Through a Looking Glass Clearly

A policy of transparency and openness at Boeing Operations is leading to speedy problem-solving, greater efficiency – and millions of dollars worth of savings.

From left, mechanics Wayne Coleman and Jeff Bond work on the C-17 ramp toe rigging at the C-17 plant in Long Beach, Calif. The C-17 program has one of the best operations records at Boeing.

By Daryl Stephenson

When something is transparent, you can see through it clearly and easily – with nothing obstructing the view.

The word "transparency" comes up frequently in discussions throughout Boeing Operations about how to bring new efficiencies to the shop floor. An open sharing of data – through such things as common processes, standard work, Employee Involvement, process action teams, online systems, and joint programs between Integrated Defense Systems and Commercial Airplanes – is providing a clear window into the true status of programs.

That's seen as a vital tool in the disciplined management of programs – and the successful implementation of initiatives such as Lean+ that yield significant improvements in cost, quality and cycle time. More and more, problems are raised widely and early, which leads to help and solutions being provided just as quickly. That results in significantly lower costs for implementing change.

Flap mechanic Steve Averill, left, who installs 737 wing flaps and flap track fairings, is shown with Chip Bonner, lead aircraft readiness log inspector, who verifies part and serial numbers on the 737 final assembly floor in Renton, Wash.

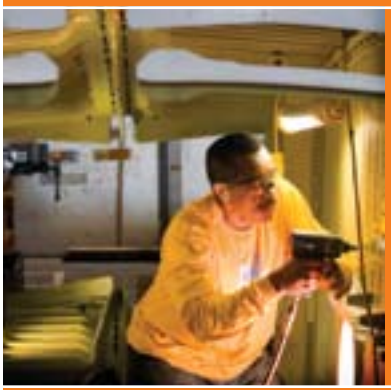
"One of the strategies for functional discipline is to create a culture of transparency and openness so everyone can make decisions using the facts and data," says Steve Goo, IDS vice president of Program Management and Business Excellence, who is

continued on page 25

Through a Looking Glass Clearly

Streamlining the C-17

At the C-17 program in Long Beach, Calif., engineers and manufacturing employees are working side-by-side on the factory floor to produce an efficiency record that is the envy of the industry.



Mechanic Rube Smith works on a C-17 wing half join.

"We have true employee ownership in the assembly build process," says Bob Stanger, director of C-17 Operations. "Lean techniques have been built into every step of the process – and the employees are fully involved in leading the effort." So far, 161 C-17s have been delivered to the U.S. Air Force and the Royal Air Force of the United Kingdom.

"Seven years ago we located everyone involved in the build process here in the shop," says Eusebio Gomez, director of Technology Integration and Lean Manufacturing, as he walks through the various work positions. "That way, we have a totally integrated team – engineers and manufacturing employees working together permanently, solving problems immediately."

Through employee involvement and "design for manufacture," the team is constantly identifying areas where savings can be made and re-engineering parts of the airplane to make them easier to build. Now, major assemblies use fewer parts, and several of them arrive already completed from St. Louis.

Engineers are continuously working to reduce weight: the metal tail has been replaced by a lighter composite tail, and the aircraft is now equipped with new landing gear doors that are stronger and more durable than the existing doors, and easier and cheaper to produce.

Factory floor space is expensive to maintain, and efforts have been under way to better utilize it. In the final assembly frontline area, for example, the team managed to save 168,000 square feet of assembly area – a 44 percent reduction – through lean efforts that reduced cycle time and the need for two parallel positions. Through what are called "ergonomic blitzes" and the use of technology in the workplace, the team is saving time and effort as well as reducing on-the-job injuries simply by making work easier and more efficient for assemblers.

Continuously updated electronic progress charts have replaced traditional paper at each of the positions. Lighter and more efficient tools – drills, rivet guns and hoses, for example – have speeded up assembly time and given the machinists better access to assemblies.

"We are a process-driven organization, and it is paying off for our team and the customer," says Stanger.

Sealer Barbara Rogers applies anticorrosion sealant to the 737 wheel well. 737 engineers have adapted a technique used on the F/A-18 to make installation of the wheel-well hydraulics more efficient.

Wheel-well hydraulics assembly techniques shared across programs

Installation of hydraulic tubing and associated parts in the main landing-gear wheel wells of the Boeing 737 traditionally has been a difficult, costly and time-consuming job.

Four mechanics, working in a confined space, install more than 2,000 parts, including about 350 tubes. They perform more than 750 torque operations in roughly two shifts. Currently installed piece by piece, many of these tubes are layered with other systems and interlaced with electrical wire bundles.

After the installation is completed, the hydraulic system undergoes what's known as the "Oil On" functional test to check for leaks. Because the installations are complex and the access to fittings is limited, leaks (as many as two or three) are common during this test. Usually, a tube connection only requires additional torque to correct the leak. Considerable effort is then required to clean the affected area of the wheel well.

Now, the 737 Hydraulics Value Stream team in Renton, Wash., believes there is a better way – transform the piece-by-piece installation of the hydraulic tubing and components into modules assembled off line. This moves most of the effort off the airplane and out of the critical path of Final Assembly.

The goal for this new process is to reduce installation time for the 737 wheel well hydraulic tubing by as much as 80 percent, says Edward White, 737 project manager for the modular installation development. And the inspiration for this concept, he points out, came from the Boeing Integrated Defense Systems F/A-18 Super Hornet production team in St. Louis.

White's team was formed within 737 Final Assembly to pursue the idea of a modular approach for installation of the wheel well hydraulics. About a year ago, during a Metals Assembly Technology Exchange, White and another member of his team saw a presentation about a nose landing gear wheel well hydraulics pre-assembly project on the F/A-18 program. "It acted as a nice catalyst, and we shared what we learned with our Hydraulics Value Stream Team in Renton," White recalls.

Then in April this year, several members of the Hydraulics Value Stream team visited St. Louis to observe pre-assembly work and installation of hydraulics in the F/A-18 nose-gear wheel well. They also noted that the F/A-18 team was using special fittings, less likely to leak because they eliminate the torquing operation that can be difficult in restricted areas. They also have a visual indicator that ensures proper installation before functional test.

Armed with first-hand knowledge from the F/A-18 program, the 737 wheel well team is designing new assembly processes for the hydraulic tubing, parts and equipment. These processes call for pre-assembling the hydraulic tubes, parts and equipment into modules away from the main 737 line, a sequenced installation of these modules, and the use of the axially swaged fittings.

The new process is expected to make it easier to access and install hydraulics system components in the wheel well, to significantly reduce the amount of touch labor and improve the quality of the installation.

Working with the Rapid Prototyping Centers in St. Louis and Seattle, the team constructed a full-scale mockup of the main-landing-gear wheel wells, stuffed with tubes, components and equipment. They are using this mockup to develop and integrate the various pre-assembly modules to work out issues before the new process is implemented in production of the 737. The team hopes to be able to do that early next year.

"It's been a real team approach," says White. "Engineering, manufacturing, mockup, Material and Process Technology, Lean support personnel, and customer support engineers – all these functions and more are working together to apply new ideas and drive improvements. This allows us to design and integrate a dramatic improvement such as this that otherwise would not have happened."

continued from page 23

also a leader of the enterprise Program Management function within Engineering, Operations & Technology. "Get it out there in the open, so we all know what is going on."

Then, he says, if a program is in trouble, "we can see where the struggles are and we can get the team the help it needs. We encourage that kind of culture. If you're a program manager and you need help, we must know about it. Programs are hard, and we know there will be problems."

An example of transparent data-sharing of program status is an online tool called Track Plan, which provides up-to-date metrics on all production programs in St. Louis. Developed about four years ago by St. Louis industrial engineers when the C-17 pylon team implemented a pulse moving line, Track Plan electronically displays color-coded, easy-to-read charts to indicate how far along work is in regard to parts and assemblies. The system is updated every hour.

"It's like a scorecard that gives you a complete picture," says Chandler Varma, an IDS manager in Industrial Engineering. "It shows cost, compliance to planned work sequencing, quality, and things that need immediate attention. If there are problems, you can see where they are quickly – in real time – and then the problems can be addressed immediately."

Shop floor employees, engineers, business operations people – anyone with a stake in a production program – are able to access Track Plan, which replaces paper status boards that used to be displayed in work areas. Efforts are under way by Varma's team to share Track Plan with other Boeing sites.

The sharing of information, processes, innovations and best practices across Boeing is the basis for Process Action Teams, or PATs, that have played a major role in saving money for Operations since 1998.

"The job of these Process Action Teams is to look across the enterprise, find the best technology, the best processes, and the best practices so that we can all get better at it every day," says

Brian Kuntz, a sheet metal assembler and riveter trims and fits a fairing on an F/A-18E/F in St. Louis.

Jim Morris, Boeing Commercial Airplanes vice president of Engineering, Manufacturing and Operations. Morris is also a leader of the enterprise Program Management, Engineering and Manufacturing functions within EO&T. "We've used them frequently as we've developed the 787 in a search for the best ideas."

Richard Van Gels, C-17 production operations specialist, left, and Tom Guenther, final install mechanic, standing above the C-17 engine and pylon in the final assembly area, discuss details of an operation.

Boeing Operations has nine PATs that include representatives from both BCA and IDS. The PATs share best practices and lean principles "by the commodities we manufacture," says John Van Gels, Integrated Defense Systems vice president of Operations and Supplier Management. "For example, we have a structures team, a field and ramp team, and others." And in the eight years they've been functioning, the PATs have saved Boeing almost $1 billion, Van Gels asserts.

The PATs also have played a major role in standardizing the Boeing quality management system across the business units and with suppliers, says Barbara O'Dell, BCA vice president of Manufacturing. Thanks to the PATs, the international quality standard AS9100 (which applies specifically to the aerospace industry) has been adopted across Boeing.

Now, there's a common understanding of processes and a much more streamlined set of procedures to follow," says O'Dell.

The PATs are just one area in which Morris, Van Gels and their respective Operations teams work together. "We go over succession plans so that we can move the best people to the right

continued on page 27

Mark Weiler, aircraft production mechanic, installs a left-hand main landing gear assembly at F/A-18E/F final assembly in St. Louis. The F/A-18 Super Hornet program, always ahead of schedule, underweight and within budget, has long been considered a model acquisition program.

Flight-line operations have been making a major contribution to efficiency efforts at Boeing. Jack Jones, director of Everett Field Operations and Deliveries and leader of the Field/Ramp Process Action Team in Washington, stands in the rain behind a Boeing 777 bound for delivery. His PAT, one of nine at Boeing, has focused on the sharing of best practices with the emphasis on lean throughout the enterprise flight-line operations. The team has helped place work at locations that offer the best cost and schedules, and provide skills and support where needed.

continued from page 25

jobs," says Van Gels. "We look at people at IDS and BCA who can be moved back and forth. There are more than 500 IDS engineers working on the 787 program, for example. And we have some Technical Fellows from BCA helping us in IDS with special projects."

The exchange of information and ideas between IDS and BCA can lead to novel solutions to long-standing problems.

Morris describes the cooperation between IDS and BCA Operations as "a great working-together relationship," which is enabling Boeing "to provide products and services to our customers that no one else in the world can provide." He cites the P-8A Poseidon Multi-mission Maritime Aircraft program as another example of that relationship. "Here we have a 737 airplane modified to support a U.S. Navy mission, and IDS and BCA have worked closely with the Navy to define the requirements to figure out what we have to do. The same kind of synergy is starting to emerge on the military tanker program, where we will use a commercial platform."

Sometimes, the exchange of information and ideas between IDS and BCA can lead to novel solutions to long-standing problems. BCA's 737 production team in Renton, Wash., for example, is implementing a new process adapted from the IDS F/A-18 Super Hornet line in St. Louis to reduce the time and cost of installing about 350 hydraulic tubes and more than 1,000 associated parts in the wheel well of the 737 main landing gear (See page 24). The solution is to convert the assembly, traditionally a labor-intensive operation, into a modular preassembly away from the main line. It's hoped that final assembly installation time for 737 wheel well hydraulic components will be reduced by 80 percent.

"Think about what could happen if we could replicate that kind of example throughout the company," says Morris. "How much more competitive would we be and what great products would we be able to produce?"

continued on page 28

continued from page 27

A major contributor to improving efficiency at Boeing Commercial Airplanes Operations is the use of moving production lines.

"The best example we have of that is the 737 moving line, which is a great example of lean," says Morris. "The 737 moving line has reduced our cycle time by 50 percent and our inventory by more than 60 percent."

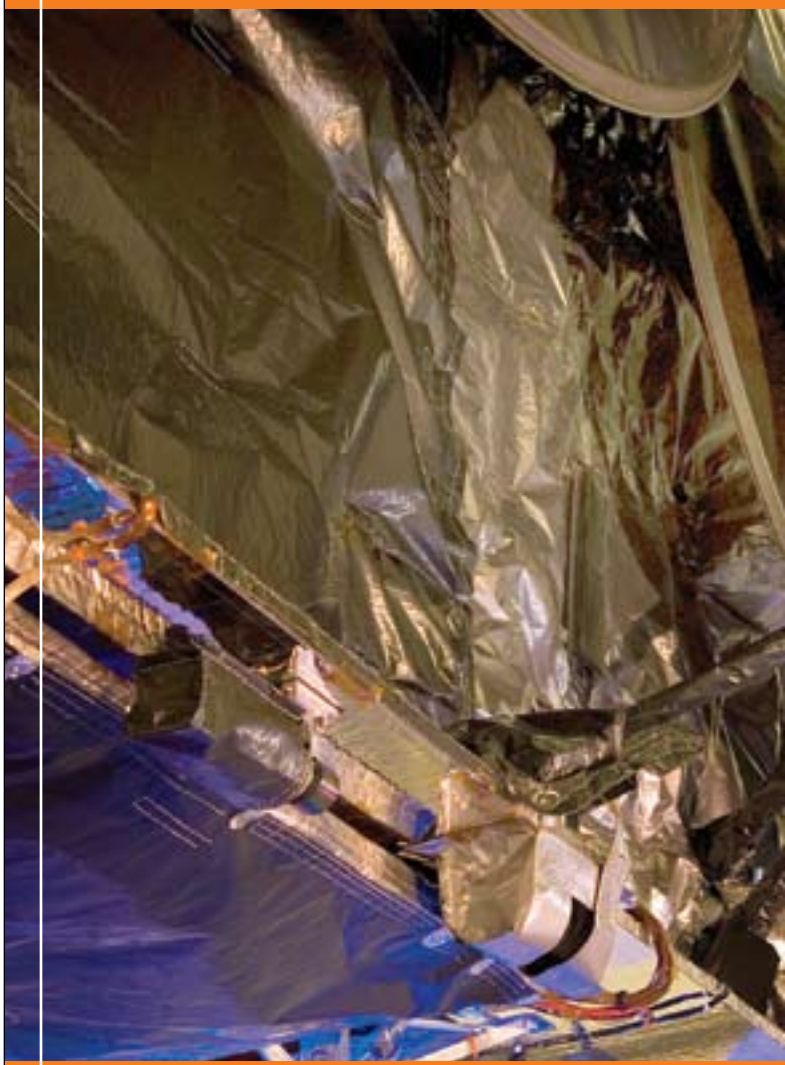
The 737 main production line became fully operational as a moving line in 2002. Because the moving line has been so

Shop floor technicians and support personnel performing a table-top review of a new manufacturing task using 3D visualization in an advanced collaborative environment at the Satellite Development Center in El Segundo. From left are: Bill Baldwin, Travis Brown, Ted Lumpkin, Chris Walker, Paul Claussen, Ron Ward and Mario Ponce.

successful, BCA Manufacturing has been working to apply the moving line concept to other lines as well. The 777 line became a moving line in early November 2006 and, down the road, the 787 production line also will be a moving line, says Morris. "The moving line has really been the best tool that we know of to eliminate waste in the production system," he says.

Today, teams throughout Boeing are "exporting all these great tools and processes around the company and to our suppliers around the world so that they can just get better all the time and be able to better support us," says Morris. "And the payoff is that we're having a very healthy business that allows us to reinvest in our future. Our productivity is enabling our growth. And we are producing the best set of products and services to satisfy our customers around the world."

Boeing Operations is becoming an organization that is dedicated to "developing people that have the expertise of building, managing suppliers and understanding quality requirements for new programs," says Van Gels, who is also a leader of the enterprise Operations Supplier Management functions within EO&T. "We're moving in the direction of becoming a multi-talented organization, in which people have experience with different programs. The more experience you have, the better off you are. It's all about continuous learning. There's no holding people back when they have all this great experience." ■



Inspector Sandy Santiel, left, and Integration Manager James Garrett check out a DIRECTV satellite being assembled at the Satellite Development Center in El Segundo, Calif.

The El Segundo satellite operation: A model of efficiency

Lean initiatives have become a way of life at the IDS Satellite Development Center (SDC) in El Segundo, Calif., where at any given time more than a dozen powerful satellite spacecraft – including some for DIRECTV – are in varying stages of production.

"We are in a very competitive industry," says Tim Miller, Employee Involvement and Lean Operations director. "Quality and cost are critical to every program and customer, so we are aggressively implementing an integrated improvement strategy comprised of lean, employee involvement, theory of constraints, and six sigma throughout the SDC."

For example, lean efforts have reduced cycle time in the final assembly area for the DIRECTV satellite program that will beam programs from space into millions of homes. The program's lean team ran a "reverse planning" workshop where members started with the desired end result and worked backwards. This produced a true network-planning document that determined the optimal sequence for many complex operations. With this, the program was able to identify the desired planning path for DIRECTV spacecraft antenna integration and deployment operations, thereby maintaining a correct sense of which task should take priority.

Through a Looking Glass Clearly

But it's not just the major programs that can claim the greatest improvements. A small team of Electronic Manufacturing technicians who build electronics systems for a number of different satellite programs were voted best-in-class by outside lean experts. They have reduced their work area by 50 percent and improved efficiency by 30 percent.

Much effort goes into making things simpler during the design and build process at the SDC. The Manufacturing Assembly & Test Proof of Concept lab center is working on a variety of high-tech ways to help people

Electronic assembler Irene Gomez is a member of a team was voted best-in-class by industry lean experts The team builds electronics systems for a number of different satellite programs.

do their jobs more efficiently. They educate and train the employees at Satellite Development Center as well as suppliers, contractors and customers.

The devices they have come up with include wearable computers, a four-screen monitor system that allows technicians to save time by looking at multiple sets of data at the same time, and in 3-D illustrated work instructions that enable manufacturing technicians and engineers to "walk through" an assembly operation before they start doing it for real.

In satellite electronics every component, slice and unit is photographed using digital photography. This photographic documentation is used for anomaly resolution as well as a training aid. SDC builds extremely reliable hardware, but should an anomaly occur, one of the first items of documentation that is used in the investigation is the digital photograph. As the saying goes, "a picture is worth a thousand words."

One recent improvement is the collocation of the photographic equipment and photographers inside the factory. The hardware no longer has to be repackaged and expedited to the photo services room. This significantly cuts down on cycle time, reduces costs and eliminates many of the opportunities for damaging the hardware due to mishandling.