

## 8. GUIDANCE AND RECOMMENDATIONS

*If you were to ask me, "From all the data you have studied so far, where will the next economic breakthrough come from?" my answer would be: From the combination of the forces within big cities, great universities, and powerful local leaders."*

*—Jim Clifton, CEO of Gallup*

The Commonwealth of Massachusetts has had great success developing and implementing policies that have facilitated and stimulated the growth of many different technology sectors over the years. In particular, the medical device, pharmaceutical, and biotech sectors have enjoyed substantial advancement and growth, leading Massachusetts to become one of the few prominent technology hubs in the world. The robotics industry shares some of the same characteristics and fundamentals as the life sciences technology sector, such as R&D processes that require substantial initial investments, specialized facilities and infrastructure, and a highly skilled and educated workforce.

The growth and success of life sciences industries in Massachusetts offers a blueprint for policy makers to identify and adopt similar programs and initiatives for the robotics industry that have been fundamental in the advancement of life sciences-related sectors. Yet, it is also vital to recognize that the robotics industry poses very unique economic and societal opportunities and challenges unlike any other technology, therefore requiring new unique initiatives, innovative practices, and sector-specific programs.

### 8.1. MASSACHUSETTS ROBOTICS CLUSTER

The Massachusetts robotics cluster is healthy and growing. As is typical of most successful clusters, the development of the Massachusetts robotics cluster was mostly gradual as a result of synergies naturally established over time between universities, research institutions, state and local organizations, industry associations, entrepreneurs, the investment community, and industry partners. Organizations like MassRobotics, an independent, non-profit robotics advocacy group, and MassTLC have formed over the years and provide industry-specific events and promotions to support the robotics cluster.

Massachusetts has one of the most innovative and sizeable robotics clusters in the country. In many robotics segments, Massachusetts is ranked as one of the top three states based on revenue and employment. The robotics cluster growth reached a critical mass and became self-sustaining, and the cluster attracted a technology and investment pipeline to withstand any cyclical economic decline. However, the rapid advances in technology, especially software-related applications, such as the emerging field of AI and machine learning, require directed attention and responsiveness in maintaining and strengthening the Commonwealth's competitiveness in the robotics sector.

## 8.2. CLUSTER STRATEGIES

The Massachusetts robotics cluster support and growth strategy can be divided in four distinct parts. The sustainability and growth of the cluster depends on supporting the entire cluster dynamics, including 1) talent development, 2) technology implementation, 3) brand building, and 4) cluster expansion. Collectively, each strategy is designed to help launch, attract, retain, and grow robotics companies in Massachusetts.

### 8.2.1. Talent Development

The most important factor in any industry cluster is the presence of a robust, skilled, and innovative labor force. Therefore, workforce education and training at each stage of company growth is critical to the cluster ecosystem. Labor training and education for robotics consist of a broad spectrum, including community college, higher-education, entrepreneurship, skills-based training, and worker re-training.

### 8.2.2. Encourage Entrepreneurship as a Part of STEM Education

Entrepreneurs have a key role in cluster development and growth. They start new companies to produce novel products or services, often by commercializing research breakthroughs, but just as likely using existing technologies in new and different ways to solve problems, produce new products, or fill an unexploited niche.

STEM workforce development programs are common throughout the world, the result of many years of efforts to make national and regional economies more competitive. A technically trained workforce and STEM talent pipeline, once decisive competitive differentiators, are now only a necessary, but not sufficient, condition for driving today's innovation economies. The Commonwealth's robotics workforce must be technically educated, but also highly entrepreneurial. Policy makers should develop strategies whenever possible that work to increase the entrepreneurial education and training of their future workforce. One example is to recommend mandating entrepreneurship courses for computer science and mechanical and electrical engineering students attending Massachusetts State universities.

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### 8.2.3. Expand Internship and Co-op Opportunities

Many universities and colleges within Massachusetts are a continuous source of an educated workforce, the Commonwealth's greatest economic asset. Failure to retain graduates diminishes the available labor pool for regional businesses, and reduces the odds that non-local firms will locate to Massachusetts based on the availability of an educated workforce. Local employment of graduating students is key to retaining the region's educated workforce, and is easier and less costly than recruiting graduates to Massachusetts.

Employers overwhelmingly cite internship experience as a critical factor when considering hiring new college graduates for full-time positions. Also, industry statistics demonstrate that more than 85% of the companies supporting internships also recruit interns for their full-time workforces. For their part, students consistently name employment as the single most important factor determining whether they will remain in Massachusetts following graduation.

Massachusetts robotics companies seek out and retain student interns in different ways. Some have long-standing relationships with a local university and work directly with placement offices or with department-level heads. Others have their own internal efforts targeting multiple, but often a selective number of schools. Public resources, such as the state-supported internship programs through the MassTech Collaborative, the Massachusetts Life Sciences Center, and the Massachusetts Clean Energy Center, have also been valuable in facilitating the connections between eligible robotics companies and students for internships.

To capture more of the student population educated in Massachusetts colleges and universities, it is recommended that the Commonwealth continue to support internship programs and consider ways to increase participation by robotics firms. These programs should be sure to evaluate their impact on improving the likelihood of college student retention in the State.

Additionally, the Commonwealth should explore the possibility of supporting co-ops, which typically run longer than the 3-month internship programs. Co-ops have been proven to increase the level of regional retention rates for college graduates from private institutions, approximating that of public universities, where these rates are generally higher to begin with.

#### 8.2.4. Develop Workforce Training and Retraining Initiatives

The speed of technology development is increasing at a rapid rate. As a result, the skills demanded by companies are also changing rapidly. In order to maintain a robust source of skilled labor, workforce training and re-training efforts must be included in any technology cluster development strategy. Therefore, there is a need to explore new initiatives, especially for those workers that need assistance acquiring new skills to be more relevant in the technology-based economy. The robotics industry has many applications in manufacturing. Offering manufacturing companies industry-specific workforce development assistance and incentives can be attractive in their expansion and relocation choices.

#### 8.2.5. Technology Implementation: Facilitate Development, Testing, and Validation

Developing robots and robotics technology is inherently challenging. Hardware is more expensive than software to develop and test. It also typically takes a considerably longer time to design hardware products. Unlike software, hardware designs must be the final product when shipped. Upgrades are difficult and very costly to implement. Releasing a minimally viable product, a common practice for software firms trying to come to market quickly, is not applicable for hardware technologies. The cost and time required to bring new robotics products and technologies to market increases the risk for young startups considerably.

Emerging technology trends like autonomous and mobile applications also increases the level of difficulty and costs in robotics systems development and testing. This is especially true for the testing of wide-ranging mobile systems designed to be used in outdoor, unstructured, and often peopled environments. Commercial unmanned aerial and self-driving vehicle markets expected to exhibit exponential growth are notable in this regard.

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The high cost and lengthy process of developing robotics technologies make this sector risky for most investors. Hence, VC firms that specialize in software investment outnumber VC firms that invest in early-stage robotics startups. Strategies that can increase the speed and lower the costs of development and testing and validation can lower the risks involved in the development of new robotics technologies and improve the odds for raising private capital.

### 8.2.6. Ensure Sustained Accelerator and Incubator Activity

In addition to workspace and mentoring, hardware-centric accelerators and incubators typically make available to program companies 3D printers, injection molders, and other equipment used for hardware development. Using these shared resources, companies can quickly and inexpensively develop componentry, molds, and even working prototypes. In some cases, it is possible to generate limited production runs of their products.

At this time, the Massachusetts robotics cluster region is home to a number of private, public, and university-sponsored business accelerators and incubators, including Bolt, MIT Global Founders' Skills Accelerator, UMass Lowell Innovation Hub, and the Harvard Innovation Lab. MassChallenge, Techstars, Greentown Labs, UMass Boston Venture Development Center, and Healthbox are notable in that they were instrumental in the launch of a number of robotics companies. At no previous time have young robotics companies had so many options to access equipment, workspace, and mentorship. For the future, Massachusetts should examine if accelerator and incubator resources are adequate and suitable to meet continued demand or whether demand outstrips existing assets and resources.

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*Massachusetts is home to many types of incubators and accelerators that provide equipment and workspace. Robotics companies have been launched through their programs.*

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### 8.2.7. Ensure Continued Support for Testing Centers

Unlike accelerators and incubators, for-profit centers for robotics testing do not exist. Many commercial companies and research laboratories do have private testing facilities, but they are often unavailable to others. However, Massachusetts is home to multiple open testing centers that are publicly funded to some degree and available to industry collaboration, such as the University of Massachusetts NERVE Center, the Massachusetts Unmanned Aircraft Systems Test Center and the Center for Marine Robotics at Woods Hole Oceanographic Institution.

These sites are not being used to full capacity at this time, but given the nascence of the emerging robotics markets they serve, as well as unresolved regulatory issues, this is to be expected. It is recommended that these centers, and possibly others, remain open with Commonwealth support as appropriate in the event of funding shortfalls, and continually be monitored regarding technical advancement, regulatory requirements, and market trends. Also, discounts for testing services should be made available for Massachusetts firms, and possibly subsidized for in-state startups. In addition, the totality of the robotics testing capabilities should be used to brand the Commonwealth as the leader for commercial robotic systems testing.

## 8.2.8. Offer Low-cost Loans for Development, Prototyping, and Testing Tools

The engineering and testing of robotics technology differs from the development of software, as well as many types of hardware. Robotics engineers require mature, robust, integrated software development environments. It is through such tools that custom development and integration, which is slow, costly, and error prone, can be replaced by a more rigorous, productive, abstracted approach. Robotics companies must also prototype and test their hardware and, in some cases, engineer them for manufacture. Development environments, prototyping and machining tools, and testing products can be costly, perhaps prohibitively so for young companies. It is recommended that a mechanism be established so that startups can be provided with access to low-interest loans for the purchase of such technologies, perhaps working in cooperation with Massachusetts-based companies providing these technologies; for example, the Mass Development Emerging Technology Fund.

## 8.2.9. Leverage State Procurement for Validation

Investigate policies that would allow the State to acquire robotics technologies and apply them if deemed suitable to the task and contributory to their purpose. Policies that would facilitate acquisition by the State of pre-commercial robotics products produced by Massachusetts' companies should be investigated, and applied if suitable to a given task and would validate newly emergent robotics technologies to the larger marketplace.

## 8.2.10. Maintain a Simple, Stable Regulatory Environment

Massachusetts should develop regulatory policies that are most conducive to development and testing. The Commonwealth should avoid implementing state-specific regulatory policies before or beyond those required by the federal government. If prematurely adopted, State-sponsored regulatory initiatives and legislation can produce unintentional consequences such as creating confusion and ambiguity, which ultimately may slow innovation.

# 8.3. BRAND BUILDING: BRAND AND MARKET THE CLUSTER

Elements of a branding and marketing strategy should include:

- 1. Rebrand the Cluster:** Brand the Massachusetts robotics cluster as the Massachusetts Robotics and Intelligent Systems Cluster (the Massachusetts Robotics Innovation Cluster is also appropriate). This better reflects today's popular understanding of the intersection of AI and robotics, the increasing levels of autonomy exhibited by robotics devices, and technological trends going forward. The term is also inclusive for critical technologies and significant market sectors that intersect with robotics, such as autonomous vehicles, the IoT, and more.
- 2. Launch Aggressive Marketing Campaign:** Formulate, begin, and sustain a comprehensive marketing campaign highlighting the many strengths and capabilities of the Massachusetts

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*The Massachusetts robotics cluster should be rebranded as the Massachusetts Robotics and Intelligent Systems Cluster or Massachusetts Robotics Innovation Cluster.*

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robotics, autonomous, and intelligent system (RAIS) cluster. The work should be undertaken by a professional public relations or marketing firm, and developed in conjunction with public and private contributors to the robotics clusters.

3. **Highlight Research Dominance:** Emphasize research, the basis for most innovation and the area where Massachusetts is dominant, over investment and other measures of cluster strength. Stress the lack of equivalence between the number and quality of Massachusetts universities and research centers with that of other robotics centers. Also, stress innovation in outbound marketing material and communication with business and technical media (“the Massachusetts Robotics Innovation Cluster”).
4. **Brand the STEM-E Workforce:** All regional robotics clusters state that they are home to a sizable, technically educated workforce. Massachusetts is exceptionally strong in this regard, but going forward, for marketing and branding activities, as well as media interactions, the qualifier of “entrepreneurial” should be added. Not only is the Commonwealth a dominant research and innovation center, it is home to a very large, educated, and entrepreneurial workforce.
5. **Promote Relocations:** As part of robotics marketing and branding material developed by Massachusetts, highlight companies that have relocated to Boston, or set up regional offices.
6. **Formalized, Proactive Tech, and Business Media Outreach:** Media outreach efforts must be proactive, regular, and outbound, and not solely reactionary based on media requests following cluster member announcements or for general information for media-generated storylines.
7. **Aggressively Solicit Events:** Aggressively seek out and solicit the leading international business, investment, and academic conferences in an effort to have them locate events in Boston. Examples include XPONENTIAL (a massive event), the IEEE ICRA (emphasis on research and technologies on the cusp of commercialization), and RoboBusiness (emphasis on investment and business development). Incentives and special attention should be considered.
8. **Deepen Event Participation:** The Massachusetts robotics cluster should continue to increase its presence at national and international trade shows and conferences. Hospitality suites, in addition to a booth on the conference show floor, should be considered for strategic events.

## 8.4. STRENGTHEN AND ENHANCE CLUSTER DYNAMICS

It is not advised that Commonwealth policy makers do direct investments to pick winners in the robotics technology space. However, Massachusetts can play a critical role by supporting programs and initiatives that facilitate knowledge transfer, networking, commercialization, cooperation, and partnership development that will result in opportunities for Massachusetts robotics companies.

### 8.4.1. Strengthen Cluster Ties

The Commonwealth can support the robotics cluster in ways that strengthen the value chain through intraregional cooperative initiatives with technology clusters where technological, investment, market, and other synergies are strong. Examples include MedTech and GreenTech.

Additionally, cluster leaders should seek to increase formal and informal cluster networking opportunities and collaboration initiatives with sector-specific regional clusters in Europe and Asia. Again, the focus should be on cluster partners where synergies are strong, such as those with competencies in UMS, advanced manipulation, and indoor mobile robots.

### 8.4.2. Increase Local Demand

Increasing the use of robots and robotics technologies in Massachusetts companies serves to: 1) improve competitiveness of the regional cluster and 2) geographically concentrate innovation and economic growth under the cluster model. In the case of the Massachusetts robotics cluster, this is the greater Boston metropolitan area.

The Commonwealth can help to educate and incentivize Massachusetts businesses to adopt robotics technologies. Emphasis should be placed on small-to-medium manufacturers, a large percentage of which have not adopted robotics automation and missed out on the benefits of robotic industrial automation, such as increased productivity, quality, and overall competitiveness.

### 8.4.3. Strategically Support Nascent and Emerging Submarkets

Within the robotics cluster, state support aligned to particular high-priority subsectors where the Massachusetts industry exhibits underlying strengths may be appropriate in order for the Commonwealth to best capture new economic opportunities. For example, manufacturing, healthcare, and sectors employing commercial UAS are examples of sizable markets where global business (push and pull), social, and political drivers intersect to provide long-term, uninterrupted demand, and also build on the Commonwealth's historical strengths to support the greater Massachusetts economy.

Additionally, maritime robotics is a greenfield opportunity with widespread cluster support and deep historical roots in the area. This field of the robotics sector is small and riskier, but the upside potential is massive. Other areas that build on existing cluster strengths, exhibit a strong predisposition for growth, and have high strategic value (and therefore strong potential for high levels of private investment and long-term market viability) include autonomous transportation, advanced manipulation, and logistics automation.

### 8.4.4. Support New Business Formation

For the robotics industry, new business formation is primarily new technology driven. Innovative startups provide a large portion of the cluster growth and expansion; therefore, the Commonwealth should monitor the robotics startup formation ecosystem and assess the need for new programs and initiatives to stimulate new business formation.

A number of research universities generate patented intellectual property that, in turn, is commercialized either through licensing to established companies or startup formation. The Massachusetts robotics cluster has already achieved critical mass that provides a steady supply of entrepreneurs, executives, and employees who have industry-specific expertise. A number of incubators and accelerators provide startup facilities and mentorship support. Additionally, associations and networking organizations play an integral role in building a vibrant robotics community. Yet, the Commonwealth can play a facilitator role to engage cluster leadership to assess the cluster health, expedite the transfer of good practices, and perform consensus building to leverage collective resources.

Another integral part of new business formation is the capital formation. A number of seed-funding sources are available for technology startups, such as federal technology development grants like the SBIR and STTR grants. Massachusetts has one of the highest numbers of awards with these grants in the nation. Additional sources of seed capital are available through universities and other State organizations. Continued support by the Commonwealth of the new business formation ecosystem is an integral part of maintaining a thriving robotics cluster in Massachusetts.