By **Ernest Granson**

# Forcing industrial change

## *Disruptive manufacturing technologies offer potential to spark new revolution*

Manufacturing is by necessity an innovative process; innovation has driven the advances in manufacturing since the beginning stages of the Industrial Revolution in the mid-1700s as it does today.

And, just as the development of mechanical technology led to widespread societal changes during the Industrial Revolution, digital technology, in the form of disruptive technologies, is poised to do the same according to economic consulting firms, industry agencies and business academics.

The term "disruptive technologies" was first defined by Harvard business professor, Clayton Christensen, in his 1997 book *The Innovator's Dilemma*. Christensen described disruptive technologies as "simpler and cheaper" technologies — usually the first commercialized in their market and usually endorsed by a company's least-profitable customers.

Christensen's premise is that, somewhat paradoxically, successful companies often dismiss disruptive technologies for this reason, only to miss out on future technologies, often to their business detriment.

Since Christensen first released his book, various technologies — such as smartphones and digital photography — have gone on to become disruptive technologies, effecting large scale change.

What are the major technologies now waiting in the wings with potential for the same type of affect? Last year, the Washington-based Manufacturing Institute (MI) initiated a research series in partnership with PricewaterhouseCoopers LLP (PWC) called Disruptive Innovations in Manufacturing. The purpose was to analyze the potential impact of those types of technologies on the workforce, market and growth of manufacturing.

Specifically, MI and PWC examined 3-D digital printing (3DP, also known as additive manufacturing), next-generation robotics and the Internet of Things (IoT) as technologies within that category.

All three of those technologies have existed in less-advanced forms for quite some time, so the survey results collected and analyzed by PwC weren't really surprising, says MI vice-president of strategic initiatives Gardner Carrick.

"I don't think I'd characterize the outcomes as revolutionary," says Carrick. "After all, we had selected those technologies to be examined because of anecdotal evidence they are beginning to have a noticeable impact already.

"But I was reasonably impressed by the number of manufacturers that are already using or adopting these technologies. In manufacturing, it's more difficult to achieve that level of entrepreneurship. After all, the cost of entry is pretty significant to finance new manufacturing technology, as opposed to, say, software development. If you're writing code, you can produce a value-added software product with minimal capital expenditures, whereas it's pretty expensive to buy machinery or set up a plant."

While these three technologies have passed the point of being considered breakthroughs, Gardiner believes their disruption capabilities will still be impactful.

"I think we'll see some interesting disruptions on the product side, especially on the 3DP side," Gardiner says. "There's a significant number of manufacturers that believe the biggest impact of 3DP will be the restructuring of the supply chain as there will be less need for parts or products to be warehoused and shipped to various locations.

Looking at robotics, Gardiner is interested in the "somewhat-surprising" amount of venture capital being invested, especially considering the time line of the expectation of return of venture capital within that general goal of a three year window.

"It seems as if manufacturers really believe that this stage of robotics will be about creating more jobs in terms of the ability to engineer and maintain this type of technology," says Gardiner. "While the last wave of robotics seemed to focus on reducing routine unskilled labour, I think the new robotics will augment the labour force rather than replace workers."

As for IoT, Gardiner believes it will have a different type of impact than 3DP or robotics. 3DP will be more revolutionary than IoT in the ability to collect data. Reading data from devices and having the devices communicate with each other isn't really breakthrough technology. The key is to analyze what's happening and adjusting the process. That technology could lead to benefits, says Gardiner

"It remains to be seen how well IoT is implemented on the shop floor. Yet on the logistics side, the ability to tag each individual product within the past 10 to 15 years has made for a huge change. That's not too dissimilar to this situation. Again, being able to utilize that gathered information could lead to a significant number of new jobs."

**'Anthozoa: Cape & Skirt' by Prof. Neri Oxman in collaboration with Iris Van Herpen was produced using Stratasys' multi-material 3-D printing technology and is in the collection of the Museum of Fine Arts Boston.** ***Photo courtesy Stratasys Ltd.***

### The dot matrix printer has come a long way

3DP has actually been around for decades, used primarily for prototyping products or manufacturing novelty products such as plas-

Perhaps one of the more startling uses for 3-D printing that is now in serious development is construction of a full-scale house.

In Amsterdam, a project team led by DUS Architects, is 3-D printing an entire house to conduct research into how new digital fabrication techniques can lead to affordable tailor-made architecture.

Work began in 2014 on the 3-D Print Canal House, which is being printed with the Kamer-Maker, a gigantic fused deposition modelling printer built by DUS.

At the University of Southern California, Industrial & Systems Engineering professor Behrokh Khoshnevis has developed a printer head that is able to squeeze out wet cement in layers, shaped by a pair of attached trowels.

The printer head is mounted on a gantry assembly so the printer can elevate as it deposits more layers.

Called "contour crafting," Koshnevis proposes the technology will eventually be used to print a whole house in a single run — from its structure to electrical and plumbing conduits in just 24 hours since the printer doesn't require any stoppages as long as there is a constant supply of material.


**UPS has made a move to be part of a possible restructured chain by equipping more than 60 locations in the U.S. with 3-D printers. *Photo courtesy UPS.***

## Man's best friend – the robot

As part of its mandate to address the major issue of the workforce, the Manufacturing Institute has been keeping close tabs on the development of robotics and its potential consequences.

The 2015 World Robot Statistics, issued by the International Federation of Robotics (IFR), based in Frankfurt, Germany, estimates that the number of industrial robots will increase from about 1.48 million units at the end of 2014 to 2.37 million at the end of 2018.

While there are varying views about the human impact on implementing robots in the workplace, the IFR's stance is "robotics will be a major driver for global job creation over the next five years" and that one million industrial robots currently in operation have been directly responsible for the creation of close to three million jobs.

"A growth in robot use over the next five years will result in the creation of one million high quality jobs around the world," it says.

The development of a collaborative robot (or co-bot), in fact, has the potential to critically affect the factory floor.

Co-bots are designed to work with, and next to, workers on assembly lines or in warehouses helping to sort and deliver packages, operate computer numerical control equipment or take care of tasks such as applying glue to parts.

Clearpath Robotics Inc. of Kitchener, Ont., has developed a line of robotics designed to operate in that type of warehouse environment.

Founded by classmates at the University of Waterloo, Clearpath's industrial robotic solutions are based on simultaneous localization and mapping (SLAM) technology — the same basic technology that powers the Google self-driving car.

Clearpath strategic initiatives director Adam Gryfe says the concept behind SLAM technology is an algorithm that creates a map of its environment and understands where the robot is located within that map.

"Once the robot generates a map for itself, it can then make an informed decision of where to drive on its own, without human intervention," Gryfe says.

"To produce a map, a range measurement device is used, such as a radar, sonar or laser scanner. Each of these techniques send out waves, sound or light waves, which bounce off landmarks and go back to the source. The distance to nearby landmarks is determined by measuring the time it takes for the waves to return back to the device."

Once the landmarks are positioned and saved in the map, SLAM uses several techniques so the robot can determine its position in relationship with the landmarks, including an algorithm called the Extended Kalman Filter (EKF), as well as odometry, which uses data obtained from motion sensors to estimate change in position over time.

**"Robotics will be a major driver for global job creation over the next five years."**

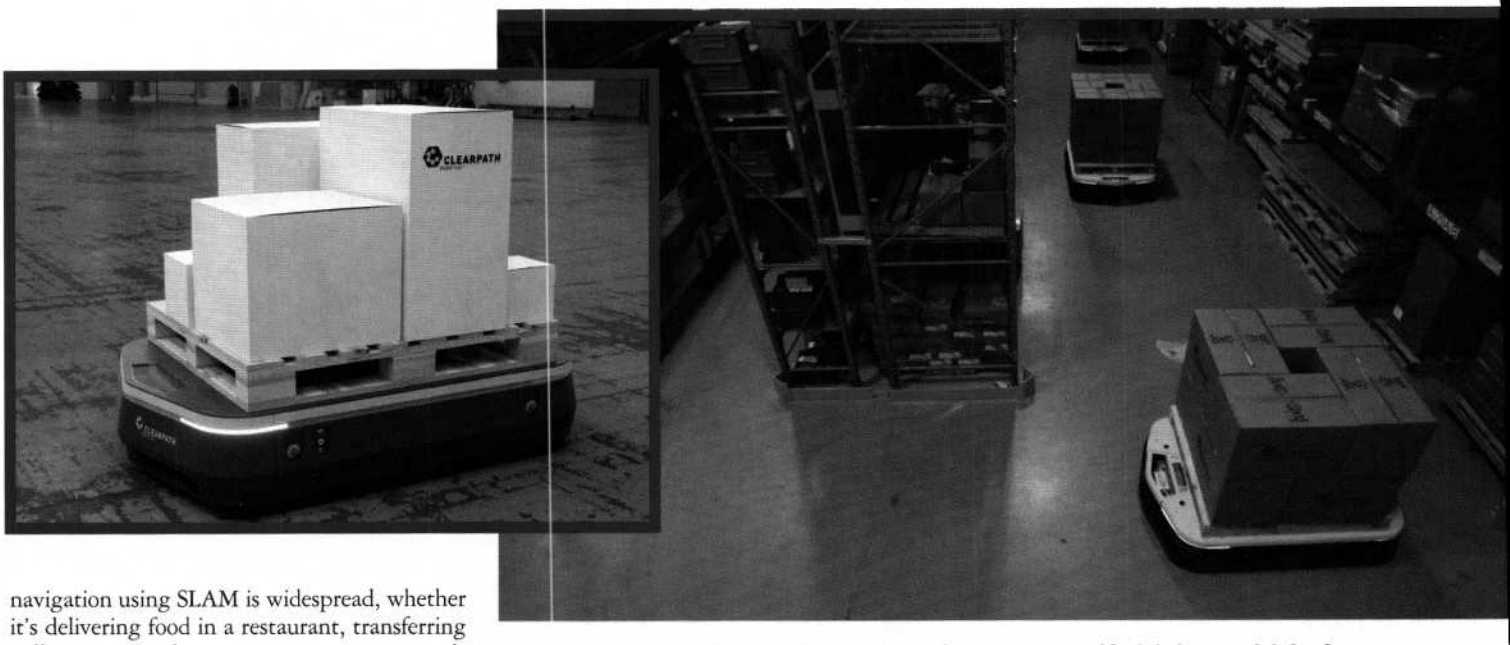
This type of autonomous navigation can be found in Clearpath's OTTO — the self-driving vehicle designed exclusively for material handling. It can be used for heavy-load transport in warehouses and other indoor industrial facilities.

"One example of OTTO is it can dock with a conveyor belt, engage those conveyors to load product onto its deck, and then move to another conveyor belt to unload the product," Gryfe says.

"OTTO can be used in different warehouse processes because it can be outfitted with appliances like a scissor lift or an industrial manipulator for picking up materials."

Gryfe adds SLAM is a disruptive technology, and its impact is similar to the introduction of smart phones from flip phones.

"The opportunity to successfully move material from point A to point B with autonomous




**Clearpath Robotics Inc. has created OTTO, a self-driving vehicle for materials handling that can be used in warehouse environments. *Photos courtesy of Clearpath Robotics Inc.***

navigation using SLAM is widespread, whether it's delivering food in a restaurant, transferring pallets in a warehouse, or even moving towels in a hotel," he says.

## Connect the dots

The number of Internet-connected devices designated with IP numbers around the world is staggering. One estimate by Cisco Systems Inc. suggests there will be almost 23 billion connected devices by the end of 2016, and more than 50 billion by the end of 2020. Over the past few years, those connected pieces of equipment have helped to form what is loosely known as IoT.

The "things" could be almost any "thing" such as home thermostats and cameras; meters to measure energy usage for plants; or sensors to collect data on wind turbines.

But those "things" can also be a devices used to monitor and identify a dairy cow that is in heat or having health problems. The list of possibilities is endless. The key is for those devices to be centrally connected so the data collected can be received and analyzed to make decisions.

For Marc Leroux, a self-described technology evangelist for ABB Inc.'s CPM Technologies R & D division, the IoT certainly has the potential to become a disruptive technology. Yet he doesn't think the necessary total interaction has quite been achieved yet.

"We're still thinking about things as a group of individual technologies," he says.

"They need to be part of a system and not just devices that are monitoring temperature and lights. Right now, there are light control devices you can pick up at local hardware that are called IoT-enabled that allow you turn off your lights by a smartphone. The question is: how does being able to remotely turning off the lights allow it relate to all the other devices in your home?"

Leroux says ABB maintains a strong position when it comes to the IoT, but has expanded its definition of the concept to the Internet of Things, Services and People (IoTSP).

"The things are the sensors and other devices, but they also include the applications — the computing power inside the devices that enable them to all come together," Leroux says.

"That's where the other components come in. The services part is what you do with the devices and the end result you're trying to achieve with them. The people are the ones that are affected by the other two components."

The people to which Leroux is referring are evaluating the IoT on a practical level for an assembly line or factory. Increased amounts of data won't be of value to them unless the data can be used to make decisions.

"How do you justify the purchase of the components to plant managers or the CEO? They are past the point of just wanting to jump on a technology band wagon," Leroux says.

"They're asking, 'what is it going to do for me?' They have to know, for instance, how the information can be used to reduce maintenance costs. That's done by taking the data, putting context to it and using that larger system to bring a true benefit to the company."

If the factory manager doesn't see a bottom-line improvement, he or she is going to resist investing in the IoT because it will be just a buzzword, says Leroux.

"It will be identical to systems he has already been investing in all along," he says. "He'll be asking, 'how is this different from the processing components that I purchased 10 years ago or the SCADA upgrade that we bought? Wasn't I promised results at that time, as well?'"

The mining industry provides an example of implementing an IoT system to achieve real results. Smart devices can be used to collect internal data and utilize them for predictive maintenance for the gearless mill drives used by mines.

"This is not all new technology," Leroux says. "We've been doing this for a long time. But we also have to recognize these technologies have life spans. That's why you'll be seeing a constant evolution from ABB in this area – intelligent and connected devices.

"What we've been saying for the past 20 years is that you have to be able to collect information, analyze and distribute. There's nothing fundamentally different in our approach. What's changed is, we're able to collect more, faster and access more readily."

*About the author: Ernest Granson is a Calgary-based writer and editor, and a contributor to PROCESSWest.*