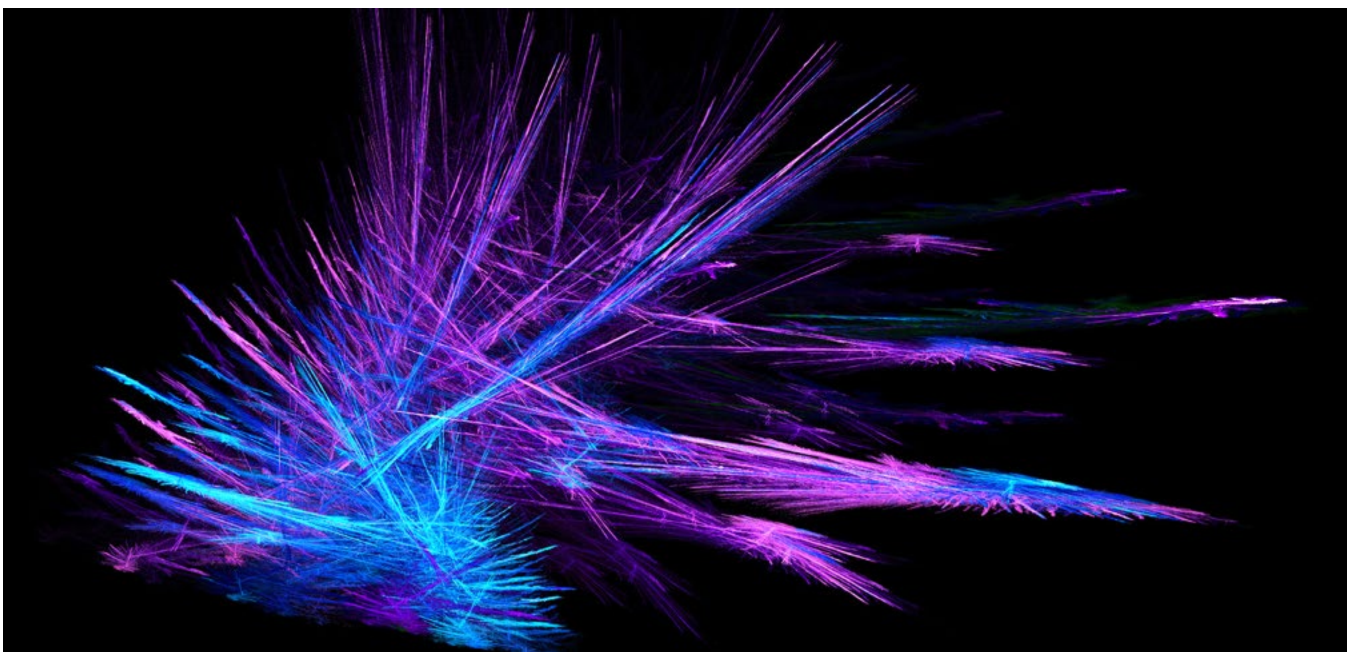
The energy of free surface plays an important part in the natural recrystallization and grain growth process. The process can be halted by grooves on the surface where grain boundaries meet the surface and anchor the boundaries to these locations. Different orientations of grains possess different surface energies, favoring the growth of grains that are large enough to overcome the groove anchoring effect. A tin grain structure with grain boundaries ending at the surface tends to impede the transition of a classical recrystallization to grain growth. When this occurs, stored energy must be released through other growth mechanisms.

An oxidized surface or a surface with absorbed impurities from the atmosphere can also alter the surface energies of different crystal planes. The anisotropic properties of tin inherently have different surface energies of grains that are exposed at the surface. This difference in energy and the mobility of grain boundaries, or lack of, cause different paths of grain growth.

In addition to the stored energy, the propensity of a tin deposit to grow whiskers strongly depends on its structure, including surface condition, grain size, grain boundary structure and the relative crystallographic orientation of grains in the deposit.

Recrystallization

During tin plating, energy is stored in the deposit as a mechanically stable but thermodynamically unstable dislocation cell structure. When temperature is high enough (or increases), the state of energy becomes more unstable, driving the system to proceed into a strain-free process. This energy release process can be separated into three identifiable stages: recovery, recrystallization, and grain growth.



Together, the three stages of the process describe the formation of a new microstructure of lower free energy in the solid state. Recovery stage, sensitive to point defects, reduces lattice strain but does not involve any microstructural change. In contrast to recovery, the ability to make structural changes that occur in recrystallization by decreasing dislocation density generates a new set of fine strain-free grains. Recrystallized grains are often the result of preexisting regions that are highly misoriented in relation to the material surrounding them. This high degree of misorientation offers the needed growth mobility for the region from which the new grains originate. If the temperature is higher than that required for recrystallization, grain growth continues. Fundamentals of physical metallurgy indicates that, as discussed in Part 2, the nucleation and growth of stress-free grains comprises four steps:

- Nucleation: incubation time
- Growth of nuclei: high rate growth of new grains
- Impingement of grains: with limited space, some nuclei at some point get to touch each other, which prevents subsequent growth
- Conventional growth: when new grains fill all the volume, the process of classical growth starts, and the remainder follows the conventional growth rate (the rate is proportional to the square root of time). Its driving force is to decrease interfacial energy

The second step of grain growth—the growth of nuclei—proceeds until the driving force for this process diminishes and at that point the recrystallization is complete.

The main variables that affect recrystallization are 1) the composition; 2) time; 3) temperature; 4) the amount of prior deformation (strain); 5) the initial grain size; and 6) the amount of recovery prior to recrystallization. A higher level of strain increases the nucleation rate and lowers the threshold temperature that is required for structural rearrangement. Both compressive and tensile stresses can participate in the initiation of the process.

Recrystallization requires a threshold strain level and a threshold temperature.

The temperature at which recrystallization occurs is usually at a fraction of the melting temperature of an alloy, and the rate of recrystallization follows an Arrhenius-type equation. The required recrystallization temperature, varying with the initial grain size, increases with the increasing grain size. With all other conditions being equal, lower initial strain also increases the recrystallization temperature.

"Recrystallization requires a threshold strain level and a threshold temperature."

Additionally, impurities in tin can increase its recrystallization temperature. If the test temperature is elevated (in relative terms), this elevated temperature may activate or accelerate the first two stages of recrystallization by overriding the nominal recrystallization temperature. As the recrystallization temperature can change with the impurity inclusions (e.g., rare earth elements, other doping elements, etc.), a different testing temperature that is selected to use, in relation to the actual recrystallization temperature, may render a different outcome in test results.

At a given composition, the initial grain size, strain level and recrystallization temperature are interrelated, working hand-in-hand.

Grain Growth vs. Solubility vs. External Temperature

The external temperature in relation to the solubility of the secondary element(s) in tin primary matrix can affect the paths of grain growth. Since the grain boundary is the region of high energy, it makes attractive sites for the nucleation of precipitates and other second-phases.

For an impure metal, as the temperature is raised, the solubility of impurities increases. When a fine-grained sample is heated just below the solubility temperature of precipitates and as the particles dissolve and coarsen, a non-uniform grain growth may occur. This may result in a few coarse grain sizes due to a few boundaries (without restrictions) that are released and sweeping quickly through the matrix. However, if the same fine-grained sample is quickly heated to a temperature above the solubility limit, all grain boundaries are released together, leading to a more uniform grain growth across the structure.

Under the environment that is prone to whiskers, the nucleation rate can affect the growth pattern. As temperature increases, the nucleation rate increases, leading to many short and nodular whiskers. Similarly, when impurities (vs. pure tin) are present in the tin coating layer, whiskers grow in a large number, but short and nodular. Comparing pure tin with SnCu coating, with all other conditions being equal, pure tin exhibits whiskers many times in length than SnCu coating. As the temperature is lower, nucleation rates decrease, and long and needle-like whiskers will form if there is sufficient stored energy (threshold strain).

Discussions of the key processes engaged in tin whisker growth will continue and be completed in Part 4, and Part 5 will summarize the theory behind tin whisker phenomena. **SMT**

Dr. Jennie Hwang is an international businesswoman and speaker, business and technology advisor, and a pioneer and longstanding contributor to SMT manufacturing since its inception, as well as to the lead-free electronics implementation. Among her many awards and honors, she is inducted to the WIT International Hall of Fame, elected to the National Academy of Engineering, and named an R&D-Stars-to-Watch. Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., Hanson, plc, IEM Corp., she is currently CEO of H-Technologies Group, providing business, technology and manufacturing solutions. She serves as Chairman of Assessment Board of DoD Army Research Laboratory, National Materials and Manufacturing Board, Commerce Department's Export Council, various national panels/committees, international leadership positions, and the board of Fortune 500 NYSE companies and civic and university boards. She is the author of 450+ publications and several textbooks, and a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees as well as Harvard Business School Executive Program and Columbia University Corporate Governance Programs. For further info, go to www.JennieHwang.com.

Graphene-based Inks for High-speed Manufacturing of Printed Electronics

Researchers at the University of Cambridge, in collaboration with Novalia, have developed a low-cost, high-speed method of printing graphene inks using a conventional roll-to-roll printing process.

The method allows graphene and other electrically conducting materials to be added to conventional water-based inks and printed using typical commercial equipment.

"We are pleased to be the first to bring graphene inks close to real-world manufacturing. There are lots of companies that have produced graphene inks, but none of them has done it on a scale close to this," said Dr Tawfique Hasan of the Cambridge Graphene Centre (CGC), who developed the method. "Being able to produce conductive inks that could effortlessly be used for printing at a commercial scale at a very high speed will open up all kinds of different applications for graphene and other similar materials."

"This method will allow us to put electronic systems into entirely unexpected shapes," said Chris Jones of Novalia.

ESSENTIAL PIONEER'S SURVIVAL GUIDE

The SMT Internet of Things—Back To Basics

by Michael Ford
MENTOR GRAPHICS VALOR DIVISION

Different people have different understandings and expectations about what the Internet of Things (IoT) actually is, especially with respect to how it could work and what it could bring to the SMT assembly industry. There are a lot of expectations to fulfil as principles behind innovations such as Industry 4.0 take hold. A key concern, however, is whether any of these expectations are reasonable or whether there is a dependence on something that is fundamentally flawed, which unfortunately would seem to be the case of SMT and related production. Let's discover the core issue within SMT that needs fixing for the SMT Internet of Things to become viable.

The Internet actually consists of two very different things. Firstly, there is the massive store of information, which includes literally anything from historical records to live videos ready for streaming. The use of the information is equally as wide, from students performing research to people watching cats do the funniest things. The information is not really controlled, or even censored; fact and fiction are liberally mixed. The format in which information is presented is also not managed, with dozens of different types and versions of documents and viewing formats. This was inevitable because of the literally billions of simultaneous sources of data. Luckily, some focal points, such as services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The fact is that in a raw form, there is a massive amount of data related to events and status of processes and products on the PCB assembly shop-floor.

from YouTube, go some way to limiting or standardizing the range of different video formats to those which most popular viewers will play. Accessing information from the Internet is often fraught with risk, requiring careful screening and cross-referenced from several different sources. This same situation cannot be allowed to happen for the industrial IoT, where the expectation is that information will be accurate and immediate so that it can be used as a part of critical business decision-making processes.

The second component of the Internet is the provision of services. Rather than just a flow of information in one direction, services on the Internet allow people to do something, such as on-line banking and shopping. The information available on the Internet for these services to work, in contrast to general information, has to be absolutely accurate, up to date, and securely managed, for example, financial bank transactional records or a database of products and prices. Huge amounts of effort go into the maintenance of these services to ensure that they remain both accurate and available. This is much closer to the requirement for the industrial IoT, both for data accuracy and the expectation that the data will be used in real-time to provide visibility, feedback, and most importantly, control throughout the production processes.

Using data collected from the SMT shop-floor to influence and control many aspects of the flow of production has been a part of manufacturing from the beginning. Data collection originally started with manual notes being taken by machine operators, which were combined and processed into reports to be reviewed at the weekly management meeting. The reports were used to make decisions related to corrections and adjustments to production for quality and delivery achievement, as well as being a crude report of productivity against target. With a de-

lay of a week between the data collection and reporting, a lot of lost opportunity went by before issues could be understood and action taken. Any result of actions taken would also take at least a week to be seen. With continuous or dedicated lines running with a low product mix, this was for quite some time acceptable to most SMT-based assembly operations.

The introduction of more automated data collection systems with Microsoft Office applications to make charts and reports has progressively reduced the lead-time between data acquisition and utilization, bringing firstly daily reports, or shift reports, then hourly reports, and many systems more recently that are able to provide immediate reporting, delivering messages and reports on phones as well as live progress metrics on overhead progress displays. These mechanisms have actually been in place for some time, using complex software, though limited in scope. This limitation is not a result of the technology of data management or reporting, but mainly as a result of the poor condition of data availability from SMT machines.

> "Communication abilities from many SMT vendors came as a by-product of their own need for real-time diagnostic information because the machines have always operated too fast to see what is going on with the naked eye."

Unlike other industries, standards have never gained traction in SMT-based production. The semiconductor industry seized on GEM-SECS as a communication standard many years ago, which delivers accurate and timely event data based on a set of configured requirements. Although some key SMT vendors decided to support it, notably Universal Instruments at the time, licensing costs caused other SMT machine vendors to look elsewhere. Panasonic had developed an effective RS-232-based protocol that communicated key events, available from their earliest machines. Communication abilities from many SMT vendors came as a by-product of their own need for real-time diagnostic information because the machines have always operated too fast to see what is going on with the naked eye. As a result, the interface mechanism, the methods and protocols for data flow through the interfaces, as well as the coding, content, and meaning of the data, were all different across the different vendors and even between different models of machines from the same vendor.

The CAM-X protocol was launched as an attempt to bring standardization into SMT. The academic theory behind CAM-X initially appeared good because standard data could be transferred with a standard protocol over a standard interface to anyone at any time. The critical weakness was that the useful data from most SMT machine platforms beyond the superficial was already heavily customized and so could not be represented in the standardized representations offered by the CAM-X format, meaning that proprietary areas within CAM-X had to be included. CAM-X could never then represent the level of standardization to meet the expectation that had been set. The introduction of CAM-X was resisted by many SMT machine vendors on a commercial basis because most likely it would reduce the competitive edge that many vendors felt they had by offering their proprietary interfaces and software to their customers, making it difficult for customers to switch or mix SMT platforms.

Another critical lesson learned from CAM-X was the limitation found in the capacity of networks within a factory. The 100-Mbit Ethernet standard was still new at the time, which, though being the best speed available, was still a bottleneck where more than a few lines of machines were connected, not including supporting processes or manual stations. The CAM-X format, based on XML, which conceptually is similar to the Internet's HTML format, was verbose because all data was expressed essentially as descriptive text, needing about 10 times the transfer capacity than the same information


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coded or using binary formats in use at the time by most SMT machine vendors, as well as GEM-SECS. As with GEM-SECS, there was the ability with CAM-X to select the data that should be filtered that was available from the machines, but again, this applied to the common and somewhat superficial area rather than the detailed proprietary data areas that ultimately clogged up the system.

The SMT shop-floor information environment resembles the Internet more in terms of massive amounts of unmanaged data than the structured approach of data belonging to Internet services such as on-line banking or shopping. This is a serious problem for those who would like to extend the industrial IoT to SMT. Significant change needs to happen for it to be viable. The first port of call would naturally be to ask the SMT machine vendors to consider the adoption of some standard through which all critical and useful information can be efficiently extended. However, the practice of using proprietary communication software as a barrier to competition should be relaxed, as well as accepting that more detailed information about the machine and it's performance will be exposed, which can in theory be used to compare the performance between vendors. In the current highly competitive climate, this in itself is a tall order.

There is then the extension of the support of the standard to the hundreds of thousands of existing SMT machines in the market, which will at least require development and application of software updates for them to conform to the new standard. Most likely in many cases, this would be more than just an upgrade to the software, as the capabilities of machines that have been in the market for many years may not currently have the capability to provide a complete set of data. The amount of work that would be necessary for machine vendors could be quite extreme and would carry with it little if any revenue. This is also a critical issue for SMT-related equipment, such as screen printers, reflow ovens, AOI, and ICT machines. More recent machines do have some communication capability, but it is nowhere near as fully developed as that for the SMT machines.

There are then the manual processes, which are also a key part of each PCB's flow through production, with tracking, material consumption, defect opportunity and discovery, all a part of the requirement for visibility, traceability, and control as part of the industrial IoT. The only mechanism for data collection from these stations today is simple effectively dumb terminals that can send key events to a central system, or it is back to manual data collection. There are actually many more manual points to consider in a PCB production operation than automated ones like SMT machines. Existing CAM systems that try to collect data from manual processes create in themselves a significant bottleneck and productivity loss, where delays are incurred waiting for the response from a central server (e.g., to confirm the WIP tracking request of each PCB into each process).

The fact is that in a raw form, there is a massive amount of data related to events and status of processes and products on the PCB assembly shop-floor. Third-party software available today does a very good job of hiding the complexity of gathering data, normalizing, and qualifying the specific meanings and presenting the result in an accurate and timely way so that it can actually be dependable and relied upon for advanced shop-floor control, such as lean, just-in-time material delivery. Progressing from this level today into an environment where, for example, production can be ultra-flexible to meet changing customer demand without suffering loss of performance is going to require the next generation of shop-floor data collection technology. Without some method to create standardized, normalized, and qualified data, in a format which is practical, secure, and absolutely reliable, the arrival of the industrial IoT to SMT and related production is going to be delayed, muted, and if not done in the right way, potentially downright expensive for all involved. **SMT**

Michael Ford is senior marketing development manager with Mentor Graphics Corporation Valor division. To read past columns, or to contact the author, click here.

Industry 4.0: Implications for the Asia Pacific Manufacturing Industry

by Krishnan Ramanathan
FROST & SULLIVAN

Introduction to Industry 4.0

Industry 4.0 refers to a new level of organization and control of the entire value chain, across the life cycle of products. Seen as the fourth industrial revolution, Industry 4.0 seeks to merge physical and virtual worlds. This marks a significant change in the level of complexity from the third industrial revolution, where electronics and information technology were used to automate production.

A brainchild of the German government, Industry 4.0 is currently widely used across the manufacturing industry in Europe, especially Germany. It is being selectively deployed across industries in the United States, but as a region, Asia Pacific has some way to go before Industry 4.0 makes an impact in the production line. Its prominence cannot be over emphasized in a world where each customer has a different preference or requirement. The increasing use of information and communication technologies (ICT) in the manufacturing sector has meant that there is not a clear distinction between virtual and real world.

Industry 4.0 in Asia Pacific—A Long Way to Go

Since Industry 4.0 integrates most parts of the value chain, its implementation will influence all elements in the production. One of the keys to successfully transitioning into an Industry 4.0 environment is to ensure a robust IT infrastructure. Unfortunately, most countries in the Asia Pacific region are not in a position to guarantee IT infrastructure that can support the digital transformation to Industry 4.0.

Many countries have discrete elements of IT systems in place, but not at a level that helps them effectively use Industry 4.0. Clearly, the objective must not be to introduce or superimpose technologies on the existing set up. This is because the priorities set by business segments towards implementing such systems and introducing changes will be different. From a networking perspective, it will

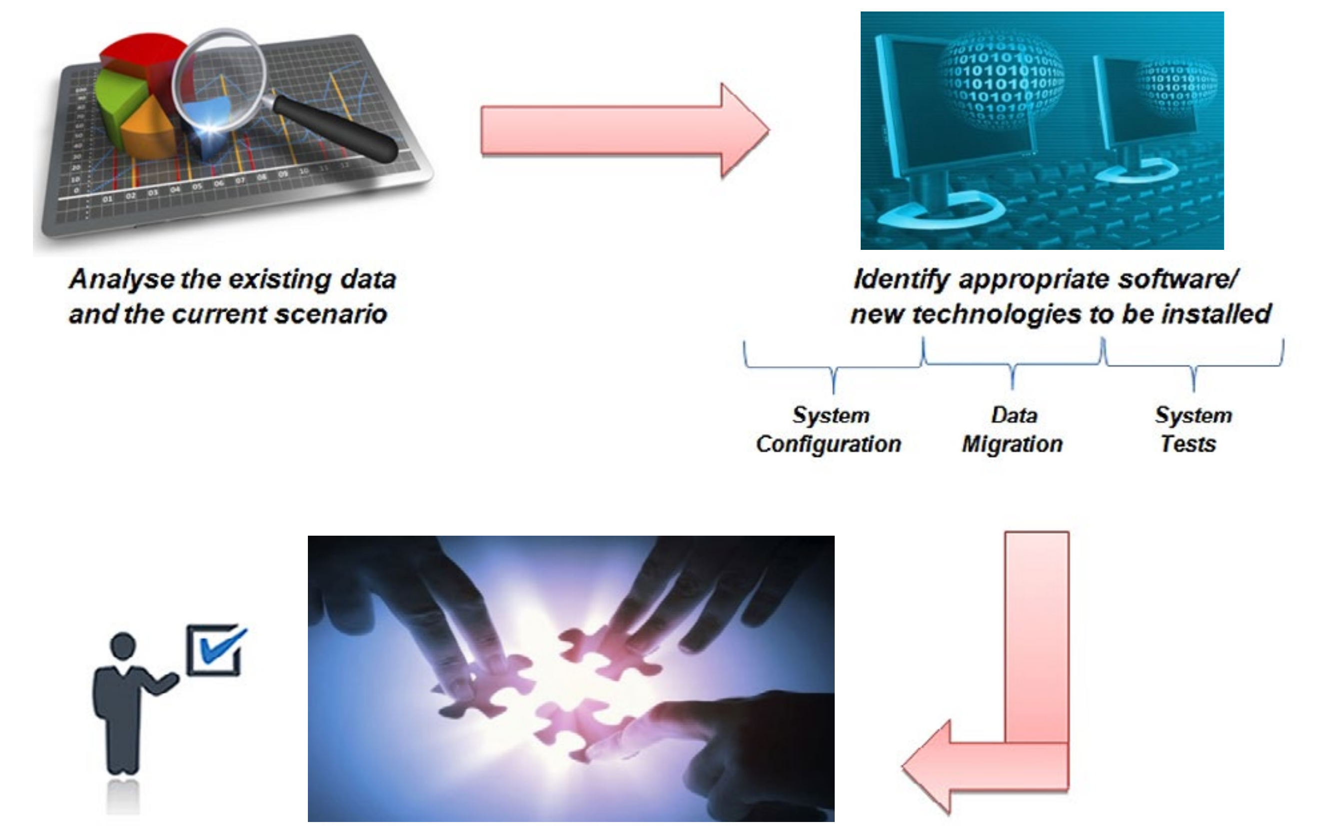
involve coordinating activities from procurement, logistics, marketing, and services. The following are the stages identified for effective digitalization. Automation suppliers are able to install and use them across a wide variety of industries.

Impact on the Automation Market

From an automation standpoint, critical industries in Asia Pacific are the oil and gas, power, water and wastewater, food and beverage, and mining and metals industries. Major changes are being planned in the electronics industry across the region as well. Foxconn plans to introduce robots in its factory floor in China. Robots are seen as the perfect solution to reduce human intervention as such companies have been criticized for the harsh working conditions for workers. Clearly, the benefits are manifold: Production stability and safer working conditions for workers are among the biggest drivers. There is uncertainty in terms of the level of interest shown by companies, and investments are hard to obtain, but with a strong electronics industry and shortage of skills, Singapore could be a major beneficiary when it comes to using robots. The average payback time for robots is also a key determinant. Savings is critical because production errors can prove expensive in the electronics industry.

While the adoption rates for high-end technology is low when compared to Europe or the United States, Southeast Asia is witnessing traction in the region for automation. The current trend witnessed is that large manufacturers are shifting base units to the Asian continent, particularly Indonesia, Thailand, and Malaysia, where the next wave of growth is expected. But this in itself is not a major driver that will help determine growth in the region.

Automation vendors are well aware of the weakening political and economic situation in many regions across Asia Pacific. Government initiatives and outside investments are expected



One of the keys to successfully transitioning into an Industry 4.0 environment is to ensure a robust IT infrastructure.

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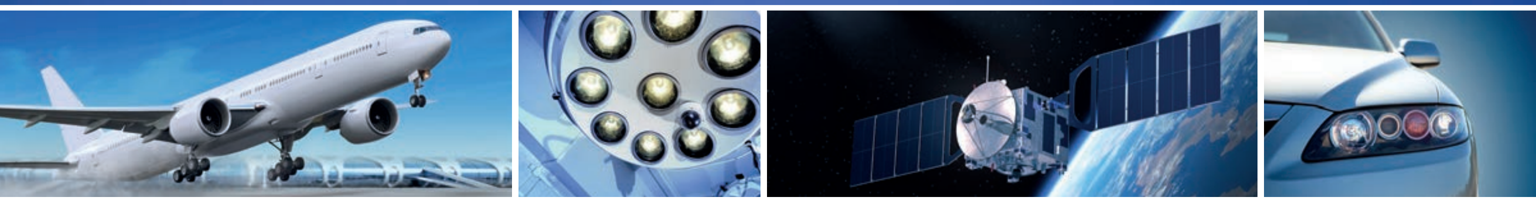

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to help emerging markets gain a grip on the automation market. This implies that a 'complete' factory concept will take time to be adopted in these growing economies and that change will be slow.

Changes in Product and System Design

Industry 4.0 requires automation systems to be able to think and work autonomously. In other words, it assumes that automation systems that are currently being used in manufacturing can be customized to such an extent that the systems will be able to perform most of the tasks that currently require human intervention on their own.

While the human element is still important, Industry 4.0 marks a shift from rigid, centralized factory control systems to decentralized intelligence. Also, the output from machines can differ from today's scenario as it is difficult to predict customer requirements. This will mean factories and machines will have to be differently organized than they are today as manufacturers have to respond quickly to customer needs, which can influence the design of automation system itself. Companies such as Festo are coming up with innovative concepts for the automation of modular production units with little need for reconfiguration. However, these are more likely to be tested in the more developed regions of Europe and the United States before being implemented in emerging regions in Asia Pacific.

"While the human element is still important, Industry 4.0 marks a shift from rigid, centralized factory control systems to decentralized intelligence."

Cybersecurity

With the growing use of complex systems and networks, one thing that is certain is that there will be security risks at multiple levels. The manufacturing industry recognizes the risk of data theft, malware and hackers as data proliferates and becomes more accessible over the network. This means that networking and connectivity in automation also becomes crucial to ensuring the safety of systems. This is possible only by enabling a clear understanding of different disciplines (IT, instrumentation, electrical and manufacturing engineering). There will have to be significant changes in the software development as well because of the security element in the automation systems.

However, since much of the research and development happens in the headquarters (mostly located in Europe or the U.S.) for automation vendors, it is not likely to have a significant impact on Asia Pacific automation industry. Because Industry 4.0, energy use and smart manufacturing work in tandem, its adoption in critical industries will require engineers and operators who can work with advanced data systems and robots. Currently, most of the countries in Asia Pacific are lacking in such skills.

Low Wage—Not a Driver

While it is known that Southeast Asia and emerging economies in the region are currently benefitting due to their low wage margins, Industry 4.0 can make production so efficient and streamlined that companies will begin to see less value in moving their production plants to countries such as China, India and Thailand.

The ultimate objective for such manufacturers and their governments is to retain manufacturing within their borders. However, opportunities for Asia Pacific manifest in the form of changing dynamics in many countries. Since Asia Pacific is a region that offers immense potential for automation, green initiatives and clean technologies in manufacturing can be made a priority. Such requirements will also play a role in the design and use of automation systems.

Although China and Japan are currently the largest users of robotics, manufacturing plants of the future will use advanced robotics for production. One of the important elements enabling robotics is the sensors which communicate with other sensors through wireless sensor networks. All this means that for Industry 4.0 to be viable, it has to yield significant cost savings that will justify the huge investments required.

Beyond the Factory Floor

A major criterion for success of Industry 4.0 is the availability of labor to support technologically advanced initiatives. In the present scenario, most Asia Pacific economies, with the exception of Japan, are not in a position to embrace Industry 4.0 due to infrastructural and economic demands. It is the progressive adoption of new technologies that will lead to the development of a fully connected plant floor. Given that the infrastructure for conventional industrialization is modest in most parts of Asia Pacific, the region can choose other paths besides the conventional infrastructure and industry path to industrialization.

In conclusion, it can be said that Asia Pacific holds promise for such advanced technology given that it offers greenfield opportunities and the potential to use radical yet innovative production techniques; but as a technology, Industry 4.0 is still in infancy and will require collaboration between various stakeholders with automation being one of the keys to success. For this to happen, automation and networking vendors must adopt an integrated approach, taking into account technologies, the engineers and operators and education in equal measure. SMT

Krishnan Ramanathan is a senior research analyst for automation and electronics at Frost & Sullivan, Asia Pacific.

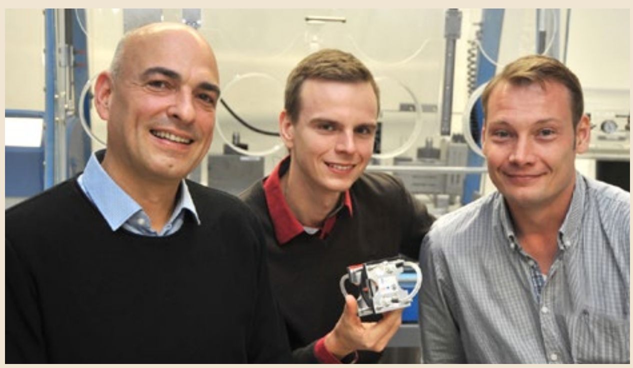
Synthetic Batteries for the Energy Revolution

A team of researchers at the Friedrich Schiller University Jena (FSU Jena), in the Center for Energy and Environmental Chemistry (CEEC Jena) and the JenaBatteries GmbH (a spin-off of the University Jena), has developed a redox-flow battery system based on organic polymers and a harmless saline solution.

"What's new and innovative about our battery is that it can be produced at much less cost, while nearly reaching the capacity of traditional metal and acid containing systems," Dr. Martin Hager says. The scientists present their battery technology in the scientific journal Nature.

In contrast to conventional batteries, the electrodes of a redox-flow battery are not made of solid materials, and come in a dissolved form: The electrolyte solutions are stored in two tanks, which form the positive and negative terminal of the battery. With the help of pumps, the polymer solutions are transferred to an electrochemical cell, in which the polymers are electrochemically reduced or oxidized, thereby charging or discharging the battery. To prevent the electrolytes from intermixing, the cell is divided into two compartments by a membrane.

In first tests, the redox-flow battery could withstand up to 10,000 charging cycles without losing a crucial amount of capacity. The energy density of the system presented in the study is 10Wh/l. Yet, the scientists are already working on larger, more efficient systems.



The research team and its new battery (from left to right): Prof. Dr. Ulrich S. Schubert, Tobias Janoschka und Dr. Martin Hager.

Electronics Industry News
Market Highlights

N.A. PCB Book-to-Bill Ratio Reaches Five-year High in August

Total North American PCB shipments increased 1.5% in August 2015 compared to August 2014. Year-to-date shipment growth stood at -0.1%, reflecting the negative sales growth rates seen earlier this year. Compared to the previous month, PCB shipments were up 3.6%.

Singapore PC Market Growth Driven by Mobile PCs in 1H of 2015

PC shipments in Singapore totaled 588,300 units in the first half of 2015, a 12% increase over the same period last year, according to Gartner Inc.

Copper Clad Laminate Industry has Entered New Round of Growth

The CCL industry has entered a new round of growth in recent years, and two regions in Asia—China and Southeast Asia—have become the fastest-growing. Relevant manufacturers have successively taken measures like capacity expansion and acquisitions to strengthen their CCL business.

Car OEM Telematics Leads IoT Segments, Generates $60B of Service Revenues in 2020

While 4G networks would be preferred by automakers to power the connected car, it is 3G networks that will carry the data driving the majority of its global telematics and infotainment services revenues. In fact, it will be after 2020 that 4G becomes the leading connection technology for OEM telematics revenues.

Survey Reveals IoT Opportunity

While the Internet of Things (IoT) continues to evolve and expand, moving from the planning stage to execution, the momentum is quantifiable. According to a new survey from IDC, 73% of respondents have already deployed IoT solutions or plan to deploy in the next 12 months.

UAV Market to Reach $10B Mark by 2024

The global defense and security market for unmanned aerial vehicles will expand at 5.5% per year over this decade, from the current figure of $6.4 billion, to $10.4 billion by 2024, according to IHS.

New Color Technology Displays to Comprise 25% of Total Display Shipment Area in 2020

Wide color gamut flat panel displays are expected to grow from 3% in 2015, to 25% of the display market in terms of area by 2020, according to IHS. Color gamut refers to the ability of a digital display to reproduce colors as they are seen by the naked eye.

Microcontroller Market Growth Tied to Rise in IoT Applications

The market for MCUs used in connected cars, wearable electronics, building automation and other IoT applications is expected to grow at an overall CAGR of 11%, from $1.7 billion in 2014 to $2.8 billion in 2019, according to IHS.

Chinese Handset OEMs to Increase Demand for Smartphone Sensors

Chinese OEMs have proved willing to try any new technology that allows them to compete more successfully. Of the many Chinese handset manufacturers, Xiaomi will consume the greatest number of sensors in 2019, according to IHS.

Asia and Americas to Push Global PV Demand Up to 58GW in 2016

The global PV demand is expected to keep rising in 2016 to 58GW as long as renewable energy policies across the world remain the same.

Improving Production Efficiencies with Better Data Strategies

by Barry Matties
I-CONNECT007

Is your manufacturing company wasting significant time and energy struggling to collect and analyze its own data? I sat down with Bill Moradkhan, the founder, president and CEO of Portus, to discuss the benefits of upgrading your data intelligence to help transform that data into actionable business intelligence and improve your business.

***Barry Matties:** Tell me a little bit about Portus and the value it brings to customers.*

Bill Moradkhan: We focus mainly on manufacturing companies, but really any kind of company of any size starts collecting a lot of data, usually in their ERP system, and will have data from all kinds of different systems. At some point or another, they need to transform that data into actionable business intelligence. This is a term we're very happy with now, meaning that data in itself isn't getting you to do something. You need to get that data to paint a picture, so you say, "Ah, I see, this is our issue. This is what we're lacking. This is what we're doing too much of and this is what we should be doing."

This process of transforming data into actionable business intelligence is what we are all about. Interestingly, no matter what, whether you have Portus or you don't, you're doing this. In some form or fashion, you're taking that data and you're transforming it into charts and reports so people know what to go do. The issue is how much time and money you are spending doing that. We want to take that to its absolute limit, meaning you won't spend any time on that. We handle the entire transformation process so that you can focus on doing something about what the reports are telling you, rather than spending 90% of your time putting the reports together.

***Matties:** What are they getting in your report that they're not already getting in the systems that they have?*

Moradkhan: First, at a two-dimensional level, the amount of data that's presented in canned reports coming straight out of their systems is limited. Our application is Web-based, and it's all built for continuous drill-down. What we've learned—because even though we are a software company, we are manufacturing people who come from manufacturing backgrounds—is that when you're analyzing a particular dynamic or asking a question, it actually turns into a series of questions.

A report can tell you how much you have on hand of a part. Then you say, "Well, I wonder how much that is in comparison to the demand I have for the part," which is another report. "Oh, I see that I have way more than what my demand is. Yet another report tells you, "I wonder who I bought this from." This is the normal way that human beings query. You don't get your answer with one question. It's a layered analysis that you're doing, where you could be drilling up, drilling down, drilling sideways; the Web is so conducive to this rather than two-dimensional reports.

The fact that Portus is linked real-time to their data sources means that it's just always there. With a traditional, two-dimensional view, you'd have to run your reports again in a week, because a week's worth of data has been added. It's this accumulative effect of effort to produce inferior two-dimensional reports, compared to always on, always available, multilayered views of the data. That's where the power comes in.

Matties: The idea is that they can get this data if they spend the time and energy, but with your system, it's just there in an instant. They don't even have to think about it.

Moradkhan: Right, and if they happen to be using one of the ERP systems that we already have customers with, then you're really talking about a plug-and-play solution, but beyond that, a plug-and-play solution that is verifiably used by

Portus President and CEO, Bill Moradkhan.

other companies, like them, to drive their business every day. There's that confidence that, "Hey, I'm using reports, and I'm using a solution that's tested and being used in production settings, and it's plug-and-play for me."

Matties:* *Is your system modifiable, where they can customize the reports that they want based on the information that's there?

Moradkhan: You can answer that question yes or no. There are lots of manipulations you can do. "Oh, I want to see this by customer. No, I want to see this by part number. I want to drill into this aspect. No, I want to drill into that aspect." In that sense, it's very interactive, and each user is using the system a different way. Having said that, all of the reports are built by Portus. The base reports with all of their options and functions are built by us. You focus on your business, we build it. Not only that, when you first start you get hundreds, maybe thousands of reports immediately from the time that you install it, so you save the time of having to develop it yourself.

Sometimes customers will have needs that go beyond what is currently reported, or an option in Portus. In this case, we start using the creative juices of our customers to improve results. If the request is something that is clearly going to be useful to the entire community, this is what we call the "community effect." Then we take the creative juice of Customer A, and build a new functionality. Customer A is happy, but now Customer B is pleasantly surprised, because they just got some new functionality that they didn't have previously.

If the request is very specific to a customer and involves their own customizations of the system beyond how customers normally use that system, then we may do that as a professional services project for them. Then again, it'll become available to other people to the extent that they use the data the same way.

Matties:* *How long has Portus been in existence and what's your background?

Moradkhan: We just celebrated our fifth year. I come from a complete manufacturing background. That's why I can be very evangelistic about this, because my 20 years of manufacturing experience has shown me that most people never actually get to the point where they're managing the business. Most of the time, they're just chasing data. That was my biggest pet peeve when I was in executive positions in manufacturing companies. We ended up, as part of my last stint, at a company called ProWorks in Santa Clara, developing it ourselves because we got tired of this. A lot of the advanced functionality became our inspiration, because I know that people struggle with this everywhere. I know that we weren't alone.

What we used to tell people back then and is still true now is, "If you're the company that's building the next great medical device or the next great telecommunications device, how much time should you be spending on developing, maintaining and deploying reports?" My answer to that is, "At the limit, none. You should be focused on your products and how to make them better, rather than having a significant amount of internal resources looking at reporting. That should be done automatically."

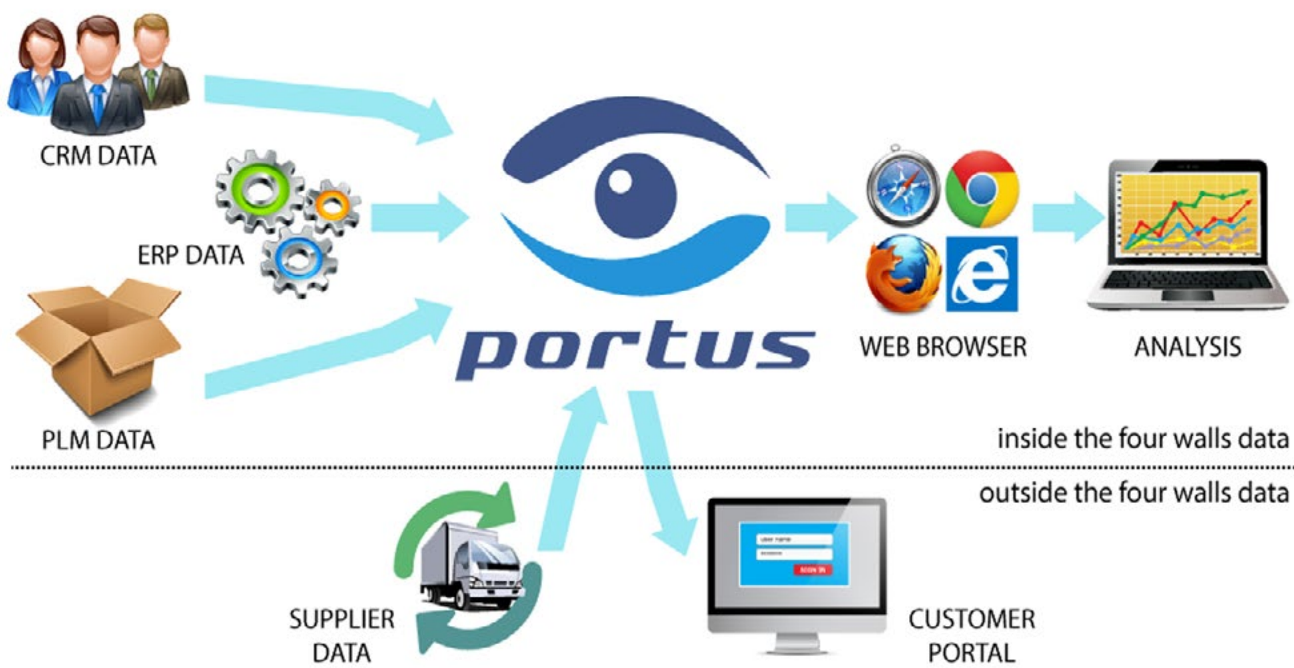
Matties:* *So your system is all online. Is their data online? Is that the idea?

Moradkhan: The kinds of data that we are querying and presenting is often sensitive data, so our deployment model is very respectful of that. What we do, even though you use a browser like Google Chrome or Internet Explorer or Apple Safari, is deploy our system inside the customer's network. A user is going into a browser, but from a server perspective they're not going into the World Wide Web. They're going to a local server resource. That way, all of that data is remaining inside our customer's firewall.

The added benefit of that, because our application is sitting on the same network as the data, is that response time is very fast. People are always shocked by how fast the reports render themselves, and we look for it to be a real Web experience. I mean, it needs to be like you're on Yahoo or Amazon. Nobody likes to wait for minutes for a link to upload.

Matties:* *Now, in terms of the data, you're also talking about reduction in cycle time. That's a big

IMPROVING PRODUCTION EFFICIENCIES WITH BETTER DATA STRATEGIES



benefit, I would think, that people are experiencing while utilizing your system?

Moradkhan: Yes, definitely. I mean, both in terms of just the cycle time of converting data into actionable business intelligence, but once you start not worrying about producing the data, a lot of our reports and analytics and optimization routines have to do with important manufacturing issues like cycle time, improvement of yields and throughput and productivity. Now they're able to see what the obstacles are and do something about them rather than, like I said before, spending 90% of their time just getting the view, and then only having a smidgen of time to say, "Okay, what is this telling me?"

Matties: Your expertise isn't about interpreting the data at all? That's entirely up to your customer?

Moradkhan: It's interesting, in a way some of our latest developments are pushing us to even cross that threshold, because often our reports will tell you in blaring colors that, "Hey, you have an issue here." For example, if you have a report that says 80% of your accounts receivable is more than 60 days past due, maybe we can say, "Well, it's not specifically telling me those words, but it's right there in your reports."

Before the end of this year, we're coming out with a new "alerts and notifications" functionality, where we're actually saying, "Look, there are literally hundreds, maybe thousands of reports available. All of them have issues that potentially need to be explored further. Is there a way for us to just go and run those and call out the most important issues, and serve them to the users as notifications and warnings?" Maybe through the notifications and warnings, they go to that report rather than hoping that the user happens to run that report. We are trying to cross that threshold, but if you do run one of our reports, it's telling you something. It's going to tell you very quickly what you need to go focus on.

Matties: As long as you interpret it that way, because it's still open to interpretation. But I like what you're saying, because I think part of the value model that you bring is not just saying, "Here's the information," but based on the analytics, it says, "Pay attention over here." Even if they're not running that particular report.

Moradkhan: Yes, exactly. This is one of the other key concepts, which is hard to communicate

but very near and dear to our hearts and goes along with the fact that we're manufacturers at heart, and we are purpose-built. It's been built by people who have been consumers of these reports. I have been reviewing accounts receivable information on a regular basis, and have developed a set of best practices of what I've seen.

Interestingly, that's a great example when you talk about it being open to interpretation. I would be willing to bet that in 99% of the companies in the United States, anybody doing an accounts receivable review is looking at how much of the accounts receivable is current, and then looking at it in pass-through buckets. It's such a mainstay of how you analyze accounts receivable, and here comes the big inefficiency, right? You've got all of these customers devoting time, effort and resources to build these accounts receivable reports, which probably fundamentally look the same. Maybe there's one that looks the best, and the best situation would be if all of them just use that rather than each developing it themselves, and that is, in a microcosm, what we are all about.

***Matties:** What's the price point for a package? How do you price this?*

Moradkhan: There are a lot of variables, and there's an evolution to the way that customers end up engaging with us. We have our base reporting and analytics module, which is what most people associate with Portus, as opposed to some optional modules that people sign up with afterwards. I'll first focus on the general model. We have two price points. You can either get your feet wet with a three-user license—that's three concurrent users, so you could potentially have more users, but three of them can be logged in at any one time for $1,500 a month.

Then you can get a site license, meaning unlimited users, unlimited logins, for $5,000 a month. It all depends on how quickly you think you're going to be running reports. Our experience is that once Portus is installed, it becomes the de facto reporting and analytics engine and it's being used all over the place, and then people graduate to the site model.

What's very key here, because we have a lot of pride in terms of utility, is that there is no big up-front investment, and we always offer a 30-day free trial because we believe the customer needs to see Portus not just in a demo setting, but actually with their own data, so they can say, "Wow, I could actually use this right now and it would improve my life," before they sign up. After that, it's sold on a month-to-month subscription basis, so it needs to be adding value every month, and we're very confident that it will.

We just want the customers to know that we don't want them to take any undue risk or make a large up-front investment. That was another one of my pet peeves when I was on the other side: people selling software based on a demo and asking for a huge up-front investment without having validated that it would, in fact, add the promised value. There's no way you can assess everything in a short assessment period, so we sell it on a subscription basis with the ability to cancel at any time.

With the optional modules we have a customer portal, a buyer's workbench, an MRP simulation engine, etc. Those are discussions you have with customers after they've been using Portus for awhile, and those have a lot of different arms and legs in terms of the pricing.

***Matties:** It sounds like there's little or no risk to try it. The value should be almost instant because*

they have full access from the trial and, as you're saying, the reports are meaningful. Of the people that you've given the 30-day demos to, have they all converted to customers?

Moradkhan: I think all but one, so we're at over a 90% rate. Once people see this with their own data, a couple of things happen. Right from the demo, I will tell you that they're very impressed with what the output is. They're still trying to justify the investment in terms of the cost, because they start thinking of us as some Cadillac/Mercedes solution to the problem they're trying to solve. In the beginning, they may even think about it as a big luxury item.

> What happens is that once people start thinking about how they really spend money in terms of employee costs, etc., transforming data into actionable business intelligence becomes a no-brainer.

Here is the key point: we are the cost leader first, because you are spending time, money and resources in transforming your unfiltered data into actionable business intelligence. A lot of times this cost is hidden, because you may not actually have a particular person employed to only do that. Maybe the director of materials happens to be strong in SQL, so you've asked them to write some queries over here. Then you've got Joe over in finance that is really good at Excel, so every week he has to put these Excel reports together.

What happens is that once people start thinking about how they really spend money in terms of employee costs, etc., transforming data into actionable business intelligence becomes a no-brainer. That's why we have such a big success rate once the trial happens, because it goes from thinking of it in terms of a luxury good to, "I'm going to get a real, leading-edge solution and, at the same time, I'm going to spend less money."

Matties: The price point of $1,500 a month seems entirely reasonable, even all the way up to the $5,000.

Moradkhan: I think we have a big "A-ha!" moment with the customers when they start converting and comparing that number to a full-time equivalent, because any company of decent size—once they analyze it—will be able to see they have at least one full-time equivalent. It's not one person, but it is pieces of different people involved in converting data into actionable business intelligence.

Matties: It's not just the cost of the time, but it's also the distraction that it brings to them. That's lost opportunity as well.

Moradkhan: Absolutely. All kinds of other dysfunctions happen when you don't really have a strategy about this, which is so important to your business.

Matties: A data strategy.

Moradkhan: Exactly, a data strategy. Really, you need that. You need to be thinking, "Hey, I want to know what's going on with my business at a surgical level." If you don't have that strategy, you may have situations where a great two-dimensional report is produced three weeks in a row, but then the fourth week, the people are busy so it doesn't get produced. Maybe that continuity of always looking at the same report on a weekly/monthly basis to make sure that you're on track causes you to lose that momentum, whereas with data collection software, it's always available.

We also talk about a single version of the truth. When you let people create reports themselves, a lot of times you're spending time reconciling them. They say, "Mine says this." "Well, how did you create yours?" "Well, I did it this way or I looked at it this way." There's a standardization that you need to have—really leading-edge or first-class management processes—so that people look at the same thing the same way on a regular basis.

One of the most gratifying experiences I have is when I visit customers and we're walking by the conference rooms and we see that people are sitting there and they're all looking at a screen discussing what's going on. People haven't walked in with mounds of paper, their own Excel spreadsheets, etc. Everyone knows that, "Hey, this is real-time, right now, a reflection of what's going on in our business." So you're right, it's more than just the cost. It's consistency and it's continuity. All of that plays into it.

***Matties:** I don't know if most companies have what I would call a document data strategy.*

Moradkhan: A lot of companies don't. You'd be surprised, and it may be shocking how even large public companies don't have a cohesive strategy for this. You know, regimes have come and gone, different tools have been tried, different approaches, and you really have a mishmash of things going on.

***Matties:** In your experience, what's the most sought-after data in the manufacturing environment?*

Moradkhan: You're going to get two camps, and the deciding factor is going to be what type of manufacturer you are. If, like in Silicon Valley where we are, a significant portion of the cost of your product is the raw materials and labor, and overhead represents a smaller portion of the cost, then the supply chain data is the most critical. That supply chain data usually is in your ERP system, Made2Manage, Oracle, and you're trying to slice and dice and manage your supply chain, because it is such a big part of your costs.

In other types of manufacturing, the raw materials are really trivial, especially in process manufacturers. I guess you could think of it like a steel manufacturer. They only have one form of raw material at the limit, which is iron ore. Their cost is in the operations, the equipment, and the labor, so now analyzing the equipment utilization and labor utilization and labor efficiency becomes more important. The type of manufacturer you are makes a difference, but for the most part you're either talking about supply chain information or labor and overhead information, and the deciding factor is which comprises most of your costs.

***Matties:** When I look at what IBM is doing with their IBM analytics through Watson—you are probably familiar with that—it seems like there's a big push of data management and awareness.*

Moradkhan: I actually saw a commercial just over the weekend that had the best tagline, but it wasn't IBM. It was one of their competitors, HP, and they're using a line that says, "Your IT strategy is now your business strategy," meaning, how you integrate with your employees, your suppliers, your customers, and how you're able to communicate and exchange information is now, in a lot of ways, the competitive advantage that people seek. Clearly if you're a product company then, yes, if your product is ten times cheaper and ten times faster, it's going to win; but that doesn't happen that often anymore. People are competitive, and it's not ten times cheaper and ten times faster.

They're about the same price, they're about the same speed, and now what makes a difference is who's easier to do business with. Who has their act together more? Now all of a sudden, to get that extra edge that puts you over the finish line is how you manage your data and how you do analytics that could be the actual deciding factor. If you're a service business, it's already there, because with service businesses—especially like contract manufacturing—you're selling a service at that point. It's not a product. You can't point to a product and say, "Look, mine is faster and cheaper."

The customer's looking for how good you are at doing what you do, and how well they can integrate with you so they're not scared about where you are in the manufacturing process, because they've bet the farm on you. If you don't deliver, they don't make their sales, right? You can use how well you manage data as a differentiator.

***Matties:** Is there a time where one of your customers would allow their customers into the Portus system?*

Moradkhan: Yes. That's one of the key optional modules where some of our longer-term customers have said, "You know what? I'm realizing that customers are calling me or calling my people, and asking a question. My employee is going into the software, looking up the answer, then responding to the customer. How much better would it be if I took some of these views and just made them available to my customers over the Web?" So we have a customer portal offering that allows you to do that, and it's done very carefully with encryption and with a higher level of security, because now there is some data traveling over the World Wide Web.

The other thing is sometimes the information that you share with your customer may not be as detailed as the information that's available to you internally, so we manage all of that. That's where we actually can turn into a strategic advantage for you, because offering that level of integration to customers may be the deciding factor for them to go with you rather than with somebody else. Let alone the fact that it brings a great deal of efficiency because they're not calling up your internal resources to answer some questions that they could just get online to see.

Matties: It's like an ATM machine. You don't want to go see a banker to get money, right?

Moradkhan: Yes, a very good example.

Matties: Is there anything that we haven't talked about that we should share with the reader?

Moradkhan: I would just emphasize being smart and analytical about this transformation process, transforming data into actionable business intelligence. Really do some soul-searching and ask yourself, "Do I have a strong strategy there? Am I doing that well?" Then, secondarily, "How much time, resources and money am I wasting there?" If you feel like you're not happy with the answers to those questions, then I think Portus could be a perfect solution for that.

Matties: When you say turning it into actionable items, give us an example that someone might consider.

Moradkhan: For example, let's say that you have data in your system about your on-hand inventory, about what you have on-order with suppliers, and you have the demand from your customers. A classic use of this is to take the demand that you have from your customers, break it down to the component level, and see if you have enough of the components either on-hand or on-order to meet that demand. A

lot of different things go into that calculation in terms of time frames. When does the customer want it? How long it is going to take for you to build it? When do you need all the material here?

That's a great example, because the data is in the database, but you need a view that goes and translates all of this data, runs a simulation on it and tells you, "Look, for this customer order, you're going to need these 100 components, and you're okay for 90 of them, but I want to highlight to you that you're in trouble for ten of them, because for five of those, the good news is you do have orders on your suppliers to get those in, but they're not coming in on time, so go do something about that. The other five, I didn't see any plan when I did the simulation to say that you have any plan for those. You don't have them on hand, you don't have them on order, so you have to either get busy or have a plan of action where you don't need those five items."

Once you have your ERP system, there's no magic button that's going to give you that analysis, but in Portus it'll give you that analysis and it'll give it to you in a layered way. For example, it'll tell you, "These five items are the ones that are not on time." Well, you're going to want to know much more about each of them. The good news is each of those part numbers is blue and underlined, so you'll click on the first one and it'll give you all the dynamics. Here's the purchase order, this is why it's late, and historically who we have bought it from.

We integrate information from outside your four walls. Who has that component available? You may want to drill further and say, "Why don't I have enough of this? Where has the inventory gone? What have been the recent transactions?" All of that stuff is in there in the database, but you need the analytics and the layered approach for it to actually give you a story with actionable things to do.

"Okay, then I know it's these five parts. That purchase order is the purchase order I've got to expedite. I'd better call this supplier and ask them to deliver it sooner." That's actionable, but in the regular database, there's nothing like that. In the database, all you know is this is how much you have on hand, and this is how much you have on order.

Matties: You mentioned you're connected to the outside component. Are companies like Digi-Key plugged in?

Moradkhan: Yes, like component suppliers.

Matties: Are you going into their database, or how is that connected?

Moradkhan: We have both. With some of them, we've advanced to what's called technically a Web service, meaning that when one of our users says, "I want to know market availability for this part," an immediate request is made at that point to the supplier, and the supplier responds and then we present that data there.

Matties: That's really streamlining their purchasing process as well.

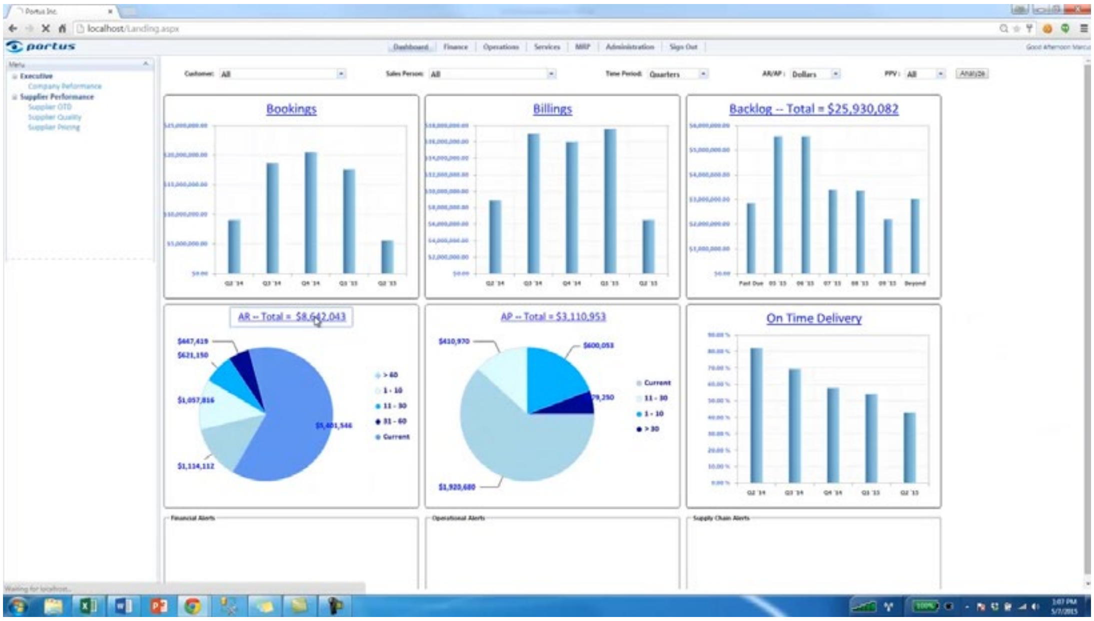
Moradkhan: It's huge, especially if you've gotten to that screen because you realize that, on a different screen, it said, "Hey, you're in trouble. You need this component." Now all of a sudden you say, "Oh and it's also telling me where in the world I can get it." That's when it really becomes powerful, rather than going and calling people or doing Web searches to find out where it is and so on and so forth.

Matties: It's done for you.

Moradkhan: With a couple of other suppliers, we do that on a nightly feed. They provide us a nightly feed, and then we make that available.

Matties: What's the revenue model there? Are you making revenue off of that exchange?

Moradkhan: No. For us, we fundamentally see ourselves as a software company that caters to our customers. We're not an advertising company. It just makes everything easier, because it's a win/win/win. For the supplier, it's free advertising. For our customers, it's very relevant information that they need, and it's right there when they need it. For us, it adds to our value proposition, so it's symbiotic. If it's highly symbiotic and no one has to worry about the money, it usually just ends up helping everybody.



***Matties:** That's a good approach. Is there a time when a manufacturer will say, "We'd like you to add this supplier to the list"?*

Moradkhan: Yes. We love to hear that, because the leverage with the suppliers is from our customers, not from us. If a customer, having gotten used to this service, says, "Hey, there are some suppliers that you don't have as part of this service, but if you did, then my hit rate would go up," then we ask them to talk to the supplier. That usually goes a long way, because the suppliers are very good and responsive to the customers, and we can then work with them. There's some level of investment that they have to do for us to work out the details technically, but then once it is going, it's just going.

***Matties:** Is there a list of the suppliers that are available through your system for the manufacturers to see prior to purchasing?*

Moradkhan: Yes, of course. We go through that, and that's changing all of the time. That's some of the stuff that you really can take advantage of during the 30-day free trial. With all of these things, because we sell this on a subscription basis, it really behooves us to have a customer that knows they're going to get value out of this, because we're looking for a long-term relationship, so the trial is great. The trial allows them to ask questions like that, "Do I have all the suppliers I need?"

***Matties:** During the trial, do they have full access to everything, up and down? Are there any limits? If I have three users, do I get the full limits or the full capabilities of somebody with 100 users?*

Moradkhan: Correct. We don't do pricing by, you know, functionality.

***Matties:** It's just, "Here's our system and here's what it does"?*

Moradkhan: Yes, and it is part of our philosophy. First of all, we talk about the fact that normal questions you may need to drill up, down or sideways. If you have some kind of a limit and the user needs to drill to something that is not part of their pricing structure, it just becomes kludgy and choppy. People also need to know that the more their people have access to the information they need, the better their company will run, and that's part of the philosophy of Portus. Let's just get it right to them so that they can do their job.

***Matties:** Thank you for your time.*

Moradkhan: Thank you, Barry. **SMT**

MilAero007 Highlights

ELCOSINT—The Future of High-Temperature Interconnect

The increasing need for electronic assemblies to endure high-temperature operating conditions in aerospace, automotive, oil and gas drilling, power management and renewable energy applications, whether those conditions involve high ambient temperatures, high cycle temperatures or high junction temperatures, is driving the development of high-temperature interconnection technologies.

NEO Tech Accelerates LEAN Implementation at Fremont, California Site

NEO Tech has made significant progress on its LEAN continuous improvement initiative at its Fremont, California manufacturing facility—making newly available more than 15,000 square feet of manufacturing space.

Briton EMS, 42 Technology Partner on Wind Tunnel System

EMS firm Briton EMS and product design and development consultancy 42 Technology have developed a sophisticated control system for Aircraft Research Association's new gust generator, the first of its kind in the world capable of simulating gusts at transonic, or cruising, speeds typically experienced by aircraft.

Plexus Earns ISO 14001 Certification in Mexico

Plexus Corp., a leading electronics engineering, manufacturing and aftermarket services provider for customers in mid-to-low volume in higher complexity market sectors, announced that its Manufacturing Solutions facility in Guadalajara, Mexico has achieved ISO 14001 certification.

TTM Technologies' Shanghai EMS Facility Gets NADCAP Certification

TTM Technologies' Shanghai EMS facility has been awarded Nadcap certification. The facility is also certified to the aerospace industry specification AS9100. This makes the Shanghai E-MS facility TTM's 12th facility to gain Nadcap accreditation.

Accelerated Assemblies Boosts Capabilities with ACE Soldering Technologies

Accelerated Assemblies has strengthened its capabilities by investing in a KISS-102IL in-line selective soldering system from ACE Production Technologies.

Kitron Signs Long-term Supply Agreement with Northrop Grumman

Kitron AS, a subsidiary of Kitron ASA, has signed a long-term agreement with Northrop Grumman Corporation to supply subassembly electronic modules for F-35 Lightning II aircraft avionics.

Sparton to Shut Down Georgia Manufacturing Facility

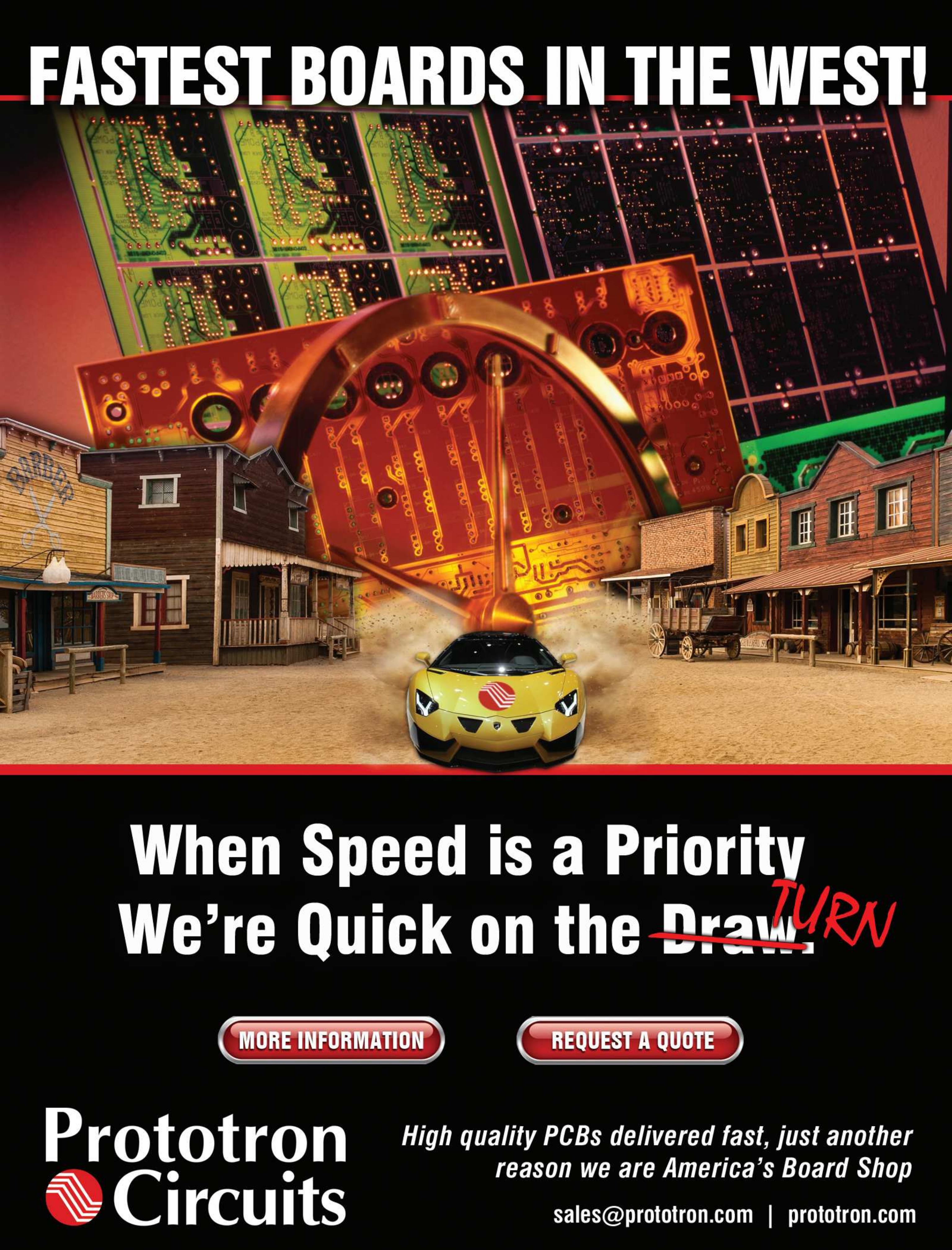
Sparton will be closing its Lawrenceville, Georgia manufacturing operations no later than June 30, 2016. The closing is in line with actions being taken related to acquisition synergies that optimize the company's facility footprint.

Nortech Systems Launches PCBA Operations in Mexico

"Adding a PCBA manufacturing option in Mexico has always been a popular request from our customers," said Rich Wasielewski, president and CEO of Nortech Systems. "We're happy to provide these partners a great option that provides high value with assuredness of Nortech's strong quality and speed-to-market."

3rd Annual DDM Novastar Open House a Success

For the third consecutive year, DDM Novastar held its annual Technical Workshop and Open House on September 15–17, 2015 and it was, by all measure, an enormous success.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Connecting the Enterprise

by Stephen Las Marias
I-CONNECT007

When we did the survey for this month's theme for our magazines—*The Data Factor(y): Looking at the Industrial Internet*—we found out that some of the key challenges for our readers when it comes to data collection include accurate data collection; real-time collection of data; and making sure that they are collecting the right data.

The growing Internet of Things (IoT) trend—or Industrial IoT, in this context—is just going to further fuel the explosion of data as more devices and systems on the factory floor get connected. To bring this manufacturing data into the enterprise where it can be used to generate value, investments in technology and equipment and a mindset shift are necessary.

I interviewed Mike Hannah, market development lead for Rockwell Automation's Connected Enterprise initiative, who discusses the evolution of manufacturing in the era of Industrial IoT and the biggest changes to expect in the production line. He also talks about the importance of investing in the right equipment, systems and technologies to take advantage of the value that the IoT will bring.

Finally, he also explains how the convergence of the plant-floor operations technology or OT—the world of industrial equipment, devices, controllers, sensors, and actuators—and the company-wide information technology or IT, which is the platform for end-to-end business processes, including ERP and CRM systems, supply-chain management, logistics and HR, can help align goals between these two organizations and focus on people, process and technology.

***Stephen Las Marias:** As we enter the age of the Industrial Internet of Things (IIoT), what will be the biggest changes in the electronics manufacturing environment?*

Mike Hannah: In this IoT era, the escalation of the Internet and Ethernet-enabled devices will drive the most significant change in the manufacturing sector, including electronics. A nearly endless range of "smart" things in the industrial sector will be embedded with intelligent sensors that can communicate seamlessly with one another within the existing Ethernet/IP infrastructure. Many are predicting that by 2025, there will be over 50 billion IoT units installed around the world. This ubiquitous connectivity will provide an unprecedented oppor-

Mike Hannah, market development, Rockwell Automation.

tunity across multiple industries, driving tangible value as data from these smart machines evolves into contextualized information. So far, companies are reporting that decision makers across the entire enterprise are gaining greater visibility into their operations which, in turn, allows them to respond to market and business challenges faster, with new opportunities to innovate and drive out inefficiencies in their processes. We tend to talk about IoT with five major areas of enabling technologies: smart things (connecting more equipment to networks); data analytics (turning data into actionable information); scalable computing/cloud (leveraging scalable computing, including off-premise resources); mobility (developing a smarter and more productive workforce); and security (simply put, making sure everything is secure).

Las Marias: What will be the advantages and disadvantages here?

Hannah: The value at stake includes: (1) maximizing asset utilization—reducing selling, general, and administrative expenses and cost of goods sold by improving business-process execution and capital efficacy; (2) increasing employee productivity—enhancing labor resourcefulness that results in fewer or more productive man hours; (3) managing more effectively supply chain and logistics—eliminating waste and improving processes; (4) enriching the customer experience—increasing customer-lifetime value and growing market share by adding more buyers; and (5) fostering innovation—increasing the return on research and development investments, shortening time to market, and creating additional revenue streams from new business models and opportunities.

Las Marias: How can manufacturers collect the correct, accurate data from their manufacturing lines to be able to derive actionable intelligence that will help decision makers formulate business strategies for the whole company?

Hannah: To successfully achieve much of the value at stake, manufacturers have to converge the plant-floor operations technology (OT) and the company-wide information technology (IT). Operations technology is the world of industrial equipment, which includes devices, controllers, sensors and actuators. Information technology is the platform for end-to-end business processes, including ERP and CRM systems, supply-chain management, logistics and HR. It is important to establish a cross-functional team that agrees that this convergence is necessary, so they can align goals between the two organizations and focus on people, processes and technology. Everybody needs to work differently and practices have to change to optimize the workflow. People have to evaluate what intelligence is needed from which units, while clearly defining how it will help enhance the process. Next, they must collect the data, organize it to enrich identified business processes, and then contextualize it to make it actionable for the user. Finally, correlation and qualitative analysis of the information has to take place, so processes can be improved and people can work more efficiently.

This is what Rockwell Automation calls the Connected Enterprise, which is boosting the advantages of smart, safe, secure and sustainable manufacturing. Customers benefit from accelerated time to market, lowered total cost of ownership, maximized asset utilization and mitigated risk management.

Las Marias: ***How important is it to invest in new equipment that will provide end-to-end visibility into the different manufacturing processes in the factory floor? What are the benefits?***

Hannah: Modernization, or technology upgrading, is very important in pursuing connectedness across an entire organization. It is important to first examine the network infrastructure, as this is really the blueprint for the successful integration of OT and IT. In addition, as more and more devices are being connected, network performance and reliability must be assessed and validated to better protect against security breaches and safeguard the architecture for future expansion. Moreover, in order to achieve significant results, manufacturers need to see if they can leverage legacy technology, determine which devices are designed for the information era and have built-in protection, and decide whether intelligence can be derived by connecting those assets to reduce unplanned downtime, decrease maintenance costs and bring products to market quicker.

Las Marias: ***From your experience, what are your customers' largest issues around data collection in the electronics manufacturing industries?***

Hannah: Achieving a connected enterprise requires the convergence of IT and OT, people, processes and technologies. These two typically independent architectures and systems need to converge into a single, unified architecture reliably and securely, leveraging one common technology—Ethernet/IP. Rockwell Automation has been partnering with Cisco Systems to develop best practices and design guidelines, including publishing the Converged Plantwide Ethernet Design and Implementation Guide, which features tested and validated designs to meet the needs of both the IT and OT teams. In addition, we are jointly developing education and training courses to further bridge the knowledge gap.

Las Marias: ***How do you help customers in the electronics manufacturing space identify the data that they need to find the weak link and improve the efficiencies in their process lines?***

Hannah: Rockwell Automation takes a holistic, open-systems-oriented approach to connecting the enterprise. Through products, solu-

The Connected Enterprise.

tions and professional services, we help customers proactively assess and address their network infrastructure, industrial security, automation, and information solutions. Our integrated control and information solutions break down barriers by bringing secure access to contextualized data to generate actionable information. We bring IT and OT together by delivering a combination of control-system design, modern automation and information applications, solutions, software, and professional services to help customers address risk and improve performance. Besides Cisco, we have also aligned with other IT and OT market leaders, such as Microsoft, Panduit and AT&T, as well as our entire PartnerNetwork, to continue to drive the vision—enabling us to solve real-world customer problems, which we could not accomplish on our own.

***Las Marias:** One of the things that is helping manufacturers cope with the high rate of change is automating processes in their manufacturing lines. From your perspective, which processes in the electronics manufacturing can easily be automated?*

Hannah: It really depends on the individual company's maturity and business objectives. Therefore, conducting an internal baseline assessment is a critical first step, as well as being mindful of the current and future operation states. Next, organizations should consider their goals regarding quality, downtime, productivity and overall equipment effectiveness (OEE). Furthermore, they have to identify primary objectives for pursuing a connected enterprise; for example, what problems they are trying to solve or where they are seeking greater efficiencies. From there, operators can build the roadmap to move from discussing and theorizing the connected enterprise to rationalizing and operationalizing it.

***Las Marias:** What about the risks and challenges when a decision has been finalized to automate certain assembly processes?*

Hannah: There are many factors that need to be considered as manufacturers evolve from the conceptual stage to becoming a truly connected enterprise. How much data collection and reporting is already automated versus manual? What metrics do they want to capture that are not being captured today or cannot be captured with their legacy system? How is the plant performing against key performance indicators (KPIs), as well as the competition? Is reporting standardized and contextualized, so it empowers operators to act on information quickly and clearly?

Las Marias: *From a production standpoint, how does automation benefit a company?*

Hannah: A great proof point is our own journey. At Rockwell Automation, we realized we could further increase our competitiveness by making changes and leveraging available IoT technologies. As a result, our inventory shrank from 120 days to 80 days; we lessened capital expenditures by 30% per year; we minimized supplier lead times by 50%; and we heightened our customer on-time-to-want from 82 to 98%. At the same time, we slashed our quality issues by over 50% to finally achieve annual productivity gains of 4–5%.

Las Marias: *What can you say about the future of automation in the electronics manufacturing and assembly industry?*

Hannah: Competitive pressures, including globalization, are accelerating the need for operators to share more data seamlessly across the entire company. To excel, each manufacturer must carefully assess and plan their connected enterprise journey to capture the right intelligence and turn it into working information capital. Technology enablers are burgeoning—IoT and the proliferation of smarter end points, big data and analytics, virtualization, and mobility—and will facilitate the decades-long pursuit of the connected enterprise for manufacturers. In doing so, savvy companies will be able to harness more skillfully the most powerful element that most operators neglect today: their own information. Garnering this intangible asset is the key to understanding operational performance at the most granular level, so operations can be optimized.

Las Marias: *Thank you very much, Mike.*

Hannah: Thank you, Stephen. SMT

Interim CEO Jeff McCreary on Changes at Isola

In a recent interview with I-Connect007, Isola's interim President and CEO Jeff McCreary discussed the impetus for the recent personnel reduction and plant closing that took place, mainly in the U.S. With a realignment towards the Asian market and improved plant utilization in the U.S., Isola expects to become more internationally competitive and improve revenue.

McCreary explained that, with long-time president Ray Sharpe stepping down followed by the reductions, many are probably wondering about the company's stability. He stated that the company has remained profitable but has suffered revenue-wise in the past few years, due in part to a general market slump in Asia. By improving on their manufacturing utilization rate in the U.S. (savings in the millions) along with more focus on the Asian market, McCreary sees the company as highly competitive going forward.

McCreary also shared his bullish view on the electronics industry in general and on what the industry may expect from Isola going forward. In addition, he explained what the company is looking for in a new CEO, which should be announced in the next few months.

To read the entire interview click here.

Supply Line Highlights

[Rehm Thermal Systems Talks 25 Years of Technology and Trends]

Ralf Wagenfuehr, plant manager at Rehm Thermal Systems, talked with I-Connect007's Stephen Las Marias about the business and technology developments and evolution that have happened at the company as it celebrates 25 years of success in this business.

Zestron Highlights Benefits of pH-neutral Cleaning Solutions

I-Connect007's Andy Shaughnessy talks with Zestron's Sal Sparacino, marketing and product manager, and Umut Tosun, application technology manager, about the benefits of the company's pH-neutral cleaning agents for defluxing applications, and their advantages over alkaline-based cleaning solutions.

BTU Talks Challenges and Trends Driving Product Development Strategies

Coco Zhang, product manager at BTU Ltd, discusses with I-Connect007's Stephen Las Marias some of the technology trends and customer challenges and requirements that are driving innovations in their reflow ovens.

Alpha Receives Best Paper Award at CISTF 2015 for Technical Presentation in Suzhou, China

Alpha recently has been honored with the Best Conference Paper Award at the 2015 China International Solder Technology Forum & Exhibition held in Suzhou, China.

Nordson ASYMTEK Employees Build Playground at Homeless Center

More than 50 Nordson ASYMTEK employees in Southern California have constructed a playground for the children who live at the Solutions for Change Intake and Access Center in Vista, California.

AIM Solder Releases Q3 Indium Market Update

AIM's quarterly review will provide perspective on the near term and long term trends in the indium market and will provide consumers with a summary on current issues impacting the market.

Para Tech Coating Opens New Midwest Parylene Service Center

Para Tech Coating Inc. has opened a coating center in Neenah, Wisconsin, expanding the company's regional capabilities beyond its California and Connecticut operations.

Juki Expands Operations in Brazil

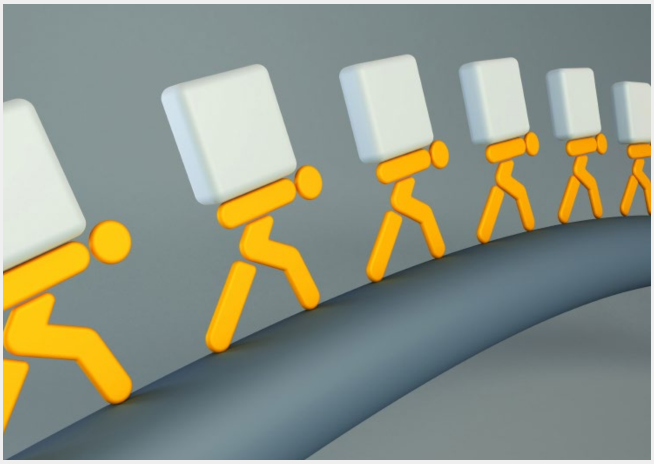
Juki is expanding its product line offerings, demo facilities, applications engineering team and service team in Brazil, to meet growing goals in this important market.

Transition Automation Unveils New Permalex Pro Reinforced Squeegee Line

Transition Automation Inc.'s Permalex-Pro "R" series is a reinforced blade assembly that enables high-speed continuous operation for extended high volume SMT printing.

STI Introduces IPC-A-600 PCB PROCESS SEQUENCE KIT

STI Electronics Inc.'s IPC-A-600 PCB PROCESS SEQUENCE KIT is designed as an aid to individuals teaching the IPC-A-600 Acceptability of Printed Boards Training and Certification Program or for anyone in need of visual aids to assist with explaining the various steps of the PCB fabrication process.



FEATURE

MANAGING BIG DATA FROM AN ANALOG WORLD

by Chandran Nair
NATIONAL INSTRUMENTS

There once was a time when hardware sampling rates, limited by the speed at which analog-to-digital conversion took place, physically restricted how much data was acquired. But the advances in computing technology, including increasing microprocessor speed and hard-drive storage capacity, combined with decreasing costs for hardware and software, have provoked an explosion of data coming in unabated. Among the most interesting to the engineer and scientist is data derived from the physical world. This is analog data that is captured and digitized and otherwise known as "big analog Ddata." It is collected from measurements of vibration, RF signals, temperature, pressure, sound, image, light, magnetism, voltage, and so on.

In the field of measurement applications, engineers and scientists collect vast amounts of data every minute. For every second that the Large Hadron Collider at the European Organization for Nuclear Research (CERN) runs an experiment, the instrument generates 40TB of data. For every 30 minutes that a Boeing jet engine runs, the system creates 10TB of operations information (Gantz, 2011).

In the age of big data, hardware is evidently no longer the limiting factor in acquisition applications, buy the management of acquired data is. How do we store and make sense of data? How do we keep them secured? How do we future proof them? These questions become compounded when systems evolve to become more complex, and the amount of data required to describe those systems grow beyond comprehension. This inevitably results in longer project schedules and less efficiency in development. More advanced tools and smarter measurement systems will be essential to managing this explosion of data and help engineers make informed decisions faster.

For engineers, this means instrumentation must be smarter and sensors, measurement hardware, data buses, and application software need to work together to provide actionable data at the right time. The big data phe-

nomenon adds new challenges to data analysis, search, integration, reporting, and system maintenance that must be met to keep pace with the exponential growth of data. And the sources of data are many. As a result, these challenges unique to big analog data have provoked three technology trends in the widespread field of data acquisition.

Contextual Data Mining

The physical characteristics of some real-world phenomena prevent information from being gleaned unless acquisition rates are high enough, which makes small data sets an impossibility. Even when the characteristics of the measured phenomena allow more information gathering, small data sets often limit the accuracy of conclusions and predictions in the first place.

"Data mining is the practice of using the contextual information saved along with data to search through and pare down large data sets into more manageable, applicable volumes."

Consider a gold mine where only 20% of the gold is visible. The remaining 80% 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, data analytics and data mining are required to achieve new insights that have never before been seen.

Data mining is the practice of using the contextual information saved along with data to search through and pare down large data sets into more manageable, applicable volumes. By storing raw data alongside its original context, or "metadata," it becomes easier to accumulate, locate, and later manipulate and understand. For example, examine a series of seemingly random integers: 5126838937. At first glance, it is impossible to make sense of this raw information. However, when given context like (512) 683-8937, the data is much easier to recognize and interpret as a phone number.

Descriptive information about measurement data context provides the same benefits and can detail anything from sensor type, manufacturer, or calibration date for a given measurement channel to revision, designer, or model number for an overall component under test. In fact, the more context that is stored with raw data, the more effectively that data can be traced throughout the design life cycle, searched for or located, and correlated with other measurements in the future by dedicated data post-processing software.

Intelligent DAQ Node

Data acquisition applications are incredibly diverse. But across a wide variety of industries and applications, data is rarely acquired simply for the sake of acquiring it. Engineers and scientists invest critical resources into building advanced acquisition systems, but the raw data produced by those systems is not the end game. Instead, raw data is collected so it can be used as an input to analysis or processing algorithms that lead to the actual results system designers seek.

For example, automotive crash tests can collect gigabytes of data in a few tenths of a second that represent speeds, temperatures, forces of impact, and acceleration. But one of the key pieces of pertinent knowledge that can be computed from this raw data is the Head Injury Criterion (HIC), a single scalar, calculated value representing the likelihood of a crash dummy to experience a head injury in the crash.

Additionally, some applications—particularly in the environmental, structural, or machine condition monitoring spaces—avail themselves to periodic, slow acquisition rates that can be drastically increased in bursts when a noteworthy condition is detected. This technique keeps acquisition speeds low and minimizes logged data while allowing sampling rates that are ad-

equate enough for high-speed waveforms when necessary in these applications. To incorporate tactics such as processing raw data into results or adjusting measurement details when certain criteria are met, you must integrate intelligence into the data-acquisition system.

With emerging sensor, processor, and battery technologies, intelligence can move much further down the signal chain. With intelligence built into the sensor, data does not have to wait until reaching the instrumentation to be processed. For example, some intelligent accelerometers can digitize and perform FFT analysis on vibration data before forwarding that data to instrumentation. Sending frequency data and not raw time domain data reduces the burden on the data transfer and reduces the processing required by the instrumentation. Right now, microelectromechanical systems or MEMS technology is playing a major role in this trend. By using new fabrication techniques, entire sensors can now be implemented in a small silicon chip. These new sensors use much less power, require much less space, and are orders of magnitude cheaper to manufacture. Coupled with lower power, lower cost processors, and improved power management techniques, engineers can integrate sensing and intelligence at a scale that would be impossible with traditional analog sensors.

The Rise of Cloud Storage and Computing

The unification of DAQ hardware and onboard intelligence has enabled systems to be increasingly embedded or remote. In many industries, it has paved the way for entirely new applications. As a result, the Internet of Things (IoT) is finally unfolding before our very eyes as the physical world is embedded with intelligence, and humans now can collect data sets about virtually any environment around them. The ability to process and analyze these new data sets about the physical world will have profound effects across a massive array of in-

dustries. From health care to energy generation, from transportation to fitness equipment, and from building automation to insurance, the possibilities are virtually endless.

In most of these industries, content (or the data collected) is not the problem. There are plenty of smart people collecting lots of useful data out there. To date this has mainly been an IT problem. The IoT is generating massive amounts of data from remote, field-based equipment spread literally across the world and sometimes in the most remote and inhospitable environments.

These distributed acquisition and analysis nodes (DAANs) embedded in other end products are effectively computer systems with software drivers and images that often connect to several computer networks in parallel. They form some of the most complex distributed systems and generate some of the largest data sets the world has ever seen. These systems need remote network-based systems management tools to automate the configurations, maintenance, and upgrades of the DAANs and a way to efficiently and cost-effectively process all of that data.

Complicating matters is that if you reduce the traditional IT topology for most of the organizations collecting such data to a simple form, you find they are actually running two parallel networks of distributed systems: the embedded network that is connected to all of the field devices (DAANs) collecting the data and the traditional IT network where the most useful data analysis is implemented and distributed to users.

More often than not, there is a massive fracture between these two parallel networks within organizations, and they are incapable of interoperating. This means that the data sets cannot get to the point(s) where they are most useful. Think of the power an oil and gas company could achieve by collecting real-time data on the amount of oil coming out of the ground and running through a pipeline in Alaska and then being able to get that data to the accounting department, the purchasing department, the logistics department, or the financial department—all located in Houston—within minutes or hours instead of days or months.

Placing near infinite storage and computing resources from the cloud that are used and billed on-demand at the fingertips of users provides solutions to the challenges of distributed system management and crunching huge data sets of acquired measurement data. Big data tool suites offered by cloud providers make it easy to ingest and make sense of these huge measurement data sets.

“By making machines smarter through local processing and communication, the IIOT will solve problems in ways that were previously inconceivable. But as the saying goes, “if it was easy, everyone would be doing it.””

That said, the application of big analog data is the precursor to the rise of the Industrial Internet of Things (IIoT). By making machines smarter through local processing and communication, the IIOT will solve problems in ways that were previously inconceivable. But as the saying goes, “if it was easy, everyone would be doing it.” The complexity arisen from the three technological trends further accentuates the need for massive investment that no one company alone can make and concerted effort across the board. Bringing this vision would require overcoming three key challenges:

Security

Both the systems and the communications within the IIoT need to be secure, or billions of dollars’ worth of assets are at risk. Standards bodies, consortiums, and co-ops, such as the Industrial Internet Consortium and the North America Electric Reliability Corporation (NERC), in many industries are working to develop the standards needed to ensure security, but there is still much work to be done. Companies looking to increase their security should begin with an IT-friendly OS, such as SE Linux, that they can securely provision and configure to properly authenticate and authorize users to maintain system integrity and maximize system availability.

"This network must meet IIoT latency, determinism, and bandwidth requirements while maximizing interoperability between industrial systems providers and the Consumer Internet of Things."

Communication

Especially within the IIoT, we need to standardize on an Ethernet-based protocol that is capable of leveraging new Ethernet technologies to create an open and deterministic network. This network must meet IIoT latency, determinism, and bandwidth requirements while maximizing interoperability between industrial systems providers and the Consumer Internet of Things. Clearly, we will need standards that support interoperability between multiple vendors, but we will also need networking technology to ensure low-latency communication on a converge network. IEEE has formed the Time Sensitive Network task group to evolve IEEE 802.1 to meet these requirements.

Flexibility

The key to the IIoT is that no one knows exactly what it will bring. Though we can't tell the future, we must still be prepared for it. In addition to being secure, these systems need to be continually modified and maintained to meet ever-changing functionality and system-maintenance requirements. Using traditional approaches to add new functionality can get complicated. As more capabilities are added, software updates are needed or more systems must be added. Soon a tangled web of interconnected components starts to form. These new systems and functionalities have to integrate not only with the original system but also all of the other systems. The thought of this gets even scarier when you imagine modifying and updating thousands or millions of systems located all over the world, including some in remote locations.

The Way Forward

The existence of parallel networks within organizations and the major investment made in them have been major inhibitors for the IoT. However, today, cloud storage, cloud computational power, and cloud-based big data tools have met these challenges. It is simple to use cloud storage and cloud computing resources to create a single aggregation point for data coming in from a large number of embedded devices (such as the DAANs) and provide access to that data from any group within the organization. This flexible hardware architecture solves the problem of the two parallel embedded and IT networks that don't interoperate, thus removing a substantial amount of the hardware complexity and makes each new problem primarily a software challenge.

The same principle must be applied to software tools to form a powerful hardware-software platform that creates a unified solution. An effective platform-based approach does not focus on hardware or software but instead on the innovation within the application itself. A prime example of this is Airbus, which is using NI LabVIEW software and reconfigurable hardware to accelerate its development process as it builds the Factory of the Future. Airbus found this platform-based design approach cut their development time by a factor of 10. By using a platform-based approach you can solve the challenges of the IIoT today and in the future. SMT

Chandran Nair is the vice president for Asia-Pacific at National Instruments.

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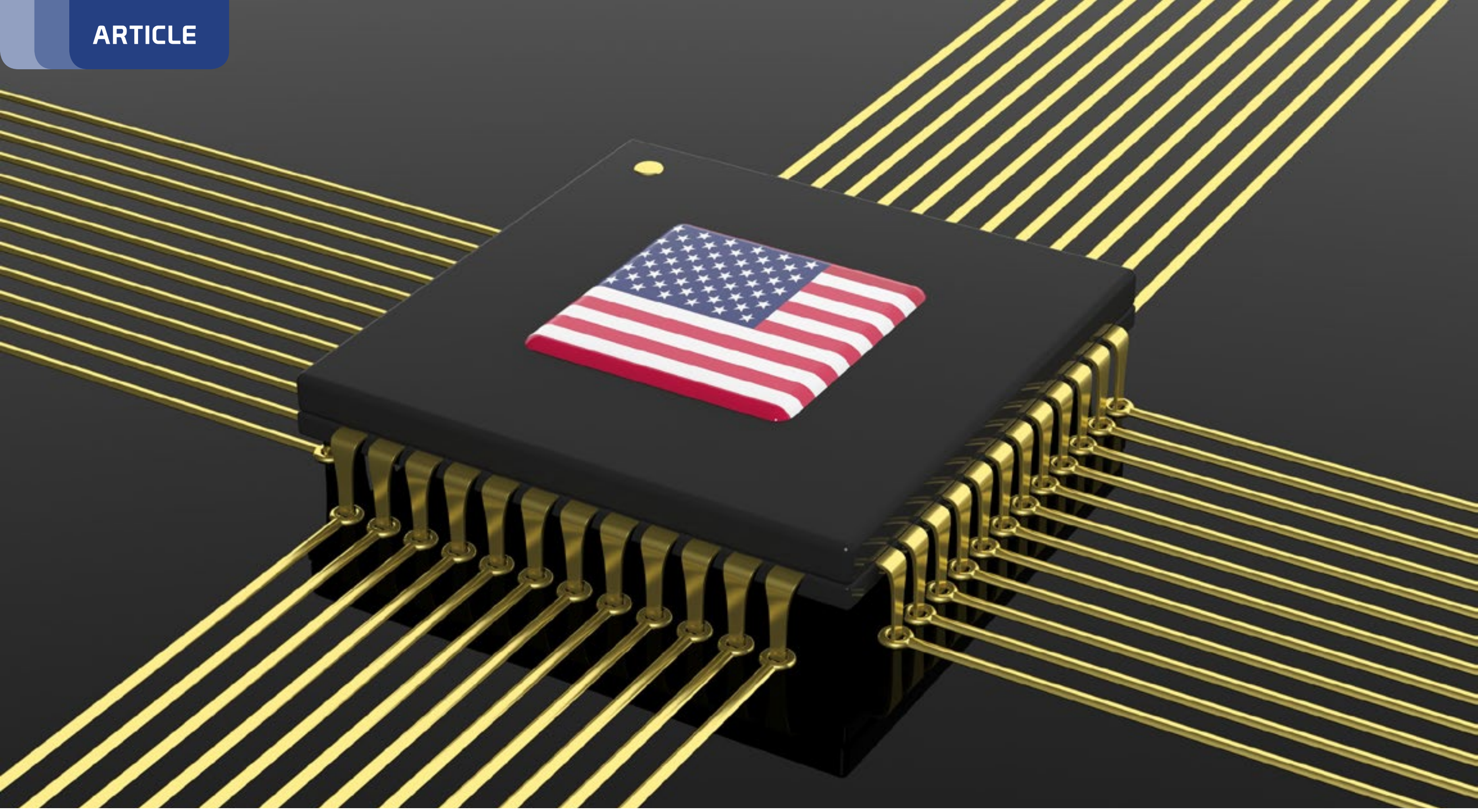
ARTICLE



MADE IN USA AND TOTAL COST: Six Ways U.S. Sourcing Saves Money

by Gary Burnett, Jr.
BURTON INDUSTRIES INC.

There is no question that manufacturing in countries known for lower labor costs can save money on some projects. In cases of high-volume production, selecting low-cost labor regions close to end markets can generate significant savings and in some cases, fulfill the local content requirements necessary for entry into those markets.

However, when total costs are considered, medium- and low-volume production often doesn't benefit from working at distance, since crossing borders increases logistics costs, adds internal costs relative to team travel and adds complexity to project transfer and support.

In cases of medium- and low-volume projects, a regional U.S. contract manufacturer may represent a lower total cost than a manufacturer in a low labor cost country. Some of that cost difference is visible, but in many cases, the reduction comes from elimination of cost surprises not evident in unit price alone. Burton Industries, a regional electronics manufacturing services (EMS) provider with manufacturing located in Ironwood, Michigan, routinely sees its customers opt to keep portions of their manufacturing in the U.S. for this reason.

Here are six areas where using a U.S. contract manufacturer often saves money.

- New product introduction (NPI)
- Logistics
- Quality
- Staff support time
- Production changeovers
- Responsiveness

New Product Introduction

The NPI process often provides the best opportunities for removing cost from the product. Design for manufacturability and testability (DFM/DFT) is one area that can drive reduction in cost and elimination of defect opportunities. Product lifecycle management (PLM) analysis can help mitigate obsolescence risk and/or identify potential obsolescence risk early enough to provide multiple remediation options. Robust feedback during production qualification runs

can also help correct any unanticipated production issues prior to the point where they generate significant non-value added cost.

When an original equipment manufacturer's (OEM) product development team and the contractor's NPI team are in similar time zones and speak the same language, all of those issues can be discussed and addressed rapidly. And it is not usual for the contractor to have a highly automated and well-defined process for doing the necessary analysis rapidly.

However, companies in low-cost labor regions do not always invest in the software analysis tools to support this rapid exchange of information. Depending on the operation and the region, manufacturing inefficiencies may be tolerated or reviews may be done manually.

Higher levels of equipment and software automation is more difficult to cost justify in regions where labor costs are low. More manual processes deliver less consistent results, typically aren't as detailed and often take more time. Language barriers may limit the amount of feedback provided during production qualification. Or, the project volumes may be so out of scale with the offshore contractor's preferred volumes that only minimal resources are provided. The end result can be production inefficiencies that remain unaddressed; or in the worst case, field failures occur that could have been avoided had the potential for these defects been minimized by addressing the manufacturability issue that was driving them.

Logistics

Crossing a border generates added cost. Inbound material may have additional duties levied or require higher levels of administrative oversight to document in ways that eliminate duties. Often "landed" quotes are based on perfect world scenarios that have significant leadtime based on a practice of consolidating shipments for lower logistics costs. This is fine when demand is predictable, but can drive cost surprises or late deliveries if demand is variable. In some countries there are limits on how much

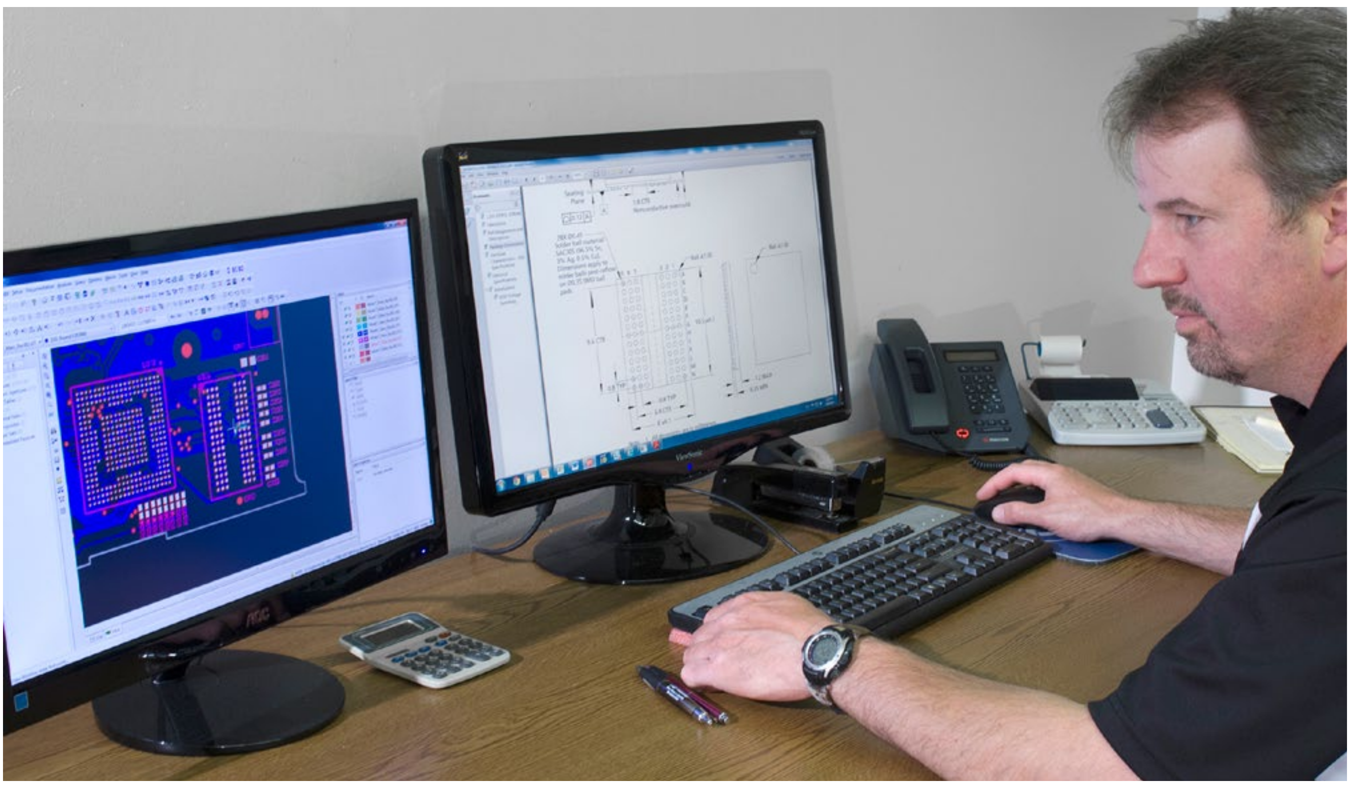


Figure 1: An engineer uses software tools to provide DFM/DFT recommendations and a PLM analysis with the quote so that clients have visibility into potential issues as early as possible.

raw material can be imported and this drives the need for frequent reconciliation between forecast and actual consumption.

For example, in China, contractors often require clients to purchase unused inventory quarterly, since otherwise this unused inventory would count against import quotas. Typically, this type of reconciliation occurs far less frequently at U.S. contractors. In many cases, minimum buy inventory or excess inventory driven by changes in demand is carried by U.S. contractors until the inventory becomes inactive. Customs documentation related to products imported back into the U.S. can also create issues. For example, required country of manufacture labeling may change a product's image in the minds of the consumer, or in the case of large corporate customers, drive demands for unit price reductions that eliminate any savings achieved by moving the product offshore.

A country's lack of infrastructure and security can also cause surprises. For example, roads in Mexico are not uniformly well maintained. Truck transport on long stretches of rough road can create product damage. Areas where trucks have been frequently hijacked may have high insurance premiums. The end result can be costs much higher than previously anticipated.

Quality

As mentioned earlier, equipment costs are the same in just about every country. Consequently, contractors in countries with lower labor costs tend to minimize equipment investments wherever possible. The end result can be processes which are automated in the U.S. to minimize labor cost are done manually in countries with labor costs that are lower than the cost of automation. This can impact quality, since manual operations are not as consistent as an automated process.

Staff Support Time

This may be the largest uncalculated cost of working offshore. Few OEMs tell their engineering or program management staffs to work the

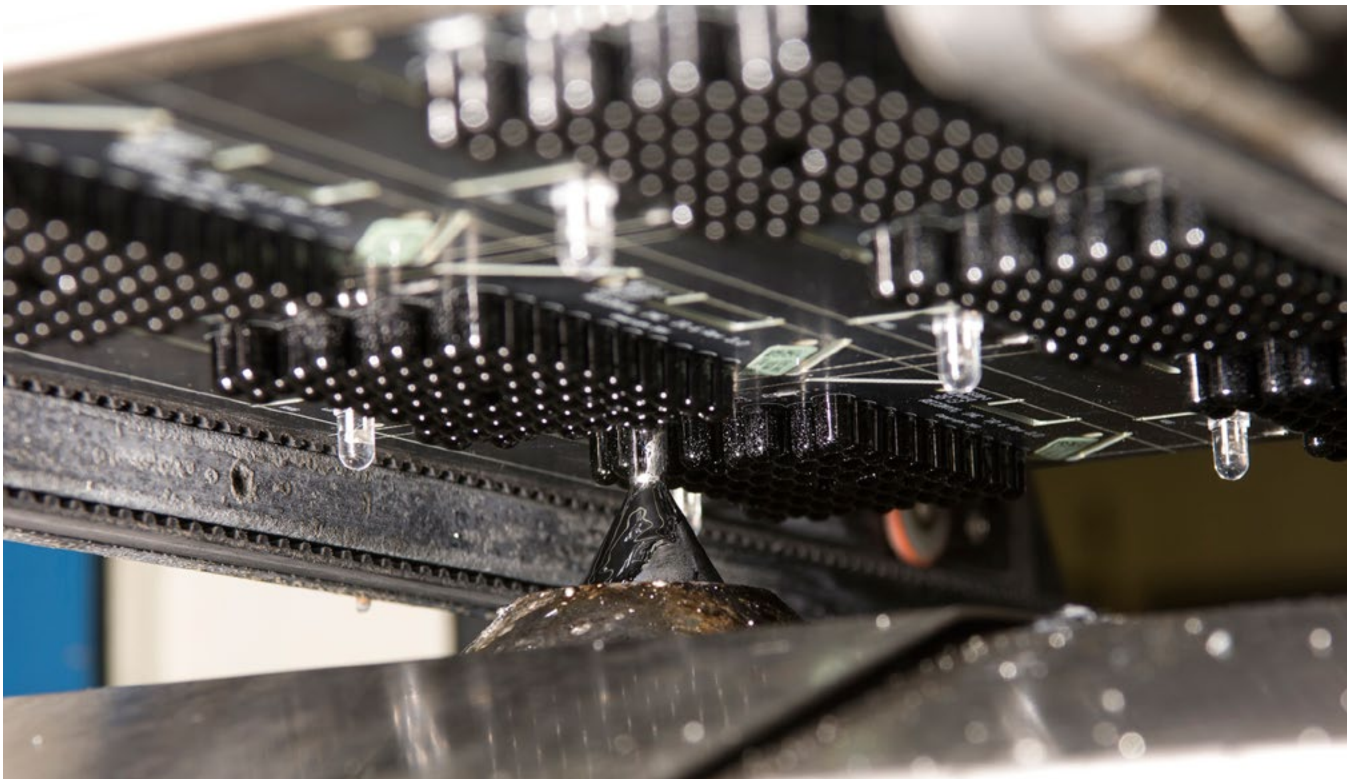


Figure 2: An automated selective solder process is used on mixed technology PCBAs with minimal through-hole components.

Figure 3: Burton Industries has invested in production equipment that is easy to program and supports faster changeovers in order to better support high mix, variable demand production.

same hours as their offshore contractors. A large time difference can translate to longer days for the team working with that contract manufacturer. Similarly, trips offshore are typically longer than trips to regional suppliers since, given the higher cost and length of travel, the visit is often set up to visit multiple suppliers in the region or spend a greater amount of time at the contractor addressing several issues or audit requirements at once. Language and/or cultural differences may drive the need for more frequent face-to-face discussions on complex projects. In addition to the cost of travel and the cost of staff time for the members of the team traveling, there can also be a "personal" cost. Team members who routinely stay late for conference calls or have to make frequent trips offshore can burn out and look for jobs with less required overtime. Loss of experienced team members creates significant uncaptured cost.

Production Changeovers

High-mix product drives production changeovers. Contractors focused on high mix product often optimize their operations to facilitate this. Comparatively, many offshore contract manufacturers are primarily focused on high volume production. Products with frequent changeovers are considered disruptive to the factory because they impact equipment utilization metrics. The end result can be that products with high changeover requirements do not carry the same importance as high-volume production. This can drive missed deliveries as volume products get higher scheduling priority. Additionally, if a contractor is filling up with high-volume production, high-mix products may see pricing increases as they become less attractive business. In the best case, this drives a cost surprise. In the worst case, it may drive a need to change contractors unexpectedly.

Responsiveness

Perhaps the biggest difference between U.S. EMS companies and their offshore counterparts is responsiveness. Time differences create some lag in the way issues can be addressed. Distance is another factor. Unless product is being stored

in a warehouse close to the OEM, even a responsive contractor may need two to three days to get product from the factory to the OEM. Cultural issues can be another problem. In many cultures it is considered rude to disagree.

Consequently, when a request is received that can't be done within the time requested, an offshore program manager may not tell the OEM that the request isn't achievable. Instead, the date will be missed and the program manager will tell the OEM that he or she tried really hard to make the date, but couldn't do it.

Comparatively, the U.S. program management model stresses responsiveness. Even contractors working at some distance from their customers have overnight shipment options, and Kanban stocking options are less costly since it is often feasible to do at the factory vs. a separate warehouse. Company culture should focus on looking ahead to address issues before they become issues and to offer customers options that help better align forecasts with demand or address issues that otherwise could contribute to missed deliveries.

Using an offshore contractor for high volume, mature product with little or no change does save money, particularly if labor content exceeds 30%. However, new products, projects with variable demand or high-mix configuration, or projects that require frequent communication with the contract manufacturer may be better served by manufacturing domestically. In those cases, the "what if" part of contract manufacturer selection should include strong focus on areas likely to drive hidden or surprise costs. OEM selection teams should look for contractor experience with projects of similar complexity and ask questions about how demand variability, manufacturability feedback, engineering change requests and quality issues were addressed. Developing a better picture of how a contract manufacturer deals with exceptions can help in better analyzing the surprise costs not likely covered by the quotation. SMT

Gary Burnett, Jr. is director of business development at Burton Industries, Inc. To reach the author, click here.

Capacitor Breakthrough

Capacitors are now key components of portable electronics, computing systems, and electric vehicles. But in contrast to batteries, which offer high storage capacity but slow delivery of energy, capacitors provide fast delivery but poor storage capacity.

Now, a group of researchers at the University of Delaware and the Chinese Academy of Sciences has successfully used nanotechnology to improve the energy density of dielectric capacitors.

The work was reported in the paper "Dielectric Capacitors with Three-Dimensional Nanoscale Interdigital Electrodes for Energy Storage," which was published in Science Advances, the first open-access, online-only journal of AAAS.

"With our approach, we achieved an energy density of about 2W/kg, which is significantly higher than that of other dielectric capacitor structures reported in the literature," says Bingqing Wei, professor of mechanical engineering at UD.

One of the keys to the success of the new capacitor is an interdigitated design—similar to interwoven fingers between two hands with "gloves"—that dramatically decreases the distance between opposing electrodes and therefore increases the ability of the capacitor to store an electrical charge.

"We expect our newly structured dielectric capacitors to be more suitable for field applications that require high energy density storage, such as accessory power supply and hybrid power systems," Wei says.

SMT QUICK TIPS

Selecting a Through-Hole Soldering System, Part 1

by Robert Voigt
DDM NOVASTAR

While through-hole assembly is much less commonly done than it was in the early days, and far less common than SMT assembly, it is still a viable and important technique that requires an understanding of the various soldering systems available. This column will outline the available methods and provide a brief overview of their strengths and weaknesses.

Methods of Through-hole Soldering

With the exception of selective soldering, the type of soldering technique you select will be largely dependent on anticipated board throughput. The simpler, less expensive techniques will only work for the lowest volume. The five methods are:

1. Manual
2. Dip
3. Drag
4. Wave
5. Selective

Manual

Manual soldering is done simply by holding a soldering iron in one hand and manually feeding solder from the other hand to the through-hole component. Solder usually in-

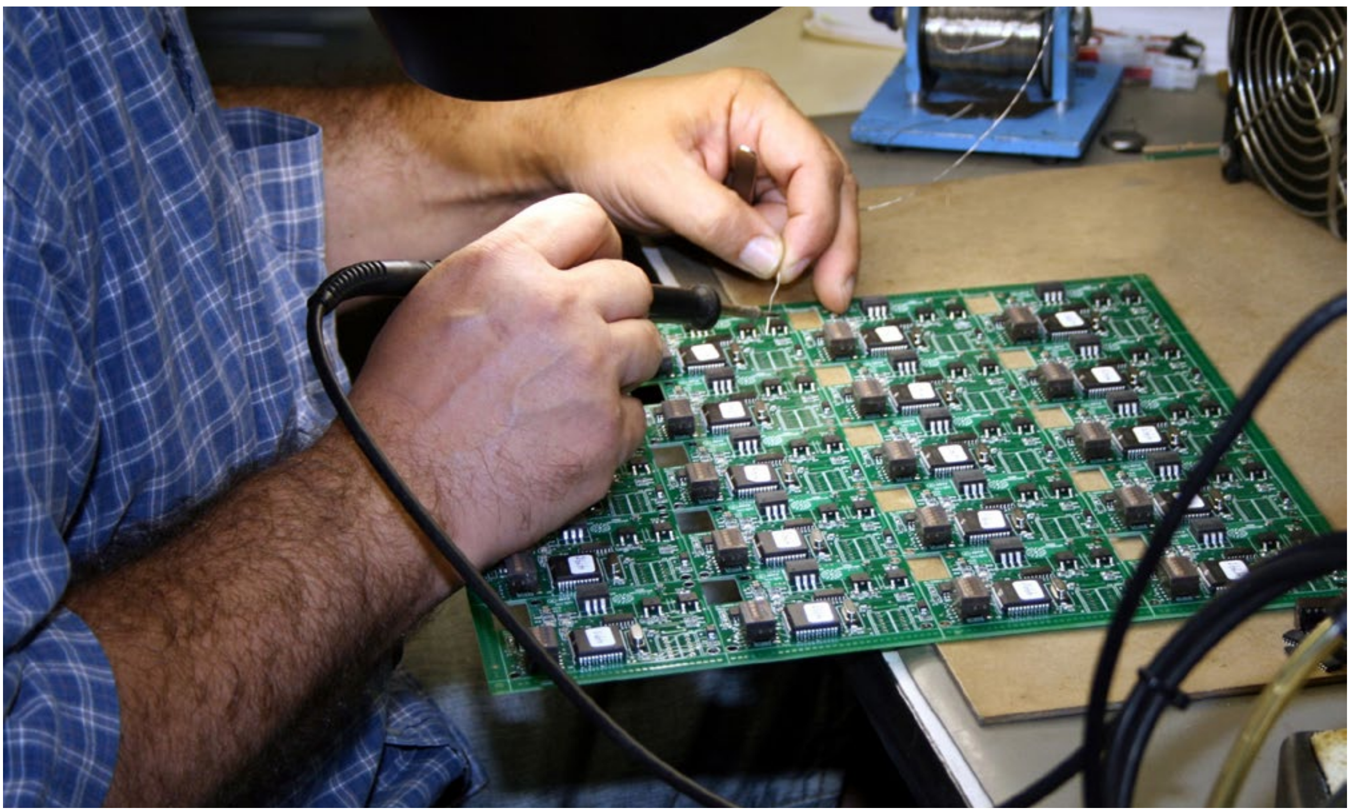


Figure 1: Typical hand soldering iron in action.


TAKE A VIRTUAL TEST DRIVE
AND THE VICTORY LAP IS YOURS

corporates a flux core, so pre-fluxing is necessary. Simple irons don't provide much control on temperature, while others can provide variable temperature control to prevent under- and over-heating components. This method is very labor intensive, and thus is used only for very low volumes. Quality is dependent on the operator's training, experience and skill. Training courses and standards are available for personnel to improve their quality level.

- ***Pros:*** Very inexpensive; prices range from $50 for a basic iron to $2,000 for a high tech version with temperature controls
- ***Cons:*** Labor intensive; quality dependent solely on operator skill

Dip

Dip soldering is done by holding a pre-fluxed board in a frame and lowering it into a static solder pot then removing it to cool. Dip soldering does not usually involve a pre-heat phase, except by suspending the board over the hot solder for some pre-determined time to activate the flux. The dip technique is an older method that was introduced as a way to solder the entire board at once, rather than one component at a time. However, it can be messy and potentially dangerous to the staff because of their proximity to the hot solder pot and from flux fumes in the ambient air.

- ***Pros:*** Low cost per solder joint; systems range from $1,000 to $5,000 for a non-automated system; relatively fast
- ***Cons:*** Old technology, low volume; messy and potentially hazardous; not terribly precise, so some bridging may occur between joints requiring inspection and rework

Figure 2: Example of a simple dip soldering system.

Drag

Drag soldering is done by holding the board in a conveyor and transferring it from a fluxing station to the solder pot on an angle. This method was introduced as a lower cost alternative to the early models of wave soldering when wave was quite expensive. It is no longer widely used. Today, this method has been replaced by the low-end wave soldering systems that are common in today's market. Like dip, the drag method can be somewhat imprecise and may require rework caused by bridging or other undesirable defects.

- ***Pros:*** Lower cost than wave; small footprint
- ***Cons:*** Slow operation; could cause bridging, requiring rework

Wave

Wave soldering is, by far, the most common and most efficient form of through-hole soldering available today. It involves a solder pot large enough to handle the width of the largest boards you expect to process. By pumping hot solder through a nozzle in a way that the bottom of the board surface encounters the wave caused by the nozzle, the resultant hot solder waterfall creates a single point of contact across all the connection joints on the board, eliminating any potential bridging. This system usually integrates a fluxing station, a pre-heat station, and a wave station in a conveyorized system, using fingers or pallet-type board mounts.

Wave is used for mid- to high-volume operations to process hundreds of boards per day or more. Actual machine specifications depend on board size and throughput requirements. They can cost from $10,000 to $80,000, depending on the features and options. Most are available in a lower cost, bench-top model or can be purchased with a stand for a simple free-standing unit.

Figure 3: Example of transport fingers in a wave soldering system. Note the waterfall of hot solder that makes contact with the board components.

- ***Pros:*** Good ROI, controllability over the solder process; repeatable; very little operator learning curve
- ***Cons:*** Cost is higher than prior methods, but it is the lowest cost per board method; Wave will take up larger footprints on the shop floor

Selective

Selective is a special type of soldering which is used for a mixed technology incorporating SMT and through-hole where obstructions on the board prevent use of other through-hole methods. Selective conducts auto-fluxing, preheat and selective soldering of each component via a small nozzle tip rather than a large wave. Pre-programmed software positions the nozzle at the board precisely at the joint contact via an X-Y movement of either the board or the solder nozzle.

Selective is the only good way to solder through-hole components on boards where other components already installed create obstructions that would prevent a wave system,

Figure 4: Cost-effective automatic single wave benchtop solder system.

SELECTING A THROUGH-HOLE SOLDERING SYSTEM, PART 1

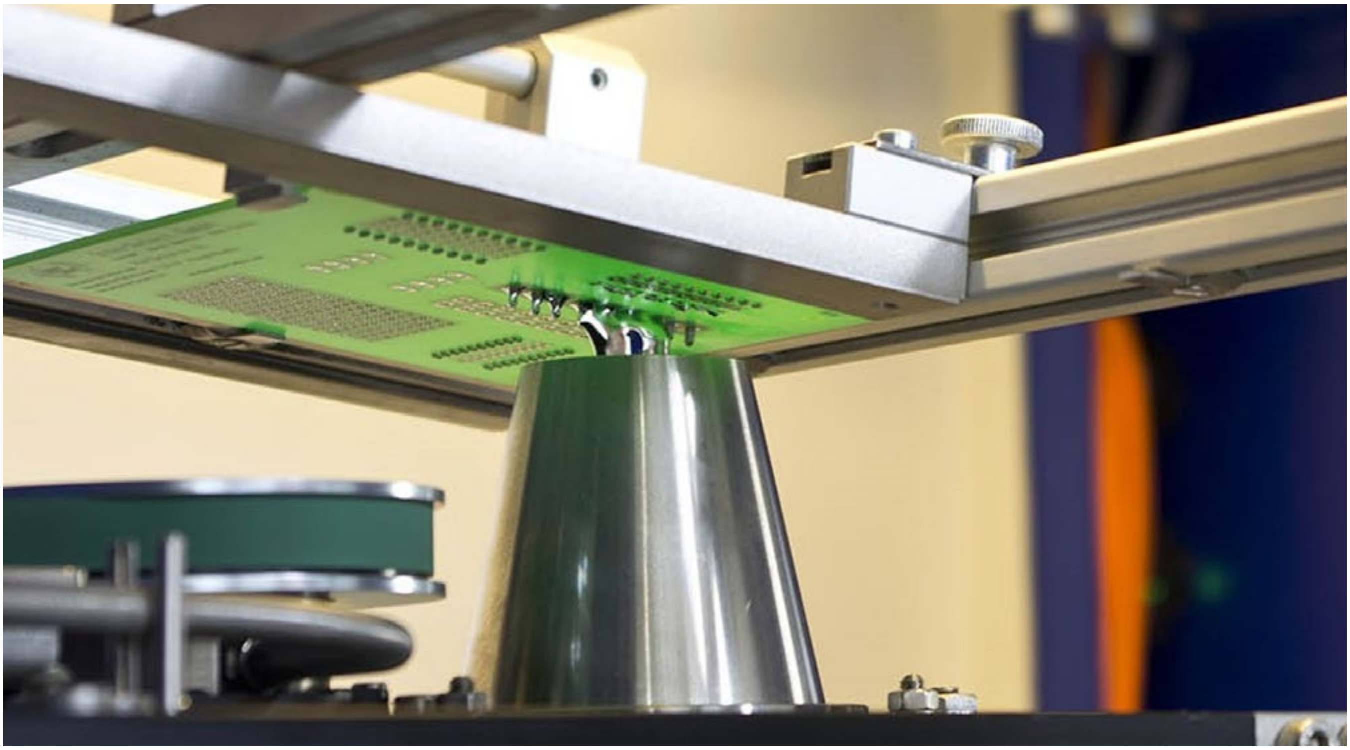


Figure 5: Solder application, viewed from under the circuit board.

for instance, from working. Selective soldering systems can cost $30,000 and up.

- Pros: Very repeatable and controllable environment; scalable: throughput can be increased by adding modules
- Cons: Fairly costly, fairly slow; can require intensive operator training but can be mitigated by available software options; very process driven related to the topography of the board

Don't Forget: Always Check References

Remember to consult a variety of machine providers, talk to the manufacturers themselves if possible, and get references to contact before making a purchase. An important consideration for a complex machine such as a wave or selective soldering system is factory support, specifically training, software, upgrades and spare parts.

Next chapter: Details on wave soldering systems. **SMT**

Figure 6: Example of a selective soldering system.

Robert Voigt is VP of global sales at DDM Novastar Inc. To reach Voigt, click here.

ARTICLE

Streamlining PCB Assembly and Test NPI with Shared Component Libraries

by Pat McGoff
MENTOR GRAPHICS

Abstract

PCB assembly designs become more complex year-on-year, yet early-stage form/fit compliance verification of all designed-in components to the intended manufacturing processes remains a challenge. So long as librarians at the design and manufacturing levels continue to maintain their own local standards for component representation, there is no common representation in the design-to-manufacturing phase of the product lifecycle that can provide the basis for transfer of manufacturing process rules to the design level. A comprehensive methodology must be implemented for all component types, not just the minority which happen to conform to formal packaging standards, to successfully left-shift assembly and test DFM analysis to the design level and thus compress NPI cycle times. The elements of such a solution include implementing de-facto standards for package and pin-type classifications, as well as DFM analysis rules that are associated with these classifications and the intended manufacturing processes. The resulting solution enables the transfer of DFM rules from the manufacturing process expert to the design and NPI engineers on the design side responsible for verifying manufacturing-process compliance of new product designs.

This paper will demonstrate the technological components of the working solution: the logic for deriving repeatable and standardized package and pin classifications from a common source of component physical-model content, the method for associating DFA and DFT rules to those classifications, and the transfer of those rules to separate DFM and NPI analysis tools elsewhere in the design-through-manufacturing chain, resulting in a consistent DFM process across multiple design and manufacturing organizations. Following establishment of a common source of component definitions and classifications, rules-based generation of assembly-level machine libraries is enabled from the same source that drove the DFM process, resulting in right-first-time launch of a new product into the manufacturing process.

Introduction

The principles of lean manufacturing, "getting it right first time," and minimizing waste and unnecessary manual interaction, are all familiar and generally accepted as contributing

factors toward cost reduction and quality maximization. In that context, this paper will examine two specific engineering-process aspects of introducing a new PCB design into assembly manufacturing and the technical barriers to be overcome to make the processes as lean as possible. The two engineering processes to be discussed are:

1. Performing design-for-assembly (DFA) verification on a new product design, as early as possible in the product lifecycle, and in any case before transferring the design into manufacturing.
2. Preparing assembly-line machine library content for fast set-up.

Before getting into the technicalities of the two topics and how they are related, it is worth first considering the business environment of PCB manufacturing. It is now about 20 years since PCB assembly manufacturing began to be outsourced in a major way, with the resulting rapid growth of the now well-known EMS and contract manufacturers. Before the outsourcing revolution, when design and manufacturing operations were generally vertically integrated, it was common to see CAD/CAM engineering processes being set up and maintained by electronics OEMs, depending for their success on internally defined library standards, a specific and relatively narrow range of manufacturing processes, and plenty of in-house proprietary software to link it all together. By contrast, today's challenge is to take full advantage of the outsourcing opportunity, the choice, the flexibility, and the cost-competitiveness, without losing the advantage through engineering-process inefficiencies related to discontinuities in CAD/CAM software, data flows, and libraries between the customer (the design organization) and the suppliers (the manufacturers). To make matters worse, the typical manufacturer of today will serve dozens, if not hundreds, of design-customers, and the design organization may use dozens of EMS providers. This many-to-many interface between design and manufacturing tends to drive engineering processes toward standardized "lowest common denominator" workflows that are relatively manual, error-prone, and slow. These workflows are certainly somewhat "standard", but they are far from lean, in terms of minimizing waste and maximizing consistency through automation.

The two engineering processes described in this paper are specifically designed to enable a high degree of production-portability between a product's design organization and multiple manufacturing facilities and processes.

Portability of DFA

Design for assembly refers to the dimensional analysis of a PCB design to check its compatibility with the intended manufacturing processes. Figure 1 shows illustrations of two specific DFA analysis checks: one checking the pin-to-pad distances against the rules of the reflow process, the second checking component-to-component spacing against the access-requirements of the rework process. The variety of rules typically scales with the range of intended assembly and test processes, as well as the number of component types or combinations of component types.

Now consider the DFA business process between a designer and a manufacturer, as illustrated in Figure 2. The designer has responsibility for the definition of the product, whereas the manufacturer is the owner of the manufacturing processes and the knowledge of their limitations relative to the characteristics of the products being manufactured.

The designer's interest is to design the product so it is optimally manufacturable by the widest range of manufacturing suppliers. To be as lean as possible, the DFA validation

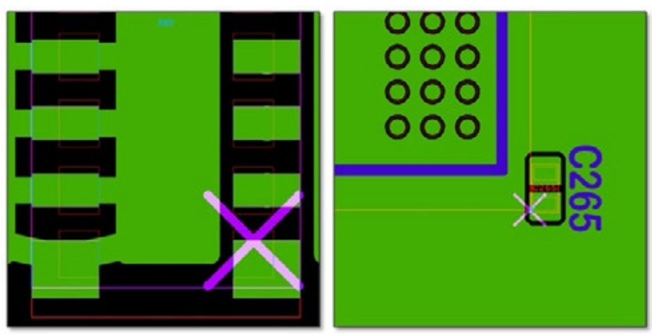


Figure 1: Two DFA checks: pin-to-pad analysis (left), and component-spacing analysis (right).

process should be carried out in one place, on the design side, before handing the product to the manufacturers for production. But unless there is a formal common language for defining the product-model and the rules to be applied, the DFA process cannot be left-shifted from the manufacturing level into the design domain.

Figure 3 shows a simple real-life example of what happens when the designer is looking at the product with the design library, and the manufacturer is looking at the product with the manufacturing library. The component is the same, but its modeling is different. On the design side, the library sizes the pin of the component according to the pad it is standing on, whereas the manufacturing library sizes the pin according to the actual pin that is part of the component that will actually be placed on the board. Any communication between the designer and the manufacturer about what is an acceptable pin-spacing is meaningless unless a common modeling of the component is supporting the discussion. The same applies to the DFA rules themselves, unless the rules have the same meaning at both ends of the DFA process, the process will bring incorrect results and be of no value.

First Requirement

The previous examples have shown how the models of the components must be standardized across the DFA workflow. The first assumption is that existing formal standards such as EIA, IPC, or JEDEC would meet the need. Assuming a reliable source of content could be found to deliver component models according to the standards, all mapped to their commercially purchasable part numbers, the standards approach would have had obvious benefits. However, we discovered, when examining the master parts lists of major DFA practitioners, barriers to a scalable solution based purely on the formal standards.

- There are PCB-mounted components that do not conform to a standard of any kind. Figure 4 shows several examples of commercially available components that cannot be described by the JEDEC standard.

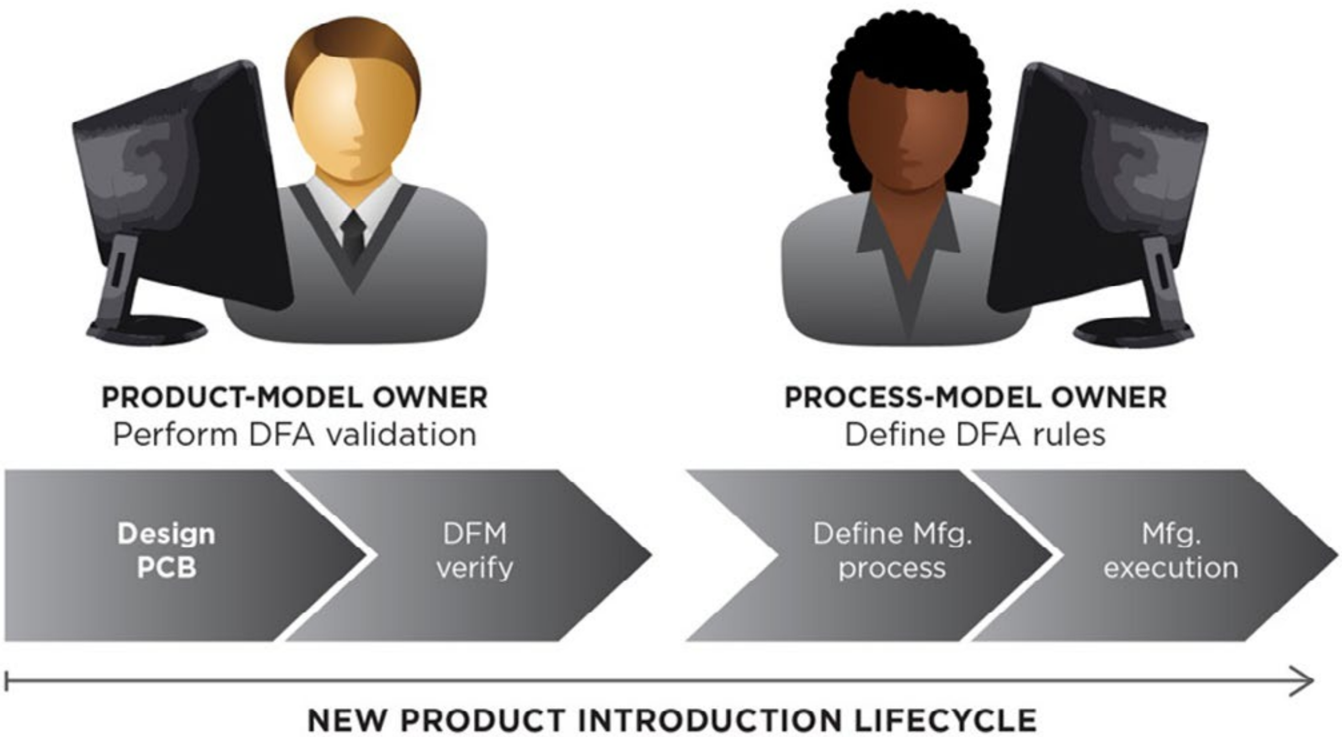


Figure 2: Outsourcing separation between design responsibility and manufacturing-process responsibility.

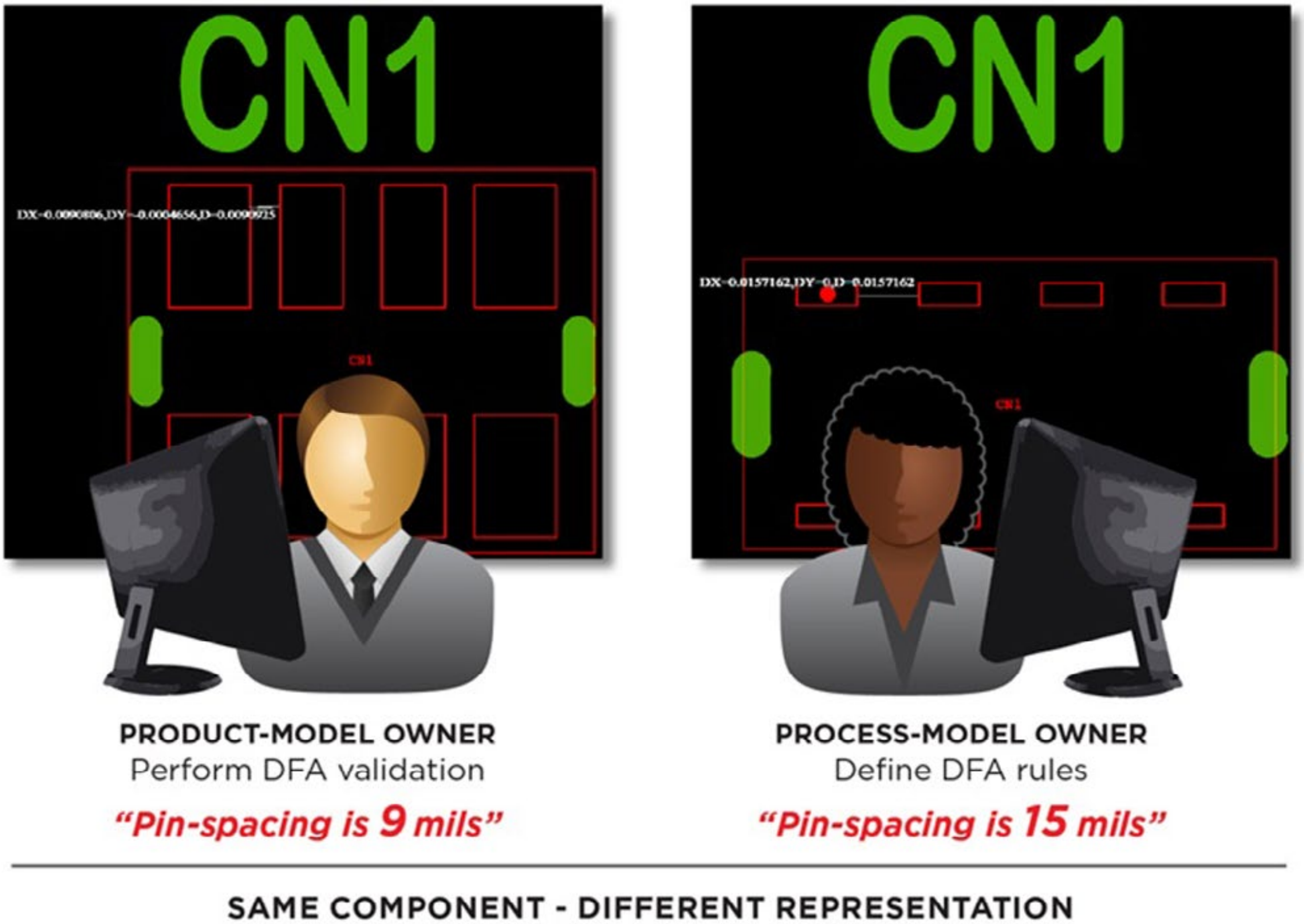


Figure 3: Outsourcing the need for a shared standard for component models.

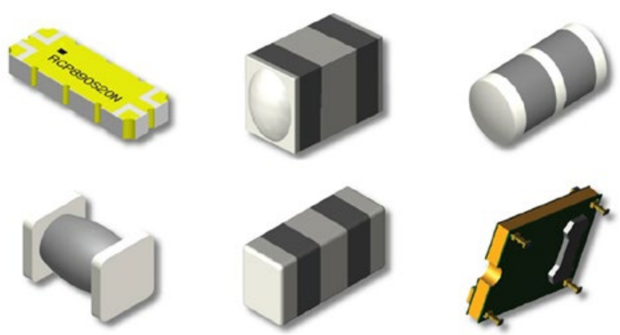


Figure 4: Formal component-modeling standards do not cover all purchasable parts.

• We found examples where the component manufacturer may declare that the component conforms to a standard, but in reality some of the dimensions are outside the tolerances set by the standard. Figure 5 shows one such example where some of the dimensions are outside the limits set by JEDEC. The size of the deviations may be small, but they could be enough to cause DFA violations to slip through into manufacturing; and in any case, a component is either within tolerance of not. We found that, from a sample of some 20,000 component package models of chip-style components that you would expect to be modeled by JEDEC in the "0402" or "0603" range of categories, approximately 20% were impossible to map correctly to the standard as defined. Therefore, the standards designation is not enough; a full graphical representation of the component and its pins is required.

The second prevailing assumption, especially in the design community, is that the library of the PCB layout system should be used for the purpose of DFA. From the standpoint of the

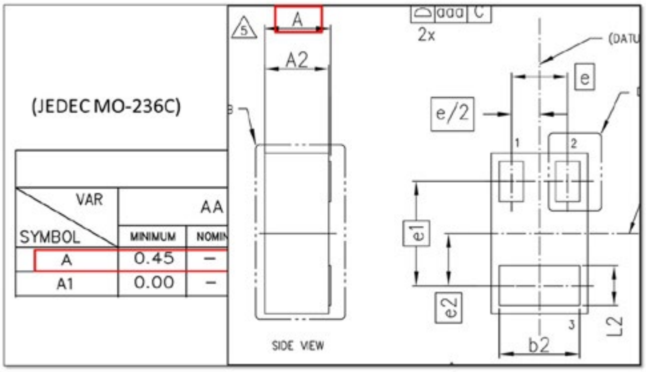


Figure 5a: According to JEDEC MO-236C, minimum component body height is 0.45 mm.

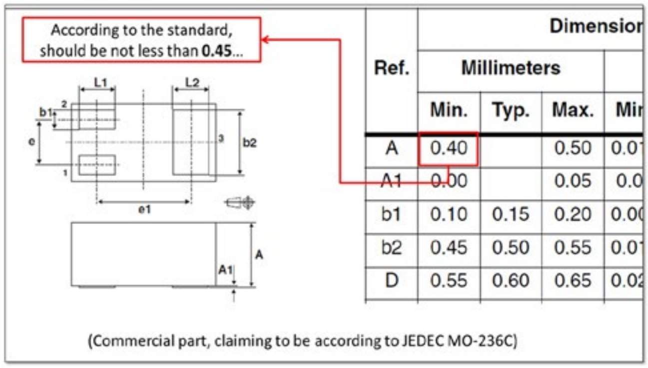


Figure 5b: A commercial part, claiming to conform to JEDEC MO-236C, but actually does not conform.

designer, such an idea has obvious attractions. But the design library fails the suitability test for four reasons. Firstly, design library content is not systematically constructed according to any level of standardization that is recognizable outside the boundaries of a specific design organization. The rules and meaning of the design library content is defined and owned by the librarian, and it is highly likely to be inconsistent with the library content from a library in another organization that is under the control of a different librarian.

Secondly, the design library usually does not model the physical pin of the component at all, focusing instead on the component body outline and the related pad stacks; yet it is the relationship of the physical pin to the pads and solder mask openings that mainly determines the quality of the soldered joints that will be created in the manufacturing process.

Thirdly, the design library component model is usually an approximation based on all alternative purchasable parts that may be placed there (according to the master parts list or AVL), thus it cannot be said to support the DFA analysis of any specific part that may be used in production.

Fourthly, many design libraries contain multiple outlines for the component bodies, representing anything from the actual outline, to a "keep-out" box that will be used to enforce component spacing design rules. As a consequence, when the product model is output to manufacturing and especially in an outsourced manufacturing environment, it is not always clear what the component body outlines actually represent and thus which DFA rule-values to apply.

Therefore, and as part of developing a portable DFA process, a dedicated library format was defined that provides a shared standard for the participants in the DFA workflow. The approach taken was to use the JEDEC classification system, but with extensions to give the granularity required to support the full range of DFA rules to be applied. The essential structure of the library is shown in Figure 6, showing how the linking of the component manufacturer and purchasable part number(s) to the component model comprises a classified name linked to the graphics of that particular model. Examples of component models are shown; the principle being that, whenever a different graphical model is required to fully represent the detail published in the component manufacturer's datasheet, a new unique classified name is generated.

But it is not only the definition of the library structure and format that is essential to the solution, but also the availability of the content, as a service to the DFA engineers; the greater the extent to which the library can deliver the content for any particular PCB bill of materials (BOM), the greater the comprehensiveness of the DFA analysis that can be performed. After 15 years of building the content on behalf of DFA engineers around the world, there are now approximately 100,000 uniquely classified graphical models in the library mapped to up-

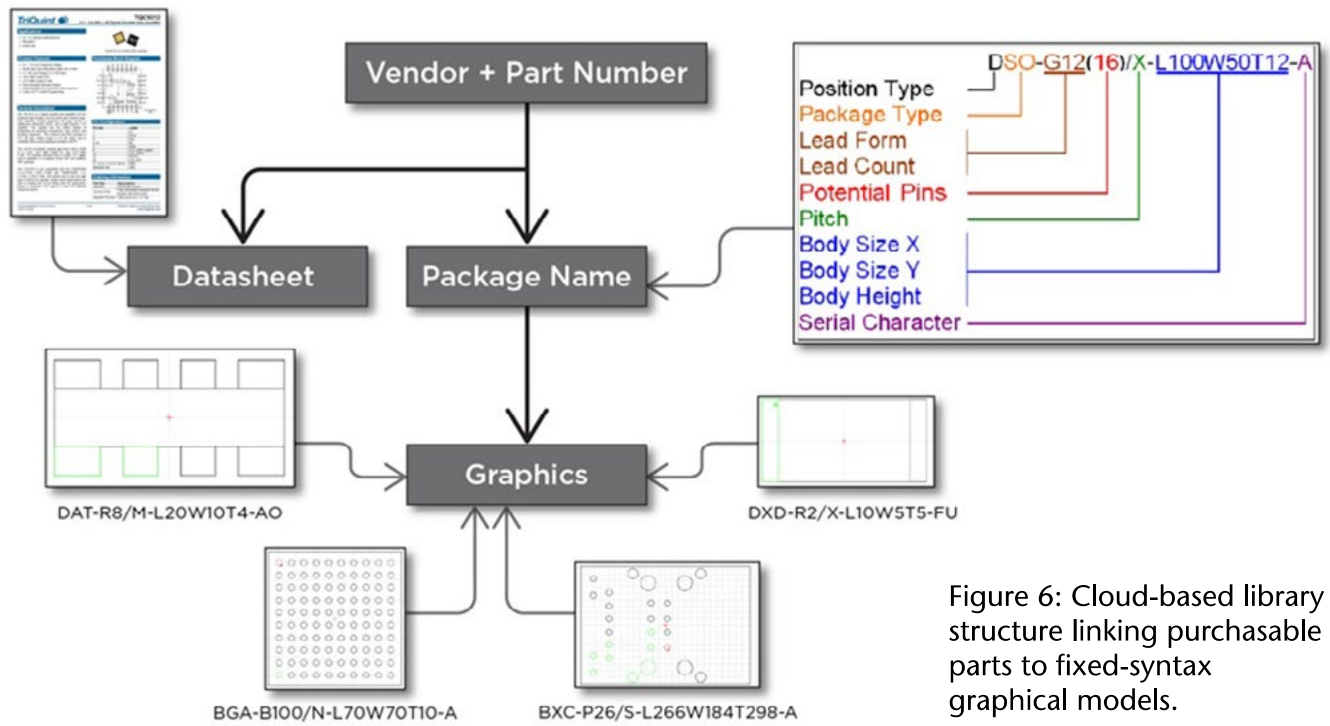


Figure 6: Cloud-based library structure linking purchasable parts to fixed-syntax graphical models.

wards of 35 million purchasable part numbers. To date, there has not been a single instance of a PCB-mountable electronic component that cannot be modeled in the library for DFA purposes.

Second Requirement

The second major requirement to enable portability of the DFA process is to establish a standardized package- and pin-classification system in which the DFA analysis rules can be managed. The main challenge arises from the need for relevant spacing measurements between pairs of components of different classification. For example, the acceptable spacing between a small chip-resistor and an adjacent BGA will probably be different to the acceptable spacing between the BGA and a connector. Thus, the number of component-to-component rules can be proportional to the square of the number of different types of components in the library. Obviously, while it is necessary for the sake of DFA measurement accuracy to have available a number of unique component models on the order of 100,000 (as described in the previous section), to have 100,000 x 100,000 separate DFA rules to manage is obviously impracticable.

The approach we took was to consult people who are using DFA technology to determine the maximum granularity of component package types and lead form types needed to ensure that the DFA analysis measurements are appropriate to the combinations of components on the PCB. After many years of gathering feedback, we have 17 different package types and 23 different lead-form classifications, which result in a range of DFA rules measured in the hundreds, not the billions that would result from using the library-level classifications to define the distinction between DFA rules.

Figure 7 shows an example of a component model defined in the library as DAT-R16/M-L38W16T5_CPN081. This is the same syntax for unique definitions of the component models from the library definitions explained in the previous section. From this component model classification, the DFA software is able to automatically derive the package type as "chip" and the lead form as "c-bend-wrap." The rules for defining these two type assignments are also shown in Figure 7.

The advantage of deriving the type assignments within the DFA software is that as the DFA requirements of the industry evolve, the

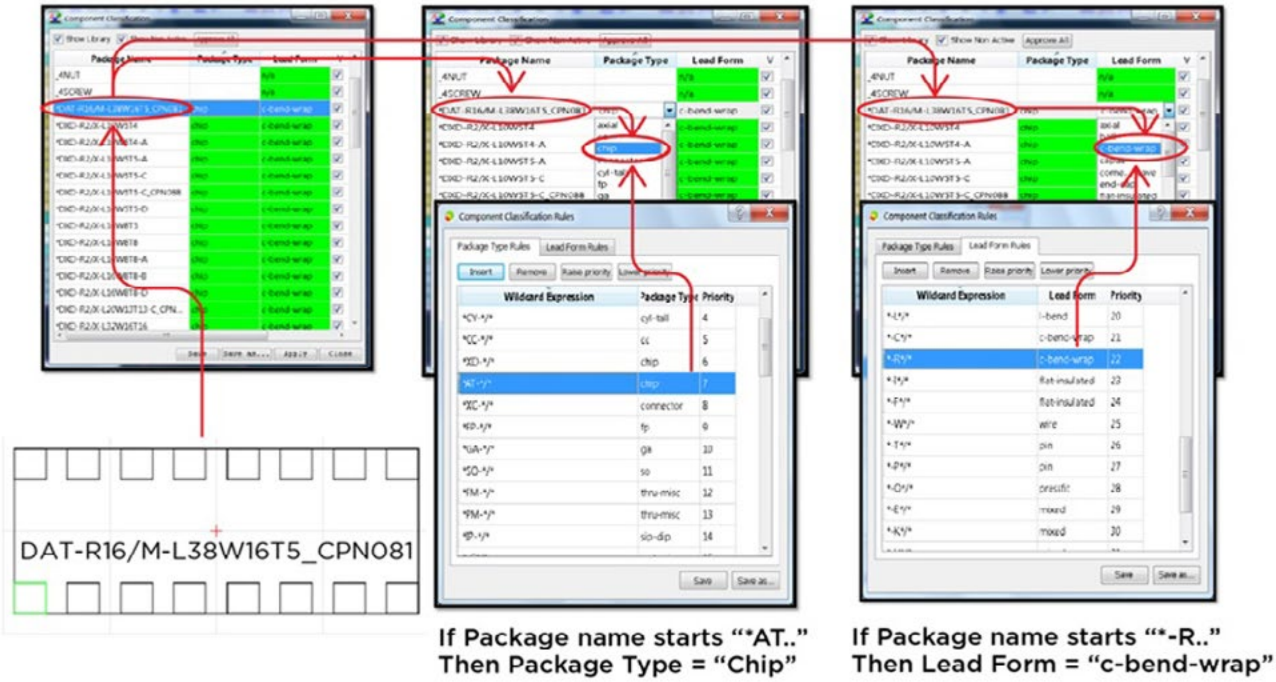


Figure 7: Rules-based classification of package and lead form for DFA rules management.

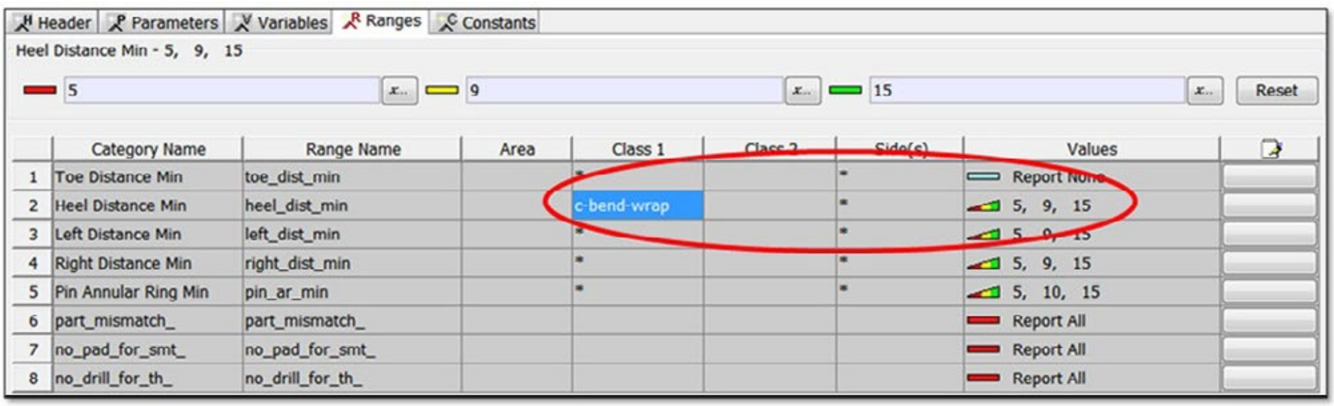


Figure 8a: A DFA rule for minimum heel distance for a specific class of component.

method for deriving the type assignments, and the connection of those assignments to the rules themselves, can be released via software updates without disturbing the library content that is at the root of the process.

To illustrate the application of a DFA rule in the context of the type-assignments, Figure 8a shows a minimum heel-distance rule for components with lead forms of type "c-bend-wrap." The rule calls for a minimum spacing of 5 mils, with 9 mils being the target for best yield. Figure 8b then shows the result of applying this specific rule to the relevant components; in this case, the minimum heel distance is actually negative, thus calling for either an engineering change to the land pattern, of a change of components supplier on the master parts list, or maybe both.

Third Requirement

The third element of the portable DFA solution is a documented language of rules that can be transferred between manufacturer and designer for application as early as possible in the

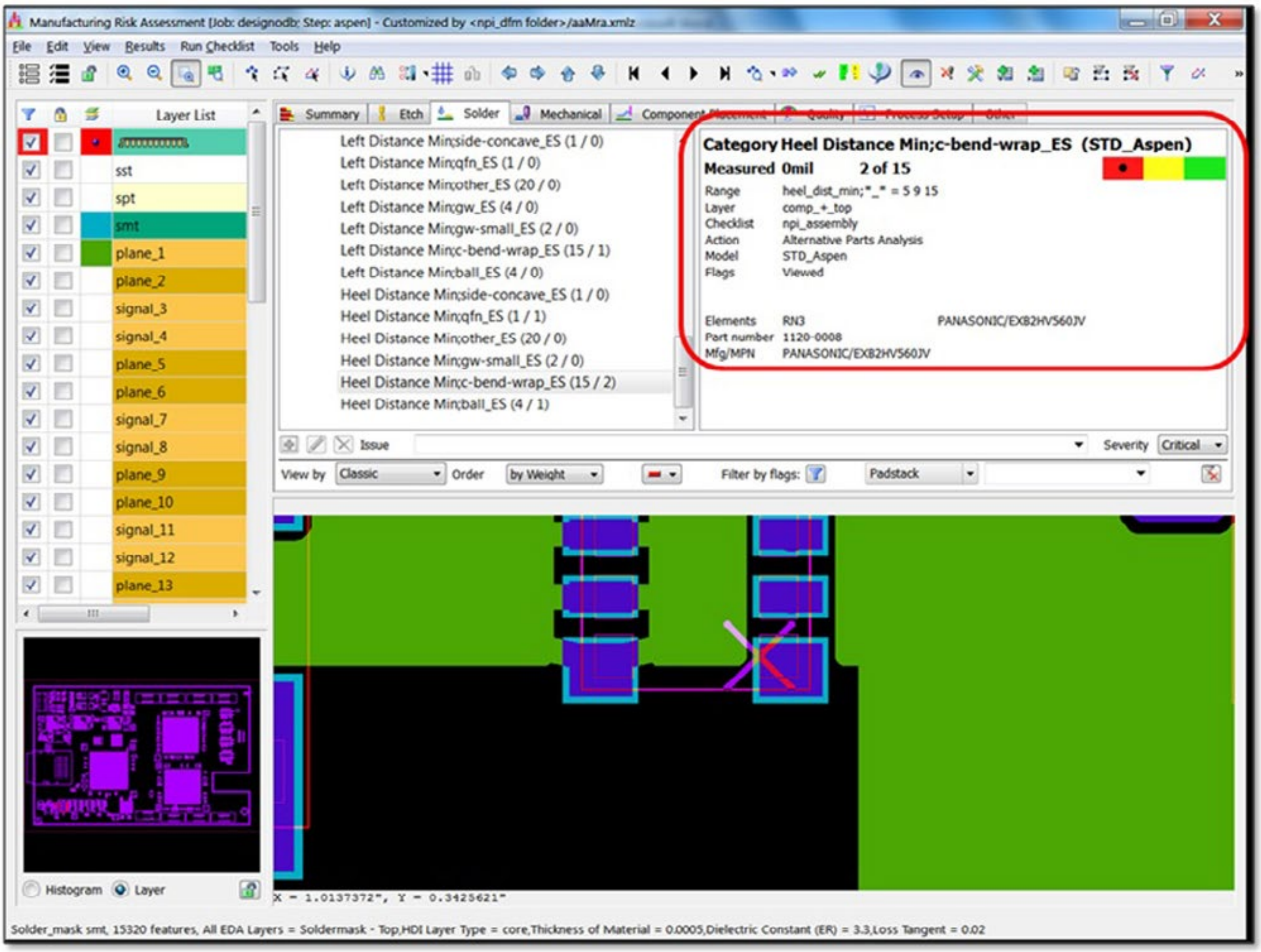


Figure 8b: Application of a minimum heel-distance rule to a PCB assembly model.

design process. By exporting the DFA rules that are proven by the manufacturer to represent the constraints of the manufacturing processes, they can then be transmitted to the design organization to run the complete DFA analysis process while the design is still taking shape and the cost of finding and fixing the manufacturability problems is so much lower than if left until later in the NPI cycle.

In summary, Figure 9 illustrates how the portable DFA solution comprises the following multiple aspects that combine to make a working solution:

- A library of component models mapped to commercially purchasable part numbers. The library exists outside the internal networks of individual organizations, thus supporting the outsourced design-through-manufacturing flows of today.
- Availability of content in the library to describe the components listed in the bills-of-materials of the participating design and manufacturing organizations. Part-number coverage must run to the tens of millions, with rapid service to create missing content on demand to support scalable implementation by designers and manufacturers worldwide.
- DFA analysis software tools that can be used both in the context of design and manufacturing environments, with common functionality for the derivation of package and lead-form assignations, and a common DFA rules language.

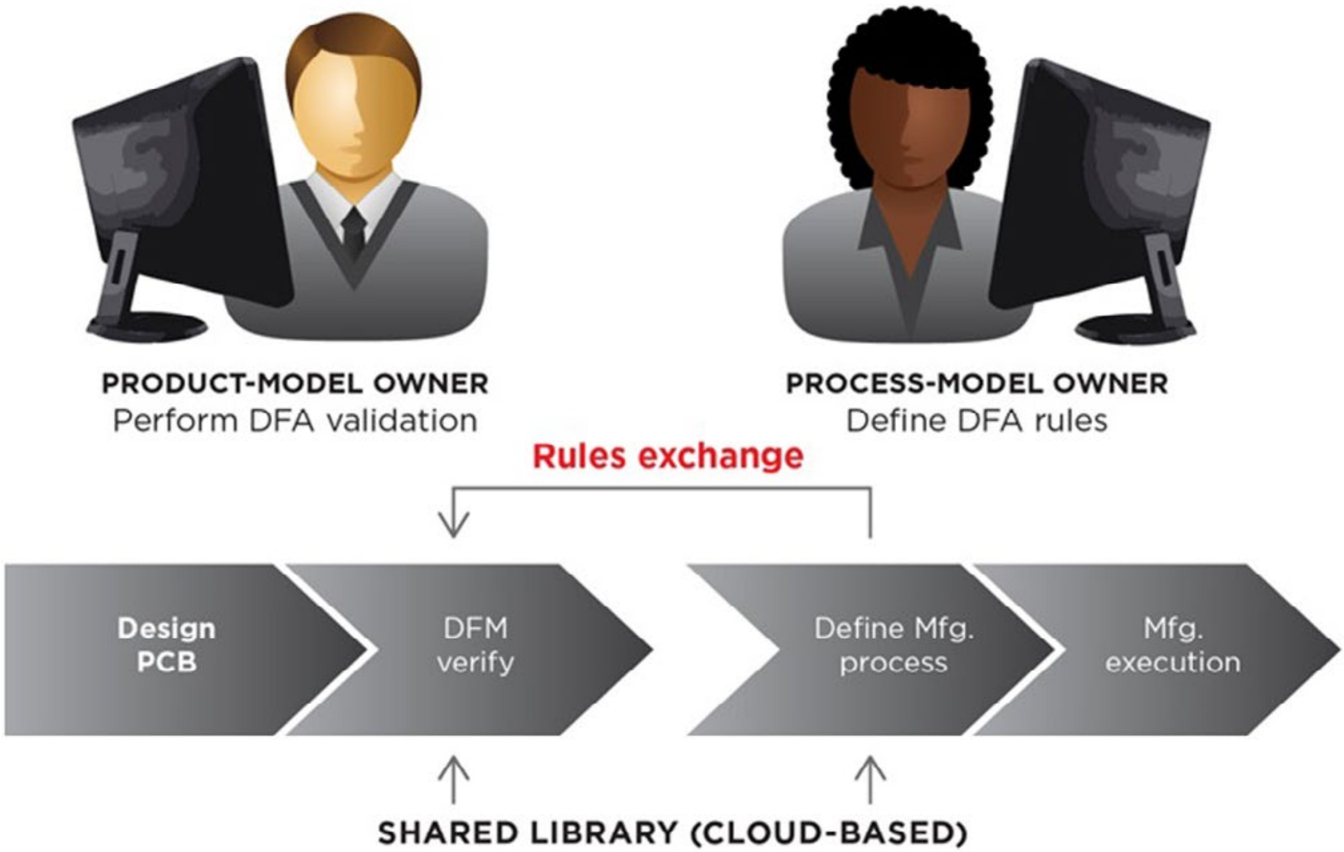


Figure 9: Shared library content, classifications, and rules enable portable DFA analysis.

Portability of Production between PCB Assembly Lines

In the context of PCB assembly operations, by portability, we mean the ability to easily move the assembly of a specific PCB design from one assembly line to another or from one factory to another, or rapid switching on a specific assembly line between the production of different products. The business drivers behind this are:

• Reduction in working capital resulting from lean production techniques that call for small lots of PCB assemblies to be produced according to downstream inventory demand signals.

• Supply-chain discontinuities making it impossible to continue production of a certain product, requiring fast switching to production of another product.

• Supply-chain flexibility for the product-owner to switch rapidly from one manufacturing service provider to another.

• Maintaining high asset utilization of the assembly lines themselves. Typically, the machinery that comprises the assembly line ties up the majority of the fixed-asset capital of the manufacturer so, just as airlines need to keep their planes in the air to earn money, the assembly manufacturers need to maximize the time when the assembly lines are assembly products.

Assuming that component supply and machine availability are not limiting factors, the most important capability for addressing the above-mentioned business drivers is fast machine programming with all the data necessary to begin production of a new product. The primary burden here is the generation and management of the machine-level component libraries that determine how the different machines (placement, inspection, text) will treat each component on the PCB.

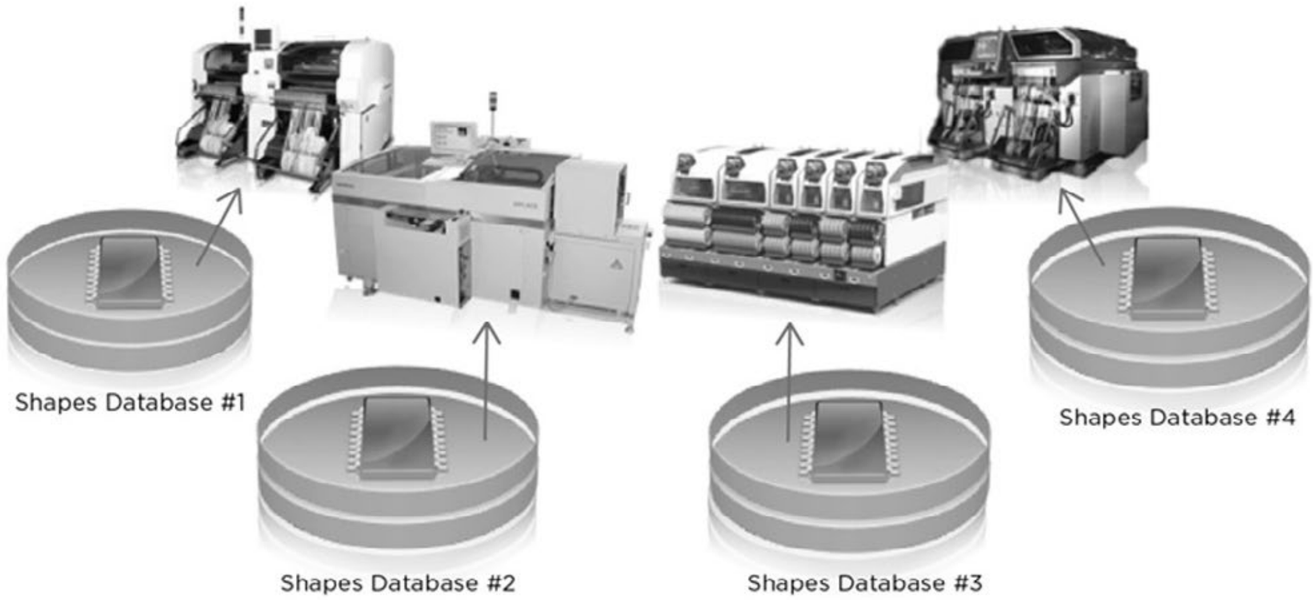
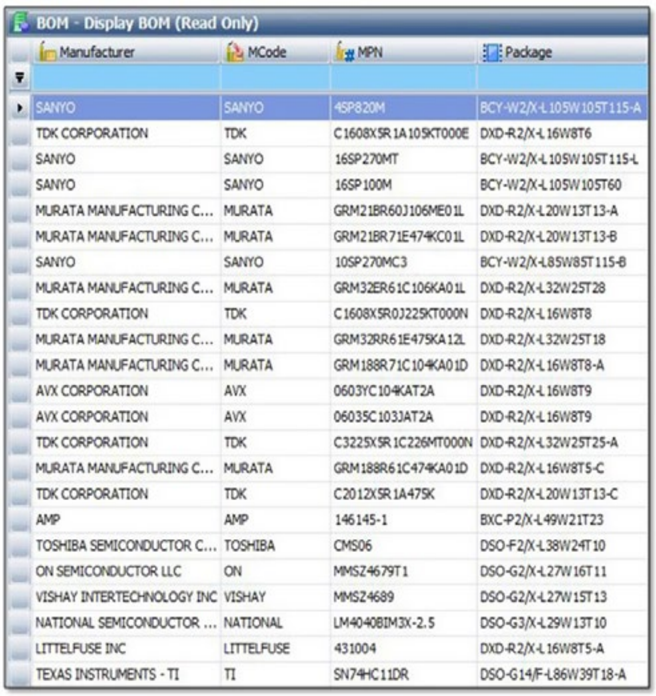


Figure 10: There are as many machine-library standards as there are types of machines in the world.

As shown by Figure 10, each different machine has its own library, which must contain definitions of the parts it will handle. A single assembly line may have five to six different machines all with their own libraries; across a large factory, the number of separately maintained libraries can run to the hundreds. Just consider the time involved, per new part, per machine. An industry average is to spend 15 minutes per new part, per machine type, preparing and testing out the part data. If there are 20 new parts in a PCB that is new to that assembly line, that is five machines in the line. It will take 1,500 minutes (more than two hours) of machine down-time to prepare the machine libraries for that particular product. In an environment of lean manufacturing with small lot sizes, such set-up overheads can mean that the manufacturer spends more time with his assembly lines down than up and running.

When we examined the nature of the parts data in the machine libraries we discovered that, with the exception of data that cannot be found in a component's datasheet such as color changes and markings that vary with lot code, the machine library content can all be derived from a standardized 2.5D model through the use of machine-dedicated rules. The flow for the solution, together with the requirements at each stage, is as follows.


BOM - Display BOM (Read Only)

Manufacturer	MCode	MPN	Package
SANYO	SANYO	4SP820M	BCY-W2/X-L105W105T115-A
TDK CORPORATION	TDK	C1608X5R1A105KT000E	DXD-R2/X-L16W8T6
SANYO	SANYO	16SP270MT	BCY-W2/X-L105W105T115-L
SANYO	SANYO	16SP100M	BCY-W2/X-L105W105T60
MURATA MANUFACTURING C...	MURATA	GRM21BR60J106ME01L	DXD-R2/X-L20W13T13-A
MURATA MANUFACTURING C...	MURATA	GRM21BR71E474KC01L	DXD-R2/X-L20W13T13-B
SANYO	SANYO	10SP270MC3	BCY-W2/X-L85W85T115-B
MURATA MANUFACTURING C...	MURATA	GRM32ER61C106KA01L	DXD-R2/X-L32W25T28
TDK CORPORATION	TDK	C1608X5R0J225KT000N	DXD-R2/X-L16W8T8
MURATA MANUFACTURING C...	MURATA	GRM32RR61E475KA12L	DXD-R2/X-L32W25T18
MURATA MANUFACTURING C...	MURATA	GRM188R71C104KA01D	DXD-R2/X-L16W8T8-A
AVX CORPORATION	AVX	0603YC104KAT2A	DXD-R2/X-L16W8T9
AVX CORPORATION	AVX	06035C103JAT2A	DXD-R2/X-L16W8T9
TDK CORPORATION	TDK	C3225X5R1C226MT000N	DXD-R2/X-L32W25T25-A
MURATA MANUFACTURING C...	MURATA	GRM188R61C474KA01D	DXD-R2/X-L16W8T5-C
TDK CORPORATION	TDK	C2012X5R1A475K	DXD-R2/X-L20W13T13-C
AMP	AMP	146145-1	BXC-P2/X-L49W21T23
TOSHIBA SEMICONDUCTOR C...	TOSHIBA	CMS06	DSO-F2/X-L38W24T10
ON SEMICONDUCTOR LLC	ON	MMSZ4679T1	DSO-G2/X-L27W16T11
VISHAY INTERTECHNOLOGY INC	VISHAY	MMSZ4689	DSO-G2/X-L27W15T13
NATIONAL SEMICONDUCTOR ...	NATIONAL	LM4040BIM3X-2.5	DSO-G3/X-L29W13T10
LITTELFUSE INC	LITTELFUSE	431004	DXD-R2/X-L16W8T5-A
TEXAS INSTRUMENTS - TI	TI	SN74HC11DR	DSO-G14/F-L86W39T18-A

Figure 11: Mapping purchasable component part numbers in the BOM to shared library content.

First Requirement

The flow requires a source library for the component models that links back to the commercially purchasable part-numbers used in the supply chain. This enables transferability of a

PCB product model between organizations and the use of a common component-model standard for deriving the machine-level library content for any assembly line or factory. Figure 11 shows links between component vendor name plus part number and the models in the same library as was described in the above discussion of portable DFA.

The result is that, in the context of any assembly line or factory, the model of the product to be assembled will be identical. Figure 12 shows an example of the PCB product model, after identification of the parts and integration of their models from the cloud-based library. You see the exact outlines of the component bodies, their physical pin contacts on the PCB, of course also linked to the data that is embedded in the component-model name itself.

Second Requirement

A classification system is required that can relate to any specific machine requirements to take the step from the general model of the part shown in the previous section to a machine-specific model of the part. After reviewing the libraries of the mainstream pick-and-place, AOI, AXI, and structural test machine vendors, we built a classification system as illustrated in Figure 13. From left to right, 24 component package classifications are shown for which machine-specific content can be derived. The rows in the table define the specific library content required by a particular widely used pick-and-place machine; the green cells are all instances where specific content is required for that machine to handle components of a particular classification. Thus, the purpose of the individual rows will vary according to the requirements of any particular machine, as will the definition of which classifications need each type of content (marked in green).

Each green square in the matrix can have its own unique derivation rule(s) to be applied when generating the content for that specific machine. To illustrate, we can take the example of a simple five-pin gullwing component. The

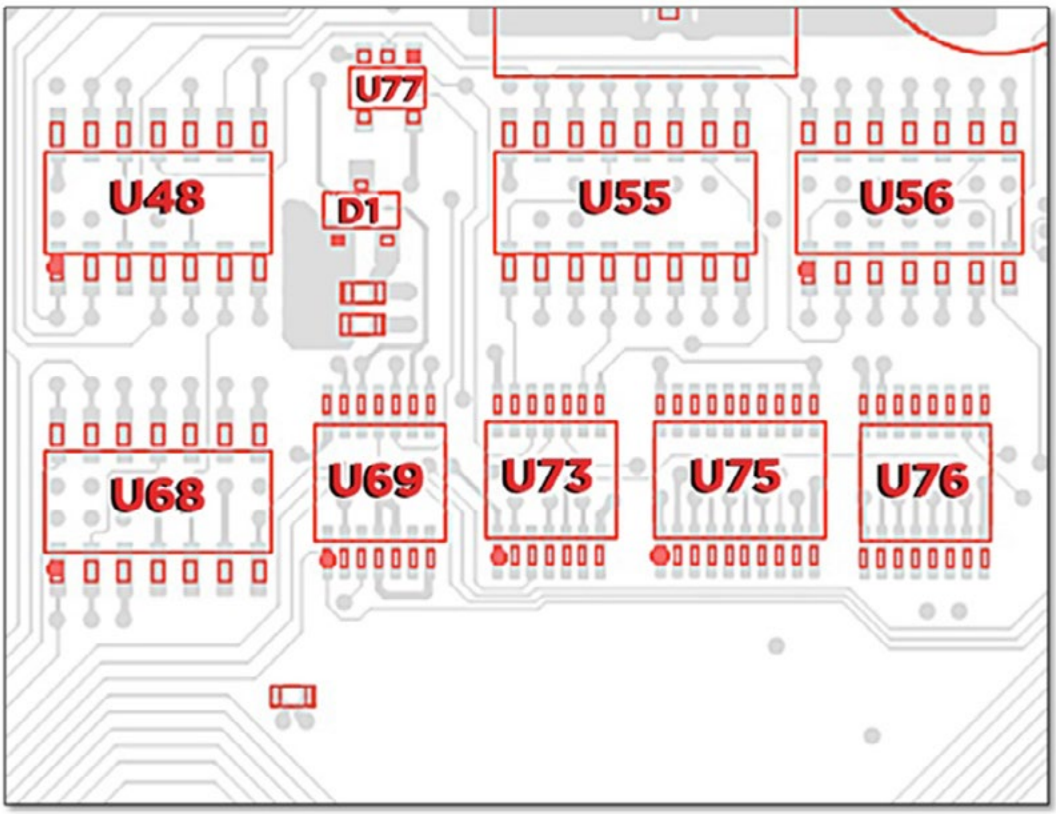


Figure 12: Component body and pin-contact models, integrated into the PCB product model.

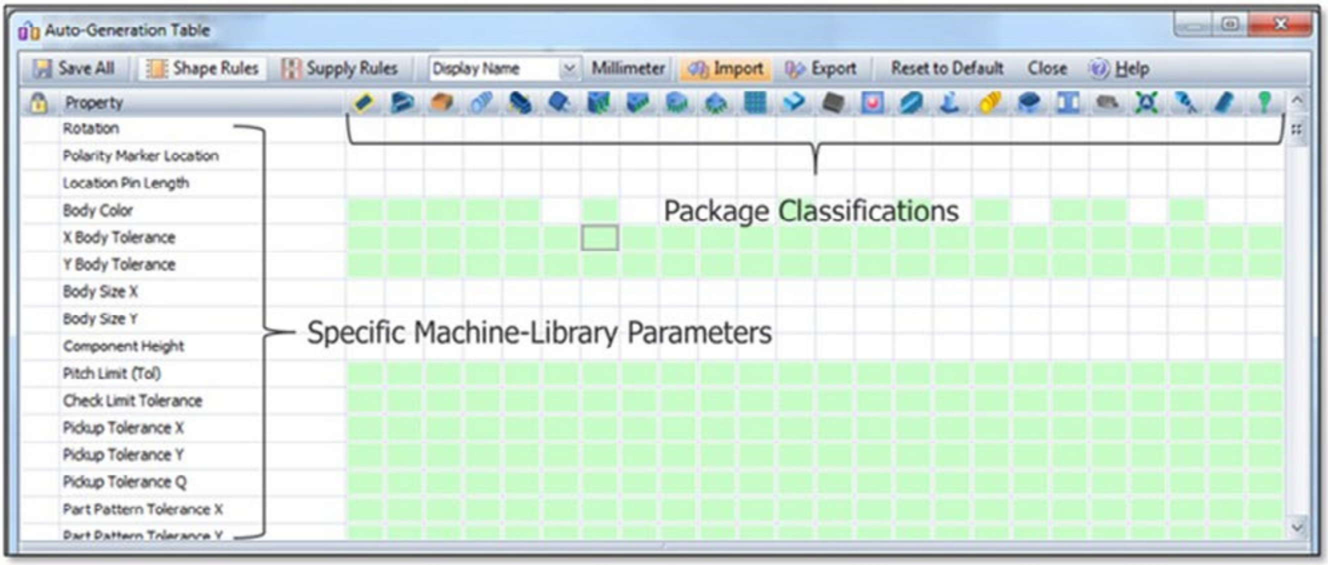


Figure 13: Matrix linking machine-library component classes to machine-library content rules.

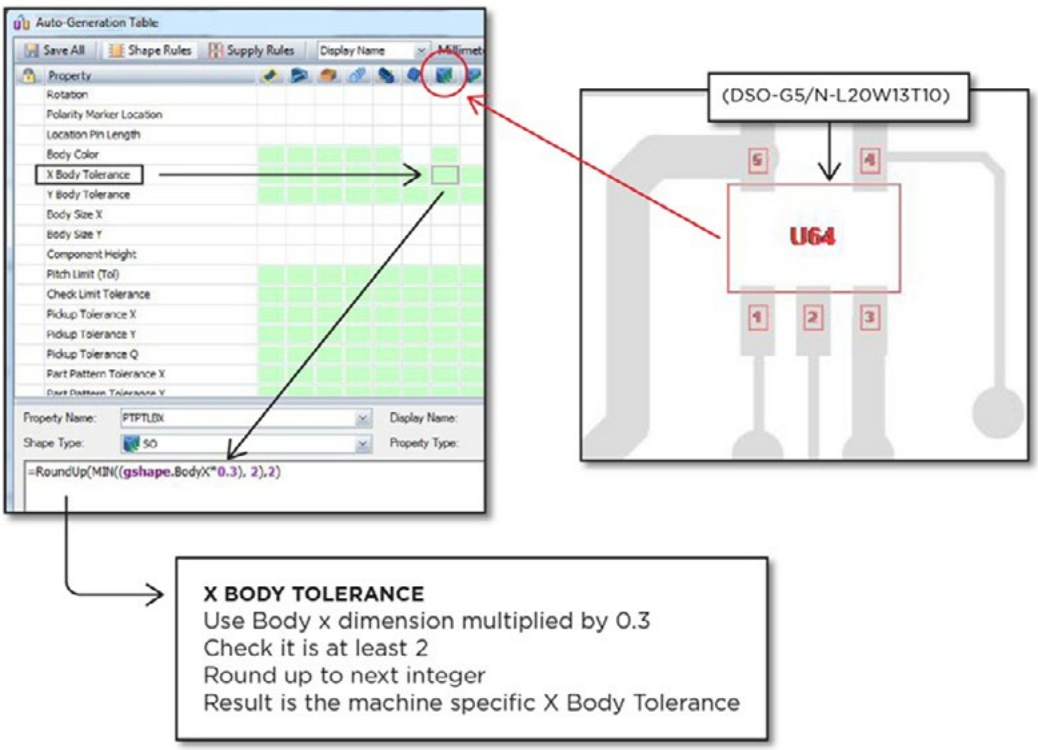


Figure 14: Automatic derivation of machine-specific library content (X-body tolerance).

component is automatically classified as "SO", which requires an X body tolerance for the specific machine we are preparing the library for. The rule for calculating the X body tolerance for this particular machine is shown in Figure 14, with a plain English version written underneath.

An example of a more complicated rule is shown in Figure 15 for the same component. In this example, the rule relates to the nozzle

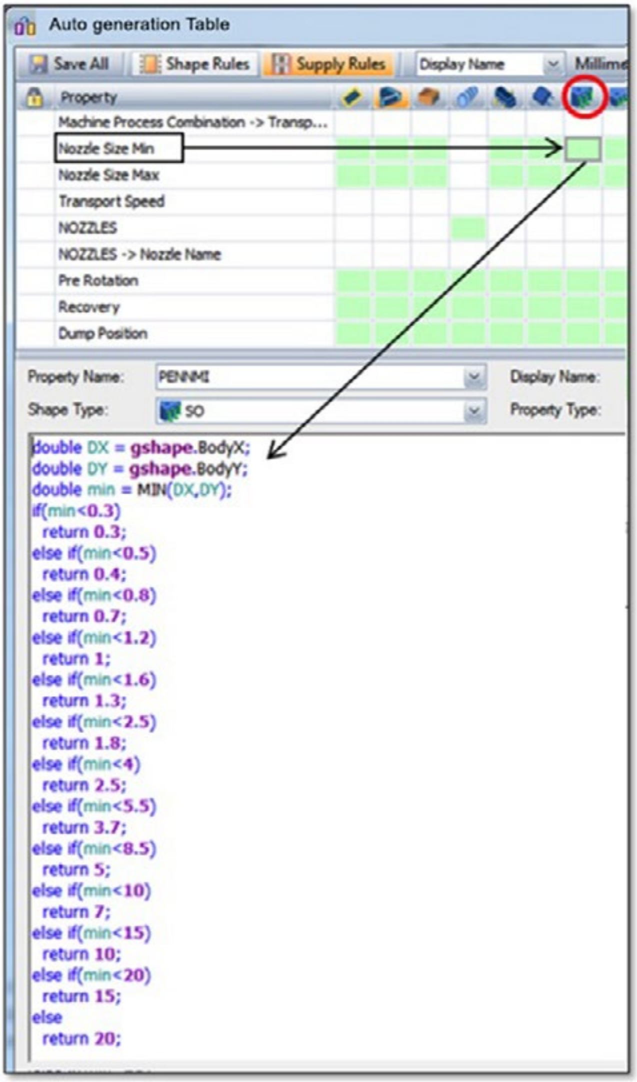


Figure 15: Automatic derivation of machine-specific library content (nozzle diameter).

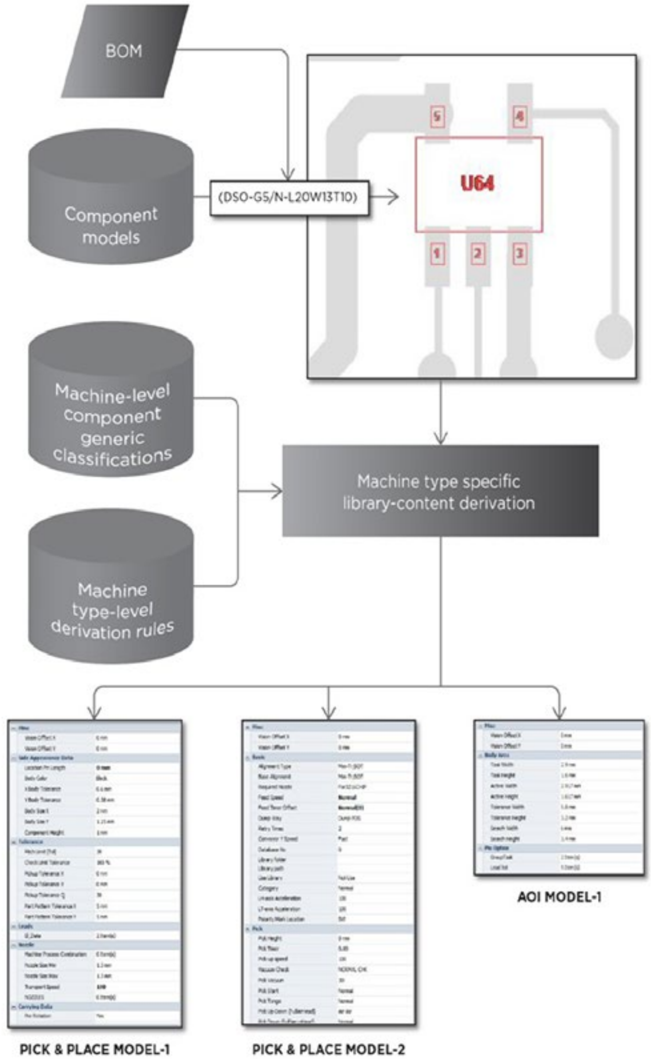


Figure 16: Automatic library content-generation from one source, for multiple machine types.

definition for the component. It illustrates the logic for selecting minimum nozzle size based on component body dimensions, for this particular machine.

Thus, by a process of creating and proving the rules that relate to the library requirements of the models of pick-and-place, AOI, AXI test machines in use across the industry, all those who use the machines worldwide can expect right-first-time set-up of their machine libraries without having to create and fine-tune the data on the machine itself. By a combination of a single globally accessible source-model for the components, plus the classification system dedicated to the needs of machine-level libraries, and a library of rules at the machine-type level, a machine-library solution is created that can be applied at a level that runs above the individual machines, lines, and factories. Figure 16 shows the full flow of the solution, starting with BOM and model of the PCB assembly, through to the run-ready libraries of the individual machines.

In effect, a unified on-demand library content service for any SMT assembly, inspection, and test line worldwide. Production of a specific PCB assembly can be switched between lines of any machine combination within a matter of minutes, bringing high flexibility in asset utilization and the opportunity to reduce production lot-sizes and thus levels of working capital. It opens the way for the full application of lean manufacturing in the supply-chain sense.

Summary

This paper describes a technological implementation of component libraries, classification systems, and rules that support DFA and assembly-line setup portability. The development has taken time because of a number of factors related to investment, time to gather and verify industry requirements, and the time required to establish library content of sufficient critical mass to meet the needs of the industry in general (tens of millions of parts). To be a working solution, multiple pieces of a puzzle had to be developed in parallel, including:

1. A globally available library that meets the requirements for DFA analysis and assembly line machines, loaded with content to match the many millions of parts in use by the design and manufacturing organizations.
2. A component classification system that meets the needs of DFA analysis.
3. A set of rules for DFA analysis, matched to the classification system, the values for which can be maintained by process engineers.
4. A component classification system that meets the needs of PCB assembly-line machine-library generation
5. A set of rules for machine-level library generation that matches the classification system, which can be extended as new machines and component types emerge.
6. The software infrastructure and tools to realize the solution in the hands of PCB designers and manufacturers in thousands of locations worldwide, together with its on-going maintenance and upgrading according to developing industry processes and requirements.

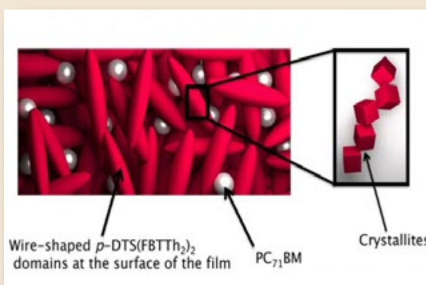
The forward roadmap is to continue the development of all the aspects described above, in parallel and according to industry requirements, and also to support additional PCB-related engineering processes that can take advantage of the same source library content so as to further reduce the per-task cost. **SMT**

Pat McGoff is a market development manager at Mentor Graphics Corp.

Solvents Save Steps in Solar Cell Manufacturing

Researchers at the Department of Energy's Oak Ridge National Laboratory (ORNL) have found a way to manufacture bulk heterojunction solar cell films (BHJs) more easily: by using a simple solvent that makes thermal annealing a thing of the past.

In a collaboration between ORNL's Spallation Neutron Source (SNS) and the Center for Nanophase Materials Sciences (CNMS), postdoctoral researcher Nuradhika Herath led a team of neutron and materials scientists in a study of the morphology, or structure, of BHJs.



The researchers compared thermal annealing with a method that adds a small amount of solvent that aids in dissolving the fullerenes within the blend and helps to make the film's structure more uniform. Using solvent additives to optimize the morphology of BHJ films could negate the need to invest more into a less effective process.

"Optimization of photovoltaic properties provides information to manufacture solar cells with fully controlled morphology and device performance," Herath said. "These findings will aid in developing 'ideal' photovoltaics, which gets us one step closer to producing commercialized devices."

Seeking Experienced Sales Person to Join Our Team!

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- Developing and cultivating new business
- Accurate and timely record keeping
- Following up on all leads
- Managing contract renewals
- Phone and email communications with prospects
- Occasional travel to key industry events
- Team collaboration
- Working independently in a virtual environment

Qualifications:

Successful candidates will have experience with managing and cultivating leads, projecting, tracking and reporting revenue. We are looking for positive, high-energy candidates who works well in a self-managed, team-based, virtual environment.

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- Highly motivated and target driven with a proven track record for sales/meeting quotas
- Excellent selling, communication and negotiation skills
- Prioritizing, time management and organizational skills
- Create and deliver proposals tailored to the prospect's needs (strong writing skills mandatory!)
- Relationship management skills and openness to feedback
- Experience in the electronics industry desirable

Successful candidates should possess a BS/BA degree or equivalent and have experience with systems-based management/TQM philosophy. This is a base salary-plus-commission position. Compensation commensurate with experience.

Qualified candidates should submit resumes here.

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GOOD FOR THE INDUSTRY

Recent Highlights from SMT007

1 IEC Appoints Jens Hauvn as SVP of Operations

In his new position as Senior Vice President of Operations, Jens Hauvn will be responsible for IEC's manufacturing facilities throughout the United States and reports directly to President and CEO Jeffrey T. Schlarbaum.

2 Celestica Appoints Jack Lawless as EVP, Diversified Markets

Celestica has appointed Jack Lawless to the role of executive vice president, Diversified Markets. In his new position, Lawless will be responsible for driving the profitable growth of the company's aerospace and defense, energy, industrial, and healthcare businesses.

3 EMS Solutions Expands PCBA Testing Department

Utah electronic contract manufacturing services provider, EMS Solutions, has expanded its testing facility space. Further facility expansion is on the horizon as the company continues to grow.

4 IPC Seeks Posters for Display and Presentation at IPC APEX EXPO 2016

IPC—Association Connecting Electronics Industries is seeking technical posters for presentation at the upcoming IPC APEX EXPO 2016 trade event.

5 IMI Automotive Cameras inside Renesas' ADAS Surround View Kits

Integrated Micro-Electronics Inc (IMI), one of the leading providers in the world of electronics manufacturing services, is providing the automotive cameras for the Advanced Driver Assistance Systems (ADAS) Surround View Kit of Renesas Electronics, a supplier of advanced semiconductor solutions.

6 SMTC Moves Corporate HQ to San Jose, California

SMTC Corp. has announced that its San Jose, California location will become the new corporate headquarters. Its Toronto, Canada location will be known as the SMTC Toronto Division and will remain an important part of the organization representing several "Centers of Excellence."

7 Scanfil Changes Outlook; Expects Better 2015 Performance

Scanfil has revised upward its estimate for turnover and operating profit in 2015 amid better than expected sales during the third quarter.

8 Vexos Strengthens Technical Capabilities with New Panasonic Lines

Vexos and Panasonic have entered into a technology evolution agreement, ensuring Vexos remains one of the leading providers of SMT placement and manufacturing capabilities worldwide.

9 ESCATEC Focuses on Designing out EMC Issues

ESCATEC has just completed an intensive training course for its design engineers that focused on the causes of EMC and how to prevent it. The initiative follows on from the company's investment earlier this year in state-of-the-art EMC testing equipment.

10 Exclusive Video Coverage of SMTAI 2015

If you didn't make it to Chicago for SMTA International 2015, don't despair. We have complete Real Time video coverage of the event, so you won't miss a thing.

EVENTS

For the IPC's Calendar of Events, click here.

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For a complete listing, check out *SMT Magazine's* full events calendar here.

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November 3–4, 2015
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PCB Carolina 2015
November 4, 2015
Raleigh, North Carolina, USA

LA/Orange County Expo & Tech Forum
November 5, 2015
Long Beach, California, USA

CEA Innovate!
November 8–10, 2015
New York City, New York, USA

productronica 2015
November 10–13, 2015
Munich, Germany

2015 EFRA-CEFIC Workshop
November 11, 2015
Munich, Germany

Space Coast Expo & Tech Forum
November 12, 2015
Melbourne, Florida, USA

Indiana Fall Forum & Expo
November 13, 2015
Columbus, Indiana, USA

LED Assembly, Reliability & Testing Symposium
November 17–19, 2015
Atlanta, Georgia, USA

Rapid Oven Setup & PCB Profiling—Seminar
November 24, 2015
Warwickshire, UK

2015 International Printed Circuit & APEX South China Fair
December 2–4, 2015
Shenzhen, China

IPC APEX EXPO Conference & Exhibition 2016
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