

## The Robots are Coming



**September 2014:** Rapid advancement in technology is one of the greatest forces reshaping the world. Nanotechnology, biotechnology, neuroscience, genomics, clean technologies, space sciences, smart materials, ubiquitous computers and sensors, artificial intelligence, geoengineering, and information technology are driving innovations that help the world address critical issues such as resource constraints, food security, water access, pandemics, infant mortality, and climate change. They are also the fuel igniting changes in the way we live, work and organize our societies.

Robotics and automation, including use of smart machines and the rise of the internet of things, is entering a new phase as these technologies advance. In its initial stages, this emerging industry of the future has been largely built on passionate researcher and visionary advocates. However, it has become obvious that robotics technology is no longer for the few but a technology permeating our world.

One important reason is changes in global demographics, which are creating imbalances in the global workforce. Despite the fact that the global population projected to grow to 7.6 billion by 2020, many countries are expected to see a decline in the working-age population. In Japan more people are already leaving the labor force than there are people prepared to take over, a challenge that is shared with countries such as the U.S., Russia, Canada, South Korea, China, and many European countries. The healthcare industry, for instance, is already experiencing a lack of healthcare professionals and, according to the [WHO](#), the world will be short of 12.9 million healthcare workers by 2035; today, that figure stands at 7.2 million. The need for more workers in some industries is critical and may be alleviated by technological advances in automation and robotics.

Even though these new technologies can empower individuals, businesses and societies there are fears that the human race, in the long term, will be outnumbered, outdated, and outthought by the next generation of robots and smart machines. In this briefing, based on our forthcoming report, "Industries of the Future: Robotics," we consider:

- How robotic technology is impacting existing industries and markets.
- How innovative robotic technologies could impact jobs and skills required for the future.

How is your organization preparing for an age of robotic workers and smart machines?

### The next wave of the robot revolution

The history of human-invented automation actually dates back to the ancient Greek engineer Hero of Alexandria who produced two texts, *Pneumatica* and *Automata*, which documented the existence of hundreds of different kinds of "wonder" machines capable of automated movement. However, it wasn't until the 1950s that industrial robotics really took off, predominantly in manufacturing industries. Then we had to wait around 50 years for service robots to start to find the way into our

professional and private lives. Generally the world's robot market is segmented into two broad categories: industrial robots and service robots. Industrial robots dominate the market today, but service robots are rapidly gaining market share.

Today, robotics and the associated computing technologies have advanced radically, influencing many aspects of everyday life. Think self-driving trains, assembly line robots, automated fuel pumps, bank ATMs, and self-service checkout lanes. These robots are already taking over jobs that require specific repetitive tasks, and gradually have become more sophisticated.

The next phase of the robotics revolution promises more dramatic advances. Increasingly, robots are able to absorb data, recognize objects, and respond to information and objects in their environment with greater accuracy. This will increase both the number and complexity of the tasks that they can take on – or take over from human workers. Robots are also becoming much less expensive – think about vacuum-cleaner robots – and are finding their way into the home as well as the work environment, driving up interest among ordinary people as well as engineers and researchers.

Robots everywhere is no longer a futuristic vision but part of modern living. As the technologies evolve, our private and professional life will change dramatically – and forward-thinking companies want to be part of the next stages of the revolution. Companies including Google, Amazon and Facebook have shown a keen interest in robotics recently. Google bought more than eight robotic companies in 2013/14 and Amazon and Facebook are following suit.

In many industries we already see dramatic changes driven by emerging robotics technology. Here are just a few examples of how it will impact industries and markets in the near future:

### *The rise of intelligent agriculture*

**The “delicate crop” harvester robot:** One of the big challenges for researchers is designing robots that can be used in fields with delicate crops, e.g. fruit and vegetables. To construct workable robots that do not damage these crops requires integrating advanced sensors, electronics, computer vision, robotic hardware, and powerful computing algorithms, as well as networking and high precision GPS localization technologies. It's a difficult task, trying to replicate human hand-eye coordination. However, harvesting robots are being tested: The Spanish company Agrobot is working with Californian strawberry farmers to develop a strawberry harvester. Experts suggest that it could take up to ten years before this type of harvester will become commercially available for most fresh-market fruits. (Source: [AP](#))

**Weeding and pruning bots:** While delicate harvester robots remain a challenge, researchers have been more successful developing various weeding bots. One is the Lettuce Bot from Blue River Technology that uses video cameras and visual-recognition software to identify which lettuce plants to eliminate with a squirt of concentrated fertilizer that kills the unwanted buds while enriching the soil. The Danish Robovator can be used for selective hoeing in row crops. Digital cameras recognize weeds based on the height of the plant and send a pulse to the hydraulic lines, and the hoeing tools swivel in and out. The gardener can intervene and change settings manually at any time. Frenchman Christophe Millot has created the Wall-Ye bot which is a self-propelled robot for pruning vines, removing young shoots, and monitoring soil and vine health. A similar but less advanced bot, the Intelligent Robotic Vineyard Pruner, has been developed by American Vision Robotics. (Sources: [Business Insider](#), [Modern Farmer](#), [RBR](#))

**Revolutionizing agriculture – drone technology:** The potential of drones has become a hot topic in 2014. Drone technologies, or Unmanned Aerial Vehicles (UAV), are already playing important roles globally, from transporting vaccines to remote parts of South Asia, to assisting game wardens in South Africa's Kruger National Park to protect rhinos from poachers, to military operations. Farming is no exception and drones will, without doubt, play a key role in the future.

While some places, e.g. the U.S. and the EU, are struggling with regulatory issues, drones are already being used in agriculture in countries including Brazil and Japan. Today, drones equipped with cameras and other sensors can survey crops, monitor for disease, and precision-spray pesticides and fertilizers. But the future possibilities are endless: UAVs could be used to scare birds from fields, pollinate trees, do snow surveys to forecast water supply, monitor irrigation, or plant and harvest crops. Farmers believe that such applications could revolutionize agriculture by boosting crop health, improving field management practices, reducing costs and increasing yields. (Source: [Huffington Post](#))

**Teeny-tiny bee bots:** Engineers from Harvard have invented a teeny-tiny bee bot, claimed to be the smallest flying robot ever made. The goals of this RoboBee are many, from autonomous pollination to post-disaster search and rescue. In the UK, scientists from the University of Sheffield are working on an autonomous bee with a more structured goal: mapping the honeybee brain so they can completely synthesize bee behavior — and keep the world's food chain intact. (Sources: [Modern Farmer](#))

### *A robotic future for healthcare*

**Cognitive computing:** [Watson](#), IBM's artificial intelligence computer, has been tested by U.S. clinics since 2013. It has proven to be valid and valuable in the medical decision-making process: [IBM](#) has already trained Watson to help doctors arrive at better individualized cancer diagnostic and treatment recommendations in partnership with [Memorial Sloan-Kettering Cancer Center](#). It has also been trained to help speed up the claims review process with the health insurance company [WellPoint](#). (Sources: [PSFK](#), [Kurzweilai](#), [The Burrill Report](#))

**Robot-assisted recovery and rehabilitation:** The rehabilitation robot market, currently valued at US\$43.3 million, is expected grow dramatically to reach US\$1.8 billion by 2020. (Source: [Wintergreen Research](#)) Interesting inventions are coming from companies such as [Eksobionics](#) which is developing and manufacturing intelligent, powered exoskeleton bionic devices that can be strapped on as wearable robots to enhance strength, mobility, and endurance — offering the potential to enable a paralyzed person to walk. Bionics like these are still at a nascent stage but will continue to play a growing part in rehabilitative therapies.

**Robot surrogates:** Henry Evans was paralyzed by a stroke at the age of 40. Today, he uses head movements and a finger to communicate with a computer using experimental interfaces. Through collaboration with [Georgia Tech](#) professor Charlie Kemp, these interfaces allow Evans to use the [Willow Garage](#) PR2 robot as a surrogate, directly moving the robot's body, including its arms and head. It also lets him invoke autonomous actions, such as navigating in a room and reaching out to a location, e.g., for the first time in ten years he is able to scratch an itch for himself and shave his cheek. While this is only a first step, it demonstrates how people with severe physical disabilities could use personal robots to gain independence. (Source: [TED](#), [Willow Garage](#)). Meet the Robots for humanity [here](#).

**Assistive robotics:** In New Zealand assistive robots have already made their debut. After a successful trial at [Selwyn Retirement Village](#) in Auckland, four healthcare robots have been deployed by [Gore Health](#), a rural community owned hospital, to help reduce costs, save staff time, and improve patients' long-term health. The robots can check a patient's heart rate and blood pressure, alert nurses to a fall, remind users to take medication, or pump out a music video to keep them smiling (Sources: [stuff.co.nz](#), [The New Zealand Herald](#)). The Japanese government, for instance, is reaching out with financial assistance to companies that develop low-cost robots to care for the elderly to offset the country's deficit in nursing care workers.

## The future of robotic warfare

**The human robot soldier:** Think about the Iron Man movie and you will be tuned in to the next big project for the U.S. army. The U.S. army is asking the technology industry, government labs, and academia to help them build an [Iron Man](#) suit or a TALOS (Tactical Assault Light Operator Suit) that could give troops “superhuman strength.” According to Lt. Col. Karl Borjes, a science adviser at the U.S. Army's research, development and engineering command the requirement for the project is “a comprehensive family of systems in a combat armor suit where we bring together an exoskeleton with innovative armor, displays for power monitoring, health monitoring, and integrating a weapon into that.” The aim: To get it out in the field in three years! (Source: [BBC](#)).

**Killer robots:** Rapid advances in technology are also making it possible to build fully autonomous weapons to deploy in war zones instead of human beings. Autonomous, weaponized robots are no illusion, but are thriving even though the technology is not yet fully developed. Whilst the army doesn't see these robots replacing the foot soldier, it does see them becoming members of the squad working alongside the humans. Even as military planners prepare for a future of robotic warfare, in 2012 Human Rights Watch called for a pre-emptive ban on autonomous killer robots “before it's too late.” Robots are clearly able to collect and process vast quantities of data in a short amount of time, while also being extremely mobile and difficult to destruct. However, when used for attack, campaigners argue that robots do not possess the ability to distinguish between civilian and non-civilian targets, claiming that drones have already killed hundreds of innocent civilians. (Source: [The Telegraph](#)) What will happen if countries rethink the rules of war, leading to a robotic arms race?

**Future applications for military and civilian uses:** There is no lack of imagination when it comes to developing future military robots. Already in Afghanistan the U.S. military has used more than 2,000 robots, beyond drones, to transport gear, navigate rough terrain, monitor remote areas, and search for roadside bombs. The benefit is that they may also be used for civilian applications in emergencies and for security. Meet some of the robots under development or starting to be deployed here: (Source: [Informationweek](#))

- **The four-legged robot Cheetah:** Was named the “fastest robot in the world” by setting a record of 18 mph. Cheetah is just one of the so-called “legged squad support system” robots being developed, with potential for domestic police work.
- **SAFFiR** (Shipboard Autonomous Firefighting Robot): Is a human-sized mechanical firefighter able to walk and climb, feature a gas sensor and infrared camera to see through smoke, and be programmed to receive commands wirelessly from a remote controller.
- **Big Dog** became something of a YouTube sensation when a video showed its human developer kicking it in the side as it strode around the lab. Big Dog staggered but stayed upright and a robo-star was born. Big Dog and its two siblings, Alphadog and Littledog, together represent the army's effort to develop robotic replacements for the pack mule.
- **RHex:** Is a six-legged, 30-pound, crawling robot inspired by a cockroach. With its sealed body it can climb in rock fields, mud, sand, and vegetation, across railroad tracks, up telephone poles, slopes, and stairways. It is controlled remotely at distances up to 700 meters, and infra-red cameras and illuminators provide front and rear views from the robot.
- **Sand Flea:** Another insect-inspired development, this rolling robot can jump up to 30 feet high, over walls, or onto rooftops.
- **Recon Scout:** Can be thrown into any environment, from which it transmits real-time video to help examine vehicle undercarriages, inspect bunkers and caves, and evaluate suspected IEDs.
- **Petman:** Is “the first anthropomorphic robot that moves dynamically like a real person.” It can walk upright or crawl on all fours, and was demonstrated doing push-ups. Petman already has a big brother by the name of Atlas.

### *The future of smart warehousing and logistics*

**Swarm intelligence:** At the Fraunhofer Institute for Material Flow and Logistics (IML) in Dortmund, Germany, researchers are working on a project to develop autonomous warehouse vehicles using the movement of ants. Though an ant is not particularly clever on its own the insect can solve complicated tasks in a community. The researchers intend to put this “swarm intelligence” to use in autonomous vehicles that go by the name Multishuttle Moves® as a means of improving the flow of materials and goods in the warehouse and logistics sector. (Source: [Fraunhofer](#))

**The worker robot:** Indian-based start-up Grey Orange Robotics is building worker robots and assistance systems for warehouse automation. To date it has developed two products. The Butler system is the company’s flagship product, a materials handling system made up of small robots that traverse on a grid of paths across the warehouse floor to fetch racks of items for the packer. Once the packer removes the item and packs it for shipping, the racks are replaced by the robots. The second product is the Sortation System, an automated sorting, scanning and weighing system that sorts and diverts packets to the designated delivery vendors. (Source: [Medianama](#))

**Delivery drones:** Are delivery drones the new unmanned [UPS](#) trucks of the skies? Delivery drones have been used by the U.S. Marines for years so the technology itself is not new. However, as online shopping becomes increasingly popular and the streets more crowded with delivery trucks, drones could be a viable alternative to traffic congestion, making delivery more efficient and sustainable. [Domino’s Pizza](#) has already developed the DomiCopter for [drone pizza delivery](#), while [Amazon’s](#) Jeff Bezos has hit the news with his drone delivery ideas. However, he does point out that drone delivery will be years away at least in the U.S. (and in Europe we suggest) due to strict air traffic control regulations, although the company is reported to be starting tests in India. Delivery drones have been spotted in China where local businesses are not subject to such strict aviation regulations. (Sources: [Wired](#), [TechCrunch](#)).

**Cart pushing robots:** Aethon’s TUG is a robotic system that takes care of moving basic supplies like medication carts, linens, or food around a facility, moving through corridors as scheduled to make deliveries. It is a job that can actually cost up to US\$4 million a year in a U.S. 300-bed facility. The company claims one such unit working two shifts daily would end up costing less than one full-time employee while doing the work of nearly three. (Source: [Wealth Daily](#))

### **When the robots come, what will happen to our jobs?**

Robots have already changed our lives in so many ways and for so for many years that sometimes we don’t even think of these changes as due to robotic technology. In the future we will most likely not question that robots: write our news, take our blood pressure, are inserted in/as a part of our body for healthcare purposes, teach our children social skills, mathematics or biology, serve us food and drinks in restaurants, help our elderly carry groceries and keep them company, pick our fruit and vegetables, build our roads, and fight our wars. Robots will work alongside human beings in everyway possible way.

Nonetheless, as robotics technologies advance rapidly, many people are questioning the use and safety of robots. For some, the thought of robots being a part of everyday live is still a little “sci-fi.” Equally, a lot of attention is focused on how robots will take away jobs, making even more people jobless as well as hurting job growth. Yes, the truth is that robots will take our jobs away, something they have actually already done for some while – they take away unsafe, backbreaking, repetitive and boring jobs, freeing up humans’ capacity to do more interesting and less physical strenuous jobs. More importantly, as robots take on more jobs, we hopefully will dream up new jobs just as humanity has done for decades.

Let’s sum up some of the discussions and data around robots and jobs.

	<b>Robots-as-job-creator/booster</b>	<b>Robots-as-job-killer</b>
Who?	Debate includes robotics manufacturers, industry lobbyists, some futurists, and the many companies (e.g. Amazon) that use robots.	Debate includes economists, those on the left of the political spectrum, and concerned futurists.
Basic points?	<ul style="list-style-type: none"> <li>• Only companies that embrace robotics will survive.</li> <li>• Robots will take jobs that humans don't want or shouldn't do.</li> <li>• Robotics will create new industries that will in turn create new jobs.</li> </ul>	<ul style="list-style-type: none"> <li>• Robots will crush their human competition.</li> <li>• Robots will become so intelligent that no job will be safe.</li> </ul>

(Source: [Fast Company](#))

### **Robotics as a job-creator/booster**

- One advocate of robots-as-job-creators is [International Federation of Robotics](#) revealing in a report that the direct employment rate due to robotics is 4 to 6 million jobs created in world manufacturing through 2011. This represents 3 to 5 jobs created per robot in use. Indirect employment created through 2011 as a result of robots increases the overall number to 8 - 10 million jobs. The report also projects that 1.9 to 3.5 million jobs will be created by robots between 2012 and 2020.
- [WANTED Analytics](#) has analyzed the quantity and type of job ads searching for robotics skilled professionals, suggesting that the demand for robotics skills in the U.S. has increased 13% year-over-year, from 2012 to 2013. Some 45,000 jobs for robotics skilled professionals were advertised online during 2013. However, there is great disparity of intended hiring depending on the industry, e.g. healthcare jobs accounted for 35% of robotics hiring demand with 16,000 positions, surpassing demands for tech and engineering occupations.

### **Robotics as a job-killer**

- As workplaces become more automated the fact is that robots and computers are taking over a growing number of tasks. The question being asked more and more often is whether technology is to be blamed for stubbornly high unemployment rates. For instance, a recent study from [Oxford University](#) suggests that nearly half of U.S. jobs are at risk of being taken over by computers as artificial intelligence improves.
- Knowledge-based jobs have long been regarded as a safer career choice than manual jobs when taking advances in technology into consideration. However, it is highly believed technological advancements will in the future increasingly challenge high-skilled professions such as doctors and lawyers as well as more traditionally middle-class careers such as administrators, bookkeepers and secretaries. In 2012, Silicon Valley investor Vinod Khosla predicted that algorithms and machines would replace 80% of doctors within a generation. (Source: [The Guardian](#))

## **In October: Look out for trends in action on Waste: Avoiding, Managing or Designing It Out**