

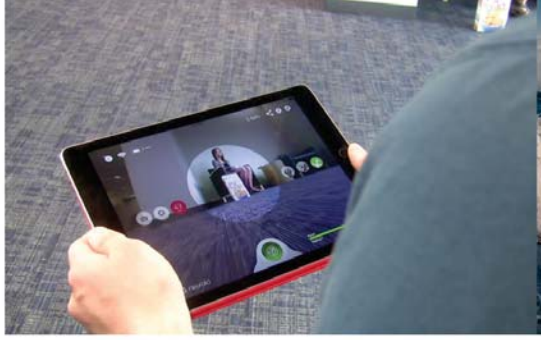

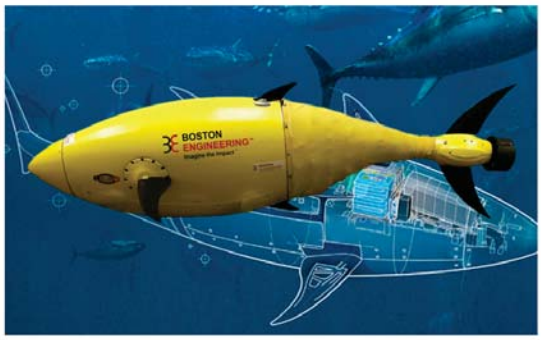

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THE MASSACHUSETTS
ROBOTICS CLUSTER

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TECHNOLOGY
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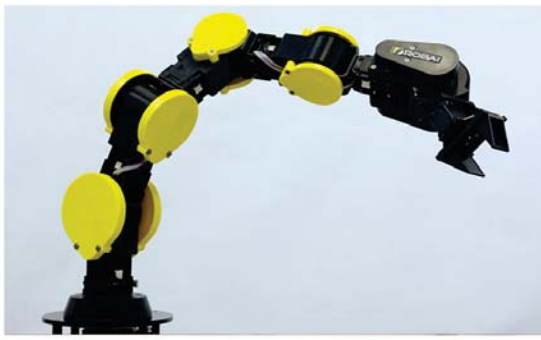






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2. EXECUTIVE SUMMARY

2.1. ROBOTS AND ROBOTICS TECHNOLOGIES ARE FOUNDATIONAL

Robots are mechanical devices that sense, think, and act in the physical world, often autonomously. It is the physicality inherent in robotics systems that differentiates the technology from software, although it is increasingly powerful software that allows robots to physically interact with, move through, and modify their environments. These capabilities set robots apart from most other computerized or automated systems, allowing them to take on a wide range of functional roles in the workplace, public places, the home, and more, with an operational sphere that includes air, sea, and land, and even deep space.

Robotics is a foundational, technology-based capability that can be applied across many industries and markets.

Robots and robotics technologies are increasingly characterized as the physical instantiation of artificial intelligence (AI). In terms of an innovation driver, it might better serve to think of robotics as a foundational, technology-based capability that can be applied across many industries and markets.

2.2. ROBOTS AND ROBOTICS TECHNOLOGIES ARE TRANSFORMATIVE

For advanced economies, innovation is the most critical determinant of long-term competitiveness, and is responsible for the majority of productivity and *per capita inc*ome growth in regions, states, and nations. But it has been technological innovation that has proven to be the most transformative, creating entirely new products, services, and industries, and as a result, generating increasing levels of economic activity for extended periods of time. Robotics is no exception, particularly as systems become increasingly interconnected to each other and the world around them, using and sharing a broad spectrum of intelligence, and becoming increasingly more capable and autonomous in the process. The sectoral multiplier effect of robotics is substantial.

Technological innovation, robotics technologies included, is transformative, and capable of generating increasing levels of economic activity for extended periods of time.

2.3. STRONG, CONTINUED GROWTH FOR INDUSTRIAL ROBOTS

Business drivers and political/social drivers, in combination with technological advancements, have greatly accelerated the use of industrial robots. In 2014, 229,000 industrial robot systems were sold worldwide, up 29% over 2013 and accounting for approximately US$32 billion in revenue when services are included (International Federation of Robotics (IFR), 2015-1). It is estimated that in 2018, 400,000 industrial robots will be sold worldwide.

More than US$30 billion was spent on industrial robots in 2014.

2.4. MASSACHUSETTS COLLABORATIVE ROBOTICS MARKET LEADERSHIP

One recently developed industrial robotics sub-segment, collaborative robots, is very active at this time, with Massachusetts-based firms acting as market share and mindshare leaders. Collaborative systems are human scale, easy to set up and program, and capable of being used by workers with a wide range of qualification levels. The collaborative robotics sector is expected to increase roughly tenfold between 2015 and 2020, reaching more than US$1 billion from approximately US$95 million in 2015. Universal Robots, a subsidiary of North Reading, Massachusetts-based Automated Test Equipment (ATE) supplier Teradyne, is the collaborative robotics market leader. Boston's own Rethink Robotics is also a key collaborative robotics supplier.

Massachusetts companies are strongly positioned in the rapidly growing collaborative robotics space.

2.5. IROBOT LEADS IN CONSUMER ROBOTICS

Consumer robotics, robots, or robotics technologies purchased by individuals that educate, entertain, or assist, often in the home, have sold in the millions and continue to exhibit strong growth, yet have only begun to scratch the surface in terms of market penetration. In 2015, the consumer robotics sector was responsible for shipments reaching approximately 33 million units, resulting in revenue of US$3.5 billion. By 2025, total shipments are forecast to increase to 165 million and total revenue to more than quadruple, reaching US$17 billion.

iRobot is the market leader for the consumer robotics sector with more than 15 million of its Roomba robotic vacuums sold. The Bedford-based firm has over 475 employees working in the State. Another Massachusetts-based consumer robotics firm, early-stage startup Jibo, has attracted more than US$38 million in investment. Jibo's primary offering, also named Jibo and based on years of Massachusetts Institute of Technology (MIT) research, exemplifies an entirely new class of consumer product and one with high expectations: social robots. Jibo will become available for sale in 2016.

Massachusetts-based iRobot (14 million Roombas sold) dominates the consumer robotics sector with more than 60% market share of robotic floor cleaners.

2.6. MASSACHUSETTS STRONG IN KEY SERVICE ROBOTICS MARKETS SEGMENTS

Massachusetts robotics cluster member companies are recognized internationally as leaders in key service robotics markets. For example, 90% of the mobile ground robotics supplied to the U.S. military were developed by Massachusetts-based companies QinetiQ North America and iRobot (now Endeavor Robotics). The State also leads the world as a source of mobile robots for retail e-commerce logistics, critical technologies in support of the US$1.2 trillion worldwide retail e-commerce market. Amazon Robotics alone has fielded more than 30,000 mobile robots for e-commerce logistics work.

Amazon Robotics alone has fielded more than 30,000 mobile robots for e-commerce logistics work.

Massachusetts is widely acknowledged as a leading, if not the foremost, international center for the development of unmanned underwater vehicles (UUVs), a market expected to reach US$4.6 billion by

2020, up from US$2.2 billion in 2015. The same holds for advanced manipulation technologies and healthcare robotics solutions. CyPhy Works and other firms produce commercial small unmanned aerial systems (UAS), a market that will surpass US$8.4 billion by 2018, up from US$2.8 billion in 2014, according to ABI Research.

Massachusetts is the leading center for UUV development.

More than 2,100 workers in Massachusetts develop service robotics products and technologies, which resulted in US$576 million in revenue attributed to the companies employing them.

2.7. SKYROCKETING INVESTMENT

Private sector investment in robotics companies increased dramatically in 2015. Approximately US$1.5 billion was invested in companies producing robotics technologies and products, or offering services, a dramatic increase over the previous year. Massachusetts-based companies received US$190 million in private investment in 2015, representing 23% of the total funding to U.S. firms, exceeded only by California, a state with a population more than five times that of Massachusetts. The Commonwealth can also boast of a venture capital (VC) community second only to Silicon Valley/San Francisco for technology investments. The City of Boston itself is one of the top three VC investment hubs in the world overall, accounting for more than US$3.1 billion in outlays (Florida and King, 2015).

Massachusetts-based robotics firms attracted approximately US$190 million in private investment in 2015. Both on a per capita basis and in terms of real dollars, Massachusetts attracts a disproportionally larger amount of private robotics investment than other regions.

2.8. ROBOTICS CLUSTER SUBSTANTIAL AND GROWING

To eliminate ambiguity, reduce subjectivity, and increase the accuracy of both the current and future cluster assessments, it is necessary to define cluster membership as formally as possible. To do otherwise reduces the value of the current exercise, making cluster monitoring and analysis, as well as comparisons to other regional robotics clusters, more difficult, costly, and error prone. For this study, cluster membership was limited to those entities that met the following requirements:

- **Headquarters:** Commercial cluster members should be headquartered in the Commonwealth, or have an office in the State that is a major subsidiary or regional division office.
- **Primary Robotics Cluster:** The focus of this report is the primary robotics cluster which consists of over 97% of all robotics companies in the State (see Appendix H). Formally defined, the primary robotics cluster consists of the concentration of localized, mutually supportive businesses found within 50-mile radius of Boston and Cape Cod. The robotics companies outside this area lack the critical mass and concentration to form another regional robotics cluster.
- **Revenue or Support:** Commercial cluster companies must derive approximately 35% or more of their revenue from robotics products, enabling technologies, or services, or a robotics division or subsidiary within a larger firm must do the same. Exceptions are made for startups without revenue, as well as larger firms evaluating robotics opportunities or supporting the cluster in other ways.

- **Universities and Labs:** Massachusetts-based private and public university research laboratories; national laboratories, and testing centers; or private, non-profit laboratories with currently active robotics research programs or initiatives are cluster members.

The Massachusetts robotics cluster is mature, substantial, and growing. Using the formal cluster definition given above, the cluster includes 122 commercial companies, which employ approximately 4,716 individuals. The average yearly salary for the various classes of engineers employed for robotics development in the Massachusetts robotics cluster region is substantial, and higher than for the United States as a whole (see Appendix D). These commercial firms generated US$1.6 billion in revenue for robotics products, technologies, and services in 2015.

It should be noted that a significant number of businesses do not qualify using this formal definition. Some are not geographically proximal to the Boston robotics hub, including companies in Western Massachusetts, New Hampshire, and Rhode Island. Others do not develop robotics products or technologies per se, but support the cluster indirectly with a variety of business services. Examples include design firms, public relations companies, marketing and engineering services providers, and more.

The Massachusetts robotics cluster is not reliant on a single, large industry.

As a whole, the Massachusetts robotics cluster is not reliant on a single, large industry, and therefore is at a reduced risk from the effects of a sector downturn. Manufacturing was the largest single target industry for Massachusetts robotics cluster members' products and services, followed by the healthcare and warehouse/distribution sectors. The State is also strong in the defense and consumer sectors.

2.9. NEW ROBOTICS BUSINESS FORMATION

Approximately 61% of robotics cluster member companies were formed since 2000.

New robotics businesses are being created in the State at a steady rate, especially over the last decade. Between 2011 and 2015, 33 new robotics businesses were created, up 57% from the previous 5 years, which itself was an increase of 31% over the preceding 5 years. Approximately 61% of robotics cluster member companies were formed since 2000.

Table 1: The Massachusetts Robotics Cluster at a Glance

Number of Commercial Companies	122
Number of Company Employees	4,716
2015 Revenue	US$1.6 billion
2015 Private Equity Investment	US$190 million
New Business Formation 2011 to 2015	33 companies
Research Laboratories and Testing Centers	17

(Source: ABI Research)

2.10. EXITS AND ACQUISITIONS

The approximately 122 robotics firms located in Massachusetts speak to a booming Bay State robotics sector, as does the 33 robotics companies formed within the last 5 years alone. So, too, do the number of mergers and acquisitions of robotics companies. For example, in April 2015, North Reading, Massachusetts-based ATE supplier Teradyne acquired Universal Robots for US$285 million. The Denmark-based and privately held Universal Robots is far and away the leading seller of the new generation of collaborative robots, advanced systems that can work safely and efficiently in close proximity to human co-workers. Conversely, in March 2012, Amazon acquired North Reading-based Kiva Systems, for US$775 million in cash, a 7X plus multiple on Kiva revenue and Amazon's second-largest acquisition at the time. Kiva Systems is joined by suppliers of UUVs, such as Bluefin Robotics and Hydroid, both of which were acquired and now operate as subsidiaries to General Dynamics Mission Systems and Kongsberg Maritime, respectively.

In March 2012, Amazon acquired North Reading-based Kiva Systems, for US$775 million in cash, a 7X plus multiple on Kiva revenue and Amazon's second largest acquisition at the time. Amazon Robotics currently employs over 600 workers in Massachusetts and is actively hiring at this time.

2.11. EDUCATION AND RESEARCH ARE KEY ASSETS

Massachusetts is home to a collection of leading, world-class universities and research centers, such as MIT, Harvard University, Worcester Polytechnic Institute, the University of Massachusetts, Boston University, Northeastern University, and many more. With respect to robotics, this collective asset is unequaled in the world. These institutions and others are the primary source for the Commonwealth's greatest asset: its educated workforce. They are also home to cutting-edge pure and applied research, which is the basis for robotics innovation (see Appendix C). The State is also home to the New England Robotics Validation and Experimentation (NERVE) Center at the University of Massachusetts Lowell, one of only three robotics test facilities sanctioned by the National Institute of Standards and Technology (NIST).

The State's universities and research centers are the source of its educated workforce, as well as the pure and applied research that undergirds robotics innovation and commercialization.