INTRODUCTION
The global economy continues to experience a rapid and dynamic period of transformation with manufacturing activities being decomposed and recomposed on a global basis. While it has become commonplace to regard the North American economy as predominantly a service oriented one, with a growing proportion of manufacturing shifting to other parts of the globe, the current reality is far more complex. The application of information technology and increasingly sophisticated advanced manufacturing technologies makes the locational choices of large multinational firms and domestic ones infinitely more complex than it has been in previous decades. While labour costs were long considered to be the driving force in these locational decisions, there is growing recognition that access to skills, research and development and a strong supply base of technologically sophisticated manufacturers are increasingly important in determining locational decisions for advanced manufacturing and research intensive firms. There is also a growing recognition of the critical importance of the link between R&D and manufacturing and a growing acceptance of the fact that the loss of manufacturing activity eventually undermines the capacity of advanced economies to retain their research and production base (Berger 2013). This recognition is leading to an increased emphasis in most industrial economies, particularly those states and regions in the industrial heartland of North America, of the need to strengthen and improve their research base and their institutions with the capacity to upgrade the capabilities of advanced manufacturing firms.

Halton region is situated at a critical juncture, both geographically and strategically, in this transformation that is currently underway. Halton is a dynamic part of the Western GTA and Hamilton regional economy that has experienced steady economic growth since the downturn of the 2008-09 recession. Halton is located at the juncture of the Hamilton, Toronto and Waterloo region economies which puts it within a one hour drive of most of the key public and private research institutions in southwestern Ontario, as well as close proximity to some of the most dynamic firms in high technology and advanced manufacturing in Ontario’s manufacturing core.
While services predominate in the Halton economy, the region is home to almost 1,000 manufacturing firms that include a number of technology-intensive sectors, such as advanced manufacturing, clean tech, digital media, ICT and biotechnology.

Advanced manufacturing in the Halton and Golden Horseshoe regions is extensive and is integrated in various industries such as automotive manufacturing, metal manufacturing, food manufacturing, biotechnology, plastics, machinery manufacturing, and wind energy equipment manufacturing. Although some multinational enterprises are involved in advancing technological processes and products, many small- and medium-sized companies involved in advanced manufacturing techniques have also emerged (Focus Business Consulting 2013). As such, Halton has a strong interest in the need to expand the role that innovation intermediaries can play in intensifying the linkages between Ontario’s world class research institutions and its dynamic manufacturing firms and thus helping to overcome what the Council of Canadian Academies has referred to as the “paradox” of the growing disjuncture between our research strengths and innovation weaknesses (Council of Canadian Academies, 2009 2013).

While government policies are placing greater emphasis on the need to establish mechanisms to ensure that the various elements of regional and local research infrastructure are effectively linked to the productive capabilities of local firms, there is also a growing understanding of the gaps that currently exist in the institutions that promote the transfer of research and technical skills to the manufacturing economy (Bramwell, Hepburn and Wolfe, 2012). This, in turn, is leading to an increasing awareness of the role that innovation intermediary organizations play in driving the innovation process. Dalziel (2010) defines innovation intermediaries as organizations or groups within organizations that support innovation, either directly by enabling the innovativeness of one or more firms, or indirectly by enhancing national, regional, or sectoral innovative capacity. Examples of innovation intermediaries include science, technology and business parks and incubators; industry associations; trade associations; research and technology development institutes; economic development agencies; chambers of commerce; research consortia; and international standards organizations (Dalziel and Parjanen, 2012; Dalziel, 2010). Despite their diversity, these organizations perform three core roles to enable innovation: funding support, networking and collaboration, and other supportive functions that benefit firms and research institutions; some of those supportive functions include encouraging technology transfer and innovation diffusion, promoting technology exploitation, providing business intelligence, and facilitating innovation management (Dalziel and Parjanen, 2012; Howell, 2006). Overall, these “bridge builders” play a
key role in enhancing the innovative capacity of their jurisdictions, building trust between research and innovation actors (OECD, 2013; Dalziel and Parjanen, 2012).

This report draws attention to one type of innovation intermediary – technology institutes or technology innovation centres (TICs) – and discusses the important role they play in advancing regional innovation and commercialization efforts. In addition to discussing the international pervasiveness of TICs and the impact of these organizations on regional innovation and commercialization, the report addresses the key question: What lessons can the Halton region take from the German, UK and American TIC models that will inform efforts at advancing economic growth and wealth generation in a competitive knowledge-based economy?

The first section of the paper defines the purpose of technology institutes, distinguishes these organizations from their more research-oriented counterparts (i.e. “competence centres” and “centres of excellence”) and discusses the value-added contributions technology institutes make. Section two reviews the technology and innovation centres established in Germany, the UK and the United States. The similarities and differences between the British, German and American models are discussed in the third section. The report ends with a consideration of how these international models may inform efforts at advancing technology-based innovation and regional economic development in the Halton region.

TECHNOLOGY AND INNOVATION CENTRES (TICs)
Technology and innovation centres are mission-driven organizations that work with higher education institutions to develop in-house knowledge and capability that can facilitate the activities that bridge research and technology commercialization (Hauser, 2010). The Hauser Report, undertaken for the U.K. government, provides an international comparison of Technology and Innovation Centres (TICs) in 12 countries and finds that although their roles and rationales within national innovation systems differ, most countries see TICs as critical intermediary organizations that deliver governmental and wider public sector programs, policies and strategies to promote innovation. These roles include a wide variety of activities, such as undertaking basic research; conducting applied research in the innovation chain between the initial discovery phase of university research and industrial development for commercialization; supporting innovation in SMEs by providing knowledge, equipment and applied research; providing technical and commercialization services to large and SME firms; and contributing to the development of a highly skilled workforce. Entrepreneurs and innovative companies that collaborate with these TICs share the costs of R&D and access invaluable skills, machinery and
equipment in order to reduce risk, shorten time to market, and intensify the exploitation of new technology (Hauser, 2010). Most TICs are financed by both public and private investors and a portion of this funding is used to provide local entrepreneurs and high-growth innovative firms with a range of research and business services they need to support their innovation activities (Wolfe et al, 2011; OECD, 2013).

TICs are prominent members of many innovation ecosystems around the world. However, it is important to distinguish them from other centres that also play an important innovation intermediary role. Research-oriented centres, namely “competence centres,” or “centres of excellence,” bring together academic and business partners to collaborate on research projects. They tend to run multi-annual research programs in a specific field which they receive a mix of public and private funding (OECD, 2013). These centres are largely science-oriented and have a high R&D intensity. To this end, research-oriented centres act as critical knowledge mediators and knowledge producers. On the other hand, TICs are more business-oriented. In an innovation ecosystem, these centres act as knowledge mediators, knowledge suppliers, technology developers and infrastructure providers. They have a low or medium R&D intensity and place a strong focus on providing business services, mostly to SMEs, using a “consultancy-like approach” (Astrom et al, 2009; OECD, 2013). As such, TICs provide firms with on-demand services that are specific to these clients’ needs. Overall, these services, combined with open access to world-class technology infrastructure, can significantly improve the collaborating firms’ and entrepreneurs’ efforts at developing or commercializing a new or improved product, breaking into a new market, and/or increasing their exports.

TICs play a central role in boosting national and regional levels of innovation, which in turn, advances economic growth and wealth creation in competitive, knowledge economies. Firstly, these organizations enable knowledge flows and technology transfer between research communities and industry. By increasing the mobility of people and other resources between these two communities, TICs help capture knowledge spillovers (OECD, 2013). This process narrows the “cultural divide” between firms and research institutions, which if left unaddressed, intensifies conflicting views held by both sets of actors regarding the purpose of research and ultimately complicates academia-industry collaborations (OECD, 2013, Bramwell et al., 2012).

Secondly, because of their collaborative orientation, TICs help to build partnerships between actors across the research community, industry (i.e. SMEs, LMEs, and entrepreneurs), public and private investors, government departments and agencies and other innovation...
intermediary organizations. Partnerships between research and innovation actors that are strengthened and sustained by TICs support efforts at technological specialization and help to build up a jurisdiction’s absorptive capacity as well as the financial and human capital necessary for generating cutting-edge ideas and bringing them to market. Moreover, in light of the ongoing communication, interaction and learning that takes place between these actors, partnerships enabled by TICs help knowledge suppliers identify and address the continuously changing R&D and knowledge requirements of local firms on the one hand, and on the other hand, support local firms in identifying the shifting needs of their customers.

Most notably, TICs have the capacity to enhance demand for new technologies among sophisticated buyers (OECD, 2013). By delivering programs and information-diffusion initiatives, TICs can improve firms’ awareness of corporate customers’ needs. Additionally, technology demonstration events, seminars and conferences that provide accurate information on market trends, and other networking opportunities hosted by TICs can increase firms’ awareness of technological innovations that could benefit their business.

TECHNOLOGY AND INNOVATION CENTRES IN GERMANY, UK, AND USA

Overall, technology and innovation centres significantly contribute to effort at harnessing a jurisdiction’s research and innovation capacity and driving technology transfer and commercialization. Hence, a number of firms, private investors and national and regional governments continue to support these innovation intermediaries. The following section discusses the role, structure and achievements of TICs in Germany, the UK and the United States. Special attention is paid to each model’s (1) financing structure, (2) governance and organizational structure, (3) global presence, and (4) notable successes.

The German Model

The Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (i.e. the Fraunhofer-Gesellschaft or Fraunhofer Society) is a critical partner in Germany’s innovation ecosystem. The core function of the Fraunhofer-Gesellschaft is to conduct application- and results-oriented research activities that will generate technological innovations and new systems solutions for the benefit of private and public sector contractual partners, as well as the

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1 Absorptive capacity is “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal, 1990: 128)
community at large. To realize this, the institute offers five types of services to its customers:

- **Research and Development**: The Institute performs contract research for government and industry to create and optimize technologies, processes, and services up to the production of prototypes and small batch series. Six key areas of R&D expertise include (i) health, nutrition, environment; (ii) safety and security; (iii) information and communication; (iv) transportation and mobility; (v) energy and living; (vi) environmentally friendly production, i.e. resource efficient production.

- **Studies and Analyses**: Fraunhofer-Gesellschaft advises their contractual partners prior to research cooperation through custom-designed studies; feasibility and acceptance studies; market observations; trend analyses; life-cycle analyses; profitability calculations; authorization studies and clinical test patters; examination and evaluation of chemicals; and, innovative screening methods.

- **Advice and Support**: To facilitate private and public sector partners’ efforts at introducing innovations into their business, the Fraunhofer Institute provides a number of support services including testing in demonstration centres; on-site training of participating employees; additional services during and after the introduction of these innovations; usability services; and, advice on funding particularly for small and medium-sized businesses.

- **Inspection and Certification**: The Institute’s accredited test laboratories provide clients with services and can offer verification for adherence to obligatory standards.

- **References**: A number of experts across a range of tech-based sectors are associated with the Fraunhofer, and provide their advanced knowledge and services to improve the business of companies.

- **Training**: the institute also plays a central role in building up local human capital by training talented researchers in technical and scientific fields, enabling them to develop the professional and personal skills needed to work productively within their institute, in industry and across a range of sectors.

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2 Fraunhofer customers and contractual partners include industry (i.e. companies of all sizes and from all industrial sectors – from small and medium-sized companies to global enterprises), service sector and public administration.


4 Examples of usability services: evaluation of software and web applications, online services, eCommerce or eCRM and hardware, etc. Source: [http://www.fraunhofer.de/en/range-of-services/advice.html](http://www.fraunhofer.de/en/range-of-services/advice.html)
On the basis of the five services rendered, the primary objective of the Fraunhofer is to promote economic development, international competitiveness, and social welfare while ensuring that the innovations produced are ethically sound and environmentally compatible.

**Financing Structure**

The Fraunhofer-Gesellschaft has an annual research budget of €2 billion.\(^5\) Of that total, €1.7 billion comes from contract research with companies and public-sector customers. More than 70 per cent of the Fraunhofer’s contract research revenue is derived from contracts with industry partners and from publicly financed research projects.\(^6\) Almost 30 per cent is contributed by the German Federal Government and the Lander in the form of basic funding\(^7\), i.e. a reliable source of support that enables the institutes to take a more long-term approach to their work programs (Reid et. al 2010).

The Fraunhofer-Gesellschaft financing model has three components:

- Funds from the federal and state governments provide the institutes with support to conduct basic research which may in the future form the basis of industry-oriented knowledge transfer.
- Funds from research projects commissioned by public partners support the long-term development of cutting-edge technological innovation that will address industrial needs.
- Funds from research contracts with industry allow direct access to the Fraunhofer’s range of competencies

**Organizational Structure and Governance**

The Fraunhofer Society is Europe’s largest TIC, employing over 23,000 employees – the majority of whom are scientists and engineers – working in 67 institutes and research units across Germany.\(^8\) In order to pool resources, generate a critical mass of knowledge and skill and intensify the impact of collaborative open innovation, the Fraunhofer-Gesellschaft units have established and organized themselves into a number of groups, alliances and clusters. Each institute has a membership in one of seven Fraunhofer Groups which were created to help define business policy and act to implement the organizational and funding principles of the Fraunhofer

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The Fraunhofer Alliances enable customers to access the services and research results of the Fraunhofer-Gesellschaft. An expert representing each of the 22 alliances acts as a common point of contact for customers; this individual provides advice on complex issues related to a particular field and help to identify appropriate solutions. Institutes also organize themselves into 20 innovation clusters. Each cluster includes networks of industry, universities, and other local research institutions and innovation intermediaries that specialize in the relevant thematic areas. Through this cluster initiative, Fraunhofer-Gesellschaft aims to develop existing strengths, skills and expertise in those specific areas of focus. It is worth noting that collaborations are generally restricted within one federal state; project-oriented; and the success of the effort is contingent on additional funds industrial partners and the state are willing to invest in new projects within a region. Refer to Appendix 1 for a review of the Fraunhofer-Gesellschaft’s specialization areas by groups, alliances, and clusters.

Overall, the Fraunhofer-Gesellschaft’s research activities are decentralized, which allows the members of its institutes and research units to identify a broad range of areas of technology that are relevant to industry across different sectors and devise creative solutions for meeting the long-term and short-term demands of their private sector clients. The semi-autonomous units in turn cultivate their own market presence and manage their own budgets. This decentralized model however incorporates line functions overseen by centralized control mechanisms that provide the Institute with a cohesive strategy that runs through its 67 components. Appendix 2 illustrates the structure of the Fraunhofer-Gesellschaft.

Global Presence
The Fraunhofer-Gesellschaft participates in international research and innovation activities across Europe, North and South America, Asia and the Middle East and North Africa (MENA) Region. Most notably, the Fraunhofer Society has established subsidiaries in Austria, Italy, Portugal, Sweden, UK, the United States and Chile. Research partnerships between the Fraunhofer and local Asian markets are cultivated through Fraunhofer representative offices and

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10 Ibid.
senior advisors located in Asia and the MENA region. The Fraunhofer Brussels office engages in dialogue with European policy makers, issue public statement and providing information services.\(^{14}\) The Fraunhofer-Gesellschaft also participates in international networks and organizations, including the European Research Consortium for Informatics and Mathematics (ERCIM), the European Association of Research and Technology Organizations (EARTO), the Global Research Alliance (GRA) and the World Association of Industrial and Technological Research Organizations (WAITRO).

The Fraunhofer Society also has a presence in Canada. In 2012, the University of Western Ontario entered into a long-term research partnership with the Fraunhofer-Gesellschaft to launch the Fraunhofer Project Centre for Composite Research, located in the university’s Advanced Manufacturing Park (Western News, 2012). The mission of the Centre is “to develop materials with specific desirable properties, particularly those that are lightweight or have low life-cycle impact for manufacturers in automotive, transportation, construction, defence and renewable energy sectors.”\(^{15}\) The Centre’s service portfolio includes: research in the fields materials, simulation, and design; optimizing of existing processes and materials; development of new processes and materials as well as transition of lab scale basic research results into industrial applications; part, process, material and tooling innovations; and, competence along the entire value chain from product engineering to manufacturing of demonstrator parts (Government of Ontario 2013).

### Notable Successes: Innovation and Technological Achievements

Over the past 65 years, the Fraunhofer-Gesellschaft has significantly advanced the global innovation frontier and brought to market a range of technology-based products, processes and services that have benefitted communities around the world. In particular, the Fraunhofer Society has been successful in the areas of audio, image and video coding. The MPEG Layer 3 or mp3 was one of the most well-known commercial breakthroughs made in the early 1990s, led by the Fraunhofer Institute for Integrated Circuits (Fraunhofer IIS) in collaboration with a team of researchers from the Erlangen-Nuremberg University.\(^ {16}\) By 2006, mp3 was responsible for creating more than 10,000 jobs, and the tax revenue from the German state was estimated to be €300 million each year in the early 2000s\(^ {17}\). €95 million from mp3 licensing fees revenue was

\(^{14}\) Ibid.
\(^{15}\) University of Western Ontario website: [http://www.eng.uwo.ca/fraunhofer/](http://www.eng.uwo.ca/fraunhofer/)
used to set up the Fraunhofer Future Foundation, established to provide the necessary research capital to support the development and commercialization of pre-competitive research in targeted fields of technology where patent clusters could be formed (Fraunhofer-Gesellschaft 2009: 33). Over the year, the Fraunhofer worked with other innovative companies to build on the mp3 technology. In 2009 Technicolor, in collaboration with the Fraunhofer IIS, developed and launched the mp3HD as a solution for lossless audio coding.\(^{18}\) That year, the fourth phase of the development of the H.264/Mpeg4-AVC format – a video coding standard\(^ {19}\) – was completed by the Fraunhofer IIS. Today, the Fraunhofer IIS continues to be an active participant in the standardization for video compression.

Research conducted by Fraunhofer-Gesellschaft scientists and engineers has contributed to the development of innovations across different technology-based sectors including (Fraunhofer- Gesellschaft 2010; Fraunhofer-Gesellschaft 2009):

- The first white light-emitting diodes (LED)
- Autonomous energy systems for repeaters which work independently of the power grid or ultra-powerful antenna systems
- A cochlea implant which can restore rudimentary hearing to the deaf
- A micro membrane pump to reliably and continually transport small quantities of fluid\(^ {20}\)
- The first energy-autonomous solar house which functions without any external energy supply
- New techniques for 3-D sound and vision for cinema
- Television 3-D screens which do not rely on stereoscopic glasses

Moreover, many Fraunhofer scientists and engineers have received prestigious national and international awards, recognizing research excellence in their fields. For example, in 2005, Prof Dr. J. Luther, director of the Fraunhofer Institute for Solar Energy Systems received the German Environmental award for his work on the development and expansion of solar energy use. That year, Prof Dr. A. Tunnerrmann of the Fraunhofer Institute for Applied Optics and Precision Engineering was also recognized for his pioneering work in the development of high-power fibre lasers; he won the Leibniz Prize for the development of the colour laser. In 2008, Prof. Dr. Holger Boche of the Fraunhofer Institute for Telecommunications was awarded the Leibniz Prize


\(^{19}\) The H.264/Mpeg4-AVC format became the standard for mobile phones, iPods, Blu-ray Discs, internet streaming and HDTV

\(^{20}\) This invention has been patented in Germany, the USA and Japan. Source: Fraunhofer-Gesellschaft 2009
for his research on mobile communication networks of the future (Fraunhofer-Gesellschaft 2009).

The UK Model
The Catapult Centres were established in 2011 as a network of elite technology and innovation centres “designed to transform great research rapidly into commercial success” and enable the UK to generate economic growth for the future (TSB 2013a). In particular, these Centres provide UK-based businesses with the resources, expertise, equipment and contacts they need to develop new marketable products, processes and services. They also provide actors from the research and academic community with leads to funding, opportunities to network, access to state-of-the-art facilities and IP protection (TSB 2013b). Overall, the Centres bridge the gap between universities, research institutions and businesses in order to help “turn great ideas into commercial realities” (TSB 2013a).

The Catapults were created by the UK’s national innovation agency, the Technology Strategy Board (TSB), in response to the Hauser Report, *The Current and Future Role of Technology and Innovation Centres in the UK.* In 2010, Prime Minister David Cameron committed over £200 million over four years to establish six technology innovation centres in key areas, and the following year, the TSB consulted with local businesses to develop a strategy and implementation plan that outlined the vision and plan for the new centres. This plan to develop Catapult Centres was one part of the UK Government’s broader agenda to stimulate long-term support for business innovation and growth, as defined in the TSB’s 2011-2015 strategic plan, *Concept to Commercialization* (TSB 2011).

Each Catapult Centre is focused on advancing an area with great market potential that will create new global opportunities for the UK. As of February 2014, seven Catapult Centres have been established:

- High Value Manufacturing (HVM) (Strathclyde; Wilton/Sedgefield; Rotherham; Coventry; Ansty; Bristol)

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21 In this report, entrepreneur Hermann Houser recommends the development of a national system of applied research institutes similar to the Fraunhofer-Gesellschaft in Germany.


23 The HVM Catapult is comprised of seven centres across key manufacturing processes. More than £140 million of government investment has been planned over a 6-year period, with investment matched by private industry
Each centre is at different stages of development; some are further advanced in their respective projects and partnerships. In the 2013 HM Treasury report, *Investing in Britain’s Future*, the government committed an additional £185 million in resource funding for the TSB in 2015-16 to support innovation. A portion of this funding will be invested to establish two new centres, the Energy Systems Catapult and the Diagnostics for Stratified Medicine Catapult (TSB 2013a).

**Financing Structure**

The Catapult Centre has a 5-year budget of approximately £1.4 billion; every pound invested is projected to create £7 in growth (TSB 2013b). The funding model for each technology and innovation centre is described as the “one-third, one-third, one-third model” – similar to the German model. As such, funding will come from three sources:

- Core public funding from the Technology Strategy Board for long-term investment in infrastructure, expertise and skills development
- Funds from private sector R&D contract research, won competitively
- Competitively won R&D projects funded jointly by the public/private sector.

Each centre, once fully established, will need to attract around £10 million to £15 million per annum from business to be viable.24

**Organizational Structure and Governance**

The seven Catapult Centres employ over 1,400 people who connect the UK’s research base with large and small companies across technology-enabled sectors in order to advance the common goals of accelerating business innovation, building up research capacity and generating the critical mass needed to compete in global value chains and high growth markets (TSB 2013b; TSB2013a). The centres that make up the HVM Catapult include the Advanced Forming Research Centre in Glasgow; the Advanced Manufacturing Research Centre in Sheffield; the Centre for Process Innovation in Wilton; the Manufacturing Technology Centre in Ansty; the National Composite Centre in Bristol; the Nuclear Advanced Manufacturing Research Centre in Sheffield and the Warwick Manufacturing Group in Coventry.

24 [https://www.catapult.org.uk/funding](https://www.catapult.org.uk/funding)
TSB 2011). While the Catapults all work under this rubric, similar to its German counterpart, each centre is an independent entity. To this end, the seven centres are established as a company ltd by guarantee (CLG) and exist as a separate legal entity from the TSB, any host organization or other major partners.\(^{25}\) Each centre has operational autonomy which allows them to respond to the changing needs of their customers and business base. Moreover, individual centres are responsible for business planning, the delivery of their objectives, assets and liabilities, ownership and management of facilities, equipment, and intellectual policy (TSB 2011). Every centre has a Governance Board, composed of business users and experts in the respective technology to guide the work of the centre and oversee its activities. An Executive Management team for each Catapult is responsible for the day to day management of the centre.\(^{26}\)

This decentralized model of governance is overseen by the TSB. As of 2011, plans have been established to develop a specific directorate within the TSB, headed by an Executive Director, to handle the internal management of responsibilities for setting up and overseeing the TICs. An oversight committee will also be assembled to provide advice on the establishment and running of the network. Acting in an advisory capacity to both the TSB and the TICs, the oversight committee will consist of representatives from industry, the research base – including the research councils, the Department of Business, Innovation and skills and the TSB (TSB 2011).

**Global Presence**

All of the Catapult Centres are located in the UK. Relative to the German TIC, the UK model’s international presence is not as expansive. Nonetheless, the Catapults remain committed to building international partnerships with firms and similar centres, and promoting UK businesses and innovation around the world.\(^{27}\)

For instance, in May 2013, the Cell Therapy Catapult signed a collaboration agreement with the Canadian Centre for the Commercialization of Regenerative Medicine (TSB 2013a). Both centres plan to work together on R&D projects, clinical trials, standardization and

\(^{25}\) [https://www.catapult.org.uk/governance](https://www.catapult.org.uk/governance)

\(^{26}\) [https://www.catapult.org.uk/governance](https://www.catapult.org.uk/governance)

regulatory efforts as well as in other initiatives such as training.\textsuperscript{28} Other Centres are building up their global profile by participating in and/or organizing events that bring together entrepreneurs, firms, researchers and other experts in the field to exchange ideas, showcase new innovations and build up partnerships. For example, the Future Cities Catapult holds seminars and workshops for businesses in order to establish collaboration with world leading centres in Paris, New York and Singapore (TSB 2013a). The Catapult Centres have also increased their global presence by developing collaborative agreements and partnerships with multinational corporations such as GlaxoSmithKline (collaborated with the Cell Therapy Catapult) and Rolls Royce (collaborated with the High Value Manufacturing Catapult).

\textit{Notable Successes: Establishing Partnerships and Initiating Projects}

Compared to the German model, the UK model is in its early stage of development. Hence, the Catapult Centres have not achieved the same degree of technological and innovation advancements as the Fraunhofer-Gesellschaft. Nonetheless, the Catapults have had a number of successes during its first year of operation, i.e. 2012-2013:

- The High Value Manufacturing Catapult has 571 businesses directly involved in programs. The Centre has participated in 830 projects with private sector clients and had over 1800 engagements with SMEs. 35\% of the centres £134 million of innovation activity came from industry. The HVM Catapult has secured commitment to substantial sources of additional funding totaling £241 million across the various constituent centres (TSB 2013a).

- The Cell Therapy Catapult published its database of ongoing UK clinical trials in the cell therapy field in January 2013, which is being used to identify potential programs for development or partnership and to provide a benchmark for progress. By May, it included 34 trials. The Centre has also developed a number of research partnerships, including one with SME ReNeuron Group plc, aimed at working on new cell therapy manufacturing technologies and assays (TSB 2013a).

- The Off-shore Renewable Energy Catapult has four major pilots underway: the development of a Marine Farm Accelerator; standardization; offshore cables, and performance & reliability. The catapult will explore the roles each area plays in fuelling

innovation, promoting competition, lowering technology costs and accelerating market growth (TSB 2013a).

- The Satellite Application Catapult is currently focused on four market-led programs, which between them have a global growth potential of more than £60 billion over the next decade. These programs focus on transport, security and civil protection, natural resources management, energy and climate change, and the internet of things (TSB 2013a).

- The Connected Digital Economy Catapult has launched a number of new projects including an integrated transport and weather information pilot; Greater Manchester Data Synchronization Project; Trusted Data Accelerator; Open Health Data Platform; Digital Copyright Exchange; 5G Demonstrator.29

- The Future Cities Catapult organizes activities and launch initiatives aimed at helping UK businesses develop cutting edge high-value urban solutions they can sell to the world.30

To date, the Catapult is working on four projects to achieve its core goal: Smart Cities Forum, the Cities Unlocked Program, Sensing London, and the Greater Manchester Data Synchronization Project.31

- Transport Systems Catapult has launched four projects aimed at collaborating with business, government and academia to deliver new products, services and solutions for the transport system market: the Low Carbon Urban Transport Zone (LUTZ); the Sentiment Mapping Project; the Instant Weather initiative; and, the Real Time Departure Planning Information.32

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29 https://cde.catapult.org.uk/projects
30 https://futurecities.catapult.org.uk/news-template/-/asset_publisher/Qw0bKmomFN4g/content/future-cities-catapult-and-level39-join-forces-to-unlock-finance-for-future-cities/
31 The Smart Cities Forum brings together government, industry and sector experts to develop plans for the next generation of UK cities. Source: https://futurecities.catapult.org.uk/project-full-view/-/asset_publisher/oDS9tiXrD0wi/content/project-smart-cities-forum/?redirect=%2Fprojects
32 The Cities Unlocked Program assists blind and partially sighted people to move around the city by providing options for technology-enabled navigation. Source: https://futurecities.catapult.org.uk/project-full-view/-/asset_publisher/oDS9tiXrD0wi/content/project-cities-unlocked/?redirect=%2Fprojects
33 The Sensing London initiative collects real city data and experiment with new ideas in order to understand how city infrastructure is used and the impact the city has on human health, well-being and the natural environment. Source: https://futurecities.catapult.org.uk/project-full-view/-/asset_publisher/oDS9tiXrD0wi/content/project-sensing-london/?redirect=%2Fprojects
34 The Greater Manchester Data Synchronization Project allows local authorities to use open data to help them to more efficiently deliver important public services. Source: https://futurecities.catapult.org.uk/project-full-view/-/asset_publisher/oDS9tiXrD0wi/content/project-greater-manchester-data-synchronisation-programme/?redirect=%2Fprojects.
35 The LUTZ is focused on addressing increasing mobility in an effective and cost-efficient way. Source: https://ts.catapult.org.uk/lutz  The Sentiment Mapping for Transport Systems project will use the sentiment mapping and analysis of publically available social media channels to improve passenger experience in different transport
The USA Model
In the 2013 State of the Union Address, US President Obama announced his Administration’s first priority is to make America “the magnet for new jobs and manufacturing.” The National Network for Manufacturing Innovation (NNMI) was launched that year to realize this objective, and more specifically, “to create an effective manufacturing research infrastructure for US industry and academia to solve industry-relevant problems” (Executive Office of the President et al. 2013: 4). This kind of infrastructure is intended to provide a unique “teaching factory” that educates and trains students and workers in a range of focus areas across the manufacturing sector, while helping companies – most importantly, small and medium sized manufacturers – to access the research capabilities, machinery and equipment necessary to bring new innovations to market (White House, 2013).

The Obama administration has promoted the NNMI as an important network of technology and innovation centres that fills a gap – “the missing middle” – between the US R&D education and training activities and the production and deployment of technological innovations from the manufacturing sector. The federal government’s decision to focus on manufacturing is premised on the belief that this sector is critical for advancing innovation, productivity, job growth, exports and national security. Indeed, manufacturing accounts for about 12% of the United States’ gross domestic product and nearly two-thirds of America’s exports (Sargent 2014). Moreover, manufacturing firms currently employ nearly 12 million American workers and through the supply value chain, indirectly support millions of jobs in other industries including banking, shipping and insurance (Ibid.)

The NNMI consists of Institutes for Manufacturing Innovation (IMIs), each of which is comprised of a consortium of industry, academic and government representatives working collaboratively to leverage existing resources and co-invest in order to drive manufacturing innovation and accelerate commercialization. Obama proposed the creation of 15 regional IMIs in the 2013 State of the Union, and in July he further proposed building out the network to establish 45 IMIs within the next 10 years. It is envisioned that each Institute will have a unique

modes. Source: https://ts.catapult.org.uk/sentiment-mapping The Instant Weather initiative is a pilot project that explores the development of weather and transport data solutions. Source: https://ts.catapult.org.uk/instantweather Real Time Departure Planning Information project will connect a large number of UK airports into the European Network Manager to share real time Departure Planning Information. Source: https://ts.catapult.org.uk/dpi.

and well-defined focus such as an advanced material, a manufacturing process, an enabling technology or an industry sector (NNMI, 2013). The establishment of these Institutes will require legislation from Congress (White House, 2014a).

In 2012, a pilot institute in Youngstown, Ohio – the National Additive Manufacturing Innovation Institute (NAMII)\(^{36}\) was launched, and as of February 2014, three IMIs have been established:

- Lightweight and Modern Metals and Manufacturing Institute (LM3I) in Detroit
- Digital Manufacturing and Design Innovation Institute (DMDI) in Chicago

IMI activities include, but are not limited to, applied research and demonstration projects that reduce the cost and risk of commercializing and manufacturing new technologies or that solve generic manufacturing problems; education and training at all levels, from K-12 to professional training; development of innovative methodologies and practices; and engagement with small and medium-sized manufacturing enterprises (SMEs) (Executive Office of the President et al. 2013: 4). In particular, IMIs encourage SME participation through direct outreach to partners and intermediaries that work closely with SMEs; information and services tailored specifically to SMEs; tiered fee structures and allowance of in-kind contributions to facilitate access to small companies; and, staged licensing of intellectual property, and similar arrangements (NNMI 2013:8).

**Financing Structure**

The United States 2014 Budget proposed the creation of a one-time $1 billion investment to establish the NNMI; this investment must be authorized by Congress. See Table 1 for the proposed expenditure over nine years. It is envisioned that federal funding will be matched by private and other non-federal funds.

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\(^{36}\) NAMII is smaller in scale in relation to the IMIs. It was established as a benchmark for the NNMI institutes. NAMII funded by the Department of Defense. In October 2013, NAMII was rebranded America Makes. Sources: Executive Office of the President et al., 2013: 3; Advanced Manufacturing Portal: [http://manufacturing.gov/dmdi.html](http://manufacturing.gov/dmdi.html); [http://manufacturing.gov/nmni_pilot_institute.html](http://manufacturing.gov/nmni_pilot_institute.html).
The Obama administration estimates each Institute’s federal funding contribution between $70 million and $120 million over a 5 – 7 year timeframe, depending on the magnitude of the opportunity, maturity, and capital intensity of the technology, and the scope of the focus area (Executive Office of the President et al. 2013: ii). The federal government also anticipates that the level of government funding will be larger during the early years of the IMI, and will become progressively lower as the Institute progresses towards self-sufficiency (NNMI 2013:9). During the early stage of an IMI, non-federal funding is expected to be based on in-kind items like equipment and buildings, though overtime the funding is likely to shift to project revenue, member fees, user fees, licensing and other sources (NNMI 2013: 9).

As of March 2014, the following investments have been made to support the existing IMIs:

- NAMII (Ohio): received an initial federal investment of $30 million and a non-federal funding commitment of $39 million, provided as cost share mostly from industry and states of Ohio, Pennsylvania and West Virginia (Executive Office of the President et al 2013: 21)
- LM3I (Detroit): received an investment of $50 million from the Department of Defense, with other government funding, rounding out the balance to $70 million. This funding is combined with an expected 1:1 investment match from non-federal sources\(^\text{37}\)
- DMDI (Chicago): received $50 million from the Department of Defense with other government funding rounding out the balance to reach $70 million. This funding is combined with an expected 1:1 investment match from non-federal sources\(^\text{38}\)
- The Next Generation Power Electronics National Manufacturing Innovation Institute (North Carolina): was awarded $70 million over five years by the Department of Energy, matched by at least $70 million in non-federal commitments by the IMI consortium and the state of North Carolina (White House 2014b).

Organizational Structure and Governance

In 2012, the Advanced Manufacturing National Program Office (AMNPO)\(^{39}\) consulted broadly with representatives from industry, academia, non-profit organizations, state and local economic development organizations, professional associations and private individuals regarding the design of the NNMI program. On January 16, 2013, the federal government released the National Network For Manufacturing Innovation: A Preliminary Design which incorporated the extensive input received. This document detailed the characteristics of the IMIs (i.e. focus, activities, funding, partners and members, governance, selection process, etc.); the NNMI mechanisms aimed at ensuring cohesiveness between the IMIs; and, the rationale for federal investment in the NNMI.

According to the Preliminary Design document, the focus of each Institute is proposed by applicants through a competitive proposal and review process managed by AMPNO, AMPNO partners and other experts (NNMI 2013:11). Each IMI proposal should outline the methods by which decisions will be made, including those decisions related to operations, membership, intellectual property, project selection, funding allocation and progress toward sustainability. Draft Institute membership and governance agreements should also be included in proposals.

Most institutes will be led by independent, US not-for-profit institutions that strongly leverage industry consortia, regional clusters, and other resources in science, technology and economic development (NNMI 2013). The preferred model for these institutes is a consortium with extensive industry participation and leadership. Refer to Appendix 3 for an overview of consortia composition and focus area for each Institute.

Similar to the German and UK counterparts, every IMI within the NNMI is unique, with substantial autonomy from its partner organizations as well as the other institutions in the network. Each Institute also has an independent fiduciary Board of Directors predominantly composed of industry representatives (NNMI 2013). Despite the significant autonomy of the Institutes, several mechanisms are in place (or will be developed) to ensure the cohesiveness and coordination of the NNMI (NNMI 2013):

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\(^{39}\) The AMNPO is run by the Department of Commerce’s National Institute of Standards and Technology (NIST) and includes an interagency team that include federal agencies involved in US manufacturing including the Departments of Commerce (DOC/NIST), Defense (DOD), Education (ED), and Energy (DOE); the National Aeronautics and Space Administration (NASA); the National Science Foundation. Sources: Executive Office of the President et al. 2013: ii; NIST, 2013.
• The NNMI’s Network Leadership Council – composed of representatives of the Institutes, federal agencies, and other appropriate entities – will actively look for opportunities to leverage existing resources between institutes.

• The Network will operate along common policies particularly in regards to intellectual property, contract research, operations, accountability, and marketing and branding.

• Common policies will also be established to facilitate interaction with SMEs, promote collaboration and movement within the Network and allow IMIs to share services such as human resource management.

• Each institute will have their own web presence, however they will also participate in and link to the AMNPO hosted “Manufacturing Portal” (www.manufacturing.gov). This portal directs interested parties to Network’s resources and capabilities. Content: information about the focus of each Institute, structure, governance, contacts, annual reports, news, success stories, member information and more.

Global Presence
Relative to its German and UK counterparts, the American TIC model currently has a low global profile. All of the IMIs are located in the United States and led by institutions situated in the USA. However, as the NNMI develops, it is expected to link and leverage all available resources so that they can have a national and global impact (Executive Office of the President et al. 2013: ii). Indeed, one of the core missions of the NNMI is to enhance American industrial competitiveness on a regional, national and global level (Ibid: 11).

Notable Successes
Even though the NNMI is relatively new, it has been effective in developing new partnerships across America’s manufacturing sector; this accomplishment has been significantly facilitated with the establishment of the IMIs. For instance, in one year the pilot NAMI:

• Attracted 79 member organizations including companies, universities, community colleges and non-profits;

• Implemented a governance model and elected a Governance Board, Executive Committee and Technical Advisory Board;

• Adopted a membership agreement and an organization charters

• Co-funded 7 R&D collaborative projects to be conducted by 7 teams including 35 industry, university, and non-profit organizations

• Developed plans for education and workforce training and outreach

In light of these achievements in developing a robust consortium of partners as well as those associated with the other three IMIs (Refer to Appendix 3), the President has continued to initiate competitions for other IMIs. On February 25, 2014, President Obama announced the competition for the first of four additional manufacturing innovation institutes that will be announced this year: the Clean Energy Manufacturing Innovation Institute for Composites Materials and Structures. The Department of Energy anticipates committing up to $70 million, spread over five years – subject to congressional appropriations – matched by the applicant consortium with at least $70 million in non-federal funding (White House, 2014a). The deadline for applications is April 22, 2014.41

According to the Obama Administration, in the near term the NMII will measure success based on a short list of indicators: the amount of co-investment attracted, membership in the institute, project portfolio, success stories, and/or other benchmarks (NNMI 2013: 12). In the longer term, success will be measured by a number of outcome metrics such as measures of workforce health and size, the availability of new advanced manufacturing technologies resulting in new products and processes, increased trade exports, on-shoring of foreign companies to the U.S. and many other economic indicators. Notably, according to the National Network For Manufacturing Innovation: A Preliminary Design, continuation of federal funding will be contingent on the completion of annual reports, and on the successful completion of a gate review process examining performance vis-à-vis the quantitative and qualitative metrics mentioned above. It is anticipated that the gate review will occur at least the third year after initial funding (p. 13).

A Comparative Analysis of International TICs
There are a number of similarities between the three TIC models reviewed in this report. Firstly, these TICs are focused on achieving several commonly held goals:

- Bridging the divide between the research community and business: These TICs fulfill their role as connectors by sharing expertise with other research and innovation actors in order to close the gap between concept and commercialization, and enhance innovation in technology-based areas.
- Building up human capital and developing their jurisdiction’s concentration of talent: A broad range of resources have been established to build up the innovation capabilities of

TIC scientists and engineers as well as employees from local companies in an effort to enhance domestic innovation capacities.  

- Advancing industry-driven activities to support economic development: Research and services provided are industry or “challenge” led and aimed at developing new solutions and products to meet current and future market needs.  
- Increasing business innovation  
- Technology development and diffusion  
- Contributing to a jurisdiction’s level of competitiveness, productivity and wealth creation capacity  
- Developing a competitive advantage in the global market

Second, the German, UK and American models all have a similar decentralized organizational structure that provides their individual centres with the autonomy necessary to develop innovations in highly-specialized areas of focus. However, each of these TICs have established a central governing body and governance mechanisms (e.g. common policies related to intellectual property, accountability, marketing and branding) that link them together as a coordinated system.

Third, the funding structures between the three TIC models are also similar. Each TIC receives financial support for a broad range of research and innovation actors including national and local governments, business, other research institutes and private investors. Moreover, in each case, multi-year government funding is dedicated to these TICs, demonstrating that decision-makers understand long-term investments are needed in order to build up national innovation capacity and critical mass.

Fourth, every TIC has had a great deal of success in building up partnerships with/between local actors, including members of the research community, businesses across multiple industries, investors, economic development offices and local government agencies. This dynamic has fed into cluster development, enabled the flow of ideas and the exchange of

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42 For instance, the Fraunhofer Technology Academy was established in 2005 to promote knowledge transfer through continuing education and vocational training (Fraunhofer-Gesellschaft 2009). The school offers a number of publicly funded training programs and courses to specialists and managers in business and industry; areas of specialization include production and testing technology, technology and innovation, energy and sustainability, logistics and production, and information and communication. All courses feature the practical integration of application-oriented Fraunhofer research, and students often know about the latest technologies and applications before their commercial launch. Source: [http://www.academy.fraunhofer.de/en/events_trade_fairs.html](http://www.academy.fraunhofer.de/en/events_trade_fairs.html).
capital, which in turn has facilitated the development of innovative products, processes and practices.

Given that the Fraunhofer Society was established decades before the Catapult Centres and the NNMI, it has had a longer period of time to address innovation bottlenecks that often impede technology and knowledge transfer.\footnote{For an overview of bottlenecks that challenge knowledge transfer, refer to Bramwell et al 2012: 17 – 20.} Hence, relative to the other two models, the Fraunhofer-Gesellschaft has had more experience and success building innovation partnerships and translating cutting-edge ideas into creative solutions. The American and UK governments have taken note of these achievements, and more importantly, the breadth of processes and practices the German TIC has implemented. Several studies from the USA and UK have been conducted on the Fraunhofer to inform the development of the American and British TIC models (Hauser 2010; Reid 2010; Hart et al, 2012; Executive Office of the President 2011, NNMI 2013), and arguably helps to account for some of the similarities between the three models. While the UK and United States accept that lessons can be learned from the German model, government decision-makers also acknowledge that there is no one size-fits-all approach; each jurisdiction has unique needs and resources that must be accounted for as it seeks to develop its own TIC model.

To this end, there are a number of differences between the German, UK and American TIC models, particularly regarding (1) focus areas; (2) global partnerships and, (3) level of collaboration between centres. Firstly, the Fraunhofer-Gesellschaft and the Catapult Centres have identified a short list of key areas of focus, while the US model is concentrated on the manufacturing sector. Despite this difference, it is important to note that for each TIC, these focus areas were selected on the basis that increased investment in these industries would help to build up their jurisdiction’s competitive advantage in areas where it could capture the global market.

Second, the Fraunhofer Society has established a larger network of international partnerships relative to the Catapult Centres and NNMI. While the Catapult Centres appear to be building out their international relationships, the NNMI’s approach to international partnerships appears most restrictive when compared to the other two models. According to the NNMI Preliminary Design report (2013), non-domestic participation in an IMI will only be allowed only if it is in the economic interest of the United States; can make a significant contribution to employment in the United States; and commitment that any technology arising from or assisted
by the institute be used to promote domestic manufacturing activities (Sargent 2014). Additionally, participation restrictions for non-domestic organizations may apply in some circumstances (Ibid).

Third, the level of collaboration between the individual centres of each TIC differs. In the case of the US model, there has been no significant level of collaboration between any of the IMIs. However, as the NNMI develops, increased collaborative efforts between its institutes are anticipated. Comparatively, the Catapults have shown some degree of collaboration between its centres. For instance, The Transport Systems Catapult collaborates with the Connected Digital Economy Catapult as well as the Sunderland Software City (a private firm) and the Met Office (national government) to advance the Instant Weather project – an initiative aimed at combining real-time weather and environmental hazard information with the development of new services and applications, which can help the transport industry address business problems such as disruptions, routing, extreme weather events, impacts on infrastructure, etc. The Fraunhofer Society is by far the most advanced in encouraging collaboration between its institutes. As mentioned earlier, clusters, group and alliances facilitate the flow of knowledge and technology between the Fraunhofer units. Furthermore, the Fraunhofer-Gesellschaft also encourages “job hopping” of scientists and engineers between its institutes (Theil 2012).

CONCLUSION: LESSONS FOR HALTECH
The German, American and UK models of technology and innovation centres each exemplify a number of the key strengths which have enabled them to build and leverage their local research and innovation capacity. Any regions seeking to upgrade their advanced manufacturing capabilities would do well to draw upon the lessons outlined in this report in designing their own local version of an innovation intermediary organization.

As noted at the outset, Halton region is strategically situated to serve as the home to such an innovation intermediary organization. It is at the juncture of the region’s transportation infrastructure, including several main branches of the 400 system of highways and the rapidly expanding GO train service in the Toronto-Hamilton corridor. Halton is located close to many of the province’s leading advanced research institutions in the public and private sector, the Sheridan Park research facility, and the dense system of postsecondary educational institutions, including McMaster University, Mohawk College and Sheridan College’s Centre for Advanced

Manufacturing and Design Technologies in Brampton. It has a well-educated and highly talented labour force that is steadily serving as a key attraction for the region’s growing cluster of specialized advanced manufacturing firms – both small and large. Feeding into this local cluster of high technology firms are a growing complex of specialized and focused research and training institutions that include the McMaster Automotive Resource Centre, the CanMet Labs in the McMaster Innovation Park and the University of Toronto Mississauga’s newly established Institute for Management and Innovation (IMI). Halton is also home to a number of critical skills training centres for apprentices – such as the Centre for Skills development in Burlington, Sheridan College in Oakville & Brampton, Mohawk College in Hamilton.

There are a number of pre-existing efforts underway in and close to the region that have helped to lay the groundwork for the establishment of a local technology and innovation centre – HalTech’s manufacturing initiative (seminars, workshops, peer to peer groups and expert advisors), the Golden Horseshoe Manufacturers Network (which involves a breakfast speaker series / networking) and the growing focus on advanced manufacturing in the greater Hamilton and Niagara regions. The comparative study of TICs presented above contains a number of critical lessons for the establishment of a comparable organization in Halton region.

In building upon the solid base that already exists in the region, there a number of key design features and capabilities that HalTech and other innovation intermediaries should consider incorporating into the mandate of such an organization:

**A strong commercial focus**
This type of mandate will ensure that limited resources are aimed squarely at initiatives that can produce commercializable solutions. The revenue from the licensing and/or sale of these innovations can feed back into the continued development of the TIC.

**An independent research agenda**
Even though an innovation intermediary’s mission is guided by goals of the national local economic and research policy, these organizations should maintain a high level of research independence. To this end, innovation intermediaries should remain neutral in all dealings with interest groups from the political, corporate and social sectors.

**(Creative) ways of engaging companies**
Most partnerships with the three TICs reviewed in this report are initiated by a representative from industry or another research or innovation institution who contacts an institute seeking a
technological solution. The TICs are strongly focused on working with SMEs to promote the development, adoption and diffusion of new technologies. In this respect, they overlap to a limited extent with the mandate of Canada’s IRAP program and care would need to be taken to avoid any duplication of services. However, TICs and other innovation intermediaries should continue to organize seminars, trade fairs and other events to actively reach out to potential or existing contractual partners. In the case of the German model, the Fraunhofer Vision Technology Days and Innovation and Start-up Day provide the TIC and other technology based firms the opportunity to network, exchange ideas and build working relationships.45

**Intense customer service orientation and open lines of communication with contractual partners**

With an annual customer base of over 2,000 companies,46 the Fraunhofer Society has an excellent reputation for providing superior customer service. There are a number of services and resources the Fraunhofer has established to ensure a high number of repeat orders from these clients (Fraunhofer-Gesellschaft 2011: 4). Firstly, given that the size of the client, the sector, the research problem, and other specificities influence cooperation between innovation actors, the Fraunhofer offers a number of different collaborative models to accommodate the needs of its clients, including one-off contracts, strategic partnerships, large-scale projects with multiple partners, innovation clusters, spin-offs and international cooperation (Fraunhofer-Gesellschaft 2011: 50 – 51). Another way the Fraunhofer demonstrates an intense customer orientation is in its approach to intellectual property (IP). Customers engaged in projects with the Fraunhofer receive the rights to the products, prototypes and other material objects developed by the Fraunhofer. Customers also receive the rights to use the inventions, IP rights and know-how generated over the course of the project (Ibid: 6). Thirdly, the Fraunhofer delivers high quality customer service by ensuring that a number of its institutes are certified according to EN ISO 9001; innovations developed in collaboration with these institutes are more readily reproducible by the customer (Fraunhofer-Gesellschaft 2011: 4). A fourth way the Fraunhofer showcases its commitment to providing superior customer service is through its after-sales service. After the launch of an R&D project the partnership does not end. The customer may request information from the institute it worked with to address ongoing needs, e.g. staff training and development (Ibid).

**Ongoing investment in state of the art machinery and equipment (M&E)**

Investments in machinery and equipment are critical for enabling innovation and productivity (Deloitte 2011).

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46 Fraunhofer USA website: [http://www.fhcmi.org/About/model.html](http://www.fhcmi.org/About/model.html).
The German, American and UK TICs have benefitted significantly from acquiring state of the art M&E, making their efforts at developing new platform technologies more realizable. Markedly, a well-equipped TIC will advance recruitment efforts by attracting new, bright scientists and engineers to the organization on the one hand, as well as attracting other research organizations and firms seeking new partnerships; these new employees and partners gain access to the cutting-edge M&E and infrastructure that TICs have.

*Close ties with the local research community*

The close partnership between the institutes and the research community facilitates the flow of research from the lab bench to market and plays a critical role in training the next generation of scientists, engineers and other researchers. The NNMI’s Next Generation Power Electronics National Manufacturing Innovation Institute is currently led by the North Carolina State University, and the IMI is located on the university’s Centennial Campus. The university will also host some of the institute’s shared research and development facilities and testing equipment, as well as workforce development and education programs (White House, 2014a).

NC State was chosen to lead the new IMI because of its proven track record in developing innovations and working with public and industry partners to deploy them. Among NC State’s partners in the new IMI, four other universities are included – Arizona State, Florida State, the University of California-Santa Barbara and Virginia Tech – and 18 energy industry leaders. This consortium will offer a range of business and research skills and resources to advance the IMI’s mission.

*A strong brand and reputation*

TICs that develop a strong brand are most successful at marketing their services to local and international firms and start-ups, thereby attracting significant levels of contract research funding. Moreover, TICs with a strong reputation are more adept at securing increased government funding, as decision-makers allocate long-term predictable support (and discretionary funding) based on the innovation and commercialization performance of the TIC. A strong brand and reputation can also give a TIC an “employer of choice” standing, which can help in recruiting some of the most brilliant scientific minds (Reid et al. 2010).

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47 NC State’s Manufacturing Innovation website: [http://www.ncsu.edu/power/](http://www.ncsu.edu/power/).
## Appendix 1:

### Fraunhofer-Gesellschaft

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<tr>
<th>Groups</th>
<th>Alliances</th>
<th>Clusters</th>
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<tr>
<td>Information and Communication</td>
<td>Adaptronics</td>
<td>Adaptive Production for Resources Efficiency in Energy Generation and Mobility AdaM Aachen</td>
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<td>Technology</td>
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<td>Life Sciences</td>
<td>Ambient Assisted Living</td>
<td>Automotive Quality Saar AQS, Saarbrücken</td>
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<td>Microelectronics</td>
<td>AutoMOBILE Production Alliance</td>
<td>Bioenergy, Oberhausen</td>
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<td>Battery</td>
<td>Cloud Computing for Logistics, Dortmund</td>
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<td>Defence and Security</td>
<td>Building Innovation</td>
<td>Digital Commercial Vehicle Technology, Kaiserslautern</td>
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<td>Materials and Components</td>
<td>Cleaning Technology</td>
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<td>Cloud Computing</td>
<td>Electronics for Sustainable Energy Use, Nürnberg</td>
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<td>Green Photonics, Jena</td>
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<td>Design Alliance</td>
<td>Nanotechnology</td>
<td>Plastics and Plastics Technologies for the Solar Industry, Halle/Potsdam/Schkopau</td>
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<td>Numerical Simulation of</td>
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<td>Personal Health, Region Erlangen, Nürnberg, Fürth</td>
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<tr>
<td>Products, Processes</td>
<td>Photocatalysis</td>
<td>Smart energy and resource-efficient regional value adding chains in industry - ER-WIN® Magdeburg</td>
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<td></td>
<td>Traffic and Transportation</td>
<td>Technologies for hybrid lightweight construction KITehyLITE, Karlsruhe</td>
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<td>Vision (Image Processing)</td>
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<td>Virtual Development, Engineering and Training, VIDET, Magdeburg</td>
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<td>Water Systems (SysWasser)</td>
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Appendix 2:

The Group Spokesmen and the Executive Board together form the Presidential Council of the Fraunhofer-Gesellschaft. The Presidential Council consists of the members of the Executive Board and the chairmen of six of the seven working alliances. It participates in Executive Board decision-making processes.

The Senate of the Fraunhofer-Gesellschaft is comprised of respected representatives from science, business, industry, and public life, plus representatives of national and regional government, and members of the Scientific and Technical Council. The Senate has a total membership of approximately 30 persons. The Senate is responsible for decisions concerning basic science and research policy, and formulates decisions concerning the establishment, the incorporation or devolution, the merger and dissolution of research entities belonging to the Fraunhofer-Gesellschaft.

Source: Fraunhofer-Gesellschaft website

Fraunhofer-Gesellschaft.⁵⁰

The General Assembly is made up of the members of the Fraunhofer-Gesellschaft. Official membership is open to members of the Senate, the Executive Board, institute directors and senior management and the governing boards. Ordinary membership is open to people and legal entities who wish to support the work of the Fraunhofer-Gesellschaft. Honorary members may be elected from among the research staff and patrons of the Fraunhofer-Gesellschaft in recognition of outstanding services to the organization. It elects the members of the Senate and discharges the Executive Board of its responsibilities. It also formulates decisions concerning amendments to the Statute.⁵¹

The Scientific and Technical Council is the organization’s internal advisory body. It consists of the directors and senior management of the institutes and an elected representative of the scientific and technical staff of each institute. The Scientific and Technical Council provides advice to the Executive Board and other constituent bodies in matters of fundamental importance. It issues recommendations concerning research and human resources policy. Furthermore, the Scientific and Technical Council issues statements of opinion concerning the creation of new institutes or the closure of existing institutes, and participates in the appointment of the directors of the institutes.⁵²

The Governing boards/Advisory boards are attached to the institutes, and consist of representatives of science, industry, business and public life. For each institute, approximately twelve members are appointed to the governing board by the Executive Board with the approval of the director(s) of the institute. Their annual meetings are attended by at least one member of the Executive Board. They provide advice to the director(s) of the institute and the Executive Board on matters concerning the research orientation and any structural changes to the institute.⁵³

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## Appendix 3:
### National Network for Manufacturing Innovation

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<tr>
<td>Will accelerate additive manufacturing technologies. Sometimes called Digital Manufacturing or 3-D printing, where parts are directly manufactured by computer-controlled equipment using data from descriptive geometry files.</td>
<td>Will improve the performance, enhance the safety, and boost the energy and fuel efficiency of vehicles and machines. For the Department of Defense, lightweight and modern metals will strengthen defence capabilities, like enabling the creation of armoured vehicles strong enough to withstand a roadside bomb but light enough for helicopter transport.</td>
<td>Will address the life cycle of digital data interchanged among myriad design, engineering, manufacturing and maintenance systems, and flowing across a networked supply chain.</td>
<td>Will make wide bandgap semiconductor technologies cost-competitive with current silicon-based power electronics in the next five years. These improvements will make power electronic devices like motors, consumer electronics, and devices that support our power grid faster, smaller, and more efficient.</td>
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</table>

| Lead Institution | National Centre for Defense Manufacturing and Machining (NCDMM) (non-profit organization) | EWI (non-profit organization) | UI Labs | North Carolina State University |

| Composition of Consortia | Includes a total of 79 manufacturing firms, universities, community colleges, and non-profit organizations from the Ohio-Pennsylvania-West Virginia “Tech Belt” | Includes 34 companies, 9 universities and labs, and 17 other organizations for a total of 60 members | Includes 34 companies, 9 universities and labs, and 17 other organizations for a total of 60 members | Includes 18 companies and 7 universities and labs for a total of 25 members |

| Federal Government representation | Departments of Defense, Energy, and Commerce, the National Science Foundation, and NASA | Department of Defense | Department of Defense | Department of Energy |

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