ROBOGLOBAL®

ROBO Global Database & Classification of Companies

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ROBO Global® Database - ROBO Global® created and maintains a unique database of companies across the globe who have a portion of their business and revenue associated with robotics and automation. Our database has well over one decade of history and captures the entire value chain of robotics, automation, artificial intelligence and other enabling technologies specific to the industry.

ROBO Global® Industry Classification- In the absence of a benchmark industry classification system for identifying companies engaged in the global robotics and automation industry, the ROBO Global® Industry Classification was created by ROBO Global® in consultation with industry experts from our Advisory Board. The ROBO Global® Industry Classification has identified sub-sectors of high relevance and high growth to the robotics and automation Industry and will expand overtime. These sub-sectors are intended to capture companies throughout the "production value chain". The production value chain includes not just the manufacture of physical robots but also the software, technology and artificial intelligence that enables the automation.

A summary of the tiered approach to Industry Classification is provided below:

Tier 1 - In the first instance, the Classification Committee aims to identify publicly listed companies (globally) from the ROBO Global® database that derive a substantial or a material and growing proportion of their revenues from robotics-related and/or automation-related products and/or services.

Tier 2 – sub-classification as "bellwether" or "non-bellwether": *"Bellwether"* are well established leading companies, whose core business is directly related to robotics and automation, typically they will operate on a global scale. These companies are also referred to as "pure plays". *"Non-bellwether"* companies have a distinct portion of their business and revenue in robotics and automation and the potential to grow within this space through innovation and/or market adoption of their products and/or services.

Tier 3 – sub-classification of sectors: Companies within the ROBO Global® Industry Classification are organized into several sub-sectors which are expected to increase in number as the robotics and automation industry continues to evolve. Currently, the Classification Committee has identified the following 12 sub-sectors within the ROBO Global® Industry Classification which can be easily bifurcated into either Technology or Applications.

- **Technology** - captures all index companies that manufacture or provide services related to any machinery, equipment, devices or sensors supporting a robot performing its task. It also

includes those companies that provide key-enabling software and processing technologies used to advance the conversion to autonomous systems. Essentially, we are looking at the companies that enable robots to sense, process and act.

- **Applications -** highlights all index companies that incorporate multiple robotic and automation technologies into their product or manufacturing process to improve efficiency in traditional business lines as well the development of entirely new business proposition

Companies are further sub-classified into the following 12 sub-sectors under either Technology or Applications, the number of which 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

Companies who believe they are eligible for inclusion in the ROBO Global® Industry Classification System under the rules above, or that they are more appropriately classified in a different subsector, should apply in writing to the Index Management Committee, care of ROBO Global®.

Please refer to www.roboglobal.com for more information relating to the ROBO Global® Industry Classification.

Sensing - In order for a system to exhibit autonomy, it must be able to sense its environment, in addition to determining its own internal state. For human beings, these are called exteroception and proprioception. Sensing is important for the same reasons that our exteroceptive senses (sight, sound, etc.), and our proprioceptive senses (ability to know where our limbs are and what they are doing without directly observing them) are important for human beings. For robotic systems, however, we are not limited to the standard senses. Almost anything that can be measured can be made into a sensor.

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 is what allows the processing of information to produce actuation to take place. This 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). Machines are getting smarter, as AI becomes increasingly pervasive. 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, but for machines, we 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 – figuring out how to put all of these components together – in order to achieve a desired 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, freeing workers from tedious manual labor to focus on strategic, high-level tasks that really use their expertise. While the automotive industry was the first to deploy robotics and automation to a large extent, 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 adds yet another capability by depositing different types of materials where they are needed. One of its main benefits is the potential for customization that is not economically feasible with traditional techniques, also called additive manufacturing.

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

Food and 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 to greatly reduce costs – and in the process lower our environmental footprint – by applying water and fertilizer on an as-needed basis. Meanwhile, the

food processing industry continues to automate aggressively to meet increasingly demanding volume, cost and safety requirements.

Security & Surveillance - Removing people from harm's way has always been one of the main drivers for robotics research. This has been a very difficult problem, due to the flexibility and cognitive skills that humans possess, and that up until recently, have been difficult to duplicate with automated means. With the new capabilities offered by today's technologies, however, this is rapidly changing with unmanned aircraft and ground vehicles now able to detect hazardous materials, dispose bombs, operate in space and perform critical national defence functions (surveillance).

Energy - Exploration, extraction, and maintaining the energy infrastructure operational require extensive, and growing, resources. As robotics and automation continues to expand from structured environments -- such as warehouses and factories -- to unstructured ones - such as outdoors, underground, and in the oceans – the Energy sector will reap the rewards of this transition, with the main benefits being much lower operational costs.

Healthcare - As healthcare costs continue to rise globally, robotics and automation is poised to provide a countering force to this trend. Using robotics and autonomous systems in areas ranging from 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 difficult surgeries and neurological treatments.

Consumer Products – These are companies that produce robots in the areas of toys, games, interactive robots, household cleaning, and other tasks done at home that can be automated. The Internet of Things promises to usher in a new area of interconnectivity. By communicating through the existing internet infrastructure, devices will no longer be isolated islands of limited capabilities. This impact will be particularly pronounced for these type consumer products, which need to be inexpensive for wide adoption. Through the internet, robotics and automation will finally become broadly affordable to individuals.