



Manufacturing

INNOVATION REVOLUTION

nanomanufacturing
3D printing
rapid prototyping
modeling & simulation
advanced materials
visualization
robotics
flexible specialization
high performance
automation
process innovation
systems integration
design & development
sensors
visualization
global supply chains
manufacturing engineering
mass customization
rapid response
skills
logistics
optimization
machine tools
green manufacturing
craftsmanship
lean
precision machining

Building Bridges to Growth: A Roadmap for Advanced Manufacturing in Massachusetts



John Adams Innovation Institute



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Dear Friends,

I am very pleased to present to you ***Building Bridges to Growth: A Roadmap for Advanced Manufacturing in Massachusetts***. Massachusetts is launching an ambitious agenda designed to enhance the competitiveness of Massachusetts manufacturing and lead the national effort to revitalize this country as a place that makes things. The *Roadmap* that follows is the result of a collaborative effort by leaders in industry, academia and government, launched by Governor Deval Patrick in 2010, to set the state's ambitions and framework for action in manufacturing.


Massachusetts is also launching a new partnership, the Advanced Manufacturing Collaborative, to organize and execute the state's advanced manufacturing strategy. Governor Patrick's approach to innovation-based economic development is to bring together all of the state's leadership, resources and thinking to collaborate on public-private solutions that will move the state forward. The Advanced Manufacturing Collaborative takes this same approach.

The state's Advanced Manufacturing Agenda is focused in five areas:

1. Promoting Manufacturing
2. Workforce & Education
3. Technical Assistance and Innovation
4. Cost of Doing Business, and
5. Access to Capital

I invite you to read this *Roadmap* and to consider joining our effort to accelerate the growth and competitiveness of advanced manufacturing in Massachusetts.

Sincerely,



Gregory P. Bialecki, Secretary
Executive Office of Housing and Economic Development
Commonwealth of Massachusetts

Building Bridges to Growth

A Roadmap for

Advanced Manufacturing in Massachusetts

November, 2011

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I. Introduction

The Patrick Administration has worked to accelerate the growth and competitiveness of the Massachusetts economy through strategic partnerships, focused on the state's world-class clusters and capabilities. This strategy has involved deploying targeted initiatives to strengthen and grow industry clusters across regions of the state. Efforts have included initiatives to align support around life sciences, clean energy, digital technology, defense, marine sciences, design and other sectors.

In early in 2010 Governor Deval Patrick challenged his administration to address conditions for enhancing manufacturing, a cross-cutting sector that is an enabler of in-state growth and innovation in other industry sectors and that is, on its own right, an exciting opportunity to leverage innovation to promote job-creation in the state, particularly in regions outside Greater Boston.

A. The Advanced Manufacturing Initiative

Following the Governor's request, Secretary of Housing and Economic Development Greg Bialecki approached the heads of key associations, along with other thought leaders to help convene a dialogue among stakeholders and industry leaders of the Commonwealth's manufacturing sector **to articulate the role the state and its partners in industry and academia can play to enhance manufacturing competitiveness in Massachusetts**. The Secretary tapped the Massachusetts Technology Collaborative's John Adams Innovation Institute (MTC's Innovation Institute) to provide management support for the state's **Advanced Manufacturing Initiative**. Two mandates came with this request:

- To convene and manage an industry-led dialogue that would lead to actions to help make successful enterprises even stronger through programs targeted at companies that have proven success or clear potential for growth.
- To foster a New England perspective and leverage the potential for regional synergies while focusing on Massachusetts as the epicenter of the region's advanced manufacturing capabilities.

The Secretary and MTC's Innovation Institute worked with an ad hoc Organizing Committee including representatives of the Associated Industries of Massachusetts, the Massachusetts Manufacturing Extension Partnership, the New England Council, and regional economic development organizations, to convene a group of stakeholders as a Steering Committee to prepare for the launch of the initiative.

On May 21, 2010, Governor Deval Patrick held a roundtable discussion with industry executives following a cabinet meeting held at American Superconductor Corporation. Governor Patrick asked attending sector leaders and key stakeholders to start a

dialogue to identify key unmet needs as well as near-term opportunities, projects and policies that his administration could implement in order to enhance the competitiveness of Massachusetts manufacturers.

To move towards a framework for action, the Advanced Manufacturing Initiative has brought together a cross-cutting Steering Committee that includes representatives of suppliers (particularly small and medium-sized enterprises), OEMs and system integrators, as well as key public sector stakeholders, support organizations and industry associations. The AMI's Steering Committee has held five full meetings, two focus group sessions, and a series of individual conversations.

II. Advanced Manufacturing in Massachusetts

The invention of interchangeable parts at the Springfield Armory spawned the machine tool industry in the Pioneer Valley. The construction of canal systems in Holyoke, Lowell and Lawrence enabled the development of extensive planned industrial complexes that made the Commonwealth global leaders in textiles and paper making. The Massachusetts Institute of Technology and Northeastern University were pioneers of industry-academic research collaboration and cooperative education.

Today, Massachusetts has one of the most highly developed innovation economies in the world, attributable at least in part to its unparalleled research enterprise. What is less recognized is that the Commonwealth's innovation economy also includes a stable and innovative base of manufacturers in multiple industries and segments of the value chain - a major source of jobs and economic strength. In this regard Massachusetts joins other advanced industrial economies, such as Germany, that compete globally in manufacturing even though they are characterized as having high-cost environments.

Massachusetts manufacturing companies will continue to prosper, compete globally, and grow by building on practices and business models proven to succeed while furthering innovation and world-class business practices. **The public sector can play a catalytic and facilitating role by promoting conditions and strengthening the institutional infrastructure that will enable businesses to self-organize and reach their full potential.**

Recent studies¹ suggest that the region is in fact very competitive in certain types of manufacturing and that manufacturing should be viewed as an integral element of an innovation-intensive economy. The competitive edge for companies that manufacture in Massachusetts resides in their **advanced manufacturing capabilities.**

¹ Bluestone et al. (2008). *Staying Power: The Future of Manufacturing in Massachusetts*; Deloitte - New England Council (2009) *Reexamining Advanced Manufacturing in a Networked World- Prospects for a Resurgence in New England.*

This roadmap adopts a definition of **advanced manufacturing** as a process – *a way of producing* — that “**makes extensive use of computer, high precision, and information technologies integrated with a high performance work force in a production system capable of furnishing a heterogeneous mix of products in small or large volumes with both the efficiency of mass production and the flexibility for custom manufacturing in order to respond rapidly to customer demands.**” (NACFAM)

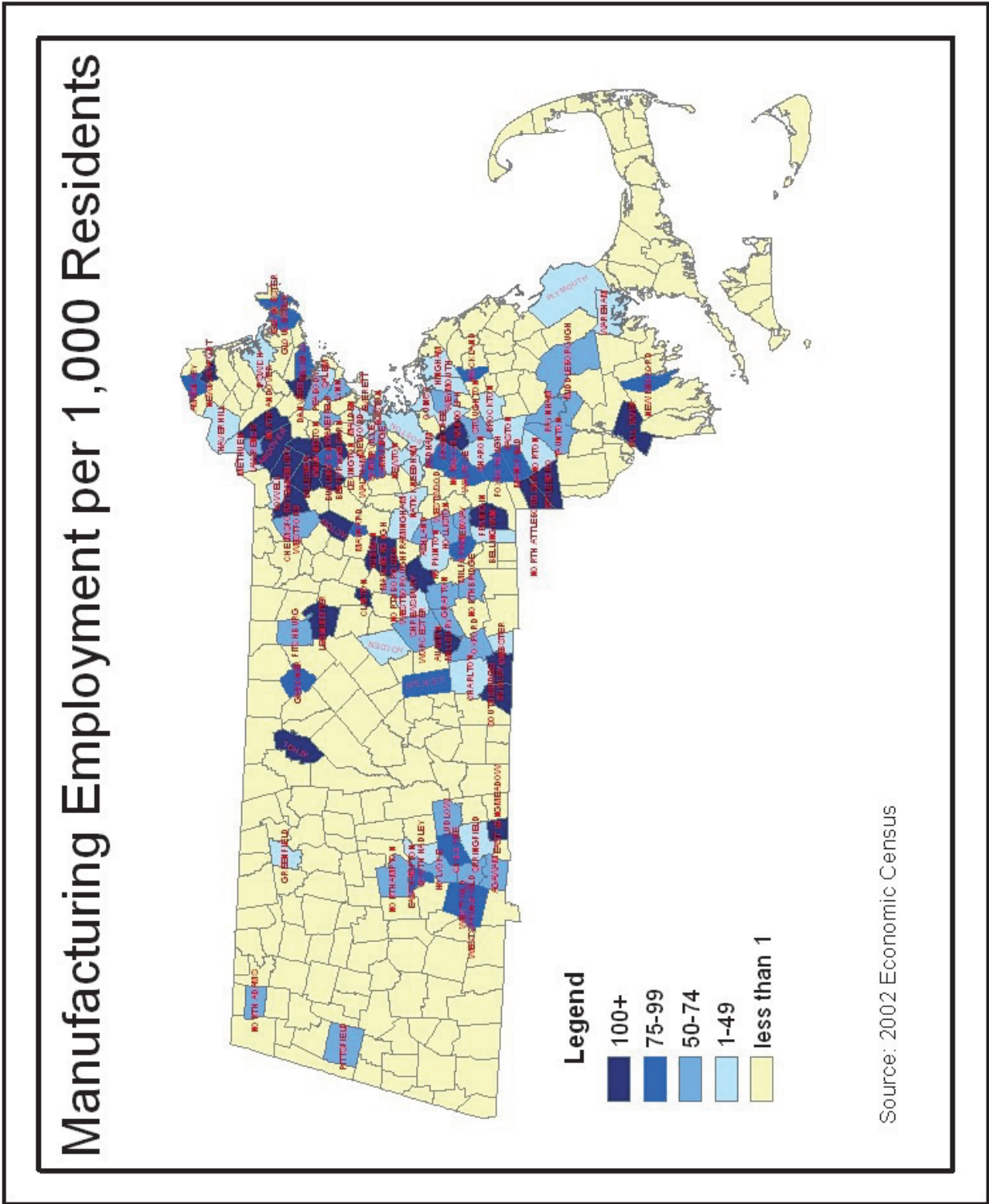
In Massachusetts, companies with advanced manufacturing capabilities comprise three categories:

- Companies that manufacture products for end-users, often in niche markets, selling both directly to consumers and business-to-business.
- Companies that manufacture parts and components for tech sector OEMs and system integrators in Massachusetts, the United States, and the world, by definition on a business-to-business basis.
- Companies that manufacture traditional products for established markets in novel ways.

The Commonwealth also has a long-standing legacy of public and industry-led initiatives to enhance the conditions for manufacturing companies to prosper. Multiple public and private entities and programs already channel organizational energy and resources to support manufacturing companies and enhance manufacturing competitiveness in the Commonwealth. These entities already work with the Commonwealth’s strong cadre of OEMs and system integrators, as well as with its sophisticated supplier base.

Although there has been a decline in academic programs throughout the United States focused specifically on manufacturing, the vibrant innovation ecosystem in Massachusetts continues to be a major driver of advanced manufacturing processes. Importantly, these industries and institutions engage in the development of novel products that demand new manufacturing technology and capabilities. In addition, there is a vibrant investment community characterized by innovation and accustomed to assessing the risks associated with bringing new products, processes and technologies to market (the venture capital industry was invented in Massachusetts in 1946, for example).

Taken together, this repertoire of organizations, expertise, and resources represent a foundation of assets and strengths upon which to build future action to enhance the competitiveness of the sector and **build a world-class advanced manufacturing cluster.**



From Bluestone et al. (2008). *Staying Power: The Future of Manufacturing in Massachusetts*

III. Building a World-Class Advanced Manufacturing Cluster

The vision of the Advanced Manufacturing Initiative is to build in Massachusetts the world's most competitive and innovative cluster of companies with advanced manufacturing capabilities. Massachusetts can become the most successful hub in North America for companies that utilize advanced manufacturing capabilities to compete in the global marketplace. **A concentration of world-class advanced manufacturing capabilities can become a magnet to attract and retain manufacturing operations and to help expand the in-state value chain for companies that already perform R&D in the Commonwealth.**

The state's existing base of manufacturing companies, supported by a vibrant research and innovation infrastructure, represents a unique opportunity to enhance the state's competitive position. The state's advanced manufacturing cluster would be characterized by:

- Continuous improvement and continuous innovation to adapt to manufacturing products characterized by rapid obsolescence.
- Flexible specialization and mass customization to make and adapt products and components rapidly.
- Self-organizing in teams as suppliers, OEM's and system integrators, capable of rapidly assembling a portfolio of capabilities in a flexible manner to meet demanding customer requirements.
- Meeting the high-performance, precision, compliance and certification requirements of sophisticated and demanding customers around the world.
- With a record of innovation in advanced materials, energy efficiency technology, and leadership in environmental science and engineering, Massachusetts manufacturers have a solid foundation to move towards green manufacturing.

IV. Ambitions and Impact

A. Expanding Prosperity for Regions and Citizens across Massachusetts

Enhancing the competitiveness of manufacturing companies represents an exciting opportunity to expand opportunities for prosperity for the state's citizens, industries, and regions. Manufacturing creates opportunities for economic growth throughout the Commonwealth, including locations outside those generally associated with the state's "high tech" economy. Manufacturing is widely recognized as providing career

ladders and high paying jobs in diverse industries for individuals with a wide spectrum of skills.²

B. Growing Industries

Manufacturing represents a significant opportunity for Massachusetts to capture the downstream economic benefits of research and innovation by expanding the in-state value chain within industries. In addition, an environment rich in advanced manufacturing capabilities has the potential to attract new business opportunities and manufacturing operations to the Commonwealth.

C. Growing the Economy

Massachusetts has one of the largest ratios of R&D investments to GDP in the country. In fact, Massachusetts ranks #2 in the nation after California in total (public and private) investment in R&D. However, manufacturing currently represents only 9.5% of the Commonwealth's gross domestic product, compared with 11.6% for the nation as a whole. Capturing more of the downstream economic benefit of that R&D investment through manufacturing represents an unparalleled pathway to economic growth. Policies and strategies that would build on this extraordinary R&D base to increase the contribution of manufacturing to the GDP of Massachusetts to a level comparable to that of the nation as a whole would add over \$7.5 billion to the state's economy and create jobs for its citizens.

D. Enhancing Innovation

Manufacturing and product development can be highly synergistic and in many sectors are inextricably linked. For technology-intensive industries characterized by ongoing innovation, the ability to interact quickly between manufacturing and R&D helps inform and accelerate both the development of new products and the rapid and efficient transition of those products into the marketplace.

E. Leading in Exports

Massachusetts ranks 13th in the US in terms of total value of exports and fourth in terms of exports per capita. Exports continue to represent an important growth opportunity for Massachusetts manufacturers. Global markets are populated with multiple opportunities for growth, particularly in markets addressed by Massachusetts companies. Many of these markets are expanding much more rapidly than domestic markets. Maximizing the export potential of Massachusetts manufacturing is an avenue for sustained growth, job creation, and economic resilience.

² By the end of 2009 manufacturing companies employed over 260,000 in the Commonwealth, making it the fourth largest employment sector (after education, health care delivery and financial services) and arguably the largest "traded cluster" in the state.

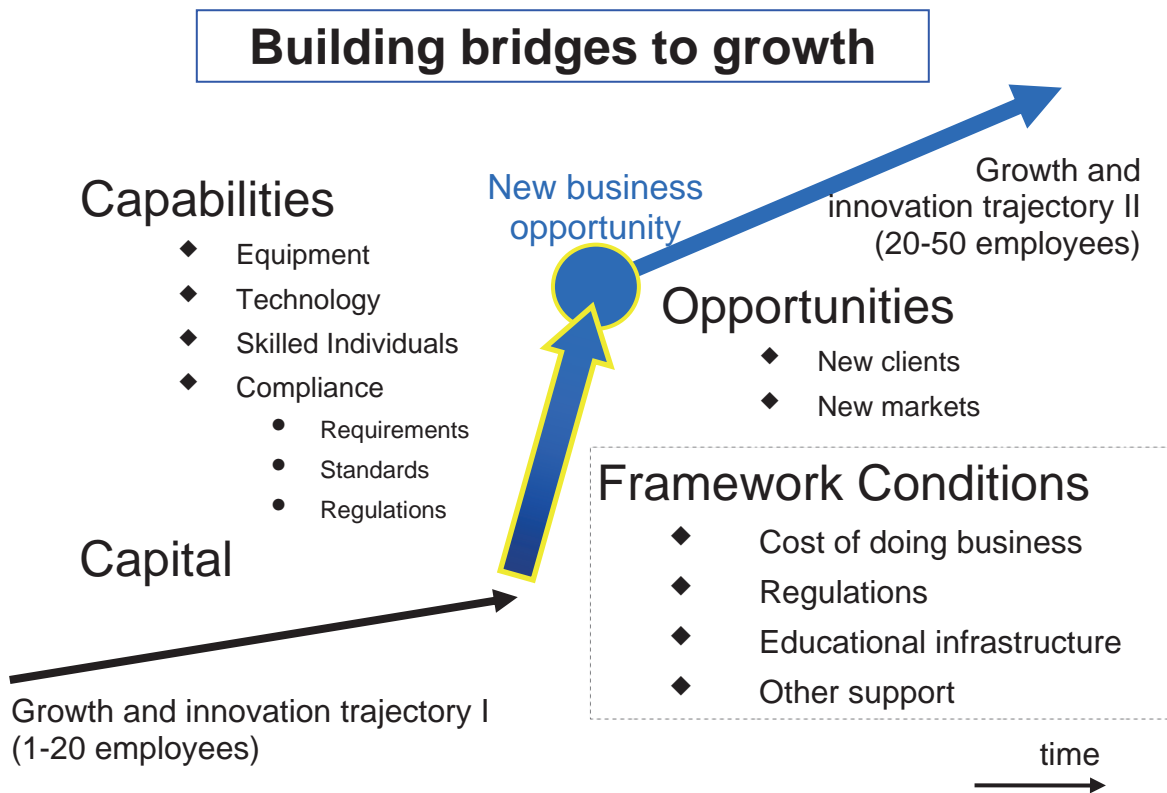
V. Building Bridges to Growth

A. The SME Challenge

The AMI Steering Committee identified small and medium sized enterprises (SMEs) as particularly important target for a state role to enhance the competitiveness of manufacturing in Massachusetts.

Small- and medium-sized enterprises tend to concentrate the largest share of employment in the Massachusetts economy. In addition, SMEs are often independent companies, created by local entrepreneurs with deep roots in Massachusetts – whether by tradition or by choice. The founders and leaders have a commitment to the region and are arguably the least likely to migrate elsewhere, even if their companies have a global scope and operations.

The chart below illustrates the growth and innovation opportunity associated with SMEs and the interplay of factors that enable this growth and innovation dynamic. This graphic brings together multiple insights captured during the dialogue of the Advanced Manufacturing Steering Committee. The dynamic is explained on the following page.



At any moment in time, an SME is on a specific growth and innovation trajectory. It could also be static, not growing and not innovating, but sustained by usual and existing businesses. A new dynamic of growth and innovation could be triggered if the SME encounters a new business opportunity. New business opportunities can take a variety of forms. For example, an SME may be a potential supplier of a part or a subsystem for an OEM or system integrator, identify an opportunity in a foreign market with different standards and regulations, be called on to develop a new product, and so on.

In order to pursue this opportunity, the SME will need to absorb organizational, personnel, and/or technical capabilities. Especially relevant are the business opportunities that require an SME to learn new organizational and technical skills and explore new territory. These new capabilities may involve hiring new employees or training existing employees to do new things; acquiring new equipment; infusing new technology into existing processes; meeting unfamiliar regulatory, standards, or certification requirements. Importantly, this process involves a learning process as the SME needs to figure out how to organize and deploy these capabilities to meet new demands.

In this scenario, if the SME successfully builds the capabilities and learning required to meet new demands, it makes a step-jump onto a new growth and innovation trajectory. With these new capabilities the SME can do new and more business, operate at a new performance level and, importantly, have acquired additional capacity to pursue additional business and growth opportunities in the future.

The multiplicative effect of an environment that facilitates and motivates this growth and innovation dynamic in as many SMEs as possible, across different regions of the state, is essential to build a world-class cluster of advanced manufacturing capabilities and realize the growth, innovation, and employment benefits of manufacturing in Massachusetts.

For an SME, making the jump to a new growth and innovation trajectory by identifying opportunities, building and deploying capabilities, and accessing capital is presents the following challenges:

1. Identifying opportunities

First, it needs the capacity to identify and pursue new business opportunities as an important step towards the continued growth of SMEs. The ability to identify new business opportunities can be limited by insufficient information, or lack of relevant relationships. Both building relationships and raising awareness are avenues to increase the likelihood of identifying new business opportunities.

2. Building and deploying capabilities

Second, it needs to locate and have access to the sources of needed capabilities: knowledge, technology, and personnel needed to meet new demands.

3. Accessing capital

In order to pursue new business opportunities, companies need an infusion of capital to acquire technology and equipment, enhance management or quality control systems, hire new employees, or meet new certification and compliance requirements. Access to capital is a structural obstacle for many manufacturing companies, particularly for SMEs, when they are faced with the need to make new investments to enhance competitiveness or to capture new growth opportunities.

B. OEM's, System Integrators, and Other Large Companies

While SMEs represent a critical target for state efforts to enhance conditions for growth and competitiveness, larger manufacturers face many of the same challenges. These larger companies are often anchors both to industry clusters and to regional economies, and typically compete in global markets where issues of the quality and quantity of talent, best available technology, and cost of doing business are critical. Fostering collaboration and linkages among these larger companies and the supplier SME community is often critical to the success of each.

Engagement of large companies, including OEM's and system integrators, in partnership with SMEs, is essential for building up a world-class cluster of advanced manufacturing capabilities in Massachusetts.

OEMs' and system integrators are critical for growth and innovation in the manufacturing sector as a whole. Their interplay with the supplier base, often constituted by SMEs, creates in-state business opportunities. OEMs and system integrators are also drivers of innovation, since many of them operate in high-tech and science-based industries that have high performance and strict compliance requirements that essentially force suppliers to perform at a higher level to do business with them. This interplay between OEMs, system integrators, and manufacturing SMEs can create a learning dynamic and accelerate innovation in the development of new products and new manufacturing technology, which is often iterative in its earlier stages and benefits from geographical proximity that facilitates interactions, learning, and the exchange of information.

C. The Role of State Government

The goal for the Advanced Manufacturing Initiative Steering Committee, as defined at the outset by Governor Patrick and his economic development team, has been to identify and articulate the areas where state government can make a real difference in enhancing the competitiveness of manufacturing of Massachusetts.

During the dialogue of the AMI Steering Committee, it became clear that engagement and participation of public sector leaders, both in the executive branch and in the quasi-public arena, will be essential to achieve the competitiveness goals identified by the Committee. State government plays a critical role in supporting or negotiating policies regarding taxes; regulations; education and workforce development; business technical and financial assistance, and others. In addition, the Commonwealth's government has developed a unique approach to innovation-based economic development in which state government serves as enabler, facilitator, and partner of industry and academia in the collaborative pursuit of shared objectives.

VI. The Massachusetts Advanced Manufacturing Collaborative

The work of the Advanced Manufacturing Initiative Steering Committee demonstrates the unique and fruitful role of the state as convener, facilitator, and partner of industry and academia in the pursuit of innovation-based economic development objectives. This approach has proven successful in life sciences, digital technology and others. In these two sectors, the Life Sciences Collaborative and the Tech Hub Collaborative have strengthened collaboration and led to the launch of numerous initiatives that respond to unmet needs and opportunities specific to each sector.

Recognizing the unique challenges of advanced manufacturing, **the AMI Steering Committee recommends that state government enable, facilitate, and partner with key stakeholders and the private sector in the creation and operation of the Massachusetts Advanced Manufacturing Collaborative.**

A. Organization

The Commonwealth has a rich legacy of public and private entities and programs that already channel organizational energy and resources, and design and implement programs and initiatives to enhance manufacturing competitiveness and provide targeted support to companies. Given this existing foundation and capacity to implement projects, the Advanced Manufacturing Collaborative is envisioned as a body focused on developing cross sector understandings and on policy development.

The mission of the Massachusetts Advanced Manufacturing Collaborative will be to strengthen the conditions necessary for growth and innovation of advanced manufacturing companies and capabilities in Massachusetts, with a particular focus on SMEs. The Collaborative will play a central strategic role as the focal point for a rich public-private dialogue that will assist stakeholders in identifying emerging priorities with continuous learning, flexibility, adaptability and consensus as key characteristics. Through this dialogue, the Collaborative will organize action and help mobilize resources and stakeholders to effect change and become a platform for the launch of high-impact projects and initiatives, while revising priorities based upon changing needs.

The Advanced Manufacturing Collaborative will have 25 to 35 members including a balanced mix of representatives of public agencies, academic institutions, relevant industry associations and businesses with manufacturing operations in Massachusetts. The business category will represent diverse sectors and market niches, with at least half of the members representing SMEs. The Associated Industries of Massachusetts and the Massachusetts Manufacturing Extension Partnership will be key implementation partners of action priorities of the Collaborative.

The Collaborative will have two co-chairs who will be selected by the Secretary of Housing and Economic Development. In consultation with the co-chairs, the Secretary will appoint all members. Compared to the Life Sciences and Tech Hub Collaboratives, the Massachusetts Advanced Manufacturing Collaborative will have significantly more engagement from relevant governmental and quasi-governmental staff who will be critical for successful implementation of programs to accelerate manufacturing competitiveness.

The state will assist the operations of the collaborative by helping convene, staff, manage the dialogue, and assist in mobilizing the resources necessary to drive the work and to effect change. Work will be organized through formal and ad hoc working groups, comprised of at least two members from the collaborative and other stakeholders as appropriate. At least one member of each working group will be a representative of industry.

B. Priorities

The dialogue of AMI Steering Committee members during the last year has resulted in an initial blueprint for action of the Advanced Manufacturing Collaborative at the time of launch. The top five priorities are: promoting manufacturing; workforce and education; technical assistance and innovation; the cost of doing business; and, access to capital.

Appendix 1 describes the universe of unmet needs and opportunities as captured by the dialogue of the past year, from which these priorities were selected and formulated for their potential of broad impact in the short and medium term.

C. Action Agenda

The action agenda, based on the input from the AMI Steering Committee, has been developed as a point of departure for the Advanced Manufacturing Collaborative. This agenda will be reviewed and refined by the Collaborative and its Working Groups, incorporating the input of additional stakeholders.

1. Promoting Manufacturing

Elevate public understanding of the current capabilities and future potential of advanced manufacturing in Massachusetts. Support the attraction of talent and help

position the Commonwealth as a hub for advanced manufacturing companies, including expanding opportunities for in-state marketing of the state's supply chain capabilities.

- Desired Impacts (12 months):
 - a. Advanced manufacturing perceived as a more viable career track for larger shares of the student population.
 - b. Massachusetts perceived by manufacturers as an attractive location to do business.
 - c. General awareness of the importance and vitality of the state's advanced manufacturing sector.

2. Workforce & Education

Expand the ability of the Commonwealth's educational system to respond to the entry and mid-skill level needs of Massachusetts' manufacturing companies throughout the spectrum of skills from craftsmanship to design and production engineering to management that are essential for manufacturing.

- Desired Impact (18 months):
 - a. Providers of educational and training services work more cooperatively with employers.
 - b. More qualified employees for advanced manufacturing openings.
 - c. Craftsmanship recognized as a value-adding and job-creating component of the state's manufacturing enterprise.

3. Technical Assistance and Innovation

Improve access to technical assistance for SMEs by bringing coherence and more integration in state resources and technical assistance services available to support manufacturing growth, including access to capital, workforce development, compliance and certification, and export assistance. This priority will pay particular attention to the need to expand the integration of innovative processes, technologies, materials or management practices in the state's SMEs.

- Desired Impact (18 months):
 - a. Pilot demonstrations of best-practices in delivering innovation-based technical assistance to SMEs.

- b. Highly visible, easily accessible, streamlined pathways to access support services for advanced manufacturing companies.
- c. University-Industry collaboration for innovation in advanced manufacturing.

4. The Cost of Doing Business

Recommend creative approaches and implementation pathways to ease the cost of doing business in Massachusetts, with an initial emphasis on energy costs and taxes, leveraging existing state strengths.

- Desired Impact (18 months):
 - a. Visible adoption of novel approaches to reduce energy costs in specific companies.
 - b. Codified changes in the tax or regulatory regime that alter the cost of doing business that directly correspond to impacts and needs presented by companies.
 - c. Increased awareness of Massachusetts strengths that offset the cost of doing business.

5. Access to Capital

Ensure that manufacturers, particularly SMEs, have the access to finance or investment necessary to support the growth of their firms and make critical investments in new capital equipment, technology, infrastructure or working capital essential for their success.

- Desired Impact (18 months):
 - a. Feedback from manufacturers that access to capital is improving.
 - b. Demonstrated performance by the state's lending agencies that they are meeting the needs of manufacturers.
 - c. Evaluation of the prospects for expanded equity investments from the angel or venture community in manufacturing oriented start-ups.

Appendix A: Identified Opportunities and Unmet Needs

Image

- In Massachusetts, as in many other parts of the United States, manufacturing is not perceived as a significant opportunity for innovation and employment. This impacts the pipeline for talent because, despite evidence to the contrary, high school and college students (and their parents and career counselors) often do not perceive manufacturing as an exciting and well-paying career. The image of manufacturing in Massachusetts as a dying industry also limits business opportunities. There is little awareness either within or outside the state about the competitiveness and advanced manufacturing capabilities of Massachusetts companies and of the potential for various regions of the state to be competitive locations for manufacturing operations.

Talent

- The pool of individuals currently working in the manufacturing sector is aging rapidly. As these individuals leave the sector or retire, there are an insufficient number of individuals with appropriate skills entering the manufacturing workforce. This is due partly to the poor public image of manufacturing as a career pathway, and partly to the lack of educational programs focused on manufacturing in high schools, colleges and universities. This impacts not only the ability of manufacturing companies to expand, but also their ability to remain in business as current employees retire.
- Advanced manufacturing requires a spectrum of skills: e.g., highly skilled craftsmanship to produce precision products; the ability to operate sophisticated management and control systems; and advanced applications engineering to address manufacturing challenges. This translates into a need to develop and attract a workforce with a wide range of knowledge and training, ranging from vocational/technical education to Ph.D's. Particularly at the vocational training and associate degree levels, there is a shortage of programs to train manufacturing workers. This translates into both a need to continuously upgrade skills of incumbent workers as well as a need to ensure an ongoing pipeline of new talent with the appropriate skills and motivation to join manufacturing companies.

Technical Assistance

- The Commonwealth has a long-standing legacy of public and industry-led initiatives to enhance the conditions for manufacturing companies to prosper. Multiple entities already offer technical assistance programs for SMEs, OEMs and system integrators in areas that range from access to capital to environmental compliance. However, there is a lack of awareness among the

business community about the availability and nature of available assistance, complicated by the multiple entities and initiatives that exist in different organizations and levels of government.

Cost of doing business

- The high cost of energy and healthcare is of concern to all Massachusetts industry sectors; however state government has a limited ability to directly affect these two components of the cost of doing business in Massachusetts.
- A reduction in the Massachusetts corporate excise tax rate would help to offset some of the high direct costs of doing business in the Commonwealth and enhance the competitiveness of this major sector. This would have an immediate impact on all manufacturing companies in the state, and would be particularly beneficial to the myriad small and medium size companies that often don't benefit from tax credits and other incentives. While corporate income taxes are only one part of the cost of doing business, they are an important element in corporate location decision-making and are one of the few cost elements that can be directly addressed by state government.

Innovation

- Even though ingredients for an advanced manufacturing innovation ecosystem already exist within the Commonwealth, there are often insufficient linkages and collaboration among the various companies and stakeholders to create a truly vibrant manufacturing innovation ecosystem in the Commonwealth.
- Building up advanced manufacturing capabilities is heavily dependent upon the ability of companies to acquire the equipment and infuse their operations with a portfolio of enabling technologies (and training to implement these technologies) to improve manufacturing processes and operations. For SMEs in particular, this represents a substantial challenge financially and operationally.
- Manufacturing related research has been de-emphasized at many academic institutions, and awareness of and access to cutting-edge manufacturing research and technology in the state's universities and other research institutions is very limited and often nonexistent.
- The infusion of new technology into existing companies, and the creation of new companies around cutting-edge technologies that are enabled by advanced manufacturing processes, is a critical avenue to build up advanced manufacturing capabilities in the state. These technologies include rapid prototyping, modeling and simulation, advanced materials, and others.

Business Opportunities in Massachusetts

- The manufacturing supply chain within Massachusetts is insufficiently articulated and promoted. OEMs and system integrators in Massachusetts are often not aware of the advanced manufacturing capabilities of the many suppliers in the state that could competitively provide parts, components or subsystems. Similarly, there is often no structured approach for suppliers to become aware of opportunities to enter the supply chain of these OEMs and system integrators or of specific vendor requirements. Together, this lack of awareness and articulation of the supply chain limits business opportunities for manufacturing suppliers in the state.
- Little collaboration between OEMs or system integrators and the supplier base in Massachusetts, also leads to lost opportunities to bring innovative insights into manufacturing processes and product development, and to expand the participation of the state's supplier base in the value chain of other industries, OEM's and system integrators.

Business opportunities abroad

- Foreign markets continue to represent a significant growth opportunity both for small and mediums sized OEM's and for suppliers with advanced manufacturing capabilities in Massachusetts. However, these enterprises often lack the capacity, resources and critical mass to become aware of and develop opportunities in foreign markets, or to meet country-specific standards and regulations.
- SMEs (both suppliers and OEM's) face a particular challenge to meet the compliance and certification requirements that come when working with novel projects that require higher levels of performance and precision than the status quo, or when entering new markets that may have different standards or regulations.

Environmental performance

- Clients and markets in the United States and in countries that are potential markets for Massachusetts manufacturing exports are setting higher standards and compliance requirements when it comes to the environmental performance of products and the environmental impact of the manufacturing processes to make them. These standards represent potential threats to existing export markets and potential barriers to expansion of exports to Europe and Asia.
- Manufacturers are continually being asked to address challenges associated with reducing the carbon footprint of the manufacturing processes, the use of

materials that are environmentally-friendly, and adopting a life cycle approach to the design and production of components, parts, and final products. This is particularly important to seize business opportunities in foreign markets that have more stringent environmental performance requirements than the United States.

Access to Capital

- Access to capital is an obstacle for many manufacturing companies, particularly for SMEs, when they are faced with the need to make new investments to enhance competitiveness or to capture new growth opportunities. These companies often need an infusion of capital to acquire technology and equipment, enhance management or quality control systems, hire new employees, or meet new certification and compliance requirements. This is a particular obstacle for companies attempting to transition from R&D to manufacturing.
- There is a structural gap in the financial and investment ecosystem in Massachusetts (and elsewhere in the US) that amplifies the barriers to access to capital in manufacturing. Large financial institutions have become increasingly risk adverse, particularly in the context of dealing with SMEs in general, and companies that are manufacturing technology-intensive products that may address new or emerging markets in particular. Smaller financial institutions often lack, or have lost, the capacity to assess the return on investment and risk profile of manufacturing, particularly the manufacturing of technology-intensive products.

Appendix B: Stakeholders, Programs, and Incentives

This list, presented in alphabetical order, is a preliminary inventory of key organizations and entities that support manufacturing in Massachusetts. A more comprehensive list of organizations, entities, programs and incentives will be available at http://masstech.org/adv_mfg in early December.

Associated Industries of Massachusetts

<http://www.aimnet.org/>

Commonwealth Corporation

<http://www.commcorp.org/>

Massachusetts Growth Capital Corporation

<http://www.mcdfc.com/>

Massachusetts Manufacturing Extension Partnership

<http://www.massmep.org/>

Massachusetts Small Business Development Center Network

<http://www.msfdc.org/>

Smaller Business Association of New England

<http://www.sbane.org/>

Workforce Investment Boards

<http://www.massworkforce.com/>

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This Roadmap reflects the vision, insights, and engagement of a community of individuals and organizations who offered their time and knowledge with a shared goal in mind: to make Massachusetts a leader in advanced manufacturing.

Executive Office of Housing & Economic Development

Gregory Bialecki, Secretary, Executive Office of Housing and Economic Development

Eric Nakajima, Senior Innovation Advisor, Executive Office of Housing & Economic Development

Rich Pellagrini, Industry Director, Massachusetts Office of Business Development

Anne Struthers, Executive Director, Massachusetts Office of Business Development

Advanced Manufacturing Initiative Organizing Committee

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Barry Bluestone, Dean and Director, Center for Urban and Regional Policy Northeastern University

Pat Cloney, Executive Director, Massachusetts Clean Energy Center

Jack Healey, Executive Director, Massachusetts Manufacturing Extension Partnership

Robert Halpin, President, Newton-Needham Chamber of Commerce

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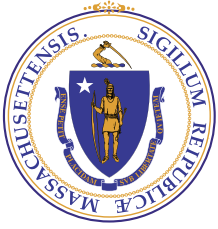
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