METROLOGY TODAY

TRENDS AND ISSUES IMPACTING METROLOGY

Innovators on the Ground and In the Air: Boeing and the 787

ho hasn't heard of the Boeing 787 Dreamliner? It's promoted as a quieter, more efficient aircraft, but it's unique in other ways as well.

Boeing has always been an innovator, but it's a more competitive market than ever in air transport, so every moment counts. So the way the 787 is built creates a competitive advantage. The entire plane is constructed from several large sections being shipped from different parts of the world. Production partners are located in Italy, Russia, Japan, Korea, Australia and the United States. In order to coordinate the assembly of the plane, and keep to the schedule, each component manufacturer has to make sure that each will fit in the end.

Boeing needs all the parts to fit within tolerances never before contemplated for large aircraft. Coupled with the all composite construction, and distributed partner production, they need to rely on tools that get the job done. One of the ways they do this is with an advanced measurement software called *SpatialAnalyzer*, made by a company called New River Kinematics. When manufacturers use a consistent measurement system like *SA* for their components, they are ensured a more reliable outcome.

The components are delivered to Boeing's enormous facility in Everett, Washington. In order to be assembled as fast as possible, these components can't hold any surprises. They must be made to precise specifications and fit together perfectly. The 787 in particular has another challenge—the material is carbon graphite composite, not aluminum, so once cured its configuration is fixed. This creates increased part precision and tighter tolerances.

John Ritter, who works for Spirit Aerosystems (formerly Boeing Wichita), said, "The 787 will set a new standard for the industry, and it's an exciting time to be working on a project of this magnitude."

"Companies like Boeing are pushing



Nose cone of 787 assembled in Wichita, Kansas.

the envelope and working in dynamic environments. They need to work with suppliers and vendors who are just as dedicated, responsive and able to provide solutions," Ritter said.

Approximately 25 Boeing 787s are scheduled for delivery in 2009—they're sure to continue to change the face of aerospace, in addition to setting a new standard for design and manufacturing.

Trends in Metrology: From Presumptions to Portability



to measure the height of a horse, but it begs the question—whose hands?

Questions like these are still relevant in an industry where mentioning GD&T or measurement uncertainty could lead to a heated discussion. Portable metrology is making strides to get everyone on the same page. Maybe some will be at the top of the page and others at the bottom, but the same page is a great start.

Bruce Thomas, an engineer with New River Kinematics who developed the industry-leading software **SpatialAnalyzer**, said "As we continue to develop ways to know how imperfect our measurements are, we can decrease the room for error. I think that technology will continue to rapidly expand because finally, computer processors are fast enough to handle all the data analysis." These changes promise a better future for the field of metrology. In the past, precision was a lofty goal, and many machines were assembled to work effectively under a "good enough" standard. But today, as the technology of metrology becomes more sophisticated, the bar has been raised.

Measuring uncertainty, and pulling out all the stops to prevent undue uncertainty are the new goals of the industry. When measurements are used to make decisions, decision makers need to know how certain those measurements are, because then they'll be able to have as much information as possible.

One of the traditional ways of measuring is with a coordinate measuring machine, also known as a CMM. These stationary machines are most often used in automobile manufacturing where the

there was the theodolite used by surveyors. This is where the science of metrology began. Actually, you might go back as far as using hands

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How Software Changed Metrology

r. Bob Salerno has been in the metrology industry for the past 20 years, and he's a problem solver. In his role as a mechanical engineer and co-founder of New River Kinematics, he gets a lot of calls from clients in the aerospace and shipbuilding industries for problem solving.

As the industry innovated rapidly, certain issues bubbled to the surface. "One of the reasons people call with production crisis is that they are doing something like trying to get a part

to fit, and can't find the reason why it's not working. Many times it's transferring data from one measurement environment to another," Salerno said.

Another challenge in the industry is the changing technological environment. "Instrumentation is always changing," Salerno said. "Ten years ago, laser trackers dominated, but now scanners are more common, and laser radar is finding more uses." It can be a challenge to find solutions for all types of instrumentation.

Each of these instruments brings a different set of strengths and weakness, but the software that they use can be universal with *SpatialAnalyzer*, a software product created by Salerno and his partner Dr. Joe Calkins.

Major changes in the aircraft industry include moves by commercial aviation and some military

"We know that it's critical that users know the uncertainty associated with every measurement."

manufacturers to create composite monolithic pieces rather than the smaller aluminum or titanium parts of the past. This means major changes to their

manufacturing and construction processes. "Many of the critical components used to be small parts, small enough to put on your

How GD&T is Changing Metrology

G D&T, or Geometric Dimensioning and Tolerancing, has become an industry standard as well as a different way of describing tolerance. Rather than the traditional reference frame, GD&T emulates the constraints of putting something together, based on the kinds of spatial relationships of the parts. It includes symbols, rules and even vocabulary for communication among engineers. It's the ultimate way that they "get on the same page," because in the past, there were differences in interpreting drawings and that caused errors.

It's been proposed and circulated by different organizations, but in the United States, it was ASME, the American Society of Mechanical Engineers, that formalized the standards for GD&T. The code was revised in 1994 to clarify the standards even further. A similar international standard is put out by the International Standards Organization, or ISO.

These codes create the framework for how the industry implements them.

Bob Salerno, co-founder of software company New River Kinematics, explained that in GD&T, the relationships are the most important. "It's like how kinematics is the science of spatial relationships, and GD&T is a way of describing them," he said.

One of the most exciting changes that has recently occurred





desk. Now parts can be the size of a fuselage in circumference. That means that how you inspect things has to change," Salerno said. "This created a window for portable metrology—it's distinctive as the only solution to provide that information."

It's a paradox that portable metrology equipment can measure much bigger objects than legacy fixed metrology gear. In fact, in parts of Europe, portable equipment is often referred to as "large-volume equipment."

Managing uncertainty in the measurement process is also a key issue for large parts. "We know that it's critical that users know the uncertainty associated with every measurement. Tolerances are getting tighter, more than ever before. Our clients say, 'We need to know where this edge is to plus or minus 0.004 inches.' If you want to know that, you need a measurement system that not only provides the edge location, but does so with acceptable uncertainty," Salerno said. For engineers in manufacturing, this can mean less rework and less waste.

Another challenge for metrology is that instrumentation needs to have compatibility with each other and be able to share data and create reports. For years, issues with instrument compatibility and equipment integration have occurred, but the industry is making a software change that may eliminate those issues. Not only is the data from different systems compatible now, the process of gathering the data is now standardized. This allows operators to be proficient at running more than one type of instrument.

Salerno also said that one of the most

is the development of methods for

directly coupling the designer's intent, as described through GD&T, to the inspection process. This effectively allows designers and measurement technicians to communicate exactly what is critical about a given part. It also puts the designer in control of the process and relieves the person doing the inspection from having to understand how this part mates to all the other parts. The implementation and continued adaptation of GD&T has brought engineering and production a long way in the past 36 years since the code was adopted, and that is expected to continue as it's adopted more universally.

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universal changes is that his clients have changed how they problem-solve. "I think they can focus more on how they wanted to solve the problem, whereas before they were limited and constrained by the tools they had. Rather than adapting a task to what they had, they could just think about how they want to solve it," he said.

Big Projects, Bigger Solutions



USS Ronald Reagan.

orthrop Grumman Newport News Shipbuilding is world-renowned, for the scope of its operations as the largest dry dock in the world, and for the ships it builds for the United States military. With more than 21,000 employees, having the right tools and processes are critical. And one component of process that's changed in the past few decades is software applications.

Phil Caudill, the supervisor of the Dimensional Control Group, shared how the shipyard operated in the past. "At one time, we'd have measurement technicians become experts on a particular measurement system and its manufacturer's software."

But then the process became more cumbersome. "With the measurement surveys increasing, becoming more diverse, and the addition of several new measurement systems, we needed to ensure any technician could use any measurement device, perform analysis, and report the results," Caudill said.

In general, the integration of portable metrology has had a huge impact on how largescale projects are built, including the nuclearpowered aircraft carriers and submarines constructed at Northrop Grumman's Newport News Shipbuilding division. "Although not the them on the ship. Caudill said portable metrology has grown to a point where it is now planned into the shipbuilding processes. It's relied upon to meet schedule and accuracy demands throughout the shipbuilding process.

Innovation at the shipyard occurs on

a constant basis.

"Technicians are now trained on one software that they use for almost everything measurement related. This change allowed each technician to become proficient and

perform analysis on their data all while using one software," Caudill said.

That one software is called *SpatialAnalyzer* and it was implemented when Ron Hicks

supervised the Dimensional Control Department at the shipyard. He said, "when I worked for Newport News Shipbuilding, I could really see how the universality of *SA* was important. People who ran the variety of software on each of the devices couldn't be used in other areas. Now

> that *SA* is the common software interface, it's easy to adjust people to other devices."

Bob Salerno, co-founder of New River Kinematics, the company that makes

SpatialAnalyzer, said that the shipyard is one of the best examples of how having the right software can make a difference to how measurement and data collection are performed.

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CMSC: The Industry Connects

The Coordinate Metrology Systems Conference, or CMSC, is well-known as the bestattended annual industry event for coordinate measurement technology professionals.

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This year, the 24th annual CMSC crams five days full of industry topics, people and products into one place—Charlotte, North Carolina. It's a time and place where booths, tables and hallways are filled with people discussing ideas, concepts, and theories with their peers. The educational atmosphere encourages attendees to network and learn about the latest innovations in the field of portable 3D industrial measurement technologies. Conference attendees hail from prominent science/research laboratories, and diverse industries such as aerospace, space hardware, antenna, automotive, shipbuilding, power generation, and general engineering.

Ron Hicks, a former member of the executive committee and last year's committee chairperson, said that the highlight of the show for him is new products. "I love to see all the innovations the product manufacturers have been working on since the last year." Hicks has attended CMSC since 1983, and said that one of the best parts is coming to see people. "Even if you don't see them at all during the year, you can count on seeing them here."

CMSC 2008 will feature whitepaper presentations by industry experts, advanced

workshops and an Exhibition Hall packed with technology and service providers. Many of the exhibitors will feature metrology systems such as electronic theodolites, laser projection systems, laser trackers, laser radar, photogrammetry/videogrammetry systems, scanning devices, and articulating arms. Workshops feature user education and technical guidance.



largest of trades that work on the ships, the impact portable metrology has made over the years is significant. Portable metrology has been used to align everything from catapults, to missile tubes, to navigation systems," Caudill said.

It's also been used to determine neat cuts on super lift units, allowing the units to be prepared for joining in a remote location long before setting

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One exhibitor, Joe Calkins, the developer of software program *SpatialAnalyzer*, said "We never miss a CMSC—not since we exhibited the first version of *SpatialAnalyzer* in 1996. It's the place to be in this industry and every year I look forward to learning something new."



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Innovations for Exploration at NASA Langley



A mock-up of the Orion space capsule heads to its temporary home in a hangar at NASA's Langley Research Center in Hampton, Va.

ne natural place for innovations in metrology is NASA. At NASA's Langley Research Center in Virginia, portable metrology is advancing innovation. Richard Chattin, a senior technician in the Material Processing and

Precision Measurements Section, works with metrology devices every day because his department works with composite modeling

development. They are using Leica laser trackers for measurements on the Orion space

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Trends

parts are smaller. In recent years, aerospace and shipbuilding have been moving in a new direction.

"In building these large scale projects, recognizing the problem is the first step to correcting it. Pulling samples off an assembly line to place in a CMM is not the most efficient way to prevent problems," Thomas said.

"Movable instruments are the way to go-and

capsule, specifically the four bay crew module.

Of course, NASA tries to stay state of the art in whatever they do, and part of that is using a software program called **SpatialAnalyzer** for their portable metrology instruments. "We had

"It's a very powerful software, and I know I haven't even scratched the surface."

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several laser trackers with different software, but now we are using SA, which has better support and can be used on all of the equipment,"

Chattin said. He also said that the reports generated in SA are more sophisticated. "It's

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Solutions

"It was an environment with a bunch of software, and although it was used the way it was designed, discrete jobs and tasks became unmanageable. When they shifted to SA as a tool, they were more able to get everything under control. It was a neat thing to see happen. I think it revamped the way they thought about their problems," he said.

Innovations to software can do more than change day to day work, it can also change the entire problem-solving process. "They were able to focus on how they wanted to solve the problem, instead of how they had to solve it," Salerno said. There's no doubt that the Newport News Shipyard will continue to produce large scale projects, so their needs for streamlining will only increase. A combination of technology, engineering and great people seems to be their recipe for success.

a very powerful software, and I know I haven't even scratched the surface. I'm looking forward to sitting down and learning more about all of the functions," he said.

Of course, NASA faces tough internal audit procedures and SA offers more efficiency, reporting options, and ease of data review. Many of the contractors are now using SA and Chattin has been working with them to get up to speed on SA. "It's changed the way we do things. Making sure that everyone is on the same page is important. The data we provide can be used by any engineer," he said.

One of the big differences with **SpatialAnalyzer** is that the company that makes it, New River Kinematics of Williamsburg, Virginia, is committed to accommodating their clients. "If we call with a problem or question, they are there anytime. It helps that they are located nearby, and they have come on site for modification of equipment," Chattin said.

He also values the responsiveness that NRK provides. "When we get an idea of how **SA** can help us, we tell them and often they'll initiate an upgrade or add it in the next release of their software." And for NRK, that's a fairly ambitious release schedule. Over the time that

Chattin has been using the software, he's upgraded it five times.

In addition to the versatility and application of the software, a big part of **SA**'s success is the



company that developed it. Chattin said, "The support staff is great. Having that mechanical engineering background helps, because they understand the lingo and there's not much explanation needed."

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portability will make a huge difference in the way that engineers work. It's already begun to make a difference."

Portable metrology is poised to dominate the field in the future if the current trend continues. And it looks fairly certain it will ... because no one wants more uncertainty in their million- or billion-dollar projects.

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