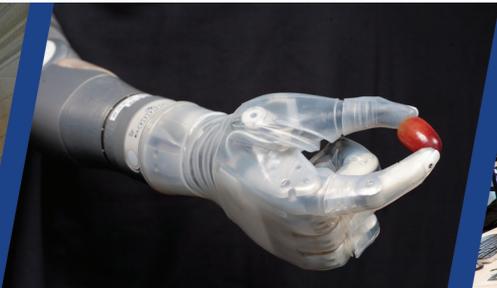


New Hampshire University Research & Industry Plan

*A Roadmap
for Collaboration
& Innovation*



The New Hampshire University Research and Industry Plan was commissioned by NH EPSCoR and guided by the NH EPSCoR Statewide Committee. It was developed by TEconomy Partners with Keen Point Consulting. This consulting team brings a proven national track record in developing plans that strategically identify, enhance and promote the connections between industry and universities and have worked with similar initiatives in Rhode Island, Connecticut, Arizona, Colorado, Georgia, Iowa and Ohio.

TEconomy Partners, LLC. (TEconomy) does not endorse or recommend particular companies, products, services, or technologies nor does it endorse or recommend financial investments and/or the purchase or sale of securities. TEconomy makes no warranty or guarantee, express or implied, including without limitation, warranties of fitness for a particular purpose or merchantability, for any report, service, data or other information provided herein

Front cover photos courtesy of Defense Advanced Research Projects Agency (DARPA), Arlington, VA and DEKA Research & Development Corporation, Manchester, NH; Hypertherm, Inc., Hanover, NH; University of New Hampshire Interoperability Lab and Glow Lab, Durham, NH.

Table of Contents

Letter from NH EPSCoR

Executive Summary.....ES1

Why A University Research and Industry Plan Matters
in New Hampshire1

Identification of New Hampshire’s Innovation-Based
Industry Drivers..... 3

Strategic Assessment of New Hampshire's Business Environment
for Innovation-Led Economic Development..... 10

An Action Plan for Advancing Innovation-Led Economic
Development in New Hampshire15

Appendices31

Letter from NH EPSCoR

Across the country, high-wage jobs and robust innovation-based economies are associated with strong relationships among industries and research universities. New Hampshire has significant untapped potential to improve its economy by purposefully developing synergies between its industry and university research enterprises. But which types of industry and university research could set New Hampshire apart in the national and global economy? Where does New Hampshire have a competitive advantage over other states and regions? What are the opportunities for public and private sector investments to produce sustained and significant economic benefit?

The NH University Research and Industry Plan provides insights based on data-driven evidence of our state's innovation strengths and suggests strategies to capitalize on opportunities. It provides a roadmap for the New Hampshire innovation economy that will inform strategic decisions about how the state can best use its assets and strengths to grow high wage jobs in industry clusters that set New Hampshire apart.

The development of the NH University Research and Industry Plan was supported by Governor Maggie Hassan. It was commissioned and guided by the New Hampshire EPSCoR program. EPSCoR (Experimental Program to Stimulate Competitive Research) is a national program that provides federal funding to develop research infrastructure in states and territories to support research-based economic development. In New Hampshire, EPSCoR provided the initial funding (\$14 million) to build a high-speed fiber network connecting its research universities to the national grid in Boston. This investment led to over \$74 million in additional federal and private funding for seven internet expansion projects that now connect businesses, research centers, hospitals, schools and residences to each other and the rest of the world. NH EPSCoR investments have built world-class research facilities, educated hundreds of high-skilled undergraduate and graduate students now in the workforce and trained teachers in K-12 STEM education. The program is governed by the NH EPSCoR Statewide Committee, which includes leaders from New Hampshire business and industry, legislative and executive branches of state government, philanthropy and the public sector, and higher education.

Where should New Hampshire make investments in the future to maximally benefit the state's economy? What industry clusters are poised to benefit from research and innovation and deliver the high wage job growth so critical to the quality of life of NH residents? We invite you to turn the page to learn more...

Jan Nisbet, Ph.D

State Director, NH EPSCoR

Senior Vice Provost for Research, University of New Hampshire

Mike Shipulski, Ph.D

Chair, NH EPSCoR Statewide Committee

Director, Advanced Development, Hypertherm, Inc.

On behalf of the NH EPSCoR Statewide Committee

Executive Summary

This University Research and Industry plan for New Hampshire is focused on accelerating innovation-led development in the state by partnering academia's strengths with the state's substantial base of existing and emerging advanced industries. These advanced industries are defined by their deep investment and connections to research and development and the high-quality jobs they generate across production, new product development and administrative positions involving skills in science, technology, engineering and math (STEM).

“Each state must exploit the unique advantages it has relative to other states and build on the strengths found in its local ‘clusters of innovation.’”

National Governors Association, “A Governor’s Guide Trade and Global Competitiveness,” 2002

The importance of innovation-led development to New Hampshire’s economic future is critical. The National Research Council in a 2013 report, “Rising to the Challenge”, explains that the capability to innovate is fast becoming the most important determinant of economic growth and a nation’s ability to compete and prosper in the 21st century.¹ This reflects a new economic era marked by the fast pace of technological change, increased globalization, and the growing strength of developing nations in generating highly educated and skilled talent to compete for economic growth.

As one of our nation’s smaller states, New Hampshire’s capacity in innovation is often overlooked. But New Hampshire has many of the right ingredients to succeed including the presence of advanced industries, a significant number of inventors and skilled workers, and a portfolio of university research and development assets that can align with industry needs.

However, there are warning signs that suggest the state is not keeping pace across many measures of innovation activity including slower growth in advanced industries and higher paying middle-skilled and high-skilled jobs.

New Hampshire stands as an innovation-intensive state:

- 20% higher level of university research than the nation adjusted for size of economy
- More than 200% higher level of patent activity than the nation adjusted for size of economy
- 3% higher in share of advanced industry employment than the nation

But warning signs are apparent:

- Lagging national growth in advanced industry employment: 2.9% NH vs 9.1% nation
- Lagging national growth in industry and university research since the 2009 economic recovery – Industry Research and Development (R&D): 5.1% in NH and 17.8% nationally; University R&D: 6.7% in NH and 16.2% nationally

¹ Charles W. Wessner and Alan Wm. Wolff, Eds. “Rising to the Challenge: U.S. Innovation Policy for the Global Economy.” 2012. The National Academies Press, Washington, DC.

New Hampshire's Experimental Program to Stimulate Competitive Research (NH EPSCoR) program supported the development of this strategic planning assessment. Guidance was provided by NH EPSCoR's 20-member Statewide Committee representing industry, the executive and legislative branches, and higher education. Highly regarded national consultants, TEconomy Partners and Keen Point Consulting, conducted an independent, data-driven assessment combined with broad stakeholder engagement from private industry, economic development and higher education. A total of 77 interviews and three industry focus groups were conducted to ensure broad-based input.

While not a household name, NH EPSCoR is a major state-federal partnership that advances New Hampshire's competitiveness in science and engineering. NH EPSCoR has a strong track record for generating federal research funding support, building out infrastructure for high-speed broadband and shared use laboratories, and strengthening the state's skilled workforce.

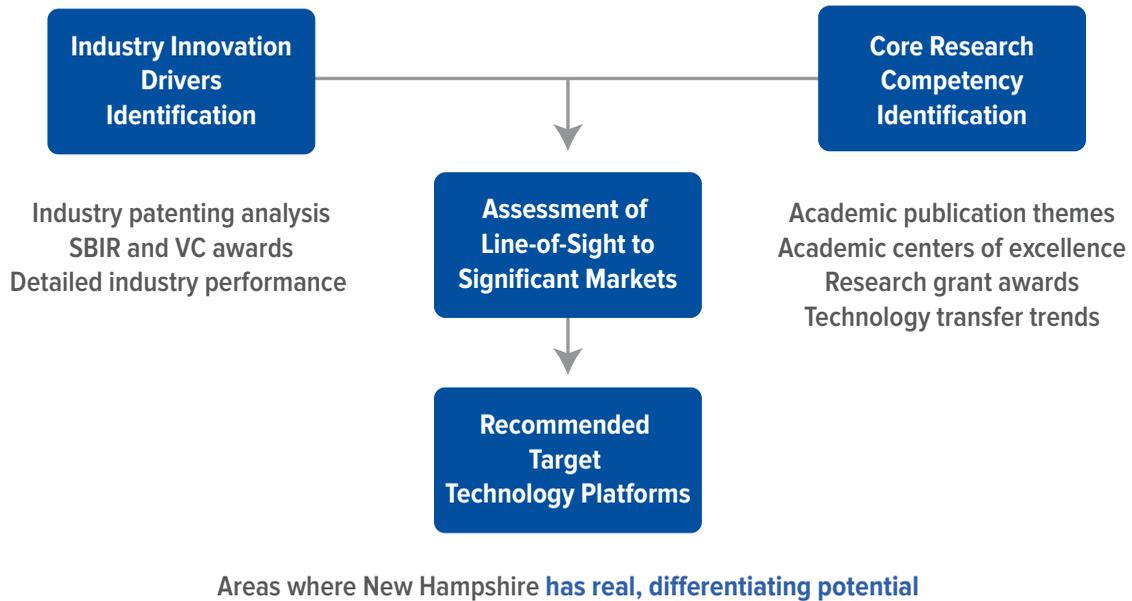
Identifying Opportunities to Strengthen Linkages Between University Research Assets and Innovation-led Industry Drivers in New Hampshire

Best practice assessments of economic development activities have made it clear that each state has its own specific industry drivers and growth opportunities through which it can differentiate itself and build specialized areas of expertise and development assets.²

To identify New Hampshire's specific growth opportunities, this analysis assessed where the state excels in innovation-led industry growth today and where it has the know-how and capacity in university research activities to grow in the future. Figure ES1 shows the specific metrics used in this assessment to identify a "line of sight" to market-driven growth opportunities. The analysis considered the market pull of New Hampshire's leading advanced industries and the technology push from the state's university research capabilities, primarily found at the University of New Hampshire and Dartmouth College.

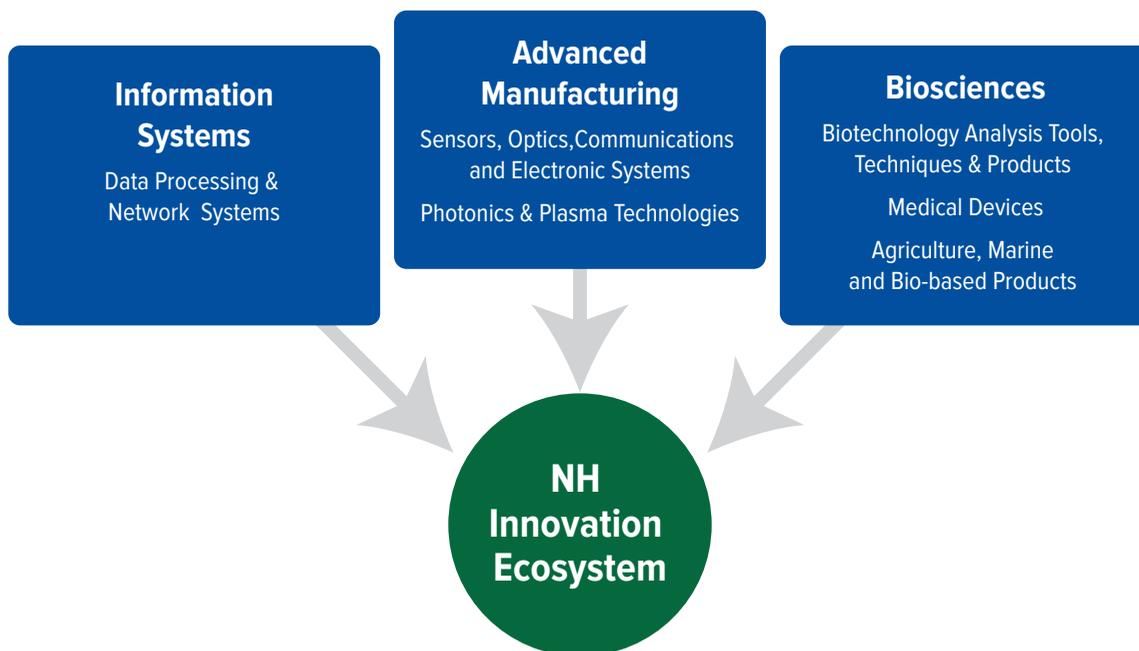
² The idea that state and regional development is driven by geographically localized concentrations of firms in related sectors that do business with each other and have common needs for trained workers, infrastructure and technology goes back in the economic literature to the writings of Alfred Marshall in the late 19th and early 20th centuries. For a discussion of the roots of these ideas in economic theory see the National Research Council's report on *Best Practices in State and Regional Innovation Initiatives*, pages 31–34.

Figure ES-1: Line of Sight Approach for Identifying Innovation Opportunity Areas for Economic Development in New Hampshire



From the line-of-sight analysis, TEconomy identified six specific niche areas of innovation-led development in New Hampshire that fall within three broad industry cluster themes (Figure ES-2):

Figure ES-2: Innovation Clusters Driving Development in New Hampshire



New Hampshire's Innovation-Led Industry Development Cannot be Taken for Granted

For the identified growth opportunities to be realized, New Hampshire needs to build on its value-added business environment for industry innovation activities. Through competitive benchmarking to 17 other similar states, extensive stakeholder interviews, and focus groups, a detailed situational assessment found that in many areas of innovation activity New Hampshire is well-positioned.

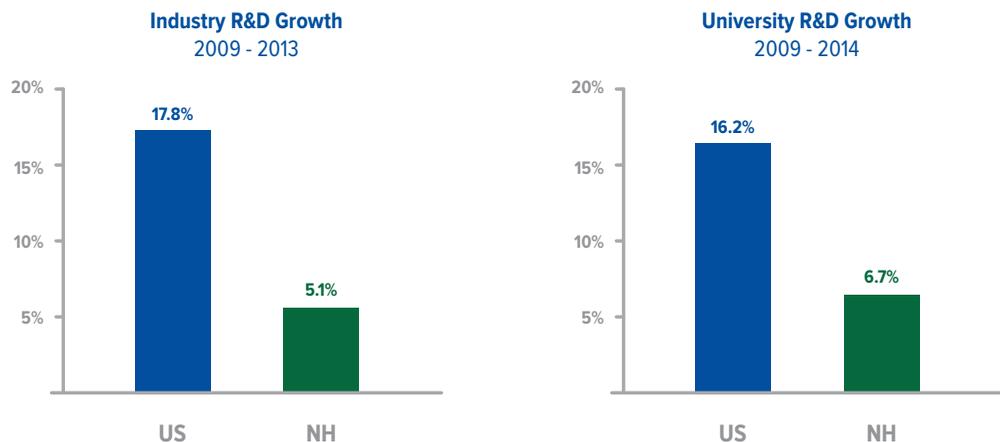
In particular, New Hampshire can build upon its strengths in its level of patent activities, presence of advanced industries, university research assets, competitiveness in federal small business innovation research (SBIR) grants and growing efforts in entrepreneurial development to continue to make its mark in innovation. Plus, New Hampshire's ranking in the top ten states for its pro-business tax and regulatory environment (according to independent studies by the Tax Foundation and the U.S. Chamber of Commerce) provides a key foundation for advancing economic development.

Still, the detailed situational assessment suggests a number of strategic areas where gaps and lagging performance are emerging that can hold the state back. These include:

- Lagging growth in research and development for both industry and universities in New Hampshire
- Untapped opportunities for industry-university collaborations that could bolster New Hampshire's innovation-led industry development
- Shortfalls in the level of entrepreneurial activity needed to drive future growth
- Challenges in keeping up with the demand for skilled talent and in attracting and retaining skilled talent.

Despite having ample opportunities for advancing innovation-led development, New Hampshire must shore up its economic foundations and innovation ecosystem to create the right conditions for growth to take place. The concerns about the lagging level of industry and university research growth and industry-research collaborations, together with a spotty record on entrepreneurial activity and skilled workforce performance, align with a major finding of this study – New Hampshire is falling behind in the growth of its advanced industries, ranking near the bottom third of the benchmark states and slipping well below the national average growth.

**Figure ES-3:
New Hampshire
Not Keeping
Pace in Industry
or University
Research and
Development
(R&D) Growth**

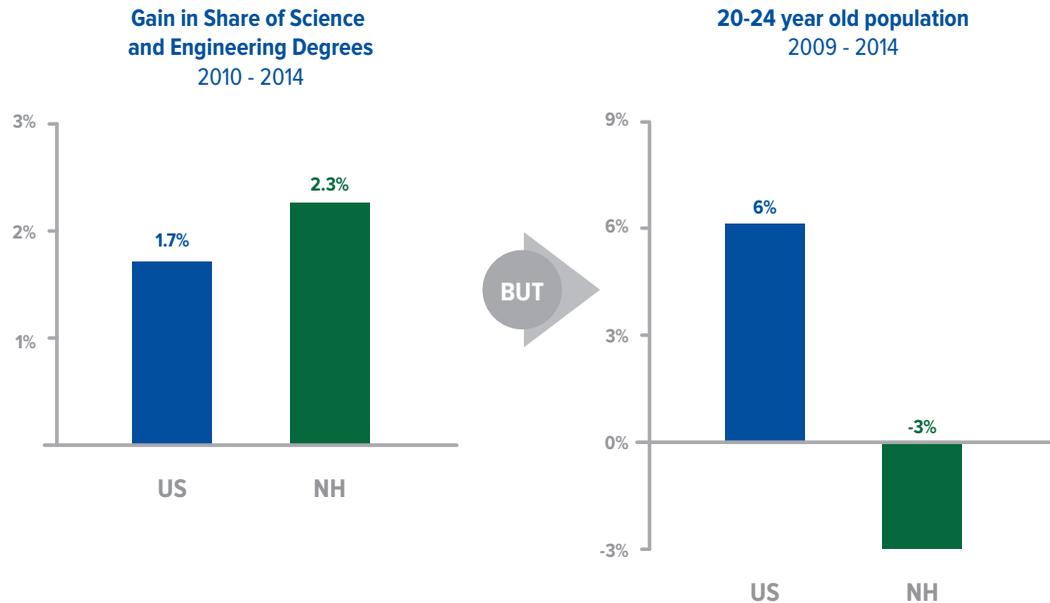


Industry-university research collaborations are not a strength for New Hampshire. The state stands below the U.S. average for industry funding of university research and among the bottom third of the benchmark states.

Discussions with industry executives point to unrealized opportunities for collaborations that are holding back advanced industry growth in New Hampshire:

- Advanced Manufacturing:** Industry executives noted the lack of statewide networking opportunities for industry to learn about university capabilities, concerns that smaller industry research projects are discouraged by universities due to resource constraints and limited opportunities to engage students around industry research needs via co-ops, internships and student projects. A gap was also mentioned around the limited availability of academic facilities that the aerospace-related industry and its suppliers can tap for advancing research and development in metals-based and non-metals-based additive manufacturing, also known as 3D printing.
- Information Systems:** Limited research and development connections and joint curriculum development between universities and industry is resulting in missed opportunities for addressing industry needs and developing students' core skills in areas, such as cybersecurity, digital health and Internet of Things (IoT).
- Biosciences:** Existing university research centers are generating new start-ups, especially in biotechnology, but missing ties to the state's specialized industry strength in medical devices.

Figure ES-4:
New Hampshire's Share of Science and Engineering Post-Secondary Degrees Rising, but New Hampshire's Population of 20-24 year olds is Declining



An Action Plan for Advancing Innovation-led Economic Development in New Hampshire

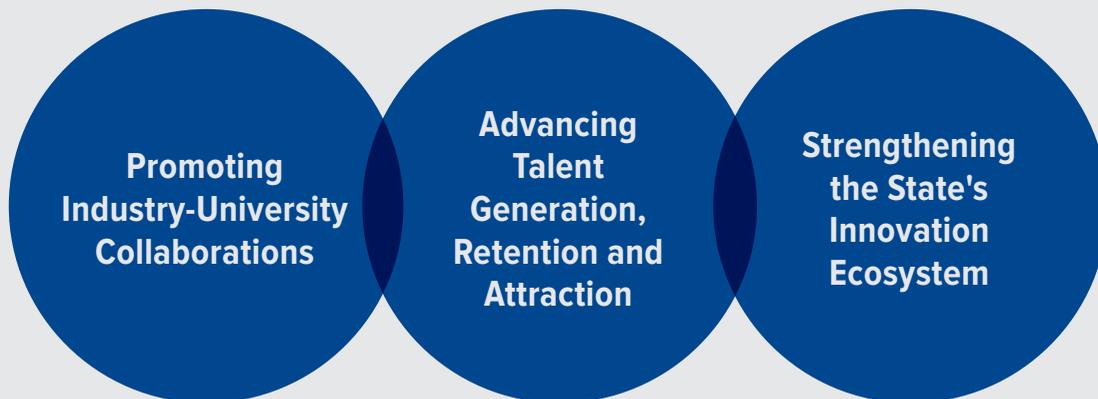
New Hampshire can continue to increase innovation-led development. This analysis, which included quantitative data, interviews, and industry focus groups identified three broad strategic priorities to be addressed:

- **Promote industry-university collaborations** with a focus on industry-facing research and growth opportunities.
- **Strengthen New Hampshire’s innovation ecosystem** to spur increased commercialization, entrepreneurial development and place-making (i.e. physical places, such as technology parks, incubators, and accelerators to promote innovation).
- **Advance talent generation, retention and attraction** through promoting industry-university collaborations and strengthening the state’s innovation ecosystem.

These three broad strategic priorities overlap and depend on each other to advance innovation-based development. Both industry-university collaborations and strengthening the state’s innovation ecosystem play a strong role in advancing talent. Talent is one of the most important competitive factors for industry development. When industry collaborates with academia, they are often seeking to engage the talent of students, faculty, or staff in their activities. At the same time, talent is more attracted to places with a thriving innovation ecosystem, where there is a substantial concentration of innovation-led companies, the presence of anchor institutions, a supporting network of resource providers, and a high-quality lifestyle.

New Hampshire already has activities underway in each of these broad strategic action priority areas (Figure ES-5), but there is more to be done. The specific actions set out in this university research and industry plan are focused on leveraging the activities already in place to create a more collaborative innovation ecosystem. In the following three pages, the suggested strategic actions, best practice examples, and recommendations for New Hampshire are summarized for each of the priority areas. Details for each of the strategic action priority areas can be found in the action plan section of the university research and industry plan.

Figure ES-5: Three Broad Strategic Priorities for the NH University Research and Industry Plan



Overview of Suggested Actions for Advancing Innovation-led Economic Development in New Hampshire (1 of 3)

Strategic Priority #1: Promote Industry-University Collaborations		
Strategic action	Best Practice Example(s)	Recommendation for New Hampshire
A. Transform larger industry consortium efforts to facilitate partnerships with academia to generate scale and focus on identified growth opportunities	<p>Signature Research Centers established by Oregon, Inc.</p> <ul style="list-style-type: none"> State funded, government-industry-university partnership approach to consortium activities. <p>Cluster Initiative Program - Maine Technology Institute</p> <ul style="list-style-type: none"> Competitive, multi-year grant awards of up to \$500,000 for industry-academia collaborative efforts in Maine's high-potential technology clusters. 	<p>Complement one-to-one industry-university research projects supported by the New Hampshire Innovation Research Center (NHIRC) with broader-scale industry consortiums, such as the following:</p> <ul style="list-style-type: none"> Adv. Manufacturing: UNH Center for Advanced Materials and Manufacturing Innovations (CAMMI) and Advanced Technology & Academic Center at Great Bay Community College. Information Systems: Interoperability Lab at UNH and Dartmouth's Institute for Security, Technology and Society (CoAE in Info Assurance Research). Biosciences: Hubbard Center for Genome Studies at UNH and Dartmouth SYNERGY Clinical and Translational Science Institute. Cross-Cutting: Integrated Academic Structure at Plymouth State; Advanced Imaging Center at Dartmouth; University Instrumentation Center at UNH.
B. Promote more university presence around networking activities	<p>Various State Universities & Industry Organizations (e.g. Tennessee – LaunchTN)</p> <ul style="list-style-type: none"> State academic institutions working in concert with various industry organizations and affiliated groups to hold more structured topic area workshops and networking. 	<p>Fledgling and siloed industry networking activities taking place in New Hampshire would benefit by having more systematic engagement with university research centers and departments.</p>
C. Advance more student research and design projects with industries	<p>Various Engineering Schools (such as University of Michigan)</p> <ul style="list-style-type: none"> Projects expose students to industry R&D, grow broader industry research relationships with a university, and help companies and students learn about each other. 	<p>Based on discussions with industry executives, the use of student design projects between New Hampshire universities and companies is limited and many of the public universities lack the infrastructure to facilitate these efforts – NHIRC might be expanded as a resource to provide industry-university collaborative grants for these projects.</p>
D. Better market and leverage university shared-use facilities for collaboration with industry	<p>Massachusetts Technology Portal by the Massachusetts Technology Transfer Center & Massachusetts Association of Technology Transfer Offices (MATTO)</p> <ul style="list-style-type: none"> Centralized location providing the technologies available at 28 research institutions in the state. 	<p>Centralized database or single website location that lists shared use facilities, information, and contacts across academic institutions in New Hampshire would be beneficial to foster industry-university collaborations.</p>

Overview of Suggested Actions for Advancing Innovation-led Economic Development in New Hampshire (2 of 3)

Strategic Priority #2: Strengthen New Hampshire's Innovation Ecosystem		
Strategic action	Best Practice Example(s)	Recommendation for New Hampshire
A. Targeted “pre-seed” commercialization funding	<p>State of Iowa - Innovation Funding</p> <ul style="list-style-type: none"> Graduated range of competitive innovation funding with a 50% match for proof of commercial relevance or initial market introduction questions for emerging technologies. Also, provides entrepreneurial assistance through a network of technology and business executives. 	More “pre-seed” stage capital is needed to validate the commercial potential and moving towards prototyping of products.
B. Establish an angel investor tax credit	<p>Wisconsin's Qualified New Business Venture tax credit</p> <ul style="list-style-type: none"> Tax credit available to certified early stage businesses based in the state developing innovative products, processes or services. 	This tool helps support the development of its early-stage innovation-led companies.
C. Uncap New Hampshire's research and development tax credit	<p>Most States Do Not Have Caps (including MA)</p> <ul style="list-style-type: none"> Predictable research and development tax credit for increasing industry research and development. 	NH has upgraded its research and development tax credit in recent years, but should consider removing the cap so businesses will have more certainty regarding the value of their research and development tax credit.
D. Promote statewide mentoring and peer-to-peer networks that connect rural entrepreneurs to others in the state	<p>Oklahoma Technology Commercialization Center – managed by Innovation to Enterprise (i2E) organization</p> <ul style="list-style-type: none"> Staff venture advisors help entrepreneurs grow viable businesses by helping them focus their business plans and strategies and through hands-on support. <p>Michigan's Small Business Development Center (SBDC)</p> <ul style="list-style-type: none"> Uses a technology team approach to help to connect entrepreneurs anywhere in the state to more specialized resources, workshops and peer-to-peer networks found across the state's incubator and accelerator programs. 	NH should complement its incubator and accelerators by growing entrepreneurial mentoring and technical assistance to connect rural entrepreneurs to others in the state.
E. Focus on place-making around innovation hubs to retain and attract talent	<p>Connecticut Innovations</p> <ul style="list-style-type: none"> Connecticut offers direct financing of tenant improvements for biotechnology lab space across the state. <p>SmartZone Program - State of Michigan</p> <ul style="list-style-type: none"> Limited grant funding for multi-tenant lab space around academic institutions in the state. 	Advance emerging “innovation districts” and multi-tenant laboratory facilities by supplementing existing local tax increment financing (TIF) approaches with add-on funding for specialized tenant improvements.
F. Promote awareness and connections with Boston/Cambridge community	<p>Oakland, California</p> <ul style="list-style-type: none"> Oakland leverages its proximity to the Silicon Valley Bay area to help drive innovation growth. <p>Winston-Salem, NC</p> <ul style="list-style-type: none"> Research Triangle Region is leveraged by the nearby city of Winston-Salem to help increase growth in innovation. 	Leverage innovation-led development of the Greater Boston region, especially in Cambridge for NH businesses to generate customers and capital and to offer a rich environment for business and talent attraction.

Overview of Suggested Actions for Advancing Innovation-led Economic Development in New Hampshire (3 of 3)

Strategic Priority #3: Advancing Talent Generation, Retention and Attraction		
Strategic action	Best Practice Example(s)	Recommendation for New Hampshire
A. Advance STEM post-secondary internships	<p>Indiana INTERNnet</p> <ul style="list-style-type: none"> A dynamic, searchable database and a matching and reporting system coupled with personal assistance, including a toll-free hotline to answer questions. <p>Iowa Student Internship Program</p> <ul style="list-style-type: none"> Program supports postsecondary student interns in small to medium sized companies in the targeted sectors. 	<p>Connections need to be generated between students and industry as NH academic institutions increase their emphasis on STEM-related degrees, such as platform to match students with industry or matching funding to support student internships with companies.</p>
B. Provide an opportunity for employers to create apprenticeship programs for a technical skilled workforce	<p>Apprenticeship Carolina - division of the South Carolina Technical College System</p> <ul style="list-style-type: none"> Works with all employers to advance “demand-driven” apprenticeships customized to employer needs, while offering young workers “scalable” wages. 	<p>New Hampshire should increase the number of apprenticeship programs for technical skilled labor to complement community college efforts and help meet the demand of industry.</p>
C. Meet industry needs for more new academic degree programs in emerging and multi-disciplinary fields	<p>Engineering Projects in Community Service (EPICS) program at Purdue University</p> <ul style="list-style-type: none"> EPICS teams are assigned to a community or educational partner allowing students to participate on projects developed over multiple semesters or years and have more complexity than semester-based efforts. <p>MS program in Engineering and Technology Innovation Management (E&TIM) at Carnegie Mellon University</p> <ul style="list-style-type: none"> Interdisciplinary program developed in collaboration with industry that prepares students in the area of technology innovation through project coursework and practical internships. 	<p>Increase the multi-disciplinary skill set for NH students in the academic curriculum to better prepare them for careers using advanced technologies.</p>

A common thread across these strategic actions is the need for public-private partnerships. Government, industry, colleges and universities and non-profits have a part to play in this strategy, but success will be dependent upon the active participation of these sectors' top-level leadership in setting the tone and keeping stakeholders focused on implementing these actions.

- State Government has a unique role as a catalyst, using limited funding and marketing resources to spur action and leverage broader private sector activity. State Government can also help serve as a convener and facilitator to advance the state's economic development goals in collaboration with non-profit economic development entities.
- Industry must help frame opportunities and needs in order for the entire innovation ecosystem to respond effectively. Industry from private venture investors to entrepreneurs to established companies will also make the largest investments as commercially viable technologies move to the marketplace.
- Colleges and universities can contribute in significant ways to advancing the state's future by pursuing use-inspired research that aligns with industry technology challenges, offering shared use facilities, pursuing translational and commercialization of research discoveries, and generating the talent that can help realize the state's industry-driven innovation opportunities.
- The non-profit sector can provide capacity for New Hampshire to succeed through its foundations investing in the state's future and through the non-profit economic development organizations and industry associations that work in concrete ways to support innovation, retention, and attraction of industry at the state and local levels.

This full fact-based assessment, including these strategic actions can be used to initiate dialogue among these stakeholders in New Hampshire to do the following:

- Create awareness of the growth opportunities for the state;
- Prepare potential solutions for the challenges that are emerging; and
- Generate and implement potential ideas on how to move forward.

It is by having this discussion that New Hampshire can take action to realize its bright future for innovation-led development in the state.

Why a University Research and Industry Plan Matters for New Hampshire

A new economic era has taken hold in recent decades marked by increasing globalization, the fast pace of technological change, and the growing strength of developing nations in generating highly educated and skilled talent to compete for economic development opportunities.

According to the National Research Council's 2013 report, "Rising to the Challenge", the capability to innovate is fast becoming the most important determinant of economic growth and a nation's ability to compete and prosper in the 21st century global economy.³ Rigorous economic studies back up this conclusion. Economists at the Federal Reserve Bank of Cleveland found that increased innovation, evidenced by growing levels of patent activities, stood out as one of the significant factors for explaining a state's level of per capita income and its level of educational attainment. Innovation and talent, which are highly linked, outpaced other factors such as tax burdens, public infrastructure, the size of private financial markets, rates of business failure and industry structure.⁴

As one of our nation's smaller states, New Hampshire's capacity in innovation is often overlooked. A closer examination points to New Hampshire's standing as an innovation-intensive state.

- University research activity in New Hampshire outpaces the nation by more than 20% given the size of its economy.
- New Hampshire stands at more than twice the national level of patent activity invented and assigned to companies, universities and residents located in the state given the size of the state's economy.
- New Hampshire stands slightly ahead of the nation in the percentage of jobs in advanced industries, defined by investment in R&D and a workforce involved in science, technology, engineering and math (STEM) fields (11.2% in New Hampshire vs 10.9% nationally). According to the Brookings Institution, these advanced industries anchor American economic well-being by "... encompass[ing] the nation's highest-value economic activity. As such, these industries are the country's best shot at innovative, inclusive, and sustainable growth."⁵

These indicators of New Hampshire's strength across university research, technology development and the presence of advanced industries point to the importance of innovation as an economic driver of New Hampshire's economy. Still, there are some warning signs that point to the need to strengthen New Hampshire's innovation capacity. Since 2009, when the economic recovery began, New Hampshire's growth in advanced industries of 2.9% is well behind the national growth of 9.1%.

"The role of innovation has been critical to economic development as the U.S. has evolved over the decades. There is a clear statistical link between innovation and gains in the standard of living."

Abby Joseph Cohen, Senior Investment Strategist and President of the Global Markets Institute of Goldman Sachs, "Innovation and Economic Growth," Private Wealth Forum, Goldman Sachs, 2011.

³ Charles W. Wessner and Alan Wm. Wolff, Eds. "Rising to the Challenge: U.S. Innovation Policy for the Global Economy." 2012. The National Academies Press, Washington, DC

⁴ Bauer, Schweitzer and Shane, "Knowledge Matters: The Long-Run Determinants of State Income Growth," *Journal of Regional Science*, 52(2), 240-255.

⁵ Brookings Institution, *America's Advanced Industries: What They Are, Where They Are, And Why They Matter*, Brookings Advanced Industries Project, February 2015, page 11.

This slower growth in advanced industries also shapes the availability of quality jobs found in New Hampshire. Both high skilled and middle-skilled jobs are growing more slowly in New Hampshire than the national average.

Ensuring that New Hampshire can strengthen its advanced industries is critical. This University Research and Industry Plan outlines findings and recommendations to increase collaboration between New Hampshire's university research centers and advanced industries focused on information and networking services, biosciences and advanced manufacturing in order to:

- Improve production processes
- Create specific talent pools
- Accelerate new product innovations
- Form high-growth potential technology-based companies

New Hampshire is an innovation-intensive state:

- 20% higher level of university research than the nation adjusted for size of economy
- More than 200% higher level of patent activity than the nation adjusted for size of economy
- 3% higher in share of advanced industry employment than the nation

But warning signs are apparent:

- Lagging national growth in advanced industry employment: 2.9% NH vs 9.1% nation
- Lagging national growth in industry and university research since the 2009 economic recovery – Industry Research and Development (R&D): 5.1% in NH and 17.8% nationally; University R&D: 6.7% in NH and 16.2% nationally

Identification of New Hampshire's Innovation-Based Industry Drivers

For today's knowledge-based, global economy, innovation is now widely recognized as the central driver of leading industry clusters within each state. As the National Governors Association explains: "Each state must exploit the unique advantages it has relative to other states and build on the strengths found in its local 'clusters of innovation' – distinct groups of competing and cooperating companies, suppliers, service providers and research institutions."⁶

In an interesting paradox, the more globally integrated the world economy becomes, the more local university and industry research and development know-how, entrepreneurial culture, manufacturing expertise and workforce skills matter for economic success. These areas of local strength in innovation capacity reflect the core competencies around which industries innovate and grow around specific locations.

The concept of core competencies is now widely understood as a critical factor for industries to be competitive. Gary Hamel and C.K. Prahalad in their landmark study, "Competing for the Future", explain how a focus on core competencies can improve competitiveness: "To successfully compete for the future...requires top management to conceive of the company as a portfolio of core competencies rather than a portfolio of individual business units...core competencies are the gateways to future opportunities."⁷

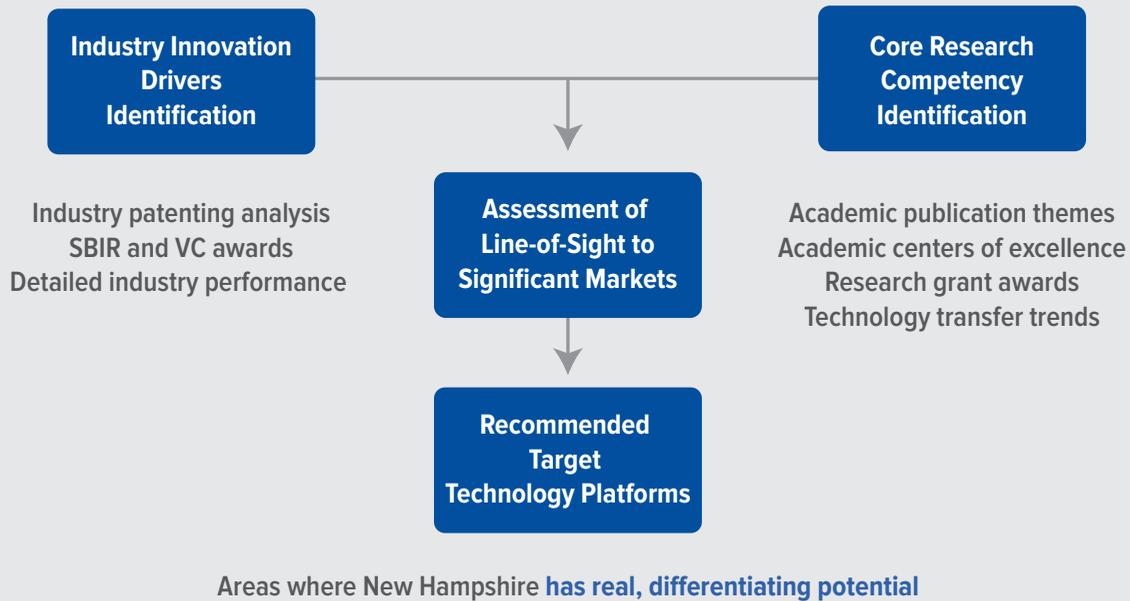
From a state and regional economic development perspective, core competencies represent a "critical mass" of know-how found within a state. This critical mass is represented by having depth across industry generation of new inventions and start-ups as well as strength in specific fields of university research. The identification of these core competencies, augmented by traditional regional industry analysis, can allow New Hampshire to think strategically about where it has opportunities for innovation-based development.

Innovation-led industry growth opportunities in which New Hampshire is best positioned to differentiate itself reflect the intersection or "line-of-sight" where the state excels in innovation-led industry growth today, and where it has the know-how and capacity in university research activities to grow in the future. Figure 1 presents the overall approach and the specific metrics used in this assessment to identify a "line-of-sight" to market opportunities that consider the market pull of leading advanced industries found in New Hampshire and the technology push from the state's university research capabilities.

⁶ National Governors Association, "A Governor's Guide Trade and Global Competitiveness, 2002, page 5.

⁷ Hamel and Prahalad, *Competing for the Future*, Harvard Business Press, 1994, pg. 90 and 217.

Figure 1: Line of Sight Approach for Identifying Innovation Opportunity Areas for Economic Development in New Hampshire



This “line of sight” approach involves five specific steps to identify industry innovation drivers (see Appendix A for more details):

Step 1: Set the broad context of advanced industry activity taking place in New Hampshire through a detailed analysis of patent activities of New Hampshire inventors in order to identify clusters of innovation activity in New Hampshire.

Step 2: Consider how emerging technology company activities aligned with these patent innovation clusters given the importance of companies with high-growth potential for fueling future state economic growth.

Step 3: Identify how well these industry innovation activities map to specific industries and their performance in New Hampshire.

Step 4: Assess how university research activities in New Hampshire support and complement innovation cluster activity found in the state.

Step 5: Assess the future market growth potential associated with each growth opportunity.

Closer Look at Patent Innovation Taking Place in New Hampshire

Patents are a primary way in which inventors are able to protect their product innovations from being replicated and are among the most widely used form of protection of novel technological inventions. Industry is the overwhelming holder of patent applications and awards making patent analysis a direct way to consider the broad base of innovation across New Hampshire industry.

Out of more than 22,000 patent awards and applications generated from 2009 to 2015, New Hampshire's strengths in innovation can be clearly identified.

Leading Patent Areas: New Hampshire stands out and is very active in the following patent areas, having a higher specialization and relative impact than those patent areas nationally. Overall, data processing & analytics is the most active patent area in the table below.

Detailed Patent Class Focus Area	Number of Patents Invented	Specialization Index	Forward Citation Impact Index
Machine learning, natural language processing, and complex data processing algorithms	791	2.01	1.63
Computer processors, virtual machine management, and other program controllers	331	2.22	2.03
Syringes, injectors, and infusion pumps	291	9.41	1.16
Manufacture and treatment of semiconductor devices	288	2.53	1.61
Touch sensor, stylus, and optical computer user interface devices	257	1.77	2.05
Implantable medical devices (stents, prosthetics, etc.)	252	2.61	2.06
Logistics and consumer data processing	246	2.08	1.64
Network security protocols or architecture	241	2.21	2.12

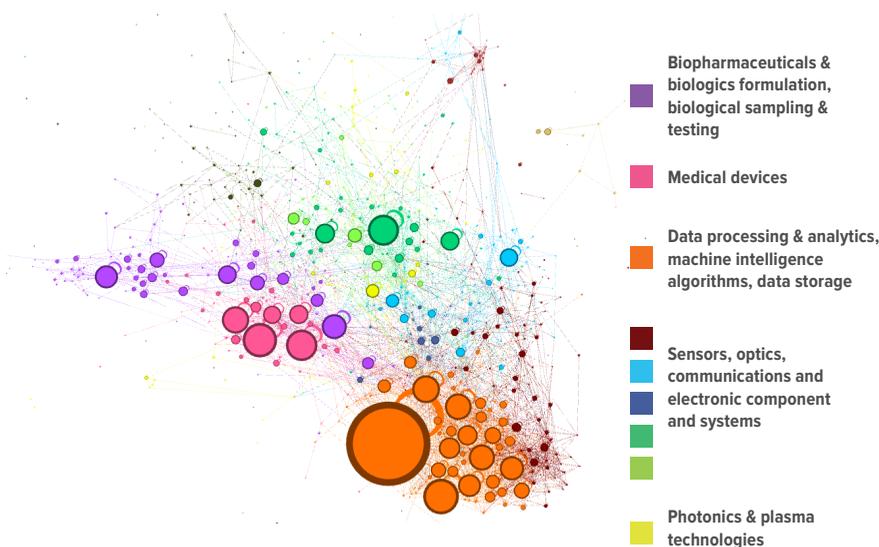
The Specialization Index column shows patent areas where the level of relative concentration in NH compares to the U.S. across specific patent areas.

The Forward Citation Impact Index shows high relative impact patent areas whose citations per patent exceed the national average.

A score of 1.0 in Specialization Index or Forward Citation Impact Index equals the national average and 2.0 is double the national average.

Source: Thomson Innovation; Calculations by TEconomy Partners, LLC.

Patent Innovation Networks: New Hampshire has several broad areas of patent activity that represent extensive connections between and among industry and universities based on an analysis of forward citations. These broad, highly connected patent cluster areas in New Hampshire, which also encompass leading areas of patent activity, suggest where the state stands out in specific innovation areas of technology.



Source: Thomson Innovation; Calculations by TEconomy Partners, LLC.

There are five groupings of NH's patent classes by technology area from the analysis of patent award and applications from 2009-15.

Lines represent interconnections between these five different groupings of NH patents by technology area using forward citations.

Data processing & analytics is a key enabling technology area based on this visual representation of its connectivity to many other patent classes by technology area.

Source: Thomson Innovation; Calculations by TEconomy Partners, LLC.

New Hampshire's Innovation-Led Growth Opportunities are Found in Advanced Manufacturing, Information Systems and Biosciences

The “line-of-sight” analysis identified six niche areas of industry innovation in New Hampshire that fall within three broad industry clusters:

Below is a brief overview of each of the specific innovation niches falling within these broad industry clusters. A profile of each these innovation niches areas is provided in Appendix A to provide a fuller explanation of the industry innovation context, the industry connections, the university research alignment and the growth potential.

Advanced Manufacturing

Sensor, optics, communications and electronic systems – New Hampshire is active in patent areas involving optical interface devices, manufacturing and treatment of semiconductor devices, magnetic field sensors, vehicle navigation control systems, and aerial antennae systems. This reflects New Hampshire's specialization in defense-related industries involving search, detection and navigation, as well as those involved in the electronic systems supply chain such as optical instruments, printed circuit assembly and electronic component manufacturing, communication and energy wire manufacturing and engineering services. These companies employ more than 16,000 workers in New Hampshire.

- **Industry presence:** Many large companies with operations in New Hampshire fall into this category, including BAE, GE Aerospace, Fujifilm Dimatix and Taiwan Semiconductor. However, most are small and mid-sized companies, who serve as suppliers to larger organizations. A notable, mid-sized company is Creare, which is highly successful in federal small business innovation research (SBIR) grant funding and received 59% of New Hampshire's 537 SBIR awards from 2009 to 2015 and created multiple spin-out companies.
- **Growth outlook:** While the employment base is not growing in New Hampshire nor across the U.S. in these industries – as emerging advanced manufacturing process technologies are being installed – they are still viewed as having solid future growth trends, with the global markets for image sensors, integrated remote sensing and advanced electronics projected to grow at close to 10% or higher annually.
- **Research capacity:** Universities in New Hampshire have a strong concentration of publications in optics, remote sensing, imaging science and spectroscopy though often applied through environmental sciences. Leading research centers include the University of New Hampshire's Center for Coastal and Ocean Mapping, the joint UNH-NOAA Hydrographic Center and Dartmouth's Advanced Imaging Center.

Photonics and Plasma Technologies – New Hampshire is a national leader in this area with very high specializations in patents for charged particle beam systems, projected and filtered light display devices, generating and handling plasma and laser systems.

- **Industry presence:** While a highly specialized, but smaller industry with nearly 2,700 jobs in New Hampshire, it is led by one of the most successful home-grown New Hampshire companies, Hypertherm. Other companies found in this innovation area include Laser Light Engines, Osram Sylvania, Solid State Scientific, QmagiQ LLC and Active Spectrum.

- **Growth outlook:** The market for laser technologies in the U.S. has overall modest growth prospects in the 5% annual growth range, but high growth of over 10% annually is projected in the specific markets for photonic detectors and sensors. SBIR funding for high performance metals machining and inspection is an active area in New Hampshire.
- **Research capacity:** There is a specialized focus on plasma physics as a publication field among universities in New Hampshire and an overlap with strengths found in optics. The UNH Space Science Center is a major research center aligned with this area of innovation focus.

Information Systems

Data processing and network systems – This area includes patent strengths found in machine learning and complex data processing, logistics and consumer data processing and network security. Industries aligned with this area include data processing and hosting, custom computer programming, computer systems and design services and software publishing. These aligned industries grew by just over 24% making it an important job generator for New Hampshire. With nearly 12,000 jobs, it stands as a specialized industry though not at the levels of specialization found in advanced manufacturing.

- **Industry presence:** This area has a healthy mix of emerging companies such as Dyn and Bottomline Technologies and more established companies such as AutoDesk, HP, Oracle and EMC. There are many emerging high-growth potential companies found in New Hampshire with extensive venture capital support for software, data, internet and computer services. Between 2009 and 2015, 29 New Hampshire companies received \$421 million in venture capital funding.
- **Growth outlook:** Global market growth rates for this area encompass a wide variety of applications with large market sizes and strong annual growth rates. For instance, the market areas of enterprise mobility networks, content delivery networks and data center and server security are each expected to grow at nearly 14% annually, and even higher annual growth rates are expected for the emerging market of software-defined networking applications.
- **Research capacity:** Universities in New Hampshire are active in this area, with more than 100 publications from 2009 to 2015 in fields such as information sciences, software engineering and interdisciplinary computer sciences applications. New Hampshire's universities stand out in the breadth of major research centers and grants, most notably the UNH Interoperability Lab and Dartmouth's efforts in cybersecurity, mobile health, digital forensics and ubiquitous computing.

Biosciences

Biotech Analysis Tools, Techniques and Products – New Hampshire's patent activity in biopharmaceutical compositions, screening and assay analysis of biological materials and measuring processes involving enzymes and micro-organisms is strong. While a small industry presence of just over 2,500 jobs, the growth across biological product manufacturing and biotechnology research in New Hampshire is hefty – growing 84% from 2009 to 2014.

- **Industry presence:** Although not large from an industry employment standpoint, there is a presence of both emerging and established companies, including Adimab, AgaMatrix, CPEX Pharmaceuticals, DEKA, Enchi Corp., Avitide, Celdara Medical, ImmuNext, and Synta Pharmaceuticals Corp. Most promising for the future is the healthy level of venture capital funding in medical therapeutics and biotechnology, and an active SBIR presence in immunotherapies and vaccines, biomarkers and next generation genetic sequencing. Venture capital funding for medical therapeutics and biotechnology in New Hampshire reached \$137.8 million over the 2009-2015 period with investments made in six New Hampshire companies.

- **Growth outlook:** Market research studies suggest that biotechnology already serves large markets in diagnostics, cell and tissue analysis, and immunoassays and project modest annual growth for these areas in the 3% to nearly 5% range. A high growth market projected to exceed 10% annual growth is drug discovery technologies.
- **Research capacity:** There are strong ties between Dartmouth College and this innovation sector with many fields of biotech-related scholarly activity going forward in the state. Dartmouth has two extensive areas of focus contributing to the growth of this innovation area: 1) immunology and microbiology reaching across cancer, lung biology and antibiotic resistance and 2) engineering in medicine with strengths in protein engineering, biomaterials and nanotechnology. Other areas of major grants include psychiatry involving substance abuse and traumatic brain injury and systems biology involving molecular epidemiology, quantitative biology and structural biology. It is notable that Dartmouth College has a very pro-active approach to forming new companies in the biosciences through Celdara Medical, which is closely affiliated with Dartmouth. Plus, Dartmouth's NIH-funded Clinical and Translational Sciences Institute, known as Synergy, is active in promoting translational research among faculty.

Medical Devices – New Hampshire's patent strengths in medical devices include syringes, injectors and infusion pumps, surgical and wound healing devices, implantable medical devices and diagnostic sensors and medical imaging. Medical device industries in New Hampshire are specialized. Its share of industry employment is at a 42% higher level of specialization when compared to the nation, but New Hampshire job growth in medical devices has declined sharply by 12% from 2009 to 2014.

- **Industry presence:** Although a small industry with just over 2,100 jobs, New Hampshire has many companies driving new innovations in this area, including DEKA, Vapotherm, Simbex, Gamma Medica and AgaMatrix.
- **Growth outlook:** The global market for medical device coatings and equipment is growing at about 7% with growth expected in the area of implantable devices, such as stents and grafts, and clinical sensors and monitors, while the global medical imaging market is increasing at an annual growth rate of approximately 5%.
- **Research capacity:** University strengths are found in many areas pertaining to medical devices, with publications in surgery, radiology, and health care sciences. Major research centers led by Dartmouth College include the Center for Surgical Innovation, Advanced Imaging Center, Center for Technology and Behavioral Health and the Dartmouth Institute for Health Policy and Clinical Practice.

Agricultural, Marine and Bio-based Products – This is a mid-sized industry in the state with about 9,400 jobs, but job growth has declined by 2.2% from 2009 to 2014. Forestry and marine fisheries are major resources in New Hampshire. There are significant efforts to create new community forests to conserve this natural resource, led by the Northern Forest Center. Advancing agricultural, marine and bio-based products have potentially strong overlaps with the activities found in biotechnology analysis tools, techniques and products. Continued efforts are needed to understand how best to apply these innovation capacities to promote natural resource development. An example is Mascoma, a spinoff from Dartmouth, which is converting biomass into biofuels and other specialty chemicals.

- **Industry presence:** There are a variety of companies in the state working in the agricultural, marine and bio-based products areas, including Monadnock Paper Mills Inc., Stonyfield Farm Inc., Gorham Paper and Tissue, Burgess BioPower, and Cedar Point Shellfish. Despite the presence of a large base of natural resources, including extensive woodlands and coastal resources, venture capital and SBIR activity in this area is low.

- **Growth outlook:** The global market outlook varies by application with the synthetic biofuels projected to have an annual growth rate of 78%, while biorefinery technologies are at the lower end of the range with a 5% global annual growth rate projected.
- **Research capacity:** Universities in New Hampshire have much to contribute to this innovation niche. In scholarly activity as measured by publications, universities stand out in many fields connected with bringing innovation forward for agricultural, marine and bio-based products including: forestry, marine biology, fisheries, biodiversity conservation and environmental sciences. Existing strengths in the UNH School of Marine Science and Ocean Engineering and a recent cluster hire made in natural resources at the College of Life Sciences and Agriculture are key drivers of new research and technology. Dartmouth College also has leading faculty researchers in bioprocessing, advancing biofuels and biomass processing. Plus, through Agricultural Extension and the Thompson School of Applied Sciences at UNH, there is capacity to advance new applied research.

Each of the six innovation niches differs in the strength of existing industry assets, the strength of existing research and innovation found in the region and their growth potential – and so should be viewed as a portfolio of opportunities that play to different strengths in New Hampshire. Table 1 summarizes the position of these growth opportunities.

Table 1: Position of Innovation Niches Across Key Criteria of Industry Innovation, Industry Performance, Research Strengths and Market Potential

Industry Innovation Drivers	Growth Strengths	Growth Weaknesses
Sensors, Optics, Communications & Electronics	<ul style="list-style-type: none"> • Specialized industry presence • Innovation strengths in patents and SBIR grants • Research strengths in university publications • Large, though modestly growing, markets 	<ul style="list-style-type: none"> • Recent job growth not strong
Photonics & Plasma Technologies	<ul style="list-style-type: none"> • Specialized industry presence • Innovation strengths in patent and university publications 	<ul style="list-style-type: none"> • Small and declining industry base
Data Processing & Networks	<ul style="list-style-type: none"> • Sizable, specialized and growing industry • Innovation strengths in patent and venture capital activity • Research strengths in publications and major university research centers • Significant and growing markets 	<ul style="list-style-type: none"> • Growth slightly lagging the fast pace of national gains
Biotech Tools, Techniques & Products	<ul style="list-style-type: none"> • Fast growing industry • Innovation strengths in patent, venture capital, and SBIR grants • Research strengths in university publications and major research centers • Large market opportunity 	<ul style="list-style-type: none"> • Small industry, not yet specialized
Medical Devices	<ul style="list-style-type: none"> • Specialized industry presence • Innovation strengths in patent and venture capital activity 	<ul style="list-style-type: none"> • Small industry base
Agricultural, Marine and Bio-based Products	<ul style="list-style-type: none"> • Significant natural resource base • Research strengths in university publications and major research centers • Growing food demand 	<ul style="list-style-type: none"> • Limited innovation presence

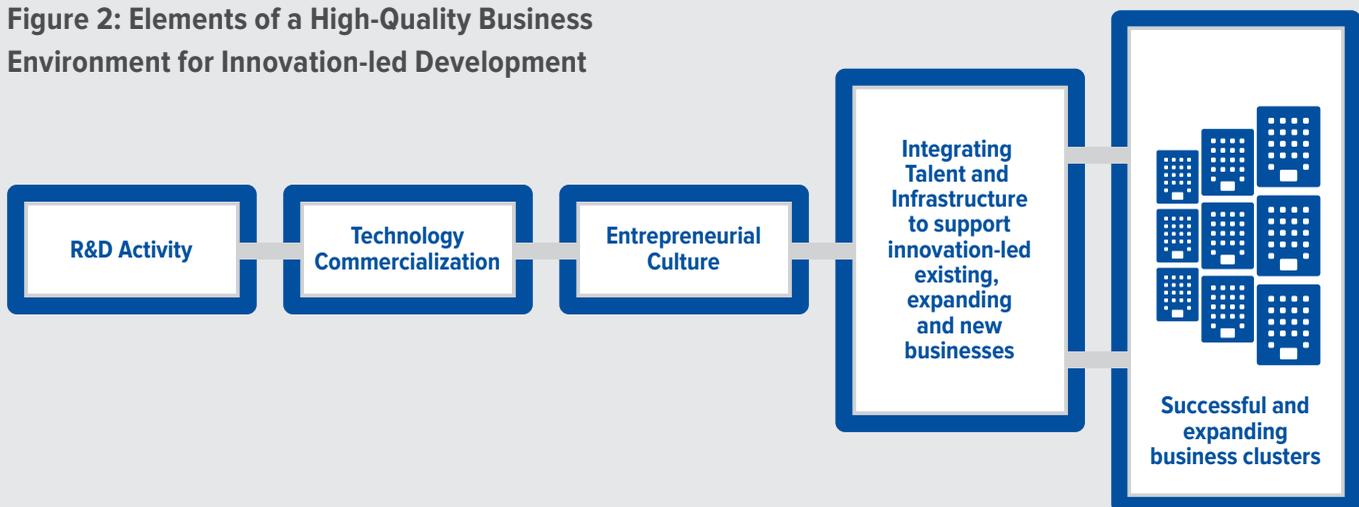
Strategic Assessment of New Hampshire's Business Environment for Innovation-Led Development

To develop its growth opportunities, New Hampshire needs to build on its existing business environment to support industry innovation activities.

New Hampshire ranks in the top 10 nationally for its pro-business tax and regulatory environment according to independent studies by the Tax Foundation and the U.S. Chamber of Commerce. This provides a key foundation for advancing economic development.

However, for innovation-led development to take place, a broader set of economic foundations is required to support the state's research and development capacity, entrepreneurial culture, access to a skilled workforce and high-quality physical infrastructure. States that excel provide these enhanced economic foundations in a high-functioning, inter-connected ecosystem able to translate research and development capacity through commercialization into new product development for existing firms as well as new firm formation. The quality of these enhanced economic foundations and the connections among organizations in the ecosystem also attract outside business investment and expansion within a state. Figure 2 captures this broader business environment involving enhanced economic foundations in the context of a high-functioning ecosystem in which innovation-led development thrives.

Figure 2: Elements of a High-Quality Business Environment for Innovation-led Development



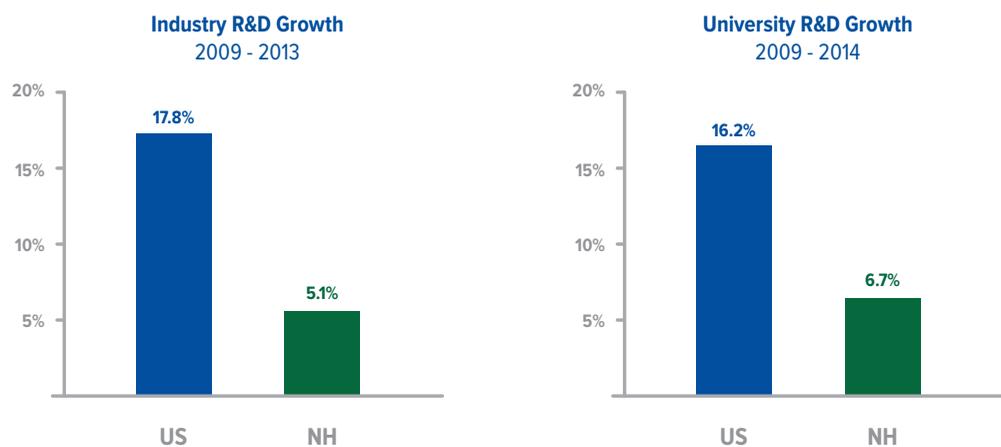
To assess the competitive advantages and disadvantages of New Hampshire's business environment, TEconomy benchmarked the state's performance in key metrics against 17 other states, (see appendix B for details and results of this analysis). Initial findings were compared to on-the-ground perspectives gained through interviews with industry executives, university leadership and faculty, state government officials and other economic development stakeholders (see Appendix C for a listing of those interviewed). Three focus group meetings with industry executives in advanced manufacturing, information systems and biosciences were conducted to inform interpretation and analysis of the data.

Strategic Gaps and Opportunities Identified in New Hampshire's Business Environment for Innovation-Led Development

Despite the healthy presence of advanced industries and high-level patent generation, data analysis revealed several strategic gaps in New Hampshire's business environment for innovation-led development activity:

Research growth in both industry and university is lagging since the economic recovery of 2009. New Hampshire's industry research and development (R&D) has increased 5.1% since 2009 while R&D growth nationally is 17.8% (Figure 3). New Hampshire also falls in the middle of the pack in R&D growth among the benchmark states. Even New Hampshire's strength in patent generation by inventors living in the state is barely keeping pace with the nation and stands well behind the average growth for the benchmark states. At the same time, growth in university research expenditures lags behind that of the U.S., suggesting a general weakness in a key foundation for innovation-led development.

Figure 3: New Hampshire Not Keeping Pace in Industry or University Research and Development Growth



There are many untapped opportunities for industry-university collaborations that could bolster New Hampshire's innovation-led industry development. Industry-university research collaborations are not a current strength for New Hampshire. The state stands below the U.S. average for industry funding of university research and among the bottom third of the benchmark states. Interviews with executives in advanced manufacturing, information systems and biosciences identified gaps and opportunities for collaboration with the state's universities:

Advanced Manufacturing:

- A lack of statewide networking opportunities for industry to learn about university capabilities.
- Perception that smaller industry research projects are discouraged by universities due to resource constraints and limited opportunities to engage students around industry research needs via co-ops, internships and student projects.
- Limited availability of academic facilities that the aerospace-related industry and its suppliers can tap for advancing research and development in metals-based and non-metals-based additive manufacturing, also known as 3D printing, which is becoming an important source of innovations around new materials and manufacturing processes.

Information Systems:

- Limited research and development connections between universities and industry resulting in missed opportunities for addressing needs in areas such as cybersecurity, digital health and Internet of Things (IoT).
- Lack of partnerships between industry and academic institutions in joint curriculum development to help enhance students' core skills and tool sets, leading to a generation of talent from New Hampshire's academic institutions who are not prepared to make a major contribution in the workforce and aid companies in producing their products.
- The UNH Interoperability Lab continues to garner strong national industry attention through its independent, interoperability standard conformance testing for data, telecommunications, storage-networking products and technologies and offers opportunities to further expand its impact in New Hampshire.
- The UNH Connectivity Research Center is also emerging as a resource for industry to perform sponsored research and collaborative projects in the areas of network engineering and communication systems.

Biosciences:

- Existing university research centers are generating new start-ups, especially in biotechnology, but missing ties to the state's specialized industry strength in medical devices.
- Industry executives noted possible opportunities around regenerative/rehabilitation medical technologies and the advancement of combination products linking therapeutics, diagnostics and devices.

Fostering increased entrepreneurial activity is an important area for driving future growth for New Hampshire.

New Hampshire's rate of annual new firm formation is well below the national average and ranks among the lowest of the benchmark states. Unfortunately, New Hampshire does not make up for this lower rate of new business formation through a higher number of jobs being created by new businesses being formed, standing roughly average compared to the nation and benchmark states.

In specific measures of innovation-based entrepreneurial activity, the data points to a mixed performance for New Hampshire. Overall, venture capital funding is well below national levels, but has increased in recent years and is more oriented towards hard to find seed and early stage capital compared to the national annual average and benchmark states. The rate of university-based start-ups is lower than the nation and the benchmark states, however, New Hampshire is strong in federal SBIR awards to small businesses in the state.

Stakeholders interviewed during this effort expressed the importance of increasing the level of entrepreneurial activity and identified opportunities to move forward. Creating connections within the entrepreneurial community both in physical place-making as well as in more virtual relationship-building and mentoring is critical. Many noted that New Hampshire will never be able to compete solely on the basis of the critical mass of entrepreneurs in the way that Cambridge or Silicon Valley can. But through continued efforts to create effective networking, New Hampshire can better nurture its entrepreneurial talent.

Effective statewide broadband infrastructure is an important factor in fostering and supporting entrepreneurship. It is essential for connecting entrepreneurs not only to technical assistance but also to markets they can serve. The condition of broadband infrastructure across the state was identified as a gap for New Hampshire because despite recent investments to provide access, there are still locations primarily in the northern part of the state where gaps in providing reliable broadband service

exist. This factor limits options and can lead entrepreneurs to select another state with better infrastructure capabilities as the location for their start-ups.

An untapped opportunity identified from the analysis is the large base of inventors residing in New Hampshire but working in neighboring states, particularly Massachusetts. Roughly one-third of all patents generated by New Hampshire residents are assigned to companies located in other New England states. This poses an interesting opportunity for New Hampshire to determine how to become a destination for potential start-ups that could be generated by these inventors.

A growing problem for New Hampshire is the slower growth of skilled jobs. Both high-skilled (occupations requiring a bachelor's degree and above) and middle-skilled (occupations requiring some education beyond high school) job growth in New Hampshire is well below the national average. The growth rate of high-skilled jobs in New Hampshire since 2010 is among the lowest of the benchmark states. In the area of information technology jobs, the lagging growth of high-skilled and middle-skilled jobs is particularly prominent, with New Hampshire at just 35% of the U.S. average growth.

Discussions with industry executives suggest the problem goes well beyond a lack of industry demand. Industry is having a hard time in filling its job vacancies and retaining talent:

Advanced Manufacturing:

- There is a mixed perception of talent produced at New Hampshire academic institutions in this area. Some companies have had a good experience, while others feel that the academic institutions are not producing strong talent with the skill sets necessary to meet industry needs.
- The talent pipeline for engineers and technicians is limited. Manufacturers are finding it particularly challenging to find high-skilled engineering talent able to drive new applications and transition prototypes into production.
- Companies perceive a limited manufacturing focus in high school career and technical education programs, which translates into a limited pool of technicians. A 2014 survey by the New Hampshire Manufacturing Extension Partnership found that increasing the pool of more technical/skilled workforce is the most important capability cited by manufacturers for growing their businesses.

Information Systems:

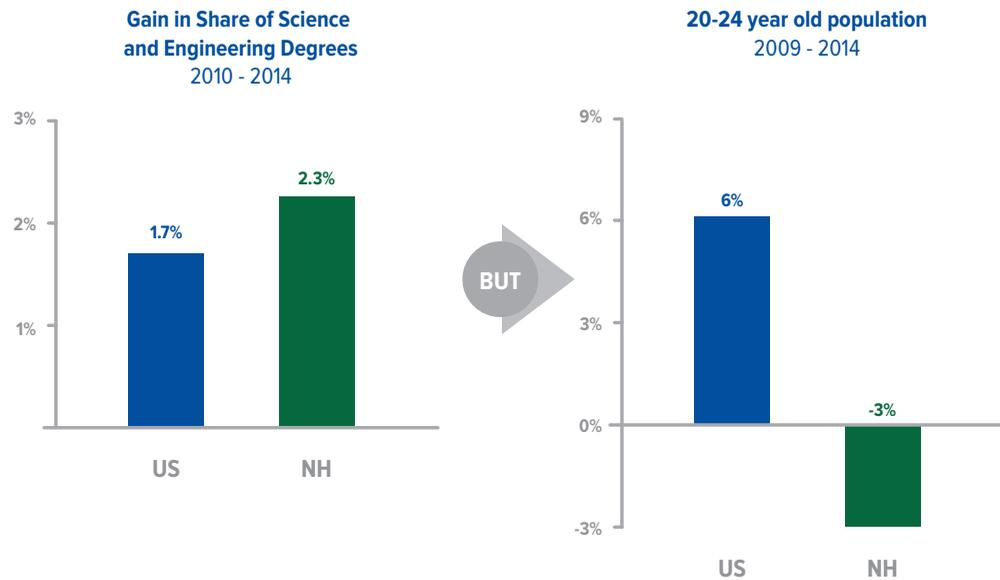
- There is a perceived lack of applied research strength and critical mass in faculty to teach practical skills to students as well as a limited quantity of the talent produced at academic institutions in New Hampshire.
- Recruiting and retaining top information technology (IT) talent is difficult. The competition with Massachusetts, together with a geographically dispersed IT industry in New Hampshire, makes recruiting a challenge.

Biosciences:

- Retaining skilled workers is becoming difficult as Massachusetts pulls top young talent out of New Hampshire.

These skilled workforce development challenges are occurring despite the fact that between 2010 and 2014, New Hampshire's colleges and universities recorded a strong gain in the percentage of post-secondary graduates pursuing degrees in science and engineering degrees. A big concern for New Hampshire is the challenge of retaining and attracting young workers. From 2009 to 2014, New Hampshire's population aged 20-24 years old fell by 3% while growing 6% nationally (Figure 4).

Figure 4: New Hampshire Share of Science and Engineering Post-Secondary Degrees Rising, but New Hampshire's Population of 20-24 year olds Declining



In summary, there are emerging signs of weakness that suggest New Hampshire's innovation-led industry growth cannot be taken for granted. Lagging levels of industry and university research growth, industry-research collaborations, a spotty record on entrepreneurial activity and skilled workforce performance align with a major finding of this study. New Hampshire is falling behind in the growth of its advanced industries, slipping well below the national average and ranking near the bottom third of the benchmark states. New Hampshire must shore up its economic foundations and innovation ecosystem to create the right conditions for growth to take place.

An Action Plan for Advancing Innovation-Led Economic Development in New Hampshire

New Hampshire can continue to advance innovation-led development. The state has many of the right ingredients including the presence of advanced industries, a significant number of inventors and skilled workers, and a portfolio of university research and development assets that can align with industry needs. Other states from Iowa to Oklahoma to Oregon have implemented targeted initiatives with significant economic impact at the scale of their state.

In their book, “The Smartest Places on Earth”, leading economic observers, Antoine van Agtmael and Fred Bakker document that the success of local innovation-led development efforts requires “collegial collaborations, open exchange of information, partnerships between the worlds of business and academia, multidisciplinary initiatives and ecosystems composed of an array of important players, all working closely together.”⁸

This University Research and Industry Plan identified a diverse set of growth opportunities for innovation-led development in New Hampshire that require a more collaborative ecosystem to realize its full potential. A key factor in regions that have successfully pursued innovation-led development is the establishment of formal networking and collaboration mechanisms (organized by a convening organization primarily consisting of industry leaders) that bring together academia, industry, non-profit, and public sector groups and organizations.⁹ This is typically formed as a non-profit organization led by a highly regarded CEO / President preferably from industry and a diversified board of directors. The majority of board members will have industry or applied research experience.

Based on the analysis, interviews, industry focus group meetings, and deliberations of the NH EPSCoR Statewide Committee, New Hampshire has three broad strategic priorities that need to be addressed:

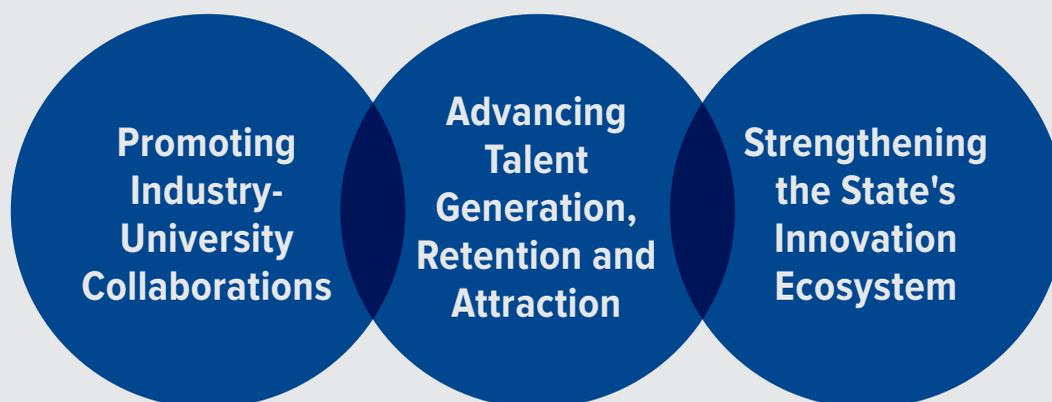
- **Promote industry-university collaborations** with a focus on industry-facing research and growth opportunities.
- **Strengthen New Hampshire’s innovation ecosystem** to spur increased commercialization, entrepreneurial development and place-making (i.e. physical places, such as technology parks, incubators, and accelerators to promote innovation).
- **Advance talent generation, retention and attraction** through promoting industry-university collaborations and strengthening the state’s innovation ecosystem.

These three broad strategic priorities overlap and depend on each other to advance innovation-based development. Creating industry-university collaborations and strengthening the state’s innovation ecosystem play an important role in advancing talent, which is one of the most important competitive factors for industry development. When industries collaborate with academia they are often seeking to engage the talent of students, faculty, or staff in their activities. At the same time, talent is more attracted to places with a thriving innovation ecosystem where there is a substantial concentration of innovation-led companies, the presence of anchor institutions, a supporting network of resource providers, and a high-quality lifestyle.

⁸ Antoine van Agtmael and Fred Bakker, *The Smartest Places on Earth: Why Rustbelts are the Emerging Hotspots of Global Innovation*, Public Affairs, 2016, page 8.

⁹ Examples of these formal mechanisms include: San Diego: CONNECT, BioCom and San Diego Software & Internet Council; Denver/Boulder: Innovation Center for the Rockies, Colorado Technology Association and Colorado Biosciences Association; Suburban Maryland: Technology Council of Maryland and TEDCO; Research Triangle: NCBiotech, Research Triangle Park and Research Triangle Regional Partnership.

Figure 5: Three Broad Strategic Priorities for the NH University Research and Industry Plan



Promoting Industry-University Collaborations

Rationale

Many of the industry executives interviewed for this study stated that increased industry-university collaborations would make New Hampshire a more competitive place to do business. This is not surprising given that the fast pace of advancement and increasing multidisciplinary nature of technology make it difficult for individual companies to have all of the expertise needed to create technology innovations in house. As a result, many technology companies are moving away from internal corporate laboratories as primary sources for new technologies and innovations to more “open” innovation models that encourage collaboration with academia, entrepreneurs, start-up companies and others.

Research universities are responding to this shift by being more industry-facing in their research activities. Dr. Steven Cross, Senior Vice Provost at Georgia Tech, explained their efforts to be responsive to industry: “Georgia Tech defined an industry facing research strategy focused both on leading-edge, use-inspired research and economic development...Georgia Tech pursues a concurrent strategy centered on the core research areas...selected because they are appropriate aggregations of core university competencies, the alignment with strategic markets within the region, and the existence of industry partners interested in working with Georgia Tech.”¹⁰

But “open” innovation is more than universities conducting research for industry. It is about creating vibrant networks around shared areas of innovation – whether it be advanced materials, big data, the Internet of Things or immunotherapies – that link together larger companies that have deep access and knowledge of market needs with smaller technology companies advancing leading-edge technologies and university research strengths found in faculty expertise, specialized lab facilities and talent generation.

10 Stephen E. Cross, “Strategic Considerations in Leading an Innovation Ecosystem,” *Global Science and Technology Forum Journal of Business Review*, 2013, vol 2, no 3, 104–109.

New Hampshire Activities

The New Hampshire Innovation Research Center (NHIRC), administered by the University of New Hampshire, is a state funded, competitive grant program that selects high-impact industry-university research projects up to \$75,000 with a 1:1 industry match. Since its inception, the NHIRC has awarded more than \$6 million in state funds to support research projects and the creation or retention of 650 jobs. Awardees have received more than \$32 million in federal SBIR grants and over \$900 million in investment/acquisition capital. It is currently funded at \$275,000 annually, enabling up to eight awards per year.

There are also efforts led by industry and other associated entities to build stronger multi-sector networking in New Hampshire. Organizations such as the New Hampshire High Tech Council’s Software Forum, the New Hampshire Aerospace and Defense Export Consortium and the Seacoast Manufacturing Exchange are bringing industries together to share their insights and needs and build new partnerships. Table 2 describes industry organizations organized by sector.

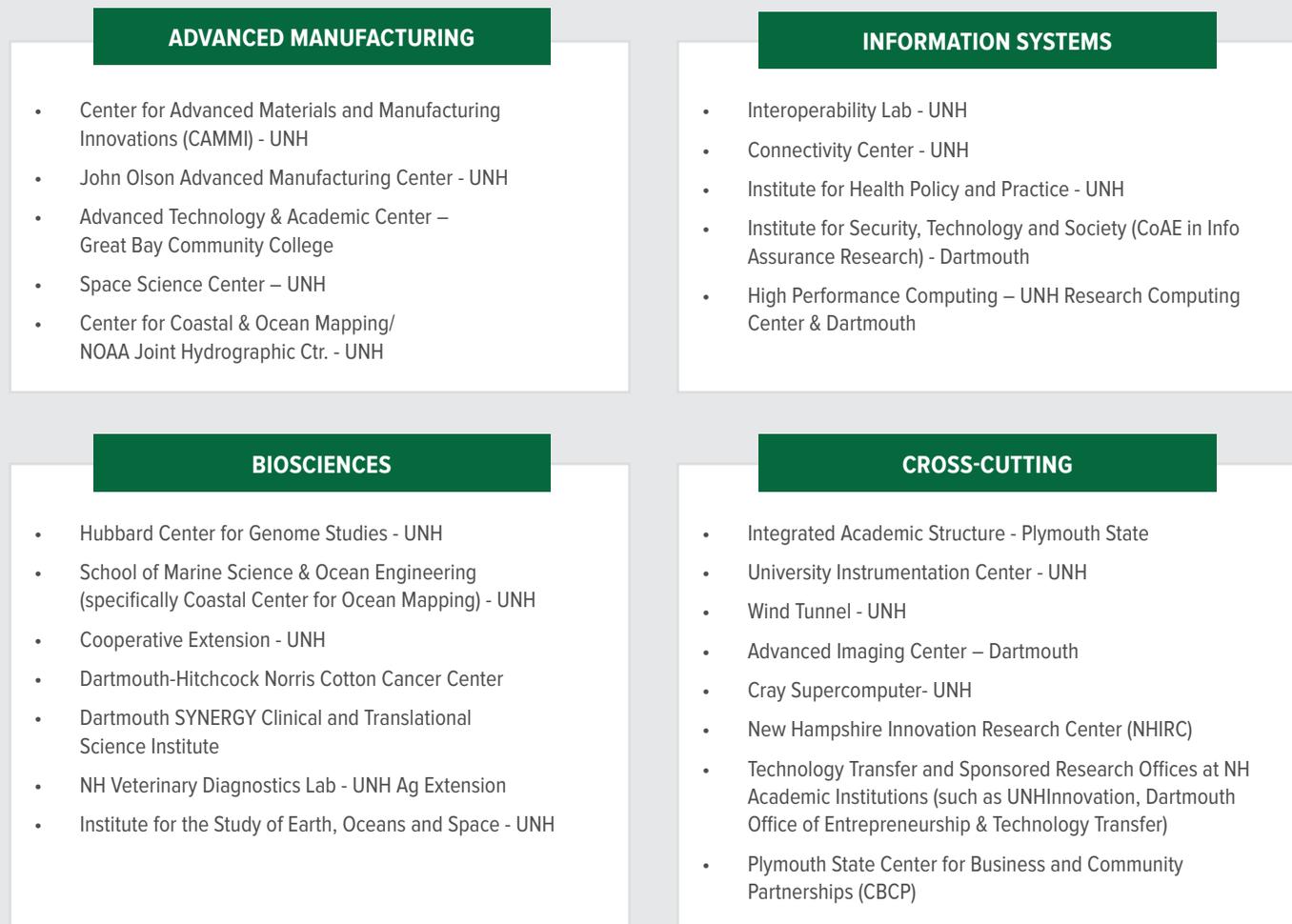
Table 2: NH Primary Industry Organizations (by Sector)

Sector	Industry Organization	Primary Focus
Adv. Manufacturing	<ul style="list-style-type: none"> Business Industry Association (BIA) Seacoast Manufacturing Exchange NH Aerospace and Defense Export Consortium (NHADEC) NH Manufacturing Extension Partnership (MEP) 	Networking and public policy (Note: NHADEC does provide commercialization support)
Information Systems	<ul style="list-style-type: none"> NH High Technology Council – Software Forum 	Networking, public policy and marketing
Biosciences	<ul style="list-style-type: none"> NH High Technology Council – Biomedical Forum Dartmouth Regional Technology Center (DRTC) 	Networking, public policy and marketing
Cross-Sector	<ul style="list-style-type: none"> NH Economic Development Association NH Small Business Development Center NH International Trade Association (NHITA) Office of International Commerce NH Dept. of Resources & Economic Development Community Development Finance Authority NH Government Contracting Assistance Center 	Networking, public policy and marketing

On the academic side, a variety of industry-university collaborative models are taking place in New Hampshire (Figure 6).

- Plymouth State University (PSU) has transformed its whole academic structure by creating a new model to take its 24 degree programs in three colleges and reorganizing them into seven interdisciplinary academic clusters with a focus on innovation and entrepreneurship to provide integrated learning, research, and service opportunities featuring open labs and partnerships with industry and the community.
- University-led consortia in collaboration with industry, such as the UNH Center for Advanced Materials and Manufacturing Innovations (CAMMI) and networking events sponsored by the state’s academic institutions are also bringing these entities together.
- Others such as the Research Computing Center at UNH offer fee-for-service contract opportunities to industry and other associated entities to leverage their specialized equipment and technical expertise to potentially establish long-term partnership initiatives.

Figure 6: Major NH Academic Institutional Collaborations with Industry (by Sector)



Suggested Actions

Transform larger industry consortium efforts to facilitate partnerships with academia to generate scale and focus on identified growth opportunities.

The one-to-one industry-university research projects supported by the New Hampshire Innovation Research Center (NHIRC) are an important tool for promoting research activity and collaborations. Its strong track record suggests it is a good investment by the state and enhanced state funding can enable it to have much greater reach. Discussions with industry executives suggest that NHIRC serves as an important source of early proof-of-concept funding for promising ideas that can benefit from the research capabilities of New Hampshire’s universities.

New Hampshire should consider complementing the one-to-one assistance offered by NHIRC with broader-scale industry consortium efforts conducted in concert with university research centers. According to the National Research Council, cooperative research centers involving universities and companies is one of the critical best practices in advancing state and regional innovation systems for “breaking down barriers between academic disciplines and between scientific research, engineering applications, and commercialization of products and processes.”¹¹

An excellent example of such efforts are the Signature Research Centers established by Oregon Inc., a government-industry–university partnership approach to consortium activities that was seeded with state dollars. It has three centers in place – one for nanosciences and microtechnologies, another for sustainable development, and a third in drug discovery and development. Each of these Signature Research Centers has established key university laboratories that work closely with industry to advance technologies, and offer opportunities for joint research projects and commercialization activities.

Another example is the Maine Technology Institute’s Cluster Initiative Program, which competitively awards multi-year grants of up to \$500,000 for collaborative efforts that spread knowledge and skills, build connections among businesses, research and service partners, and address common opportunities and challenges to increase economic growth and innovation in Maine’s high-potential technology clusters. Examples of projects funded by Maine’s Cluster Initiative Program include developing and commercializing biopolymers from potatoes and forest biomass, addressing online IT education infrastructure, and establishing an applications center for precision manufacturing.

Promote more university presence around networking activities.

The fledgling and siloed industry networking activities taking place in New Hampshire would benefit by having more systematic engagement with university research centers and departments. Various industry organizations shown in Table 2, working in concert with New Hampshire academic institutions, should consider holding more structured topic area workshops across different regions of the state. Content could inform participants about university research expertise, shared use facilities, and educational programs; discuss shared industry needs and potential areas of research interest; and provide networking opportunities like “speed dating” (one-on-one sessions between researchers and companies). Tennessee is an example of a state that demonstrates this type of engagement between its academic institutions and industry through efforts such as LaunchTN, Memphis Research Consortium, and the Institute for Advanced Composites Manufacturing Innovation (IACMI).

Advance more student research and design projects with industries.

Student design projects, in which teams of undergraduates work together on an industry sponsored research project under the supervision of a faculty member, are a well-established approach used typically by engineering schools (such as the University of Michigan’s Multidisciplinary Design program) to expose students to industry R&D, grow broader industry research relationships with a university, and help companies and students learn about each other. The cost of these projects is often in the \$10,000 range and require a technical advisor from the company to work along with the student team and faculty member.

Based on discussions with industry executives, the use of student design projects between New Hampshire universities and companies is limited and many of the public universities lack the infrastructure to facilitate these efforts. To address this, NHIRC might be expanded to offer a competitive mini-grant program to support collaboration between companies and faculty to develop student design projects across the three industry growth opportunity areas: Advanced manufacturing, information

¹¹ Charles Wessner, Editor, “Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century,” National Research Council, 2013, page 17.

systems and biosciences. In addition to providing grant money, the program would need to help facilitate collaboration in the development and implementation of the project. This could be targeted to both upper-class undergraduates as well as master's level students.

Better market and leverage university shared-use facilities for collaboration with industry.

Academic institutions such as UNH, Dartmouth, and Great Bay Community College have individual websites that list facilities. However, there is currently no centralized database or single website location that lists shared use facilities, information, and contacts across academic institutions in New Hampshire. This can be a useful tool for helping companies quickly identify potential resources and help reduce barriers to working together, especially if simple contract templates can be provided for use of facilities to do testing, validation, and other non-IP related activities.

Strengthening New Hampshire's Innovation Ecosystem

Rationale

Like many places, New Hampshire's innovation ecosystem is a work in progress. It shows promising signs, such as strong SBIR award levels to small businesses and a recent upsurge in venture capital funding. But it is held back by lower levels of venture capital than found nationally and an overall lagging record in entrepreneurial energy.

It is often stated that commercialization and entrepreneurship is a "contact sport," and the barriers and obstacles to being able to increase the size of a firm are significant, particularly for technology firms. Among the critical challenges are a lack of experienced management talent, access to capital, and finding customers and markets to serve. To some extent, these are all problems raised by industry executives and economic development stakeholders.

With a few notable exceptions, such as Silicon Valley and Cambridge, the commercialization and entrepreneurial climate necessary to generate high-growth enterprises with the ability to advance innovative technologies cannot depend on market forces alone. Instead, it takes sustained initiatives that offer high-quality entrepreneurial services and incentives to keep commercialization and entrepreneurial activity growing at increasing rates.

The rewards for staying the course and increasing the breadth and depth of services is substantial. A study prepared for the Small Business Administration's Office of Advocacy that compared regions with strong and weak entrepreneurial activity found that "the most entrepreneurial regions had better local economies from 1990 to 2001 compared to the least entrepreneurial. They had 125 percent higher employment growth, 58 percent higher wage growth and 109 percent higher productivity."¹²

¹² *The Innovation-Entrepreneurship Nexus: a National Assessment of Entrepreneurship and Regional Economic Growth and Development.* Powell, Ohio: Advanced Research Technologies, LLC, April 2005, page 5.

New Hampshire Activities

In recent years, New Hampshire has taken important steps to strengthen the focus on commercialization and entrepreneurship, led by the enhancement and permanent adoption of the Research and Development Tax Credit and the launch of the “Live Free and Start” initiative by the New Hampshire Business Finance Authority, Department of Resources and Economic Development and the Governor’s Office that created a one-stop website where entrepreneurs can connect with each other and find supportive resources across the state. There is also a growing network of incubators, accelerators and co-working spaces, creating the physical places in which entrepreneurs can thrive. This includes:

- Alpha Loft, offering co-working, incubation and acceleration for startups in Manchester, Portsmouth and Durham with extensive program of workshops and networking events
- Dartmouth Regional Technology Center, a biotech wet lab incubator located close to Dartmouth College in Lebanon
- Dartmouth Entrepreneurial Network in Hanover, one of several national locations, offering educational services, a co-working space and strategic business advice from an extensive alumni network and mentors
- Enterprise Center at Plymouth, a business incubator
- Hannah Grimes Center for Entrepreneurship’s Startup Lab in Keene, an interactive 6-week program to help participants create, implement, and present a business plan
- Mt. Washington Valley Tech Village, a technology park and business incubator in Conway
- Alpha Loft’s Accelerate NH, a three-month program to launch new startups
- Wasabi Ventures Academy that guides entrepreneurs through startup basics and more advanced courses
- Business Services North offers small business owners support by providing access to trained business consultants
- Women’s Rural Entrepreneurial Network offers entrepreneurial business training and technical assistance and creates and supports markets for entrepreneurs

To engage students, faculty and staff at New Hampshire’s academic institutions, a number of efforts have emerged and been established, such as the NSF-funded I-Corps program and the Entrepreneurship Center at UNH, the Dartmouth Entrepreneurial Network, and the Center for Business & Community Partnerships at Plymouth State University.

Suggested Actions

Raise incentives and investments for entrepreneurial development targeting the large base of inventors residing in New Hampshire.

New Hampshire’s potential for entrepreneurial development stands out given the large pool of inventors living in the state. Many of New Hampshire’s inventors work for innovation-led companies in neighboring states, particularly Massachusetts. This presents an interesting and perhaps unique opportunity to capture the attention of emerging entrepreneurs in the state with value-added incentives and investments at their critical early stage of development when they are making location decisions.

Best practice examples of targeted incentives and investments that New Hampshire should consider include:

Targeted “pre-seed” commercialization funding

A critical step for successfully transitioning innovation ideas into the marketplace is validating the commercial potential and moving towards prototyping of products. Helping entrepreneurs address these critical “pre-seed” stage questions can put

them on the right track for launching a high-quality company able to attract capital and successfully enter the marketplace. A best practice example of such an initiative is Iowa's graduated range of competitive innovation funding that starts with funding of up to \$25,000 with a 50% match for proof of commercial relevance, then offers access to a Demonstration Fund of up to \$100,000 in funding (also with a 50% match) for addressing initial market introduction questions. Participants also gain access to follow-on 1:1 matching seed funding to ramp-up business activities. One of the key success features of Iowa's efforts is having a private management company, led by a serial entrepreneur, operate the review process that engages a network of technology and management executives and offers quality feedback to the entrepreneurs applying for the state's innovation programs. An independent economic and fiscal impact study of the Demonstration Fund's efforts from 2007 to 2012 found that the 127 investments made, totaling about \$13 million, generated 600 direct jobs and annual revenue growth of \$87 million.¹³

Establish an angel investor tax credit

Across the nation, angel investment tax credits are becoming an important innovation tool for helping to support the advancement of early-stage innovation-led companies by encouraging seed capital investments. More than 20 states currently provide such a tax credit. An excellent example is Wisconsin's Qualified New Business Venture tax credit. It is available to certified early stage businesses developing innovative products, processes or services. To qualify, a company must be headquartered in the state, have at least 51 percent of its employees based in the state, have fewer than 100 employees, be in operation for less than 10 years, offer significant potential for job growth or generating capital investment and have not received aggregate private equity investments of more than \$10 million.

Once a company is certified as a Qualified New Business Venture by the Wisconsin Economic Development Corporation, the company can receive up to \$8 million in investments from qualified investors. The investors meanwhile, who can be an angel investor (accredited/sophisticated investors), an angel network or a qualified venture capital fund can receive a transferable tax credit of 25% with no limit on the amount of credits an investor can claim by investing in more than one qualified company. Over its first ten years of operation, the state's \$80 million in tax credits have leveraged \$1.2 billion in investment from private sources to early stage companies (a substantial \$15:\$1 leverage). In 2014, 178 certified companies benefiting from Wisconsin's Qualified New Business Venture tax credit generated a total of 1,436 jobs at an average salary of \$72,732 or 70% above the state's average salary.

Uncap New Hampshire's research and development tax credit

New Hampshire is lagging behind in industry research and development. One very effective tool for raising industry research and development is having a predictable research and development tax credit.¹⁴ In recent years, New Hampshire has taken important steps to upgrade its research and development tax credit, including making it permanent and increasing the available funds to \$7 million annually starting in fiscal year 2017. But the New Hampshire Business Review reports that in fiscal year 2016, businesses applied for more than \$7.4 million in research and development tax credits and so have already exceeded the cap for next year.¹⁵ This means that businesses will not be certain of the value of their research and development tax credits making the incentive less effective and undercutting this important innovation tool. Strong consideration should be given to removing the cap so that New Hampshire businesses will have more certainty regarding the value of their research and development tax credit.

¹³ Econsult Solutions, *The Economic and Fiscal Impacts of the Demonstration Fund on the Iowa Economy*, February 2013.

¹⁴ For an in-depth discussion of the economic literature on the effectiveness of state-level research and development tax credits, see Ross DeVol, Kristen Harris and Minoli Ratnatunga, *California's Innovation-Based Economy: Policies to Maintain and Enhance It*, Milken Institute, December 2015

¹⁵ Bob Sanders, "R&D Tax Credit Filings Surpass 2017 Cap," *New Hampshire Business Review*, August 4, 2016

Promote statewide mentoring and peer-to-peer networks that connect rural entrepreneurs to others in the state

Going from inventor to successful business owner is not just for those born to be entrepreneurial. Despite the popular image, successful entrepreneurs benefit from extensive mentoring and technical assistance. New Hampshire should complement its growing base of incubators and accelerators for innovation-led companies through more intensive entrepreneurial mentoring and technical assistance.

Proven efforts in entrepreneurial mentoring and technical assistance services for innovation-led start-ups are found in Arkansas and Oklahoma. The Arkansas Economic Development Commission sponsors the Innovate Arkansas program, which makes available a core group of experienced technology commercialization and innovation-led entrepreneurial consultants to provide one-on-one mentoring and technical assistance. Winrock International, a highly regarded development organization based in Arkansas, manages the outreach, entrepreneur selection process and client services by this network of consultants. As a result of Innovate Arkansas' programming, which started in the late 2000s and is now supported at an annual cost of approximately \$2 million, the state of Arkansas has benefited from the launch of more than 100 startup companies, the creation of more than 600 jobs, \$226 million in revenue generated by these growing ventures, and a total of \$265 million raised by Innovate Arkansas' clients through private investment, public investment, and federal grants.

An even longer standing effort is found in Oklahoma, where the Innovation to Enterprise (i2E) organization serves as the outsourced manager of the Oklahoma Technology Commercialization Center. i2E helps entrepreneurs grow viable businesses by helping them focus their business plans and strategies and through hands-on support including detailed mentoring in moving through a technology commercialization model linked to business success. A group of venture advisors comprise the core staff of i2E and work to customize a mix of intensive services involving mentoring, technical assistance and accessing capital. Over the years, i2E has served to manage innovation funding for Oklahoma as well, including a proof-of-concept fund, similar to what Iowa offers, plus additional seed funding. The results of i2E have been impressive with nearly 700 entrepreneurs having been served since i2E's formation in 1998. i2E has reported that \$20.9 million in its state-supported proof-of-concept to seed investments has leveraged an additional \$478 million in private investment.

What stands out about both Innovate Arkansas and Oklahoma's i2E is that they are centralized resources that serve entrepreneurs statewide. Other states such as Ohio and Tennessee rely more on regional entrepreneurial organizations to deliver services, but this seems unnecessary in a small state like New Hampshire.

As stand-alone efforts to serve innovation-led entrepreneurs, both Oklahoma and Arkansas must divert limited resources to support organizational capacities and outreach efforts. An interesting alternative is Michigan's Small Business Development Center (SBDC) Tech Team approach. The Michigan SBDC Tech Team effort leverages and complements an existing statewide small business development center network, which serves more general businesses being started by state residents, with nine consultants who have proven track records in technology commercialization to serve innovation-led entrepreneurs anywhere in the state. At the same time, the SBDC Tech Team helps to connect entrepreneurs anywhere in the state to more specialized resources, workshops and peer-to-peer networks found across the state's incubator and accelerator programs. In this way the program leverages the strengths of both the state's SBDC network and innovation-led incubators and accelerators to provide more intensive mentoring and technical assistance to innovation-led entrepreneurs.

Focus on place-making around innovation hubs to retain and attract talent

Place-based developments are becoming a competitive factor in creating healthy innovation ecosystems. This is a reflection of how industries innovate and grow around specific locations with value-added assets, such as universities, federal labs, incubators and shared-use innovation facilities. The Brookings Institution's recent white paper "The Rise of Innovation Districts: A New Geography of Innovation in America" suggests that places where leading-edge anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators can be a key differentiator in attracting and retaining talent. As The Brookings Institution explains "Innovation districts are the manifestation of megatrends altering the location preferences of people and firms and, in the process, re-conceiving the very link between economy shaping, place making and social networking."¹⁶

New Hampshire has emerging "innovation districts" that promote both access to innovation ecosystems and live-work-play lifestyles. These include Hanover where Dartmouth College is located and nearby Lebanon; Manchester which boasts significant innovation-led company presence; and Durham where the main research campus of UNH is located. But creating increased activity and density is needed in each emerging innovation district to offer more robust communities and keep up with the competition.

One of the most difficult aspects of advancing innovation districts is ensuring the availability of hard-to-find financing for multi-tenant laboratory facilities. These facilities often require specialized tenant improvements that commercial real estate markets would not normally do. Multi-tenant laboratory facilities are important for housing incubators, accelerators and emerging innovation-led companies (many of whom might be graduates of these incubators and accelerators), particularly in advanced manufacturing and the life sciences. New Hampshire should consider supplementing existing local tax-increment financing (TIF) approaches with an add-on funding mechanism for more specialized tenant improvement financing. This could be direct financing of tenant improvements such as what Connecticut Innovations did for biotechnology lab space across the state or limited grant funding for multi-tenant lab space as Michigan has done in its SmartZone program around large and small universities in the state.

Promote awareness and connections with Boston/Cambridge community

The innovation-led development of the Greater Boston region, especially in Cambridge, should be considered an opportunity for New Hampshire and not a threat to the state's innovation-led development. Having a major innovation driver neighbor presents opportunities for New Hampshire businesses to generate customers and capital and offers a target rich environment for business and talent attraction.

A key advantage compared to the Greater Boston/Cambridge area, noted by many industry executives interviewed, is that New Hampshire can offer a lower cost of doing business with access to innovation-based resources and can be very appealing with its high-quality outdoor lifestyle and schools.

A key starting point for making the case for both customer/capital access and for business/talent attraction opportunities is raising the brand of New Hampshire as an innovation-intensive state. The "Live Free and Start" initiative is a step in the right direction. And more active programming of events and outreach that highlight New Hampshire's technology, innovation and lifestyle assets in the Boston/Cambridge region was suggested by many of the stakeholders interviewed.

16 Bruce Katz and Julie Wagner, *The Rise of Innovation Districts: A New Geography of Innovation in America*, Brookings Institution, May 2014.

This phenomenon of leveraging growth of a major innovation-led place-based driver is not unusual. It is happening in Oakland, California in the Bay area and in Winston-Salem near the Research Triangle Region in North Carolina.

Advancing Talent Generation, Retention and Attraction

Rationale

New Hampshire industry executives have raised a clarion call on the importance of generating a high-quality workforce with skills in science, technology, engineering and math (STEM). The New Hampshire Business and Industry Association (NHBIA) rates workforce development as a top concern across businesses in the state noting that the “dearth of qualified labor particularly affects advanced manufacturing ... as the pool of suitable entry-level candidates grows more shallow ... [but] to be sure, workforce development challenges are not unique to manufacturing. They are present in other important sectors of the state’s economy including health care, professional and financial services, high technology and more.”¹⁷ Similarly, support for STEM education and workforce development is a part of the New Hampshire High Tech Council’s “Fix it Five Areas of policy concern”.

In this regard, New Hampshire is not alone. The 2014 Technology Council of North America (TECNA) survey completed by over 1,500 C-level technology executives from member state and regional technology councils rated talent shortage/labor prices/employee turnover as the highest factors that could slow business activity. Both technology talent quality and availability were rated as significant or moderate shortages by 74% and 76%, respectively, of these C-level executives for their states and regions.

A mismatch is emerging in the demand and supply of STEM-talent. Labor market projections reinforce the strong concerns among top executives that a shortage of STEM talent threatens U.S. competitiveness. A Georgetown University Center on Education and the Workforce assessment reveals that the steady demand and rapid growth for STEM-related occupations, compounded by job openings created by the retirement of the baby-boom generation, is outstripping workforce development leading to more than two million job vacancies nationally in STEM occupations through 2018.¹⁸

For New Hampshire, this mismatch may be more pronounced in part because of the greater presence of advanced industries and the resulting higher demands for a skilled workforce. It is also influenced by demographics. New Hampshire lost 5% of its population aged 20-to-54 years from 2009 to 2014. The next generation of workforce is also declining as the state’s population aged 19 and younger fell by 7% from 2009 to 2014. Compounding the effect of these population declines is the slow growth in the number of New Hampshire residents with an associate’s degree and above when compared to the national average. So, New Hampshire needs to maximize STEM education, retain a skilled workforce in high numbers and attract skilled workers from other places.

New Hampshire Activities

The importance of STEM education and workforce development is a growing area of concerted effort in New Hampshire. There are promising signs. Among the state’s colleges and universities, the share of graduates in STEM-related degree fields is rising faster than the nation. Still, more is needed.

¹⁷ NH BIA Report, “Workforce Development is Essential to New Hampshire’s Long-Term Economic Health,” Second Quarter, 2016, pages 1-3.

¹⁸ A.P. Carnevale, Nicole Smith, Michelle Melton, “STEM: Science, Technology, Engineering, Mathematics,” Georgetown University Center on Education and the Workforce, October 2011. STEM-related occupations in the study include computer occupations; mathematical science occupations; architects, surveyors, and technicians; engineers and engineering technicians; and life and physical science occupations.

The New Hampshire Coalition for Business and Education is leading a “65x25” initiative, which seeks to ensure that 65 percent of New Hampshire’s workforce has a postsecondary credential or degree by 2025. This would be a marked rise from the approximately 45% to 50% that currently meet this criteria.

Recently, as part of the New Hampshire Sector Partnerships Initiative, the NH Department of Resources and Economic Development partnered with companies in the manufacturing sector to develop initiatives to fill the talent pipeline by attracting, training, and employing skilled workers to meet the state’s challenge of an aging workforce and lack of interest in this sector. Initiatives are planned in the future to help fill the talent pipeline in the state for the health care, information technology, and hospitality industries.¹⁹ New Hampshire industry, state government, and others have already started to initiate efforts to address the workforce talent challenges identified in this assessment for the advanced manufacturing, information systems, and biosciences sectors.

Also promising is the increased interest in advancing experiential learning to expose students to exciting careers in STEM fields. Examples of work-based learning in New Hampshire:

- Dartmouth has a two term capstone engineering design course for students in the Thayer School of Engineering to address problems in collaboration with industry
- At the UNH Interoperability Lab (IoL) approximately 100 students are hired to work with 20 staff members to do independent standards testing on data, telecommunications and storage networking technologies and products
- UNH's Thompson School of Applied Science students get hands-on experience with industry and selling to the public through its facilities (i.e. greenhouse, culinary kitchen, veterinary clinics and tree sawing area)
- The Center for Business and Community Partnerships (CBCP) at Plymouth State University serves as a centralized focal point for students to engage in real-world projects with industry
- White Mountains Community College is working with Capone Iron Corp. to leverage the college’s program to help meet this company’s talent needs in the North Country
- Great Bay Community College’s Advanced Materials Manufacturing Program is working closely with industry, including BAE, GE Aviation, Parker Hannifin, Hitchiner Manufacturing and Turbocam, to keep its curriculum and hands-on learning up-to-date with industry needs like laser technology and nondestructive testing.

Recently, Governor Hassan’s Summit on Work-Based Learning brought together industry, educators, state government and non-profit organizations to push for a statewide action plan to expand work-based learning. The summit was supported by the National Governors Association and the Siemens Foundation.

Industry is taking a sophisticated approach to STEM workforce development. As the New Hampshire Business and Industry Association explains, it is about “aligning the competencies required by employers with the skills of the local and regional labor pool.”²⁰In this regard, the New Hampshire High Tech Council is currently working with the New Hampshire Charitable Foundation and the New Hampshire Department of Resources and Economic Development to get a much more detailed sense of the tech-related workforce needs of New Hampshire businesses and organizations.²¹

¹⁹ *New Hampshire Union Leader*, “Initiative Launched to find skilled workforce for NH”, July 12, 2016 - <http://www.unionleader.com/article/20160713/NEWS02/160719803>

²⁰ *NH BIA Report*, “Workforce Development is Essential to New Hampshire’s Long-Term Economic Health,” Second Quarter, 2016, pages 1.

²¹ *Matt Cookson*, “Defining a Tech Ecosystem: Tech Companies vs. Tech Workers,” *New Hampshire Business Review*, August 5, 2016

Suggested Actions

Advance STEM post-secondary internships

As New Hampshire's colleges and universities increase their emphasis on STEM-related degrees, it is critically important to create the connections between students and industry. Employers value workplace learning (through internships, co-op programs and capstone projects) as a valuable tool to identify the future workforce. It also offers students the opportunity to apply classroom learning in "real-world" situations, enhance their qualifications, develop a professional network, and explore a variety of career options.

Data on internships suggests the value that workplace learning can bring. The National Association of Colleges and Employers (NACE) in a survey of graduating seniors found that 63% had participated in an internship or co-op or both during their college years.²² NACE also examined the outcomes of participating in an internship and found that those with intern experience started with salaries that were about \$7,000 greater than their counterparts with no internship experience.²³

There are a number of opportunities for raising STEM internships. One is to create a platform to match students and employers. An example is a web-based internship matching program in Indiana that links employers, students, and schools. It was initially launched with support from the Lilly Endowment by the Greater Indianapolis Chamber of Commerce in partnership with the University of Indianapolis. It now operates as a non-profit organization called Indiana INTERNnet. It offers a dynamic, searchable database and a matching and reporting system coupled with personal assistance, including a toll-free hotline to answer questions and provide internship guidance and resource materials. Currently, over 6,000 employers and 17,000 students have registered and 1,300 active internship positions are listed.

More directly, New Hampshire state government should consider providing some matching funding for small and mid-sized companies, which typically find it onerous to sponsor internships. Iowa offers an example of the success this effort can have. The Iowa Student Internship Program is designed to support postsecondary student interns in Iowa businesses through grant funding of up to \$3,100 per internship with a maximum amount awarded to an employer for all internships in a fiscal year not to exceed \$9,300. The goal of the Iowa program is to transition the intern into full-time employment in the state following graduation. The program is designed with a focus that supports small to medium sized companies in the targeted sectors of advanced manufacturing, biosciences, and information technology. Program participants, both companies and students, give the program high marks and these connections result in increased student interest in working in Iowa. In 2015, 103 companies were awarded funding for more than 236 internships.

Provide an opportunity for employers to create apprenticeship programs for a technical skilled workforce

Entry level technical skilled workforce seems to be a particular challenge in New Hampshire. A traditional response is to develop technical educational programs, particularly at the community college level. This is happening in New Hampshire, but it is hard to serve the breadth of the advanced industries base given how industry is distributed across the state. Also, small-to-mid-sized innovation-led companies which encompass much of the state's advanced industry base often specialize in technologies and services specific to their customers' needs. This diversity of work to meet the needs of the marketplace results in a lack of sustained demand for workforce labor and a very limited amount of time for these companies to be involved in formal education programs.

²² National Association of Colleges and Employers (NACE), *Class of 2013 Student Survey*. Data on internships do not include those participating in student teaching

²³ NACE, *Class of 2010 Student Survey*.

An alternative is to allow employers to directly hire young workers as apprentices and then pursue registered apprenticeship programs that customize an on-the-job training and technical instruction program tied to recognized industry standards. An example of this approach is found in South Carolina. Apprenticeship Carolina operates as a division of the South Carolina Technical College System and works with all employers to advance “demand-driven” apprenticeships customized to employer needs, while offering young workers “scalable” wages. At no cost to employers, apprenticeship consultants from the South Carolina Technical College System help guide companies through the registered apprenticeship development process. The program does not require a minimum number of apprentices so a small employer can participate even if they only hire one. Plus, employers receive a \$1,000 annual tax credit for each registered apprentice employed for up to four years. The program also includes a “youth apprenticeship” approach for high school students with production and other middle-skilled jobs that will not require a postsecondary degree. South Carolina’s apprenticeship programs grew from 90 participating companies in 2007 to 794 today, and participation now reaches over 6,000 apprentices annually with companies in all counties and all of the state’s technical colleges participating.²⁴

Meet industry needs for more new academic degree programs in emerging and multi-disciplinary fields

Industry demand for talent includes a stronger emphasis on multi-disciplinary skills in addition to traditional skills in STEM fields. In particular, STEM graduates need to be able to manage more complexity in technology solutions that integrate multiple disciplines as well as more complex business situations involving open innovation. Also, the growing application of data sciences to all fields raises a need for broader systems and analytic skills.

Academia can integrate development of multidisciplinary skill sets by having students work on a portfolio of projects to better prepare them for high tech careers with employers. For example, a student in an information technology or engineering discipline is better served by having experience in a curriculum involving hardware, software, and other systems rather than solely focused on one of those areas. One New Hampshire company that was interviewed for this plan now requires potential job candidates to present a variety of projects from these different areas.

One approach that New Hampshire should consider is project-based student learning experiences where students from its academic institutions prepare for a professional career by leveraging their STEM skills to help meet the needs of community service and education organizations. An example is the Engineering Projects in Community Service (EPICS) program at Purdue University. EPICS teams are assigned to a community or educational partner rather than a project, which allows students to participate on projects developed over multiple semesters or years and have more complexity than semester-based effort.²⁵ Since its start in 1995, the EPICS program has served as a model for similar efforts at 24 universities.²⁶ Given the extensive network of community service and education organizations in New Hampshire, replicating a similar effort would be a very viable way to prepare, attract, and retain skilled talent for the state’s workforce.

Another approach is to encourage New Hampshire’s colleges and universities to establish more professional master’s programs that integrate advanced technical knowledge with business, and include internships. Carnegie Mellon University offers an MS program in Engineering and Technology Innovation Management (E&TIM). It is an interdisciplinary program that prepares students in the area of technology innovation through project coursework and practical internships. The curriculum is

²⁴ See South Carolina Apprenticeship website -- <http://www.apprenticeshipcarolina.com/by-the-numbers.html>

²⁵ Purdue University, EPICS Website - <https://engineering.purdue.edu/EPICS/about>

²⁶ <http://www.educationandcareernews.com/stem/giving-back-how-students-are-using-technology-to-help-the-community>

developed in collaboration with industry to help develop the areas of study for students.²⁷ By further leveraging partnerships and facilitating dialogue with industry through efforts such as the NH Works “Sector Partnership Initiative” academic institutions can understand talent needs from a business and technical perspective across the different sectors and start to design emerging and multidisciplinary efforts that can be implemented as part of their professional master’s programs or experiential learning offerings for students.

Summary

This plan identifies ways New Hampshire can foster collaboration to increase research and development, grow the innovation ecosystem, and create, attract and retain talent. A common thread across these actions is the need for public-private partnerships. Government, industry, colleges and universities and non-profits have a part to play in this strategy, but success will be dependent upon the active participation of these sectors’ top-level leadership in setting the tone and keeping stakeholders focused on implementing these actions.

- State Government has a unique role as a catalyst, using limited funding and marketing resources to spur action and leverage broader private sector activity. State government can also help serve as a convener and facilitator to advance the state’s economic development goals in concert with non-profit economic development entities.
- Industry must help frame the opportunities and needs for the entire innovation ecosystem to respond effectively. While state government will typically play the role of catalyst, industry will make the lion share of investments as commercially viable technologies move into the marketplace.
- Colleges and universities can contribute in significant ways by pursuing use-inspired research that aligns with pressing industry technology challenges, offering shared use facilities, pursuing translational and commercialization of research discoveries, and generating the talent that can help realize the state’s industry-driven innovation opportunities.
- The non-profit sector can provide capacity for New Hampshire to succeed through its foundations investing in the state’s future and through the non-profit economic development organizations and industry associations that work in concrete ways to support innovation, retention, and attraction of industry at the state and local levels.

The assessment and strategic actions described in this plan are meant to initiate a dialogue among stakeholders in New Hampshire to do the following:

- Create awareness focused on growth opportunities and potential for the state;
- Prepare potential solutions for the challenges that are emerging; and
- Generate and implement potential ideas on how to move forward.

It is by having this discussion that New Hampshire can set a firm direction that realizes its bright future for innovation-led development.

²⁷ Carnegie Mellon, E&TIM website - <http://engineering.cmu.edu/etim/overview.php>

Appendix A: More Details on the Line of Sight Methodology

This “line of sight” approach involves five specific steps to identify industry innovation drivers:

Step 1: Set the broad context of advanced industry activity taking place in New Hampshire through a detailed analysis of patent activities of New Hampshire inventors in order to identify clusters of innovation activity generated by industry and universities in New Hampshire. Patents are a primary way in which inventors are able to protect their innovations in products from being replicated. Industry is the overwhelming holder of patent applications and awards, and thus patent analysis is a direct way to consider the broad base of innovation across New Hampshire industry. Since it can take several years for a patent award to be issued, it is important to also consider patent applications for assessing current innovation activities, though some of these applications may not be sufficient to lead to patent awards. Although there are other forms of intellectual property protection through copyrights, trademarks, and trade secrets, patents are among the most widely used form of protection of novel technological inventions. Over 22,000 patent awards and applications were filed by inventors residing in New Hampshire from 2009 to 2015 offering a significant database to consider innovation activity in the state.

To identify where New Hampshire stands out in innovation activity, TEconomy first considered those specific patent classifications where New Hampshire is a national leader based on having: 1) A higher level of concentration than the nation, so the patent classification can be viewed as an area of patent specialization in New Hampshire; and 2) A higher level of citations for patents in that classification than the national average or what can be viewed as a higher patent impact. Patents routinely cite prior patents as references in documenting their new intellectual property, demonstrating the influence and importance of these earlier patents on future innovation.

TEconomy then examined where there are strong innovation networks around specific technology areas in New Hampshire as measured by forward and backward citations across patents invented in New Hampshire. The close relationships within patent activities that these innovation networks identify suggests where the clustering of innovation activity are taking place in New Hampshire across industry that goes beyond just the snapshot of where New Hampshire stands out in patent activities.

Step 2: Consider how emerging technology company activities align with these patent innovation clusters given the importance of companies with high growth potential for fueling future state economic growth. This assessment was considered by cross-walking venture capital-backed companies and Small Business Innovation Research (SBIR) funded companies to the innovation clusters identified through the patent analysis. Venture capital represents formal equity investment by established venture firms in emerging technology companies that offer high growth potential to generate sizable returns on that equity investment. The federal Small Business Innovation Research (SBIR) program is another source of innovation funding for emerging technology companies. The SBIR program encourages small businesses to undertake technology commercialization by requiring federal agencies with extramural R&D budgets that exceed \$100 million to allocate 2.5% of their R&D budgets to the SBIR program. Each federal agency involved in the SBIR program then issues requests for proposals on topics reflecting their technology needs and interests, and competitively awards SBIR grants based on the technical merits and commercialization potential in a phased approach.

Step 3: Identify how well these industry innovation activities map to specific industries and their performance in New Hampshire. An analysis of industry performance at the most detailed six-digit industry classifications available under the North American Industrial Classification System (NAICS) was undertaken. These detailed six-digit industries offer insights into very specific products being developed by New Hampshire companies and so enable a more refined cross-walk to Innovation Themes.

Standard regional economic measures of performance were used to assess the presence of industry activity aligned with New Hampshire's innovation clusters. These included the level of industry specialization found in New Hampshire, where the industry is generating job growth, and the relative employment growth of the industry compared to the nation. TEconomy analyzed industry performance over the 2009 to 2014 period to offer a view since the economic recovery started.

Using this intelligence on industry innovation drivers found in New Hampshire, the next two steps considered the alignment of university research strength and the market growth potentials.

Step 4: Assess how university research activities in New Hampshire support and complement the innovation cluster activity found in the state. Each university has its own set of core research competencies—based on those focus areas where there is a critical mass of activity—in scholarly activities as measured by publications as well as the presence of research centers, grants and specialized laboratory infrastructure. While investments in universities can have significant impact in better aligning their research competencies with industry needs, pursuing new fields of research capacity can only be done selectively given the high cost and time it takes to accomplish.

Step 5: Assess the future market growth potentials associated with each growth opportunity. The high level growth potential is based on market research reports from BCC Research, which assess the market size and anticipated future growth in applied technology areas that are relevant to the growth opportunities.

Detailed Growth Opportunity Area Profiles

Sensor, Optics, Communications and Electronic Systems

Sensing and optics technology, particularly integrated sensors that are used as part of larger systems, are becoming critical parts of electronics and communications infrastructure. This area encompasses a larger integrated electronics system supply chain, ranging from manufacturing of microelectronic components to integrated systems which incorporate detectors, image capture devices, and remote sensing. Many sensing and optics applications have defense or navigation applications, but there are also many technologies that enable radio communications and industrial control/automation.

NH Industry Innovation Context

Leading patent activities: (# of patents, specialization, relative impact): Magnetic field sensors (120, 6.77, 1.60), Vehicle navigation control systems (70, 8.71, 1.84), Aerial antennae systems (60, 3.78, 1.77)

Presence in venture capital: In industrial automation, two companies received \$24 million in venture capital funding over the 2009 to 2015 period.

Presence in SBIR awards (multiple award winners): Satellite remote sensing components; Navigation and range finding systems; Infrared and spectroscopic imaging systems; Wideband filter radio communications

NH Supporting Industry Base

NH Industry Profile:

- Mid-Sized (7,588 jobs)
- Highly Specialized (533% higher level of industry specialization)
- Declining (-12% job growth, 2009-2014)
- Lagging U.S. Growth (3.3 percentage points lower growth)

Examples of NH Companies: BAE, GE, L&L Engineering, Paratek Microwave, H6 Systems, Mentis Sciences, General Dynamics

NH Research Innovation Context

Publications (leading fields by publications (2009-2015) and level of specialization/relative concentration): Optics (259, 1.20); Remote Sensing (113, 2.43); Imaging Science (92, 2.12); Spectroscopy (83, 1.15)

Major Research Centers and Grants:

- UNH: Center for Coastal & Ocean Mapping/NOAA Joint Hydrographic Center; School of Marine Science & Ocean Engineering; Wind Tunnel Facility
- Dartmouth: Advanced Imaging Center; research activity in nanosensors

Growth Potential and Leading Market Applications

Overall, market for sensing and imaging technologies is sizable with strong projected growth:

- Global market in adaptive optics systems totaled \$0.1 billion in 2014 with compound annual growth rate (CAGR) of 87.9%
- Global market in image sensors valued at \$12.3 billion in 2014 with CAGR of 9.6%

- North American market in integrated remote sensing technologies valued at \$8.4 billion in 2015 with CAGR of 9.3%
- Global market in transmission antenna technologies valued at \$13.5 billion in 2012 with CAGR of 5.7%

Examples of likely market applications based on New Hampshire capacities:

- Defense imaging and sensing platforms
- Navigation and threat detection interfaces
- Signals intelligence and command and control systems

Photonics and Plasma Technologies

Photonics and plasma technologies fundamentally relate to the generation, detection, and manipulation of light and energy in order to transmit information or manipulate metals and other materials. Common photonics applications rely heavily on signal processing and transmission in enabling high precision sensing and detection capabilities in consumer and telecommunications technology through light-based signals. The plasma technology space is more focused around industrial manufacturing and materials treatment through the use of plasma streams as cutting, welding, etching, or disposition tools in creating advanced materials or precision-machined components.

NH Industry Innovation Context

Leading patent activities (# of patents, specialization, relative impact): Charged particle beam systems (182, 11.39, 2.47); Projection and filtered light display devices (121, 9.84, 0.76); Generating and handling plasma (106, 34.10, 0.89); Laser devices (62, 5.10, 0.81)

Presence in venture capital: In laser systems, one company received \$15.2 million in venture capital funding over the 2009 to 2015 period.

Presence in SBIR awards (multiple award winners): High performance metals machining and inspection

NH Supporting Industry Base

NH Industry Profile:

- Smaller (2,690 jobs)
- Highly Specialized (690% higher level of industry specialization)
- Declining (-4.4% job growth, 2009-2014)
- Leading U.S. Growth (1.6 percentage points above U.S. growth)

Examples of NH Companies: Hypertherm, Laser Light Engines, Osram Sylvania, Solid State Scientific, QmagiQ LLC, Active Spectrum Inc.

NH Research Innovation Context

Publications: (leading fields by publications (2009-2015) and level of specialization/relative concentration): Plasma Physics (126, 1.19); Applied Physics (182 pubs, 0.41); Particle Physics (134, 0.90); Optics (259 pubs, 1.2) – crosscutting with sensors

Major Research Centers and Grants:

- UNH: Space Science Center

Growth Potential and Leading Market Applications

Market for photonics-based electronics and plasma control technologies is still somewhat niche, but with reasonable projected growth:

- Global market in photonic sensors valued at \$5.6 billion in 2013 with CAGR of 15.8%
- Global market in photonic detectors valued at \$0.7 billion in 2013 with CAGR of 16.7%
- North American market in laser technologies valued at \$3 billion in 2014 with CAGR of 5.5%
- Global market in fiber optic sensors valued at \$1.8 billion in 2012 with CAGR of 4.5%

Examples of likely market applications based on New Hampshire capacities:

- Photonic switches and circuits
- Fiber optics
- Plasma cutting technologies

Data Processing and Network Systems

Many industries now rely on the ability to store, process, and analyze large databases of information and transfer real-time information via the Internet as key foundations of their business operations. Data processing systems comprise both the technology required to store large quantities of information efficiently, whether on physical on-site hardware or cloud-based servers, as well as the ability to quickly access and analyze that information to enable decision support through predictive statistics and machine learning and integrate into software tools and internet services. Network systems function as a necessary complement to allow the fast and accurate transmission of information over wired or wireless broadband infrastructure. Data processing, analytics, network communications, software tools and internet services are relevant to almost all applications areas in modern business, making the underlying technologies critical to driving growth.

NH Industry Innovation Context

Leading patent activities (# of patents, specialization, relative impact): Machine learning/natural language processing and complex data processing (791, 2.01, 1.63); Logistics & consumer data processing (246, 2.08, 1.64); Network security (241, 2.21, 2.12)

Presence in venture capital: In software, data, internet and computer services, 29 companies received \$421 million in venture capital funding over the 2009-2015 period.

Presence in SBIR awards (multiple award winners): Image processing and analysis, Geospatial data decision support tools

NH Supporting Industry Base

NH Industry Profile:

- Large (11,842 jobs)
- Specialized (20% higher level of industry specialization)
- Growing (24.4% job growth, 2009-2014)
- Lagging U.S. Growth (1.4 percentage points lower growth)

Examples of NH Companies: AutoDesk, Bottomline Technologies, Dyn, EMC, HP, Oracle, Veveo

NH Research Innovation Context

Publications (leading fields by publications (2009-2015) and level of specialization/relative concentration): Computer Science Interdisciplinary Applications (134 pubs, 0.88); Information Systems (119 pubs, 0.85); Software Engineering (100 pubs, 1.05)

Major Research Centers and Grants:

- UNH: Interoperability Lab; Institute for Health Policy and Practice; Research Computing Center
- Dartmouth: Institute for Security, Technology and Society (CoAE in Info Assurance Research); Cybersystems for Trustworthy Health & Wellness + Secure Wearable Mobile Health; Digital Forensics; Ubiquitous Computing

Growth Potential and Leading Market Applications

Market for data processing and network systems encompasses a wide variety of applications with large market sizes and will continue to see significant growth. A selection of the numerous potential markets includes:

- North American market in software-defined networking applications totaled \$0.8 billion in 2014 with CAGR of 88.7%
- Global market in data center and server security valued at \$5.6 billion in 2014 with CAGR of 13.8%
- North American market in enterprise mobility networks valued at \$31.1 billion in 2014 with CAGR of 13.6%
- North American market in content delivery networks valued at \$1.6 billion in 2011 with CAGR of 13.6%

Examples of likely market applications based on New Hampshire capacities:

- Enterprise computing analytics
- E-commerce
- Search engine and personalization algorithms
- Electronics products design and optimization

Biotech Analysis Tools, Techniques and Products

In addition to the medical devices and pharmaceuticals used in the clinical environment, a wide array of biotechnology technologies are used to drive new biomedical discovery and research. There are many different types of biotechnology analysis products and tools, ranging from next generation genetic sequencing and biomarker identification to formulation and manufacturing of additives in therapeutics. This part of the biotech market is typically driven by applications that relate to diagnostics and sample analysis, and is also a critical part of early stage drug discovery.

NH Industry Innovation Context

Leading patent activities (# of patents, specialization, relative impact): Biopharmaceutical compositions (212, 2.43, 2.63); Screening and assay analysis of biological materials (170, 2.32, 1.69); Measuring or testing processes involving enzymes or micro-organisms (134, 2.50, 2.41)

Presence in venture capital: In medical therapeutics and biotechnology, six companies received \$137.8 million in venture capital funding over the 2009-2015 period.

Presence in SBIR awards: (multiple award winners): Immunotherapies and vaccines, Biomarkers and next generation sequencing

NH Supporting Industry Base

NH Industry Profile:

- Small (2,573 jobs)
- Not Specialized (16% lower level of industry specialization)
- Fast Growing (83.6% job growth, 2009-2014)
- Well-Leading U.S. Growth (79 percentage points higher growth)

Examples of NH Companies: Merck (acquired Glycofi), Adimab, AgaMatrix, CPEX Pharmaceuticals, DEKA, Enchi Corp., Avitide, Celdara Medical, ImmuNext, New England Biolabs, ImmuRx, Woomera Therapeutics, Synta Pharmaceuticals Corp.

NH Research Innovation Context

Publications (leading fields by publications (2009-2015) and level of specialization/relative concentration): Oncology (698 pubs, 1.22); Biochemistry/Molecular Biology (602, 0.72); Genetics/Heredity (401, 2.36); Immunology (329, 0.88); Microbiology (309, 1.15); Biotech & Applied Microbiology (280, 0.97)

Major Research Centers and Grants:

- UNH: Hubbard Center for Genome Studies
- Dartmouth: Extensive activities themes around immunology (cancer, lung biology, antibiotic resistance) and engineering in medicine (proteins, biomaterials/nanomaterials)
- Others: Psychiatry (substance abuse, TBI); Systems Biology with focus on Molecular Epidemiology; Quantitative Biology and Structural Biology
- Major centers in Cancer and CTSI (Synergy)

Growth Potential and Leading Market Applications

Large market with modest growth for diagnostic and analysis products:

- North American market for in-vitro diagnostics valued at \$24 billion in 2013 with CAGR of 3.1%
- North American market in drug discovery technologies valued at \$17.7 billion in 2014 with CAGR of 12.6%
- North American market in cell and tissue analysis products valued at \$4.2 billion in 2013 with CAGR of 4.2%
- North American market in enzyme-based immunoassay technologies valued at \$2.5 billion in 2011 with CAGR of 4.4%

Examples of likely market applications based on New Hampshire capacities:

- Personalized medicine and pharmacokinetics
 - Genetic testing and diagnostics
 - Biopharmaceuticals
 - Medical screening, sampling, and testing technologies
-

Medical Devices

The next generation of medical devices used in clinical settings incorporates advances in biocompatible materials, imaging and sensing technology in order to more effectively deliver health care across the various treatment environments. From advanced wound healing technologies employed by surgical and trauma clinicians to patient monitoring sensors and drug delivery devices used in long term patient care settings to advanced imaging modalities, there is an ongoing need for new technologies to continually improve health care outcomes.

NH Industry Innovation Context

Leading patent activities (# of patents, specialization, relative impact): Surgical and wound healing devices (320, 1.98, 0.91); Syringes, injectors and infusion pumps (291, 9.41 1.16); Implantable medical devices (252, 2.61, 2.06); Diagnostic sensors (230, 2.40, 0.87)

Presence in venture capital: In medical imaging, one company received \$32 million in venture capital funding over the 2009 to 2015 period.

Presence in SBIR awards (multiple award winners): Medical imaging agents

NH Supporting Industry Base

NH Industry Profile:

- Small (2,146 jobs)
- Specialized (42% higher level of industry specialization)
- Declining (-12% job growth, 2009-2014)
- Lagging U.S. Growth (3.3 percentage points lower growth)

Examples of NH Companies: DEKA, Boston Scientific, Atrium Medical Corp., Salient Surgical Technologies, Smiths Medical ASD, Vapotherm, Gamma Medica, Xemed, Simbex, Smith & Nephew, Medtronic

NH Research Innovation Context

Publications (leading fields by publications (2009-2015) and level of specialization/relative concentration): Surgery (574, 1.07); Radiology, Nuclear Med, Imaging (412, 1.31); Health Care Sciences (401, 2.36); Biomedical Engineering (128, 0.83)

Major Research Centers and Grants:

- Dartmouth: Center for Surgical Innovation; Advanced Imaging Center (Breast Cancer Imaging); Center for Technology & Behavioral Health; The Dartmouth Institute for Health Policy and Clinical Practice

Growth Potential and Leading Market Applications

Large overall market size with modest growth for medical technologies:

- Global medical imaging market is expected to reach nearly \$34.1 billion in 2017 after increasing at a five-year compound annual growth rate (CAGR) of 5%.
- Global market in advanced orthopedic technologies, implants, and regenerative products valued at \$34.2 billion in 2012 with CAGR of 3%
- North American market in implantable biomaterials valued at \$38.4 billion in 2013 with CAGR of 5.2%
- North American market in surgical equipment valued at \$1.5 billion in 2012 with CAGR of 9%
- Global market in medical device coatings valued at \$6 billion in 2012 with CAGR of 7.3%

Examples of likely market applications based on New Hampshire capacities:

- Surgical devices
- Implantable devices (stents, grafts, discs, other prosthetics)
- Clinical sensors and monitors

Agricultural, Marine, and Bio-based Products

In addition to advanced technology areas, a key platform for growth can be based around natural resources found in a region. New Hampshire has extensive natural forests that enable wood processing and downstream products industries, a notable presence of forestry and conservation research, and a significant marine ecosystem along its coast that drives aquaculture industries. New technologies that interface with ecological conservation and remote sensing as well as agricultural and biological resource production and protection can be more easily developed around existing natural resources and have the potential to become the basis for new generation natural resource technologies such as biofuels.

NH Industry Innovation Context

Minimal presence in patent, venture capital, and SBIR activities

Presence of a large base of natural resources – extensive woodlands throughout state with significant natural forests in northern region (i.e. large amounts of forest owned by UNH/Dartmouth for innovation research) as well as coastal/marine ecosystems

NH Supporting Industry Base

NH Industry Profile:

- Mid-Sized (9,368 jobs)
- Not specialized (48% lower level of industry specialization)
- Slightly declining (-2.2% job growth, 2009-2014)
- Lagging U.S. Growth (5.6 percentage points lower growth)

Examples of NH Companies: Mascoma Corp., Monadnock Paper Mills Inc., Stonyfield Farm Inc., Gorham Paper and Tissue, Burgess BioPower, Eversource - Northern Wood Power Unit, Cedar Point Shellfish, Fat Dog Shellfish Company

NH Research Innovation Context

Publications (leading fields by publications (2009-2015) and level of specialization/relative concentration): Environmental Sciences (729, 1.75); Geosciences (630, 2.72); Ecology (579, 2.01), Meteorology/Atmospheric Sciences (450, 2.34); Marine/Freshwater Biology (236, 2.0); Oceanography (191, 2.28); Geochemistry/Geophysics (186, 1.34); Physical Geography (181, 2.84); Forestry (162, 3.08); Environmental Engineering (150, 1.35)

Major Research Centers and Grants:

- UNH: Forest Industry Training Center; Dairy and Greenhouse LGU Agricultural Extensions; NH Veterinary Diagnostic Lab; bioengineering programs within School of Engineering
- Dartmouth: multiple faculty working in the biofuels/bioengineering area – research strengths in bioprocessing
- Hubbard Brook Research Foundation & Experimental Forest

Growth Potential and Leading Market Applications

Market size and growth potential varies widely depending on application area and downstream product, and will likely be highly variable depending on regional and national market conditions affecting natural resource supply and demand:

- Global market in synthetic biology-enabled biofuels valued at \$130.5 million in 2014 with CAGR of 78.4%
- Global market for biorefinery technologies valued at \$10.2 billion in 2014 with CAGR of 5.3%
- North American market for organic foods and beverages valued at \$29.5 billion in 2013 with CAGR of 14%
- United States market for green building materials valued at \$40 billion in 2013 with CAGR of 9.5%

Examples of likely market applications based on New Hampshire capacities:

- Biofuels and biogeochemistry
- Agricultural feedstock
- Precision agriculture machinery
- Climate change and natural resource man

Appendix B: Summary of Benchmark Analysis

Selection of Benchmark States

Seventeen benchmark states were identified based on a range of similarities to New Hampshire including geography, level of university research funding, a limited state taxing approach and access to a high-quality outdoor life style. Some states fall in more than one category for benchmarking.

	New England Regional Peer	EPSCoR Peer	Business Climate Peer	Life Style Peer
Arkansas		✓		
Colorado			✓	
Connecticut	✓			
Delaware		✓		
Kentucky		✓		
Maine	✓	✓	✓	✓
Massachusetts	✓			
Nebraska		✓		
Nevada		✓	✓	
Oregon				✓
Rhode Island	✓	✓	✓	
South Dakota		✓	✓	
Utah		✓		✓
Vermont	✓	✓	✓	
Washington			✓	✓
West Virginia		✓		
Wyoming		✓		✓

Measures and New Hampshire Position across Business Environment for Innovation-Led Development

Measure	Definition	New Hampshire	U.S.	NH Ranking vs. 17 Benchmark States (1st to 18th)
Research and Development Measures				
Industrial R&D	Industry R&D Expenditures per \$10M GSP, 2013	120,175	160,076	9 (Mid-tier)
	Percent Change, 2009-13	5.1%	17.8%	11 (Mid-tier)
University Science & Engineering R&D	University S&E R&D Expenditures per \$10M GSP, 2014	45,245	36,989	4 (Top-tier)
	Percent Change, 2009-14	6.7%	16.2%	10 (Mid-tier)
Industry Support for University Research in Science & Engineering	Share of Industry Funding of University S&E Research, 2014	4.1%	5.7%	11 (Mid-tier)
	Percent Change in Industry Funding of University S&E Research, 2009-14	31.7%	13.6%	9 (Mid-tier)
Technology Commercialization Measures				
Patents Issued (US Granted)	Patents Issued (Inventor Only) per \$100M GSP, 2014	2.49	0.96	2 (Top-tier)
	Percent Change (Inventor Only), 2009-15	65.8%	66.6%	12 (Mid-tier)
	Patents Issued (Inventor & Assignee-In State) per \$100M GSP, 2014	2.15	0.95	1 (Top-tier)
	Percent Change (Inventor & Assignee-In State), 2009-15	374.9%	98.6%	5 (Top-tier)
University Tech Transfer & Commercialization				
(Rank out of 15 States)	Start-ups per \$10M in Univ. Research Spending, 2014	0.03	0.15	15 (Low-tier)
	U.S. Patents Issued per \$10M in Univ. Research Spending, 2014	1.19	1.04	6 (Top-tier)
	Licenses Executed per \$10M in Univ. Research Spending, 2014	1.15	1.09	8 (Mid-tier)
Entrepreneurial Measures				
New Company Birth Rate	Average Annual New Firm Formation as a Percent of All Firms, 2009-2013	6.2%	8.0%	14 (Low-tier)
Job Creation by New Births	Average Annual Job Creation from New Firms, 2009-2013	5.5	5.7	8 (Mid-tier)
Presence of High-Growth Companies	Number of Companies on the Inc. 5000 List of Fastest Growing Companies, 2015	19	NA	10 (Mid-tier)

Measure	Definition	New Hampshire	U.S.	NH Ranking vs. 17 Benchmark States (1st to 18th)
Entrepreneurial Activity	Kauffman Foundation's Startup Activity Index, Rate of New Entrepreneurs, 2014	0.25%	0.31%	13 (Low-tier)
Venture Capital Investments	Cumulative VC Investments per \$10M Cumulative GSP, 2009-2014	\$14,509	\$25,865	7 (Mid-tier)
	Cumulative VC Investments in Seed & Early Stage Companies as a Share of Total, 2009-2014	42%	26%	2 (Top-tier)
Federal SBIR Awards	SBIR/STTR Awards per 10,000 population, Avg. 2009-2015	\$266,370	\$74,327	2 (Top-tier)
Talent and Workforce Measures				
Skilled Employment (IT includes both computer and math occupations, and includes both High and Middle skilled occupations.)	Share Employed in High-Skilled Occupations, 2014	21.1%	22.0%	10 (Mid-tier)
	Percent Change, 2010-14	4.0%	9.6%	17 (Low tier)
	Share Employed in Middle-Skilled Occupations, 2014	29.1%	29.2%	10 (Mid-tier)
	Percent Change, 2010-14	3.4%	4.4%	9 (Mid-tier)
	Share Employed in IT-Skilled Occupations (High & Middle Skilled), 2014	2.8%	2.8%	8 (Mid-tier)
	Percent Change, 2010-14	15.0%	41.8%	18 (Low tier)
Science & Engineering Degrees	Percent of Total Degrees Awarded, 2014	15.1%	15.8%	10 (Mid-tier)
	Change in S&E Degrees as Percent of Total Degrees (% Point Change), 2010-14	2.3%	1.7%	7 (Mid-tier)
K-12 Student Achievement	NAEP Tests, 8th Grade Math, Avg. Score 2015	294	282	2 (Top tier)
	NAEP Tests, 8th Grade Science, Avg. Score 2011	162	152	2 (Top tier)
Business Environment and Physical Infrastructure				
Tax Climate	State Business Tax Climate Index, 2016 (1 = lowest burden)	7	NA	4 (Top tier)
Broadband Infrastructure	Percent Broadband Adoption (10 Mbps), Q4 2015	61.7	52.9	5 (Top tier)
	Average Connection Speed (kbps), Q4 2015	15,018	14,240	7 (Mid-tier)
Highway Access	Interstate Miles per 1,000 sq. miles, 2013	25.15	13.47	5 (Top tier)

Measure	Definition	New Hampshire	U.S.	NH Ranking vs. 17 Benchmark States (1st to 18th)
Road Condition (International Roughness Index Rating)	Percent of Reported Road Miles with "Good" Ride Quality, 2013	46.3%	41.6%	7 (Mid-tier)
	Percent of Reported Road Miles with "Acceptable" Ride Quality, 2013	73.7%	80.4%	12 (Mid-tier)
Air Service	Enplanements per Population, 2013	0.91	2.31	13 (Mid-tier)
Rail Access	Rail Miles per sq. mile, 2012	38.42	39.22	10 (Mid-tier)
	Number of Rail Carriers (Class 1/ Total), 2012	0/9	7/575	NA
Utility Rates	Commercial Rates, Cents/kilowatt hour, 2014	14.34	10.74	14 (Low tier)
	Industrial Rates, Cents/kilowatt hour, 2014	11.93	7.10	15 (Low tier)
Gas Taxes	Gas Taxes, Cents per Gallon, 2016 (1 = lowest tax burden)	23.83	NA	4 (Top tier)
Industry Success				
Advanced Industry Employment	Share of total private sector jobs in Advanced Industries, 2014	11.2%	10.9%	6 (Top tier)
	Change in Advanced Industry employment, 2009-2014	2.9%	9.1%	12 (Mid-tier)

Sources:

- Industrial R&D: National Science Foundation (NSF) Business R&D and Innovation Survey. Industry R&D analyzed in this table is industry R&D performed by and paid for by industry.
- University R&D: NSF Survey of R&D Expenditures at Universities and Colleges.
- Industry Support for University R&D: National Science Foundation (NSF) Business R&D and Innovation Survey.
- Patents: Thomson Innovation database. Note: Inventors are residents within state regardless of who owns the patents and Assignees-In-State are those who own patents and are located in-state
- Univ. Tech Transfer: Association of University Technology Managers (AUTM). 2014 data not available for ME, NV or WY.
- New Company Birth Rate and Job Creation by New Births -- U.S. Census of Business Dynamics.
- High-Growth Companies -- Inc. Magazine.
- Entrepreneurial Activity -- Kauffman Foundation. Rate of New Entrepreneurs = the average share of 100K adults that became entrepreneurs in a given state each month.
- VC: TEconomy analysis of Thomson Reuters Thomson One database.
- SBIR Awards: TEconomy analysis of Small Business Innovation Research (SBIR) Federal database (sbir.gov).
- Occupational Employment: TEconomy analysis of U.S. Bureau of Labor Statistics, Occupational Employment Statistics.
- S&E Degrees: TEconomy analysis of National Center for Education Statistics, IPEDS database.
- Student Achievement: National Center for Education Statistics, National Assessment of Educational Progress.
- Tax Climate: 2016 State Business Tax Climate Index, Tax Foundation.

- Broadband: Akamai State of the Internet, Connectivity Visualizations (Accessed on April 1st, 2016).
- Highway Access: U.S. Department of Transportation, Federal Highway Administration.
- Road Condition: U.S. Department of Transportation, Federal Highway Administration. According to the FHWA, the IRI is a generally accepted measure of pavement roughness worldwide. An IRI rating of < 95 indicates "good" ride quality, and an IRI rating of <=170 indicates an "acceptable" ride quality.
- Air Service: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.
- Rail Access: U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics.
- Utility Rates: U.S. Energy Information Administration
- Gas Taxes: Tax Foundation.
- Advanced Industry Employment: U.S. Bureau of Labor Statistics, QCEW, enhanced file from IMPLAN.

Appendix C – List of Completed Interviews for the NH University Research & Industry Plan

1. Industry Interviews

Last Name	First Name	Company
Smith	Mark E.	XMA corporation
Fuentes	Pablo	Fidelity Investments, Merrimack NH
Rupp	Adrienne	Genia
Emerson	Brandy	Scribesoft
Matson	Matt	Wire Belt Co. of America
O’Laughlin	Mike	Lydall Performance Materials, Inc.
Maxwell	Thomas	TFMaxwell Consulting LLC
Reeves	Mark	BAE Systems
Sullivan	Thomas P.	Ruger
Coughlin	Jamie	Dartmouth Entrepreneurial Network
DeLucia	Dave	ImmuNext
Beisswenger	Paul	PreventAGE Health Care
Pogue	Brian	DoseOptics
Berry	Mark	NH Manufacturing Extension Partnership (MEP)
Dion	Laura Z.	AQYR
Reder	Jake	Celdara Medical LLC
Pollard	Sam	Conductive Compounds Inc.
Kline-Schoder	Bob	Creare Inc.
Toohey	Brian	DEKA Products Limited Partnership
Mailhot	Paul	Dynamic Network Services (Dyn) Inc.
Folsom	Douglas	GE
Zanchuk	Val	Graphicast, Inc.
Mazzola	Mike	Lamprey Networks
Gerini	Bruce	Osram Sylvania Inc.

Last Name	First Name	Company
Greenwald	Richard M.	Simbex
Versteeg	Roelof	Subsurface Insights
Army	Joe	Vapotherm Inc.
Cecere	Tom	Weather Analytics, LLC
Donoghue	Joanne	Mascoma Corp.
Hall	Pam	Normandeau Associates, Inc.
Large	Terry	Eversource Energy
Shipulski	Mike	Hypertherm, Inc.
Mottolo	Cara	AgaMatrix
Kjendal	Dave	Senet Inc

2. NH Academia Interviews

Last Name	First Name	Organization
Bhakuni	Nila	Office of Entrepreneurship and Technology Transfer (OETT), Dartmouth
Gerngross	Tillman	Office of Entrepreneurship and Technology Transfer (OETT), Dartmouth
Davis	Trip	Office of Entrepreneurship and Technology Transfer (OETT), Dartmouth
Helble	Joseph	Thayer School of Engineering, Dartmouth
Lasky	Ronald	Thayer School of Engineering, Dartmouth
Baker	Ian	Thayer School of Engineering, Dartmouth
Naughton	Thomas	Tuck School of Business, Dartmouth
Smith	Elizabeth F.	Dean of Faculty Office, Dartmouth
Green	Alan	Geisel School of Medicine, Dartmouth
Green	William	Geisel School of Medicine, Dartmouth
Marsch	Lisa	Geisel School of Medicine, Dartmouth
Nisbet	Jan	Research Administration, UNH
Sedam	Marc	UNH Innovations
Christo	Ellen	UNH Innovations
Messer	Patrick	Research Computing, UNH

Last Name	First Name	Organization
French	Charlie	Cooperative (Co-op) Extension, UNH
Wraith	Jon	College of Life Sciences & Ag. (COLSA), UNH
Smick-Attisano	Regina	Thompson School of Applied Science, UNH
Vasudevan	P.T "Vasu"	Office of Provost and College of Engineering & Physical Sciences, UNH
Mayer	Larry	School of Marine Science and Ocean Engineering, UNH
Johnson	Erica	Interoperability Lab, UNH
Langan	Richard	Coastal and Ocean Technology Program, UNH
Korkorlis	Yannis	College of Engineering & Physical Sciences, UNH
Kinsey	Brad	Center for Advanced Materials and Manufacturing Innovation (CAMMI), UNH
Divins	David	Institute for the Study of Earth, Oceans, and Space, UNH
Tsavalas	John	Nanostructured Polymers Research Center, UNH
Short	Kevin	Professor Mathematics & Statistics, UNH
Kirsch	Nicholas	Connectivity Research Center, UNH
Grant	Ian	Peter T. Paul Entrepreneurship Center, UNH
Thomas	W. Kelley	Hubbard Center for Genome Studies, UNH
Van Ostern	Kristyn	Community College System of NH
Arvelo	Wildolfo	Great Bay Community College
MacKay	Ed	NH Higher Education Commission
Amsden	Ben	Plymouth State University
Leach	Todd	University System of NH (USNH)

3. Other Stakeholder Interviews (includes Economic Development, Government and Community Representatives)

Last Name	First Name	Organization
Feldborg	Eric	NH Dept. of Education
MacGrath	Ken	Core Compliance Testing Services
Eneguess	Katharine	Magalloway Consultants
Grogan	Rich	NH Small Business Development Center
Kaen	Rep. Naida	State of NH House of Representatives
Merrow	Katie	NH Charitable Foundation
Pease	Dave	NH Government Contracting Assistance Center
Stiles	Sen. Nancy	State of NH Senate
Weaver	Brittany	Office of Governor Maggie Hassan (State of NH)
Gardner	Kevin	NH EPSCoR
Lorentz	Carmen	NH Dept. of Resources & Economic Development
Carroll	Kevin	Grossman, Tucker, Perreault & Pflieger, LLC
Wivell	Dawn	NH Aerospace and Defense Export Consortium (NHADEC)
Gray	Elizabeth	NH Business Finance Authority
Freeman	Jon	Northern Community Investment Corp (NCIC)
Scala	Mike	Coos County Economic Development Council (EDC)
Coppelman	Glen	North Country Council
Kaplan	Mark	Alpha Loft
Caswell	Taylor	The Community Development Finance Authority
Scobie	Kirsten	Neil and Louise Tillotson Fund at the NH Charitable Foundation
Brahim	Zenagui	NH Manufacturing Extension Partnership (MEP)

Appendix D – References

Association of Public and Land-Grant Universities. “Economic Engagement Framework: Assessment Tools for Examining the Role of Universities in Economic Development.”, May 2014.

Battelle Technology Partnership Practice. “Utah’s Science, Technology, Talent and Innovation Plan.” Governor’s Office of Economic Development Utah System of Higher Education, 2012.

“From Tailwind to Headwind: New Hampshire’s Shifting Economic Trends.” NH Center for Public Policy Studies, 2012.

Gittell Ph.D., Ross, and Scott Lemos. “The Community College System of NH Economic Impact Study.” Community College System of New Hampshire, Dec. 2014.

Gittell, Ross, and John Orcutt. “Science and Technology Plan: Shaping New Hampshire’s Economic Future.” NH EPSCoR, Oct. 2011.

“2015 NHBR Book of Lists.” New Hampshire Business Review, 2015.

“New Hampshire Economic Development FY 2016-17 Strategic Plan.” New Hampshire Division of Economic Development, Dec. 2015. Web.

“New Hampshire Economic Outlook.” NH Center for Public Policy Studies, 2015.

“New Hampshire’s Economic Climate: Key Indicators.” NH Center for Public Policy Studies, 2013.

“2011 NHBR Book of Lists.” NH Business Review, 2011.

“Policy Notes: Women & STEM in NH.” NH Center for Public Policy Studies, 2014.

“Smart Manufacturing and High Technology New Hampshire’s Leading Economic Sector.” NH Center for Public Policy Studies for NH’s High Tech Council, 2011.

State of New Mexico Economic Development Department. “Innovate! New Mexico: Science & Technology Plan.” New Mexico EPSCoR, Nov. 2015.

“Strategic Economic Plan for NH.” Business and Industry Association of NH, Nov. 2013.

“What is New Hampshire?” NH Center for Public Policy Studies, 2014.

NH EPSCoR Statewide Committee

Industry Members

Joanne Donoghue, Director, Corporate EHS & Operations, Mascoma Corporation

Rich Grogan, State Director, NH Small Business Development Center

Lisa Hagemann, Principal Engineer, Dyn Inc.

Pam Hall, CEO, Normandeau Associates, Inc.

Terrance Large, Director, Engineering and Technical Services, Eversource

Ellen Scarponi, Senior Director of Government Relations/Economic Development NH, Fairpoint Communications

Mike Shipulski, Chair, NH EPSCoR Statewide Committee; Director of Advanced Development, Hypertherm, Inc.

Education Members

Will Arvelo, President, Great Bay Community College

Kevin Carroll, Adjunct Professor, UNH Law; Grossman, Tucker, Perreault & Pflieger, LLC

Eric Feldborg, Director of Career and Technical Education, and Administrator, NH Career Development Bureau

Todd Leach, Chancellor, University System of New Hampshire

Daniel Lee, Associate Professor of Economics, College of Business Administration, Plymouth State University

Jan Nisbet, NH EPSCoR State Director; Senior Vice Provost for Research, UNH

Martin Wybourne, Senior Vice Provost for Research, Dartmouth College

Government Members

Rep. Naida Kaen, State Representative, NH House of Representatives

Jeffrey Rose, Commissioner, NH Department of Resources and Economic Development

Sen. Nancy Stiles, Chair, Education Committee, NH State Senate

Brittany Weaver, Policy Advisor, Office of NH Governor Maggie Hassan

At-Large Members

Katharine Eneguess, Vice Chair, NH EPSCoR Statewide Committee; President, Magalloway Consultants

Katie Merrow, Vice President of Community Impact, New Hampshire Charitable Foundation