Industry Classification for Robotics and Automation

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This Industry Classification for Robotics and Automation companies is used to support the ROBO Global Robotics & Automation Index Series

ROBO Global® Database - ROBO Global created and maintains a unique database of companies across the globe that have a portion of their business and revenue associated with with robotics, automation and enabling technologies. Our database has well over a decade of history and captures the entire value chain of end-user solutions, products, and key enabling technologies. At ROBO Global, our exclusive focus, combined with our access to a unique coverage team of disruptive technology industry experts and financial professionals, allows us to identify, research, and often meet with potential database members.

ROBO Global Industry Classification - In the absence of a benchmark industry classification system for identifying companies engaged in the global robotics and automation industry, in 2013 we created the ROBO Global Industry Classification. Designed for the investment and research community, the Industry Classification currently identifies twelve subsectors of the robotics and automation theme that present a suitable level of product and technology maturity to carry high growth and returns potential. Insights from our Strategic Advisory Board have confirmed that each of these twelve subsectors is positioned well to evolve and expand to support the growth of the global robotics and automation industry.

The ROBO Global Industry Classification is maintained by the ROBO Global Industry Classification Committee, which convenes at least once each quarter and engages in regular dialogue with the ROBO Global Strategic Advisory Board.

Please visit www.roboglobal.com/about-us/ for further information.

Membership Qualification

To qualify for membership in the ROBO Global Industry Classification, companies must pass through the following multi-step screening process:

1. Companies must be included in the ROBO Global Database.
2. All non-publicly traded companies are excluded.
3. If a company's product, technology, services, or business model do not fit into one of the identified subsectors, then they are excluded. Each of the subsectors is discussed later in this document.
4. Companies must have a minimum threshold of revenue related to the theme. If a company falls below this threshold, it is excluded.
5. Within their specific subsector, companies must be in a position of market and technology leadership.
6. Companies that do not pass the ROBO Global ESG Policy are excluded. For full details of our ESG Policy please contact info@roboglobal.com or visit www.roboglobal.com/esg-policy/.

Eligible companies seeking inclusion in the ROBO Global Industry Classification System or that seek to be classified in a different subsector should apply in writing to info@roboglobal.com.

Subsector Descriptions: Robotics and Automation

All companies classified under the robotics and automation sub-sectors will be further classified as either **"bellwether"** or **"non-bellwether"; "**Bellwether" companies (also referred to as "pure plays") are well-established, leading companies whose core business is directly related to robotics and automation. Typically, these companies operate on a global scale. "Non-bellwether" companies have a distinct portion of their business and revenue in robotics and automation and exhibit the potential to grow within this space through innovation and/or market adoption of their products and/or services.

A description of each of the twelve robotics and automation subsectors within the current ROBO Global Industry Classification is provided below. Companies within these subsectors are identified as "Technology" companies or "Applications" companies:

- **"Technology"** captures all companies that manufacture or provide services related to machinery, equipment, devices, or sensors that support a robot performing a task. It also includes companies that provide key enabling software and processing technologies used to advance the conversion to autonomous systems. Essentially, we are looking to identify the companies that enable robots to sense, process, and act.

- **"Applications"** identifies companies that incorporate multiple robotic and automation technologies into their product or manufacturing process to improve efficiency in traditional business lines, as well those that are developing entirely new business propositions within the theme.

Companies are further sub-classified into the following twelve subsectors under either Technology or Applications. The number of subsectors is expected to increase as the robotics and automation industry continues to evolve.

Technology:	**Applications:**
• Sensing • Computing, Processing & AI • Actuation • Integration	• Manufacturing & Industrial Automation • 3D Printing • Logistics Automation • Food & Agriculture • Surveillance / Security • Energy • Healthcare • Consumer Products

Sensing - In order for a system to exhibit autonomy and determine its own internal state, it must be able to sense its environment. This is referred to as exteroception and proprioception. For robotic systems, this level of sensing is important for the same reasons that exteroceptive senses (sight, sound, etc.), and proprioceptive senses (ability to know where our limbs are and what they are doing without directly observing them) are important for human beings—they enable us to perceive the world around us. Robotic systems, however, are not limited to the

standard senses. In robotics, a sensor can be developed to detect almost anything that can be measured.

Computing, Processing & Artificial Intelligence – Autonomous systems must make decisions at various levels, from determining the state of the environment they are operating in to optimally planning actions and controlling motion. It is analogous to our brain and it is what allows the processing of information that produces actuation to take place. Accomplishing this in an autonomous robotics system requires raw computing and processing power, as well as increasingly advanced software. Computing can vary from embedded systems smaller than a fingernail to hyper-scale datacenters implementing sophisticated algorithms—including artificial intelligence (AI). Advancements in AI, especially machine learning, are key to the growth of autonomous systems. The main advantage of AI over human intelligence is its high scalability, resulting in significant cost savings. Other benefits include AI's consistency and rules-based programs, which eventually reduce errors. AI's longevity coupled with continuous improvement and new growth opportunities are the reasons why AI is drawing wide interest.

Actuation - Actuation is the means by which machines interact with the physical world. For human beings, this mainly refers to our limbs and, in particular, our hands. Machines, however, are not limited to manipulation. Almost anything that has an effect on the physical world can be made into an actuator. Actuation techniques include electric, hydraulic (compressed fluid), mechanical, and pneumatic (compressed air).

Integration - An autonomous system is made of up many components (sensors, actuators, and computational units), which can be distributed over large spaces. Integration consists of architecting a system to determine how components work together to achieve a defined objective in a robust, high performance, and cost-efficient way.

Manufacturing & Industrial Automation - Factory automation is an increasingly critical success factor in manufacturing as businesses pursue higher productivity and lower costs in the face of global competition. Automation also means workplace safety, as well as freeing workers from tedious manual labor to focus on strategic, high-level tasks that require human expertise. While the automotive industry was the first to deploy robotics and automation, many other industries are still in the early stages of adoption, offering significant growth potential.

3D Printing - Traditionally, things are built either by assembling separate parts together or by removing material from a larger work-piece. 3D printing (also called “additive manufacturing”) adds yet another way of building by depositing different types of materials where they are needed. One of the primary benefits of 3D printing is the potential for customization that is not economically feasible with traditional techniques.

Logistics Automation - The logistics and warehouse automation industry is at an inflection point as the boon in e-commerce continues to dramatically raise the bar for supply chain efficiency. From autonomous mobile robots and advanced storage systems to track & trace technologies, logistics automation enables increasingly speedy, safe, and error-free distribution, a shorter time-to-market, and ultimately lower costs to businesses and consumers.

Food & Agriculture - Feeding and sustaining the world continues to be one of our most important economic activities. A new generation of autonomous systems and data analytics tools are bringing the benefits of traditional automation, such as precision and the elimination of rote labor, to this domain. For example, precision agriculture offers the potential to greatly reduce costs and minimize our environmental footprint by applying water and fertilizer on an as-needed basis. Meanwhile, the food processing industry continues to automate aggressively to meet increasing demand for greater volume, lower costs, and more stringent safety requirements.

Security & Surveillance - Removing people from harm's way has always been one of the main drivers for robotics research. However, mimicking humans' ability to identify and manage threats via automation has been a major challenge due to the high level of flexibility and cognitive skills that humans possess. Using new capabilities offered by today's technologies, this is changing rapidly. Unmanned aircraft and ground vehicles are now able to detect hazardous materials, dispose bombs, operate in space, and perform critical national defense functions (surveillance).

Energy - Exploration, extraction, and maintaining the energy infrastructures requires extensive and growing resources. As robotics and automation continues to expand from structured environments (warehouses, factories, etc.) to unstructured environments (the outdoors, underground, and in oceans), the energy sector will reap the rewards of this transition, with the key benefit being much lower operational costs.

Healthcare - As healthcare costs continue to rise globally, robotics, automation, and AI is poised to provide a countering force to this trend. Using robotics and autonomous systems in areas including rehabilitation, diagnostics, exoskeletons, and care for the elderly promises to drastically reduce costs and improve the quality of life for many people. In addition, as in all other application areas, robotics and automation can enable new capabilities that transcend cost cutting, such as the use of robots for many types of precision medicine, including surgeries on the tiniest elements of the heart and lung, and neurological treatments.

Consumer Products - Robotics and AI have officially entered the home, enhancing our toys, games, and household cleaning devices, and automating many household tasks. The Internet of Things (IoT) promises to usher in a new area of interconnectivity of consumer products. By communicating through the existing internet infrastructure, devices will no longer be isolated islands of limited capabilities. This shift will dramatically reduce the cost of robotics and AI-enabled consumer products, resulting in a significant increase in adoption.