cover story

➤ BY BILL KENNEDY, CONTRIBUTING EDITOR

Machining INSIDE the BOX

Multitasking machine tool technology, combined with careful process planning, provides truly just-in-time support for U.S. troops.

Workers in high-stress situations—like soldiers, surgeons and firefighters—often describe their efforts in low-key terms. Kevin Green, a production support engineer in the Detroit civic and manufacturing organization Focus: HOPE (see sidebar, page 40), has spent a lot of time overseas in what he dryly called "a nontraditional manufacturing environment … working inside of a box."

Green is part of a team that developed and operates the U.S. Army's Mobile Parts Hospital. The key component of an MPH is a 5-axis multitasking lathe housed in an 8'×8'×20' container, which can be flown or trucked to within miles of the battlefront. Backed by a globe-spanning network of advanced manufacturing and information resources, MPH units are used to re-engineer, program, machine and deliver emergency replacement parts for military vehicles and equipment in Kuwait, Iraq and Afghanistan. A carefully crafted process plan enables the MPH units to fully exploit the speed and flexibility of multitasking machine tools in support of troops.

The MPH concept was born in the late 1990s, when the Army's Tank-automotive and Armaments Command sought a way to add mobile engineering and manufacturing capabilities to the military supply chain. TACOM's National Automotive Center, Warren, Mich., assembled a team of specialized suppliers, including prime contractor Alion Science and Technology Corp., McLean, Va.; professional services provider Cleveland Advanced Manufacturing Program Inc.; and Focus: HOPE Manufacturing, which handled the development of machining processes and equipment.

Spc. Brian Trapp, courtesy of Desert Voice magazine

The U.S. Army's Mobile Parts Hospital is on-site in the Mideast, supporting the country's war efforts by repairing and making needed parts.

The MPH has three basic components. The containerized machine shop, deployed overseas, is called the rapid manufacturing system. The RMS is supported by an agile manufacturing cell that consists of an array of machining equipment based at Focus: HOPE, backed up by an extensive Detroit-area network of specialized suppliers of services such as painting, plating,

fabrication and forging. Also at Focus: HOPE is a communications and control center, which electronically links and coordinates the elements of the MPH, providing advanced engineering support as well as a database of part manufacturing information.

Capable but Compact

From the start, the idea was to pack as much machining capability as possible into a portable package. Bruce O'Neill, Focus: HOPE project engineer, said the variety of parts that need to be manufactured in the field require a machine that can turn and mill. Initial development work for the RMS was carried out on a machining center with added turning capability. In choosing the machine that would be placed in the field, the chief criteria were the size of the machine's work envelope and its weight. "We wanted the maximum capacity we could get into the 8'×8'×20' envelope," O'Neill said. That favored a lathe-based unit. The machine now deployed is a Mazak Integrex 100SY III multitasking lathe, featuring twin spindles and a 20-tool magazine, that can machine parts up to 18" in diameter × 24" long. Together, the container and machine weigh about 27,000 lbs.

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Mobile Parts Hospital project engineer Bruce O'Neill at Focus: HOPE.

The RMS container was custom-built for this application. A unique feature is a 5'-deep push-out section, like those found on motor homes, which was added on one of the container's long sides to accommodate a machinist. The container's heavy-duty climate-control system overcomes the heat generated by the machine and the desert sun, which can easily lift temperatures inside the box to over 150° F. O'Neill pointed out that, aside from the machinist's survival, climate control is necessary for part accuracy. "If a designer says, 'I need this part to be 1" long,' you can't say, 'I'm sorry, it's 102°, it's a little bit longer,' " he said. Power for the RMS is supplied on site by a 140kV generator.

Working with a Plan

Manufacturing process planning for the RMS is blended with the flexibility needed to make a variety of parts, with standardization intended to simplify logistics and data sharing. A good example was the creation of a standard tooling package. When making test parts, the development team recorded all the tools employed. Taking that matrix of tools and parts, O'Neill said, "we combined it all as scientifically as you can when you've got a bunch of operators standing around who like one tool or another. We had to be pretty hard-nosed about it."

"The standard package means that when we want to share data, we already know how the machine is configured," Green said. "In the magazine, tool No. 1

Providing hope

Focus: HOPE successfully makes the nontraditional link between community activism, human rights and manufacturing. The nonprofit civil and human rights organization was founded in 1968 by Detroit community leaders William Cunningham and Eleanor M. Josaitis as a way to heal the wounds of Detroit's 1967 riots and, at the same time, deal with some of the issues that spawned them.

After sponsoring studies that revealed discrimination in food pricing, the organization designed and implemented a supplemental food program for children and pregnant and postpartum women. Later expanded to include senior citizens, the program is one of the largest Commodity Supplemental Food Programs in the country, with food provided through the U.S. Department of Agriculture to more than 43,000 people in the Detroit metropolitan area.

Focus: HOPE also works to eliminate the need for such assistance programs by creating educational opportunities designed to help people learn skills and enter the economic mainstream.

In 1981, the organization opened its Machinist Training Institute, through which about 3,000 students have gained precision metalworking skills. In 1989, Focus: HOPE began its Fast Track Program, and in 1997 its First Step Program, designed to help students improve reading and math skills.

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In a RMS currently being used for training at Focus: HOPE's Center for Advanced Technologies in Detroit, engineering candidate Shakemma Taylor works with the CNC of a Mazak multitasking lathe.

Founded in 1989, The Center for Advanced Technologies represents a coalition with universities and manufacturers to enable students to earn associate and bachelor's degrees through local universities. The engineer candidates gain real-world experience in Focus: HOPE Manufacturing, which is a Tier 1 subcontractor to North American automotive OEMs.

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is always tool No.1, because all the machines are completely the same." He pointed out that "none of the work we do is high-volume production, so speeds and feeds and performance are not our biggest focus. We aren't interested in specialized tools, and the tools are all off the shelf. We want a tool we can use in a variety of applications—something that's easy to use and easy to set up."

The machine is first a turning center, so the "go-to" tool, as it is in most turning shops, is the 80°-diamond turning insert. "It's beefy, all the tool manufacturers sell it and the inserts are interchangeable," Green said. Milling is more specialized, so no single tool predominates.

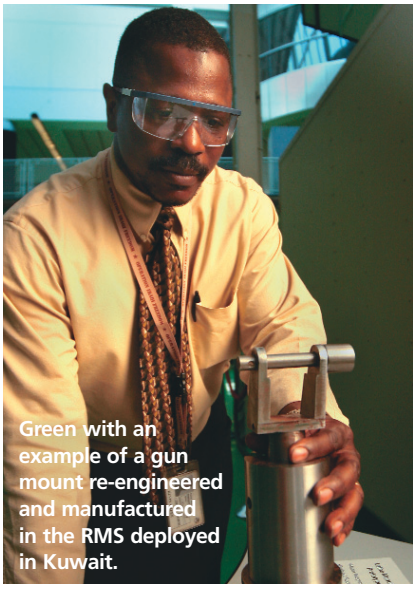
For the most part, workholding is standardized as well. "Because the machine is basically a lathe, it has a 3-jaw chuck, and that is our fixture," O'Neill said. "Ninety-nine percent of the time, it's chuck the bar in the machine and go." He admitted that material utilization suffers somewhat with that approach: "We machine off the end of the bar stock to make the part. We know we have a sacrificial piece in the jaws. It's not an economical process by any means." That issue is easily outweighed by the need to produce a range of parts on an ASAP basis.

For some particular milling applications, O'Neill said, face plates are bolted to the machine's chuck to hold the workpiece. His group is also exploring other alternatives to increase workholding flexibility on the machine, such as the Invert-A-Bolt fastener system from Lines in Motion, Fort Worth, Texas. Essentially a back-bolting system that provides front access to the fastener, the system is already in use on the machining centers in the agile manufacturing cell in Detroit.

Mobile Parts Making

Parts are made from ½"- to 6"-dia. bar stock: 304 stainless steel, 6061 aluminum, and 1018 and preheat-treated (28 to 32 HRC) 4140 and 4150 steels. The alloys inventoried reflect demand for certain parts. In quick-deployment situations, the materials travel in the RMS. For situations where the RMS is expected to be in one place for an extended period of time, the workpiece material is shipped in a separate container that is placed adjacent to the RMS.

Green said parts typically fall into one of three categories: vehicle components, "which the MPH was created to address"; weapons-mounting systems, "our biggest seller, so to speak"; and special tools. "In Kuwait, for example, we are attached to forward repair activities, which may need a special type of planetary wrench to turn a socket on a Humvee." Green estimated that over half of the inventory is preheat-treated 4140, a quarter is the other steel alloys, and the rest is aluminum and stainless steel.



Green with an example of a gun mount re-engineered and manufactured in the RMS deployed in Kuwait.

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The part-request process is organized, but not restrictive. "We are there to serve the soldiers," Green said. "Our men and women do an excellent job with what they have, and the mission of the MPH is to give them more. We don't take them through a lot of paperwork or bureaucracy." Guidelines exist regarding who can request a part, and under what circumstances. "MPH is not meant to be substituted for the military supply chain, but to augment it," Green said. However, it's not uncommon for a soldier to walk into the RMS with a broken part and say, "I need one of these," he added.

When a part is requested, the RMS technician searches the database back at the communications and control center for existing manufacturing information. If none is available, the part is reverse-engineered with data that is taken (physically measured) from the part. Such reverse-engineering takes place on about 30 percent of the parts, Green said. After a part is produced, the manufacturing data used to make it is saved in the Web-based database so all RMS technicians have access to it.

Short runs and emergency parts are generally handled at the RMS; repeat and longer runs, and parts too large for the RMS, are made back at the agile manufacturing cell. For example, six Cincinnati horizontal CNC mills and a Hurco vertical mill at Focus: HOPE were recently put to work expediting the manufacture of a 400-piece run of 1018 steel gun-mount-travel lock clamps for shipment to the war zone.

Re-engineering often involves improvement as well as simple reproduction. In 2003, a vehicle gun mount was re-engineered and manufactured to increase the weapon's range of vertical tilt, enabling soldiers to combat enemy attacks from rooftops. The Army honored the effort as one of the "Ten Greatest Inventions of 2003."

"Not only did we manufacture the part," Green said, "but the reverse-engineering gave the part functionality that is superior to the original."

A Different Breed

RMS technicians are civilians who average more than 10 years of job shop service and, as O'Neill said, are "a different breed of cat. You talk about a machinist who has to have absolute, 100 percent self-confidence that he can make whatever somebody hands him, in that machine tool."

According to Green, RMS technicians have to be complete CNC machinists, able to program, set up, operate and maintain the machine. O'Neill said that finding such machinists is a challenge. "There are a lot of operators and not many machinists out there."

When deployed, the RMS is staffed by a two-person team of a technician/machinist and an administrative engineer. Nominally, they work 12-hour days, 6 or 7 days a week. However,

Green—who has spent two 3-month stints in the RMS in Kuwait—said, "in support of our soldiers, we will work through the night."

He pointed out that in the field, "you don't have the support you would" in a standard environment. Where a normal manufacturing plant might have project managers, process and tool engineers, programmers, setup people and operators, "in the RMS, you're it," Green said.

Into the Future

The MPH is actually an ongoing R&D effort, and Focus: HOPE staff is continually introducing improvements prompted by field experience. The RMS on the floor in Detroit features an electrically operated push-out section and hydraulically actuated jacks to raise and level the unit on site. The addition of on-site heat-treating capabilities is also being investigated.

Nearing deployment is a part-scanning system that will allow RMS technicians to create CAD and CAM information directly from point-cloud data generated by a laser scan of a part that needs to be replicated.

Another new development will involve a container that houses what is called a "laser-engineered net-shaping process." The LENS process features directed material deposition, where CAD data is used to direct P/M through a 5-axis head into the path of a laser beam, where it is melted and then solidified into a near-net-shape part. Later, the part is finished in the RMS. When fully operational, use of the LENS process can minimize the need to inventory any workpiece materials except P/M, improving both the logistic efficiency and mobility of future MPH deployments.

Green said that although the work is "nontraditional," it is certainly rewarding. Even seemingly prosaic parts are important. Green recounted the case where nine pulleys for a maintenance unit's lighting system were manufactured, enabling the unit to achieve 24-hour operation. "Our deployment fills needs," Green said. "The residual effect of our work is actually helping to save American lives." △

For more information about the MPH, go to www.mobilepartshospital.com. For more information about Focus: HOPE, go to www.focushope.edu or call (313) 494-5500.