Accelerating Capital

Growing the Greater Lansing Region and Investment through Rare Isotopes

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Executive Summary

Michigan State University (MSU), in East Lansing, Michigan, has been confirmed as the location of the Facility for Rare Isotope Beams (FRIB), a particle accelerator research and national user facility. The facility is slated to finish construction sometime between the years 2020 and 2022. Once complete, it will be one of the premier particle physics research facilities in the world. To determine the impact this facility will have on the Greater Lansing Region, this report, titled “Accelerating Capital”, has been compiled.

The FRIB has the capability to be an advanced technology anchor institution within the region. As such, it has the potential to have profound impact on the economy, employment, manufacturing, marketing, and quality of life. In order to understand more specifically what kind of impacts to expect, a review of the existing regional demographics was conducted. Considering the FRIB will be operating within MSU, an analysis of university high-technology programs was completed as well. Since facilities of this type are relatively rare across the globe, a select few were chosen and studied to begin to grasp the impacts that can be expected regionally. Finally, all of this research has been integrated and common themes were identified, along with action items for regional stakeholders to consider.

As commonly known, the Greater Lansing Region is composed of Clinton, Eaton, and Ingham counties in Mid-Michigan. As a whole, the region has a population of 464,036, based on the most recent U.S. Census completed in 2010. Roughly 67% of that population has attained at least some level of college education. In order to capitalize on the FRIB investment and expected innovations, a talented and technically skilled workforce must be available.

Housing a facility such as the FRIB in a university setting provides some exciting opportunities. Universities have the potential to be valuable transfer agents to surrounding regional economies. These higher education institutions can provide knowledge transfer by educating students, promoting research and entrepreneurship, and linking with a global network of scholars. In addition, universities present the ability to catalyze technology transfer by moving new concepts from the idea stage to market-ready impact. This can be done through local business incubators and collaborative partnerships between the academic institution and private corporations.

The case study facilities that were selected and analyzed were Fermilab, based in Chicago, Illinois, Jefferson Laboratory in Newport News, Virginia, TRIUMF in Vancouver, Canada, and the current MSU facility, the National Superconducting Cyclotron Laboratory. These facilities were selected because they are internationally respected and similar in either size or scope to the FRIB. Data for each facility surrounding the topics of workforce impact, collaboration and partnerships, technology transfer and innovation, and community well-being was completed. Between each of the four case facilities, expected impacts include 340-1,757 full-time employees, 8-85 patents every decade, 3-24 conferences with 80-1,581 attendees annually, and roughly 200-2,300 visiting researchers annually. A facility of this type, on average, costs around $22.5-$478.2 million to operate annually. To support such an immense operation, it was found that these facilities generally have intellectual property assistance, a venture capital fund, and require public / private partnerships.

To capitalize on a facility of this magnitude, it is recommended that action is taken by local stakeholders including regional economic development organizations, educational institutions, and local governmental entities. Action items to consider include the creation of a branding and marketing strategy surrounding the FRIB, reviewing existing incubator facilities and determining future demand for these facilities, conducting a series of community meetings, establishing an ongoing targets and measurement strategy (with indicators such as full-time employees, conferences hosted, visiting researchers, spin-off companies, patents and royalties, etc.), holding regular stakeholder committee meetings, and determining the feasibility of educational programs specific to accelerator technology, entrepreneurship, and co-operative education. The table on the following page shows the Action Strategy that was developed.

Action Item	Responsible Party	Timeframe
Develop a branding / marketing strategy for the FRIB & Greater Lansing Region	Educational Institution, Regional Economic Development Organization	Short-Term (Less than 2 years)
Review existing regional incubator facilities and existing capacity, determine future demand	Regional Economic Development Organization	Medium-Term (2-5 years)
Hold a series of community meetings to receive input regarding FRIB and potential regional impact	Regional Economic Development Organization, Government Entity	Ongoing (for 5 or more years)
Establish an FRIB specific ongoing analytics and measurement plan with regional indicators of barriers and success	Educational Institution, Regional Economic Development Organization	
Hold Accelerator Task Force meetings to engage all interested stakeholders at a regional level	Regional Economic Development Organization	
Determine the feasibility of MSU and Lansing Community College (LCC) specific degree programs related to entrepreneurship, co-operatives, and accelerator technology	Educational Institution, Regional Economic Development Organization	

Acknowledgments

The MSU Practicum Team would like to send our sincere gratitude to all parties who have helped with the creation of this report. The United States Department of Energy Office of Science (DOE-SC) is the primary funder for the construction and partial operation of the FRIB and without their financial assistance this project would not exist. We would like to thank members of the Accelerator Region Task Force for their technical assistance and input, as well as our clients on this project; Steve Willobee, Business Development Director of the Lansing Economic Area Partnership, Inc. (LEAP) and John Melcher, Associate Director of the MSU Center for Community and Economic Development (CCED). In addition, we would like to thank the Professors of our Practicum course, Rex LaMore, Ph.D., and Zenia Kotval, Ph.D., for their guidance. Tom Nowak, Director of Procurement for the FRIB also provided invaluable input and intimate internal knowledge of the Facility itself. Without the time and effort of all of these individuals, this project would not be possible[1].

About MSU Practicum

The MSU Urban & Regional Planning Practicum course is designed to provide students a real-world project with the potential to influence significant change. These student-led, faculty-guided projects aim to aid the transition from the classroom to the world of practicing planners. Both MSU Urban & Regional Planning Undergraduate and Graduate students are required to complete this course.

FRIB

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1.0 Accelerating Capital: Introduction

1.1 Crash Course: FRIB 101

The Facility for Rare Isotope Beams (FRIB) will be a new national and international user facility for nuclear science, funded by the Department of Energy Office of Science (DOE-SC), Michigan State University (MSU), and the State of Michigan. Located on campus and operated by MSU, FRIB will provide intense beams of rare isotopes (that is, short-lived nuclei not normally found on Earth). FRIB will enable scientists to make discoveries about the properties of these rare isotopes in order to better understand the physics of nuclei, nuclear astrophysics, fundamental interactions, and applications for society (University, 2014).

What's the Big Deal with the FRIB?

"A beam of particles is a very useful tool. A beam of the right particles with the right energy at the right intensity can shrink a tumor, produce cleaner energy, spot suspicious cargo, make a better radial tire, clean up dirty drinking water, map a protein, study a nuclear explosion, design a new drug, make a heat-resistant automotive cable, diagnose a disease, reduce nuclear waste, detect an art forgery, implant ions in a semiconductor, prospect for oil, date an archaeological find, package a Thanksgiving turkey or discover the secrets of the universe." (Accelerators for America's Future, p. 4)

MSU and Nuclear Physics: Then to Now

Background

Located on the campus of Michigan State University in East Lansing, Michigan, the National Superconducting Cyclotron Laboratory (NSCL) is currently the nation's largest campus-based nuclear science facility (Michigan State University, 2014). The formation of the NSCL began in 1954 by former MSU president John Hannah when he started the nuclear physics program. Next, Professor J. Ballam formed a study committee that suggested adding new positions to the program as well as to develop funding for the purpose of building a nuclear research facility that was cyclotron based. Henry Blosser, a physicist recently out of graduate school was appointed group leader for the cyclotron project in 1958. Then, in 1961, the National Science Foundation

(NSF) awarded a grant to MSU to build the first cyclotron. The cyclotron became operational in 1965 and MSU became a leader and innovator in the field for the years to come. An attempt was made to expand the laboratory in 1969, known at the time as the MSU/NSF Heavy Ion Laboratory, but was rejected by the administration of U.S. President Richard Nixon. Over the next five years, superconducting technology started to emerge as the next advancement in particle acceleration. Professor Blosser then began working on the superconducting magnet in 1975 and it became operational in 1977. The NSF appointed MSU to host the superconducting cyclotron in 1977. After a bill was passed through Congress and signed by U.S. President James Carter in 1979 to approve the project, the Department of Energy and MSU signed a contract in 1980 and work began on the new laboratory, called the NSCL

On November 26th, 1981 the first superconducting cyclotron in the world was launched at the NSCL (Michigan State University, 2014). Development of a second superconducting cyclotron started to gain momentum with the successful test of a new superconducting magnet in 1984. This new independently operated superconducting cyclotron became operational in 1988. During this time, a new discovery in the field would change medical history. It became known that neutron radiation could be used as an alternative to chemotherapy because of greater precision. Through a partnership with the Gershenson Radiation Oncology Center located in Detroit, Michigan, at Harper Hospital, the NSCL developed the first medicinal use superconducting cyclotron that became operational in 1990. During the 1990s, a technique of introducing a second beam during experiments began to emerge. This process produces isotopes that are not naturally occurring.

After the funds to merge the two superconducting cyclotrons located in the NSCL were awarded in 1998, the laboratory produced its first beam in 2000. The NSCL then formed a partnership with the University of Notre Dame’s Nuclear Structure Laboratory and also the University of Chicago in 2003, resulting in the formation of the Joint Institute for Nuclear Physics. With the history of success from first the MSU/NSF Heavy Ion Laboratory and then the NSCL, MSU was chosen as the site for construction of a Rare Isotope Accelerator in 2008.

Crash Course in Acceleration: How it Works

In the 1960s, when MSU built their first cyclotron, it was known as the K-50 because it produced beams that were 50 million electron volt (MeV). With the introduction of superconducting magnets into the field in the 1970s, MSU started building the K-500 (Michigan State University, 2014). The superconducting materials used to produce the electromagnets are chilled at -450 degrees Fahrenheit to eliminate all resistance of the flowing electrons, thus making stronger electromagnets. This technology allows for less wire volume, making superconducting cyclotrons more powerful but weighs less. When the K-500 was built it produced double the energy of a 240 MeV that was recently built but it weighed only 100 tons compared to the 1600 tons of the 240 MeV. After the construction of the K-1200 superconducting cyclotron at Michigan State University, plans were made to merge it with the K-500 in the 1990s. By doing this, isotopes can be given a larger charge thus increasing the acceleration speeds, and increasing energy production to 10 times the K-500 alone ("Technology at NSCL," n.d.)

As of today, the lab is still fully functional but will be outdated in the near future. Because of this and the recent development of the FRIB project at MSU, portions of the NSCL will be incorporated into the FRIB complex.

NSCL: Accelerating Community Impact

For years, the NSCL has been involved in the Greater Lansing Region by hosting conferences, providing tours of the facility, participating in presentations and speeches outside of the facility, and hosting educational programs for teachers and students. Conferences have had a variety of purposes, ranging from internationally themed to simpler workshops (Michigan State University, 2014). The major learning program the NSCL provides is the 'Physic of Atomic Nuclei Program' (Michigan State University, 2014), operated by the Joint Institute for Nuclear Astrophysics, NSCL staff, and faculty. This program is open to students with one year of high school experience and high school science teachers. It is an opportunity for research on rare-isotopes and allows for hands-on experiments. Open houses are also provided every year to allow community members to experience a free tour and discover more about the facility.

NSCL: Accelerating Economic Development

With the NSCL being a user facility, it serves over 200 researchers that come from 35 countries and belong to 100 different institutions. As of 2008, the NSCL had over 240 employees with 28 faculty members of MSU and around 100 student employees with about half being doctoral candidates (Michigan State University, 2014). Of these jobs, about 200 are high skilled positions and it is also estimated that the NSCL brings close to $20 million per year to the local economy (Silver, 2008). With the success of the NSCL, spin-off companies have begun to form over the past couple of decades. An example is Niowave, Inc., which specializes in building accelerators for medical and other uses.

1.2 Methodology

This report is organized so that the overarching themes and concepts are explained prior to the case study analysis. In addition, a brief overview of current conditions in the Greater Lansing Region is provided before the in-depth discussion of case study facilities. Finally, the main themes from this analysis are described in the findings and recommendations section, along with some corresponding action items to be considered by Greater Lansing Region stakeholders.

The Greater Lansing Today (3.0) section was completed using United States 2000 and 2010 Census data, along with recent American Community Survey (ACS) five-year estimates.

Section 4.0 is structured as a literature review, where relevant scholarly and academic sources were reviewed and common themes are discussed. The topic for consideration in that section is how universities can play a role in knowledge and high-technology transfer, specifically in regard to regional economic impact.

Sections 5.0 and 6.0 are a summary of information from a detailed case study analysis of four separate cases. The case study facilities were selected based on their similarity in either size or scope to the FRIB at MSU. Each facility selected is a particle research laboratory or research site of some form. Three cases are from outside the Greater Lansing Region, these are TRIUMF in Vancouver, Canada, Fermilab outside of Chicago, Illinois, and the Jefferson Laboratory (J-Lab) which is based in Newport News, Virginia. The fourth case analyzed was the National Superconducting Cyclotron Laboratory (NSCL) based at MSU. Since this facility will be absorbed within the new FRIB site, it made sense to analyze it in its current state, prior to the future investment and upgrades. For each site, research was done by reviewing information that has already been published (e.g. plans, reports, analyses, etc.). In addition, the practicum team attempted to make contact (via phone, e-mail, and in person communication, depending on availability) with individuals from each facility or region to fill gaps in our analysis that the readily available information could not provide. Contact persons from each facility included:

- TRIUMF: Tim Meyer, Head of Strategic Planning and Communications
- J-Lab: Kandice Carter, Acting Public Affairs Manager
- Fermilab: Cynthia Zazama, Conference Events Manager
- NSCL: Matt Hund, Communications Coordinator and Media Contact, FRIB and NSCL

In terms of content, there are two separate tables in section 6.0 that show what topical information was sought. Definitions of each term are provided in the Appendices.

2.0 Driving Forces

A one-of-a-kind facility like the FRIB has the potential to take the human race to places never before imagined. The potential innovation and comprehensive impact of the FRIB could help push the Greater Lansing Region, as well as Michigan as a whole, to new heights in science and technology.

> "If we are to achieve results never before accomplished, we must expect to employ methods never before attempted" – Sir Francis Bacon

2.1 New Economy

Michigan has had firsthand experience in the decline in certain industries and the rise of others. The Great Recession that began in 2008 saw a continued decline in manufacturing and low-skill occupations across the United States, with 900,000 manufacturing jobs leaving the United States in the first year following the recession (Pierce, 2012). If Michigan hopes to sustain prosperity and push toward being recognized as an innovation-driver, problem solver, and world-class state, it must capitalize on these New Economy fields. Table 1 shows some general themes that identify the distinction between the "old economy" and the "new economy". The FRIB offers the Greater Lansing Region an exciting opportunity to capitalize on these shifts.

Key Features of the Old Economy	Key Features of the New Economy
Inexpensive place to do business was key	Being rich in talent and ideas is key
Success = fixed competitive advantage in some resource or skill	Success = organizations and individuals with the ability to learn and adapt
Economic development was government-led	Bold partnerships with business, government, and nonprofit sectors lead the charge
Industrial sector focused	Sector diversity is desired, and clustering of related sectors is targeted
Fossil-fuel dependent manufacturing	Communications dependent, but energy smart
People followed jobs	Quality places with a high quality of life matter most
Connection to global opportunities not essential	Connection to emerging global opportunities is critical
	Adapted from "The Economics of Place" by the Michigan Municipal League, p.47

Table 1: Comparing the Old and New Economy

An institution that will conduct world-class research, catalyze partnerships, and bring in innovative talent and ideas is a critical anchor to a regional economy. Senator Carl Levin noted, "This state-of-the-art facility is critical to Michigan and the entire country, and will create thousands of jobs in our state" (Levin, 2013).

2.2 Anchor Institutions

The FRIB could be an anchor to MSU, East Lansing, and the Greater Lansing Region. The facility itself is a result of more than a half-billion dollar investment from the U.S. Federal government. This sizable financial commitment predetermines the importance of such a facility. The University of Pennsylvania Institute for Urban Research defines an anchor institution as "economic engines for cities and regions, acting as real estate developers, employers, and purchasers of goods, magnets for complementary businesses, community-builders, and developers of human capital" (Penn Institute for Urban Research, n.d.).

Is our Institution an Anchor Institution?
Does it have a large stake and an important presence in your city and community?
Does it have economic impacts on employment, revenue gathering, & spending patterns?
Does it consume sizeable amounts of land?
Does it have crucial relatively fixed assets and you are not likely to relocate?
Is it among the largest purchasers of goods and services in your region?
Is it a job generator?
Does it attract businesses and highly skilled individuals?
Is it one of the largest employers, providing multilevel employment possibilities?
Is it a center of culture, learning and innovation with enormous human resources?

Table 2: Common Features of an Anchor Institution

Planning for an anchor institution, whether it is a school campus, medical facility, government institution, or research facility, requires some careful consideration. A successful synthesis between the anchor institution and the surrounding community allows greater impact to be had by all parties involved. Table 2 shows some generally recognized indicators of anchor institutions (Partnerships, 2008). The remainder of this report will attempt to provide support for the importance of a new economy anchor institution on a regional scale. These driving forces are likely going to be instrumental in the future of the Greater Lansing Region.

Figure 1: Rendering of FRIB (source: FRIB.msu.edu)

3.0 Greater Lansing Today

The FRIB facility is located in the Greater Lansing Region, which is situated in Mid-Michigan, which is comprised of Clinton, Eaton and Ingham counties. A comprehensive analysis of socioeconomic traits and anchor institutions of the region can reveal potential opportunities, which can allow the region to maximize benefits of the FRIB. The following section will provide insight on population, age, sex, race, educational obtainment, occupational and employment of the Greater Lansing Region.

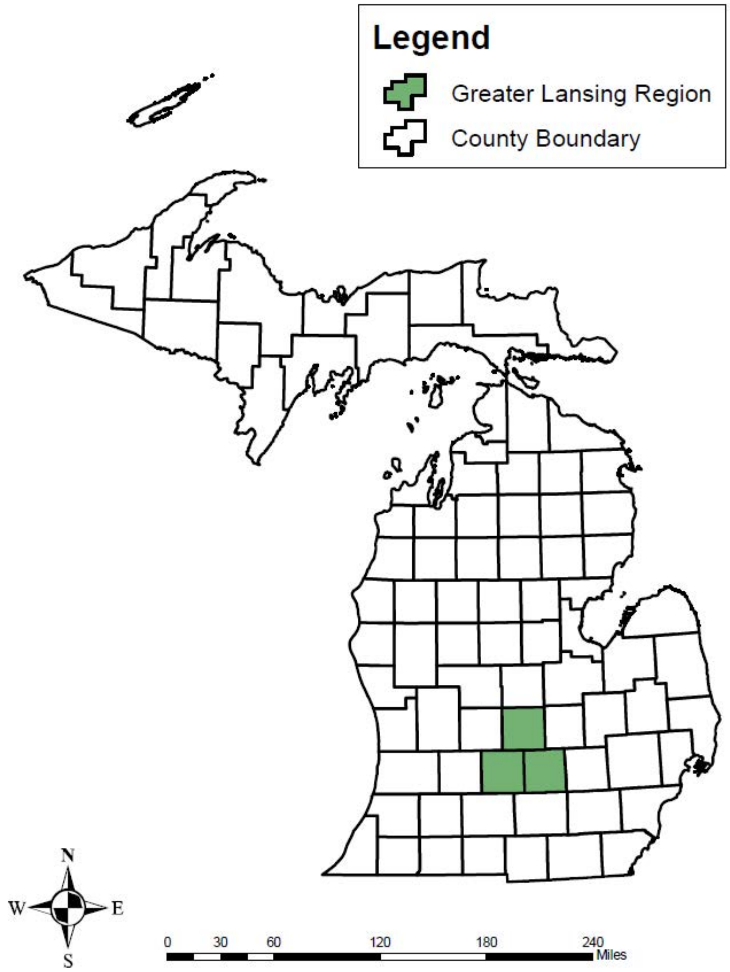

Figure 2: Greater Lansing Region (created by Practicum team)

Analysis of socioeconomic data such as population, median age, sex and race can be useful to maximize the full potential of FRIB. Such data has been obtained through United States Census Bureau's 2010 U.S. Census. The Greater Lansing Region has a total population of 464,036. Median age of those who live in the region is 34.6 years old (United States Census Bureau, 2010 Census, n.d.). Over 51 percent of the populations are female while 49 percent are male (United States Census Bureau, 2008-2012 ACS, n.d.). The racial profile of the region is comprised of 81.5 percent White, 8.9 percent Black or African-American, 3.8 percent Asian, 0.5 percent American Indian, 0.1 percent Hawaiian or other Pacific Islander, 2 percent were some other race, and 3.3 percent are two or more races (United States Census Bureau, 2010 Census, n.d.). View Table 3 for an overview of basic demographic information.

Greater Lansing Socioeconomic Data	
Population	464,036
Median Age	34.6
Median Income	$49,831
Population over 25 years old with at least some college	67%

Table 3: Basic Demographic Data of the Greater Lansing Region

Figure 3 highlights educational demographics of the Region. Education and occupational data of the Greater Lansing Region's population may provide evidence to what kind of region the FRIB is located within. According to the 2008-2012 five year American Community Survey (ACS) from the United States Census, the median household income of the Region is $49,831. The highest education level of those 25 years or older are as follows; 13 percent have a graduate or professional degree, 19 percent have a bachelor's degree, 35 percent have some college or an associate degree, 25 percent have a high school diploma or GED, and 8 percent have less than a high school diploma (United States Census Bureau, 2008-2012 ACS, n.d.). The occupational data of the Greater Lansing Region, according to the 2008-2012 ACS, are as follows; 37.7 percent are employed in management, business, science, and art occupations, 25.1 percent in sales and office occupations, 18.7 percent

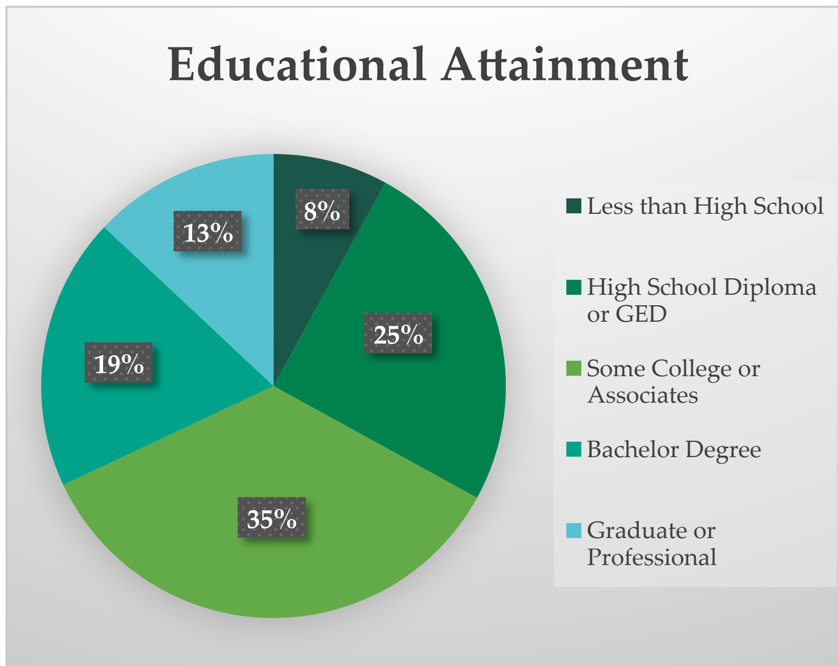

Figure 3: Educational Breakdown within the Greater Lansing Region

in service occupations, 12.2 percent in production, transportation, and material moving, and 6.3 percent in natural resources, construction, and maintenance,.

Anchor Institutions of the Greater Lansing Region
State of Michigan – 14,390 employees
Michigan State University – 11,100 employees
Sparrow Health System – 7,000 employees
General Motors – 5,800 employees
Auto-Owners Insurance Group – 3,700 employees

Table 4: Anchor Institutions within the Region (source: LEAP)

The FRIB has potential to become an anchor institution in within the Greater Lansing the region. Due to this, it is important to recognize predominant anchor institutions that employ a significant number of individuals with region. The Lansing Economic Area Partnership, Inc., (LEAP) lists the State of Michigan (14,390 employees), Michigan State University (11,100 employees), Sparrow Health System (7,000 employees), General Motors (5,800 employees) and Auto-Owners Insurance Group (3,700 employees) are the top five anchor institutions in the Greater Lansing Area (see Table 4) (Lansing Economic Area Partnership, n.d.).

It is important for FRIB officials, local government officials, and local business leaders among others to understand the current socioeconomic framework in which the Greater Lansing Region resides. Such an understanding can help those decision makers maximize the public benefits of the FRIB. A more in depth analysis of the region may yield a way for the facility to see its true potential.

4.0 Technology Transfer and Regional Impact

Universities can provide a unique value to regional economies due to their ability to promote knowledge transfer. These research institutions provide the base for the transfer of new innovations into the economy. Business incubation programs can act as an intermediary stage to bridge the gap between these innovative ideas and commercialization. Focusing university research and incubation strategies around the growing field of high-technology can provide a region exciting potential for healthy, continued success. The following section outlines some common concepts and projects that aim to capitalize on research institutions, knowledge transfer, technology transfer, and regional economic impact.

Current Trends

Figure 4 depicts a national overview of high-technology regional clusters, by percentage of high-technology jobs to total jobs (Bay Area Council Economic Institute, 2012). Michigan has some noticeable clustering around the southeast and central part of the state, including the Greater Lansing Region. These clusters are significant because regionalizing can facilitate learning and collaboration due to sharing of the same set of regional institutions (Bramwell, 2008).

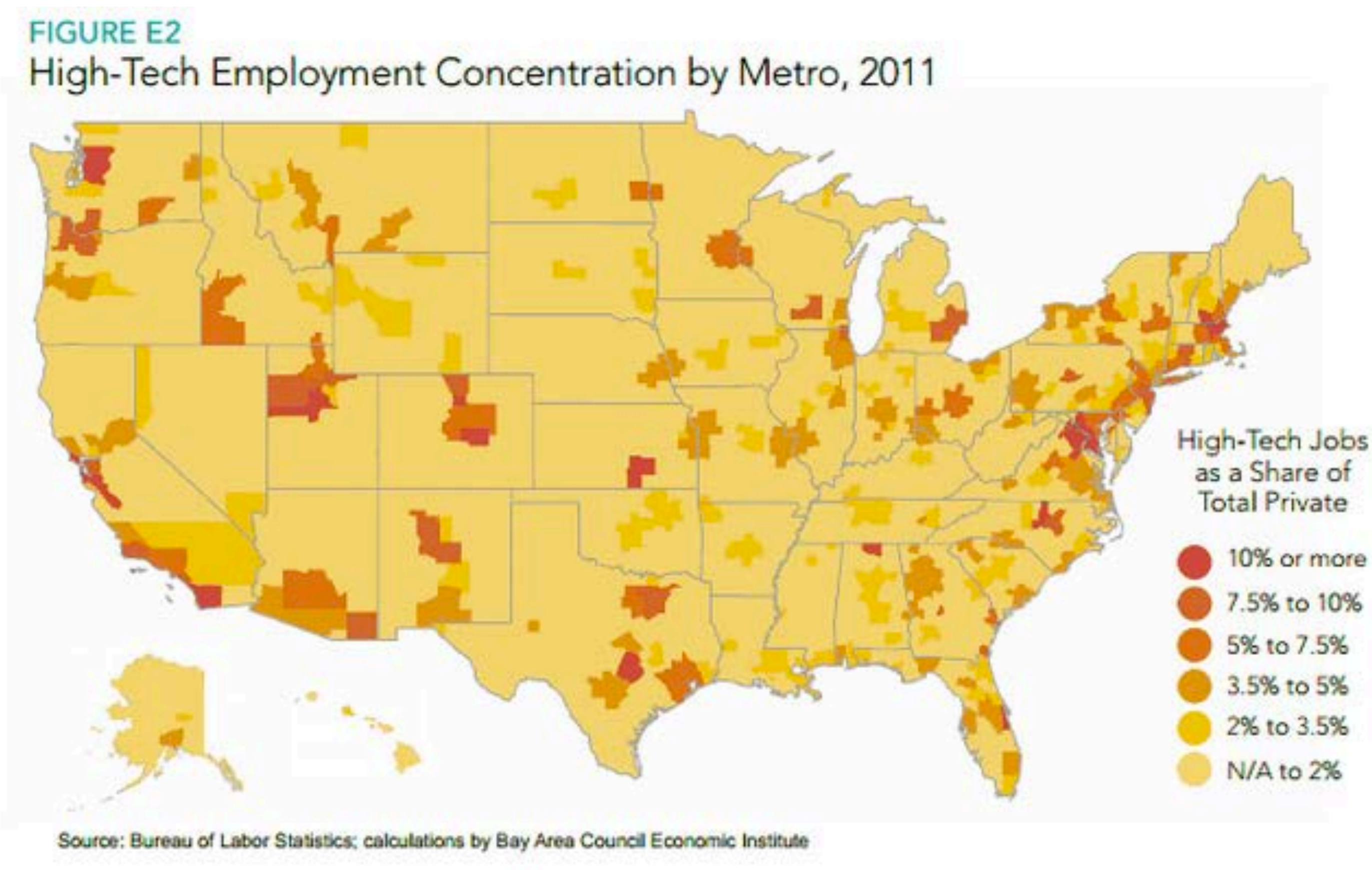

Figure 4: High-Technology Employment Clusters, Nationally

The high-technology sector can be defined as the group of industries with a large proportion of workers in the STEM fields; Science, Technology, Engineering, and Math. This sector can be a critical source of secondary job creation and economic development (Bay Area Council Economic Institute, 2012). Especially in recent years, employment growth in the high-technology sector specifically has outpaced the private sector as a whole. Employment grew 16.2% in STEM occupations nationally between 2002 and 2011, while total employment grew only 0.6% in the same time frame. In addition to employment growth, STEM workers have also seen pay growth. STEM workers in high-technology industries have been found to earn 27.3% more on average than a comparable worker in other industries and occupations (Bay Area Council Economic Institute, 2012).

Research has shown that attracting a high-technology employee to a region triggers economic multipliers that can increase employment and salaries for local service jobs (Bay Area Council Economic Institute, 2012). Michigan must realize that low-tech industry clusters can occur at places across the globe due to international differences in labor and incidental costs. Therefore, Michigan can capitalize on high-quality developments using high-productivity strategies to promote innovative, advanced technologies (Anderson Economic Group, 2010). Executives in these industries may choose to locate where other highly skilled individuals are. In other words, they seek regions that have a “buzz”, places where the most exciting work is happening (Bramwell, 2008).

If the evidence suggests that a region’s future economic well-being may be related to its ability to create and retain high-skill, high-growth, high-technology industries, the question now becomes how can a region begin to bring in these high-technology industries and accompanying employees? Universities are often seen as a way to generate knowledge and attract talent, especially around these new high-technology sectors. Policymakers tend to view universities as ‘knowledge factories’ for these new economy industries (Bramwell, 2008). When the government invests in universities, they expect to see a measurable economic return on their investment (Bramwell, 2008). Universities can play the critical role of a knowledge transfer agent for regional economies.

The concept of knowledge transfer, especially around tacit knowledge, is subjective, and hard to pinpoint. It requires interactive processes between talented people with unique skills, training, and experiences (Bramwell, 2008). Due to the fact that high-technology knowledge transfer requires this sort of interactive environment, high-technology firms therefore seek a strong pool of highly qualified scientists and engineers (Bramwell, 2008). This "concentration" of highly-skilled individuals facilitates knowledge generation in specific areas. Silicon Valley is perhaps the most widely recognized example of this concentration phenomenon. This phenomenon allows regional high-technology clusters to stay at the forefront of industry trends, innovations, and best practices. The FRIB presents such an opportunity for the Greater Lansing Region.

Knowledge Transfer – The Importance of Town & Gown

As discussed earlier, knowledge transfer is one critical role that universities can play. With the recent focus on economic impact of research universities, there has been a shift to include increased emphasis on applied research that is relevant to industry, along with providing technical support to these industries (Bramwell, 2008). The partnering of these higher education institutions along with communities is referred to as a "Town and Gown" connection. Universities provide numerous mechanisms for knowledge transfer, including but not limited to:

- Generating and attracting talent
- Formal and informal technical support, especially for Research and Development (R&D) activities
- Act as the middle-ground between regional partnerships and the global academic research networks
- The ability to act as a community anchor that continuously supports firm formation and growth
- Promotion of an atmosphere of intellectual diversity, where different approaches are tolerated and tested
- The ability to act as an incubator for new technologies and start-up companies

(Bramwell, 2008)

Global Network with Local Impact

University researchers are globally connected. They network globally, attend conferences, interact with colleagues, and engage international students. High-tech research institutions also attract talent globally with visiting scholars and engagement with professional networks. Therefore, when working with a professor, you do not merely get that one professor's perspective; instead it is a global perspective from leading institutions at a worldwide scale (Bramwell, 2008).

University of Waterloo Regional Knowledge Cluster

A detailed analysis of the Waterloo, Ontario, Canada high-technology cluster shows the way a university, in this case the University of Waterloo (UW), can contribute to growth and innovation at a regional scale (Bramwell, 2008). This analysis was based on 96 in-depth interviews completed in 2008 with firms, associations, and knowledge institutions throughout the region (Bramwell, 2008). What the researchers discovered was that throughout the years, a culture has developed at UW, not necessarily by intention, but the result is a culture of innovation, value of entrepreneurship, and celebration of professors who have gone on to start their own companies (Bramwell, 2008). UW has a reputation for being an "entrepreneurial research university" that seeks to partner with high-technology industries and promote regional economic development interests. This has led to the Waterloo

Figure 5: Waterloo, Canada Map (source: uwaterloo.ca)

University of Waterloo
Location: Waterloo, Ontario, Canada
Established: July 4, 1956
Undergraduates: 26,987
Postgraduates: 4,375

"Largest post-secondary co-operative education program in the world"

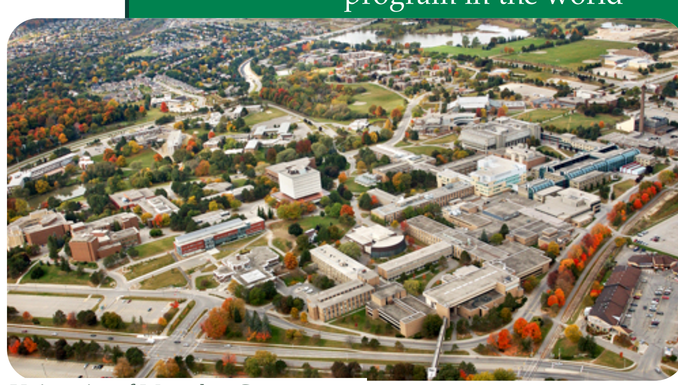

Figure 6: University of Waterloo Campus (source: uwaterloo.ca)

region becoming one of the most dynamic sources of high-technology activity in all of Canada, with over 450 companies involved in producing or facilitating high technology (Bramwell, 2008). This case provides a number of valuable insights to the FRIB project and the Greater Lansing Region.

UW seeks to link with both local and non-local industries with deliberate processes at the institutional level to promote co-operative education and entrepreneurialism. UW's success is based on these main abilities:

- Ability to attract, retain, and train top caliber graduates and researchers, and to link with potential employers
- Providing R&D assistance to local firms
- Exchanging tacit knowledge at regional and global levels
- Facilitation of entrepreneurial activities

(Bramwell, 2008)

UW has a specific Technology Transfer and Licensing Office (TTLO) that attempts to measure the impact of its knowledge transfer and technology transfer efforts. Even back in the mid-1990s, the TTLO had identified 106 spin-off companies from UW, employing over 2,000 people (Bramwell, 2008). Jumping ahead to fiscal year 2003, the annual Licensing Survey of the Association of University Technology Managers found UW received or facilitated:

- Nine invention disclosures
- Six U.S. patents issued
- 13 new start-up companies

(Bramwell, 2008)

As part of the UW curriculum, all students are offered the opportunity to complete work terms in industry through a Co-operative Education Program. This policy was adopted early in UW's history, and is currently the largest and most successful program of its kind in the world (Bramwell, 2008). Annual numbers for the program show enrollment of over 11,000 students (60% of the total student body), with 3,000 employers, and 281 local employers (Bramwell, 2008). The industry leaders recognize the invaluable importance of collaborating with students at such a mass scale. As one interviewee stated, “These students are not just cheap labor. They know about what’s hot and what’s not. They talk to the professors and they are really in the know” (Bramwell, 2008). Local firms reported four key benefits of this rotation of students to industry and back to the classroom:

- Constant source of new hires: The firms are able to know that students have work experience, and they get a chance to evaluate performance in the workplace prior to hiring
- Knowledge on the Streets: Recent graduates are able to provide fresh eyes, new ideas, and younger talent
- Students act as a transfer agent for tacit knowledge, they are exposed to new ideas in their courses and can bring this to the firm
- Competition: Due to the program’s reputation, there is competition for the best students at a global level. However, local firms enjoy the benefit of retention through location

(Bramwell, 2008)

UW offers an alternative to its traditional co-op program, known as the Enterprise Co-op Program, which allows a student to start his or her own venture instead of being placed in an established firm. The program aims to provide the student with a network of contacts and mentors to support the enterprise (Bramwell, 2008). In addition to the Co-op program, UW has recently established a Centre for Business, Entrepreneurship, and Technology (CBET). CBET is tasked with coordinating, developing, and supporting the university’s wide-reaching entrepreneurship activities (Bramwell, 2008). They aim to assess how an entrepreneurial culture is created at a university level, how faculty members commercialize their technology, issues in the relationship between researchers and the business community, and issues relating to technology transfer between those two entities. The university has an influential Intellectual Property (IP) policy, where full ownership of IP is given to the creator. This provides the creator an environment that promotes entrepreneurship instead of stalling it (Bramwell, 2008).

In sum, UW has been able to organically cultivate a culture of entrepreneurialism that has helped facilitate worldwide respect as an innovative hub. The surrounding Waterloo region has been on the receiving end of UW’s commitment to creating a high-technology cluster.

Tech Transfer – The Importance of Incubators

Once a new innovative idea is formed, the next step is to begin moving this idea toward commercialization. This is the critical crux of technology transfer that requires some assistance. Incubators can play the role of intermediary between vision and action. The mission of an intermediary is to serve by establishing contacts, arranging networks, and offering resources, all to make the region more attractive for entrepreneurs (Bramwell, 2008). Currently, most firm R&D is solutions-focused, with incremental innovations, rather than seeking first generation innovations. These paradigm-shifting first generation innovations is where incubators can play a critical role. The U.S. Department of Commerce Economic Development Administration (EDA) recently found that business incubators are one of the most cost-effective public investments in terms of job creation potential (Real Estate Research Consultants, 2009). Put into numerical terms, for every $10,000 of public investment, business incubators produce 46.3-69.4 new jobs at a cost of roughly $144-$216 per job. Considering the same $10,000 investment relative to public infrastructure or community infrastructure projects, business incubators produce almost 20 times as many jobs (Real Estate Research Consultants, 2009).

University of Central Florida (UCF) Business Incubation Program

The UCF program has received national attention and respect for being one of the most effective and well-operated incubation systems, resulting in job creation, new business development, and facilitation of research-based commercialization

University of Central Florida
Location: Orlando, Florida, USA
Established: June 10, 1963
Undergraduates: 50,968 (Spring '13)
Postgraduates: 9,213 (Spring '13)

"A University-driven community partnership providing early stage companies with the enabling tools, training and infrastructure to create financially stable high growth / impact enterprises" (source: incubator.ucf.edu)

Figure 8: Map of Orlando, Florida (source: bestplaces.net)

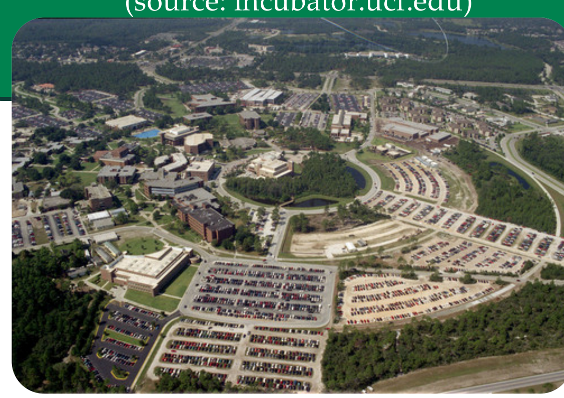

Figure 7: UCF Campus (source: ucf.edu)

in the region (Real Estate Research Consultants, 2009). Between 1999 and 2009, the UCF program facilitated the development of over 100 high-technology companies. Of those, 34 have successfully completed from the program and became self-reliant. Eighty percent of graduate companies have decided to remain local to the Central Florida region (Real Estate Research Consultants, 2009). In order to be enrolled in the program, prospective clients must have a minimum of nine to twelve months of capital resources, prove the validity and significance of their idea, and demonstrate a willingness to cooperate with the incubation guidelines (Real Estate Research Consultants, 2009). Upon acceptance to the program, these start-ups are offered extensive mentoring and monitoring services from the program staff.

An analysis of the program to analyze job and related economic benefits was completed using the Regional Input-Output Modeling System (RIMS) II, developed by the United States Bureau of Economic Analysis (BEA) (Real Estate Research Consultants, 2009). Measuring impact of this sort generally includes the assumption that a portion of dollars are retained locally, spent in subsequent activities, and then eventually lost to adjacent areas. The local impacts of this subsequent spending, or downstream benefits, is generally calculated using the concept of a multiplier (Real Estate Research Consultants, 2009). A multiplier is the relationship between jobs and successive economic activity, in this case subsequent spending and resulting benefits as a result of the creation of initial jobs from the UCF incubator. Three basic multipliers were used in by the researchers estimating economic impact in this case:

- Annual output: estimate of imputed sales and production value of the incubator and additional (i.e. indirect and induced) sales created as a result of the incubator
- Employment: total jobs created as the result of employment within the incubator
- Earnings: Measures change in personal and property income generated annually as the result of each new income dollar earned

(Real Estate Research Consultants, 2009)

The analysis of UCF's incubation program resulted in some key findings[2]. First, the incubator program was found to be responsible for creation of over 1,600 jobs in the region, after accounting for multipliers. These jobs are responsible for more than $70 million in earning and nearly $200 million in total economic output annually. Business and job growth also generate revenue for the local governments in the region. For example, the incubation program had an estimated impact of $4.5 million in public revenue within Orange and Seminole counties for 2009. This represents a return of $5.25 for every $1.00 invested by these local governments (Real Estate Research Consultants, 2009). In a separate study, it was found that the creation of one job in the high-technology sector of a region is associated with creating 4.3 additional jobs in the local economy in the long run (Bay Area Council Economic Institute, 2012).

Conclusions

Michigan has the potential and resources to capitalize on high-technology industries. With some of the nation's leading research universities and a history of innovation, there are only missing intermediary pieces to potentially begin to see substantial impacts. Knowledge transfer and technology transfer programs and policies at a regional and state level can catalyze the development of high-technology clusters within Michigan. As seen in the research cited in this section, there is real potential for meaningful regional collaboration between universities, public institutions, and private corporations (Bramwell, 2008) (Bay Area Council Economic Institute, 2012) (Real Estate Research Consultants, 2009).

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[2] Note from UCF researchers: These estimates are limited and inherently conservative. They inadequately address many related activities that also have current and future value even if value is hard to define at completion of this analysis (Real Estate Research Consultants, 2009)

5.0 Accelerating Tomorrow: Similar Facilities

Overview

In order to understand how the Greater Lansing Region can capitalize on and enhance the impact of this enormous investment, case studies of similar projects from across the globe were conducted. The case studies we analyzed are similar in either size or scope to the FRIB. This facility will be one-of-a-kind when it is completed, and so we attempted to identify projects that were similar in some form or another, such as other nuclear research facilities. After preliminary research, we settled on four major accelerator facilities (see figure 9). Topics analyzed for each case include collaboration and partnerships, innovation and technology transfer, community well-being, and workforce impact.

Case Study Facilities

- ✓ TRIUMF, Vancouver, Canada
- ✓ Thomas Jefferson National Accelerator Facility (J-Lab), Virginia, US
- ✓ Fermi National Accelerator Laboratory (Fermilab), Illinois, US
- ✓ National Superconducting Cyclotron Laboratory (NSCL), Michigan, US

Figure 9: List of Case Study Facilities

We recognize that given the relative rarity of facilities such as these, there is a limit on the amount of research that has been compiled. Therefore, we understand that some of the data we find may be susceptible to biases depending on a variety of factors such as multipliers used and the funding entity for the research.

Crash Course: TRIUMF 101

TRIUMF was founded in 1968 by Simon Fraser University, the University of British Columbia (UBC), and the University of Victoria; the University of Alberta joined the TRIUMF consortium almost immediately. There are currently eleven full members and seven associate members from across Canada in the consortium that governs

Figure 10: Aerial view of TRIUMF site (source: cerncourier.com)

TRIUMF.

TRIUMF is an enterprise that includes on-site technical, engineering, and administrative staff; university researchers and students; private-sector collaborators and licensees; international collaborators; and publicly funded agencies supporting basic research in Canada's interests. TRIUMF's organization reflects these multiple stakeholders working together in concert.

Figure 11: Map of Canada highlighting location of TRIUMF

TRIUMF was founded to provide the centralized resources, tools, and expertise in pursuit of compelling science in comprehensive ways that no single university could build or maintain. At its core, then, TRIUMF is a partnership among leading Canadian research universities.

TRIUMF outlined three goals in its 2008 Mission Statement:

- Make discoveries that address the most compelling questions in particle physics, nuclear physics, nuclear medicine, and materials science
- Act as Canada's steward for the advancement of particle accelerators and detection technologies
- Transfer knowledge, train highly skilled personnel, and commercialize research for the economic, social, environmental, and health benefit of all Canadians

(Management, 2008)

> In science, there is no second place for the Nobel Prize, and no reward for repeating experiments already completed by others. Remaining on the cutting edge of science is vital to the long term existence of TRIUMF (TRIUMF Five-Year Plan, 11)

TRIUMF is recognized across the globe and has received recognition from scholars, ministers, presidents, and scientists worldwide. The Federal Minister of Finance in Canada, Jim Flaherty, who has been interacting with the on goings at TRIUMF for many years believes that:

> The facility brings together leading scientists, postdoctoral fellows and graduate students from across Canada through a unique 18-member university alliance, and connects these talented individuals with leading counterparts from around the world to explore the fundamental structure and origins of matter. Through TRIUMF's ambitious international partnerships, Canadian researchers have been at the centre of some of the most important international research projects, most recently making critical contributions to the discovery of the Higgs boson particle at the Large Hadron Collider at the European Organization for Nuclear Research (Meyer, 2014).

The Federal Minister of State for Science and Technology in Canada, Gary Goodyear, speaks highly of TRIUMF and believes that its "World-class research facilities provide researchers with the tools they need to succeed. The ARIEL (Advanced Rare Isotope Laboratory) that is in the process of being built is a great achievement for Vancouver and for all of Canada" (Meyer, 2014).

Crash Course: J-Lab 101

The Jefferson Lab (J-Lab) began construction in 1987 in Newport News, Virginia as a U.S. laboratory site. This site is 169 acres and is funded by the Department of Energy. J-Lab's director, Hermann Brunder, Ph.D. (Jefferson Lab, 2014) stated this facility cost $600 million for initial investment and employs 700 people (Golembeski, 2014). J-Lab is the site of construction for the free-electron laser. The free-electron laser, a military defense tool, offers unique capabilities for defense applications (Jefferson Lab, 2014).

Figure 12: Aerial view of J-Lab site (source: jlab.org)

The J-Lab is a national laboratory (Golembeski, 2014). Visiting scientists from around the world use this laboratory to conduct their research. The researchers use J-Lab's Continuous Electron

Beam Accelerator Facility (CEBAF) to conduct basic experiments that build an understanding of the atom's nucleus.

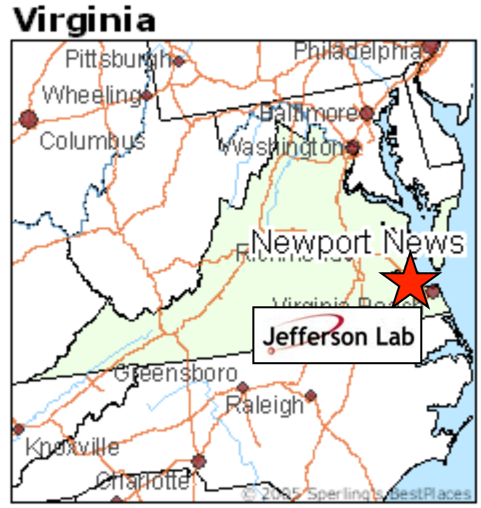

Figure 13: Map highlighting location of J-Lab

Research for the J-Lab was supplemented by a phone interview with Dean Golembeski, Public Affairs Manager. A list of questions relating to the study topics of this report was created. In addition, access to background documents for the planning phase of J-Lab was requested, as well as information about problems and deviations reports related to J-Lab and the region.

While Mr. Golembeski was not able to answer all questions, he facilitated the process of contacting others who would have the information for questions he could not answer.

Crash Course: Fermilab 101

Fermilab began as the National Accelerator Laboratory in 1967. The laboratory was renamed Fermi National Accelerator Laboratory in 1974 after Enrico Fermi, a Nobel-prize winning physicist. It is an American particle physics laboratory located just outside of Batavia, Illinois, 35 miles west of downtown Chicago. Fermilab is a U.S Department of Energy Office of Science laboratory managed by the Fermi Research Alliance, a joint venture of the University of Chicago, Illinois Institute of Technology and the Universities Research Association (URA).

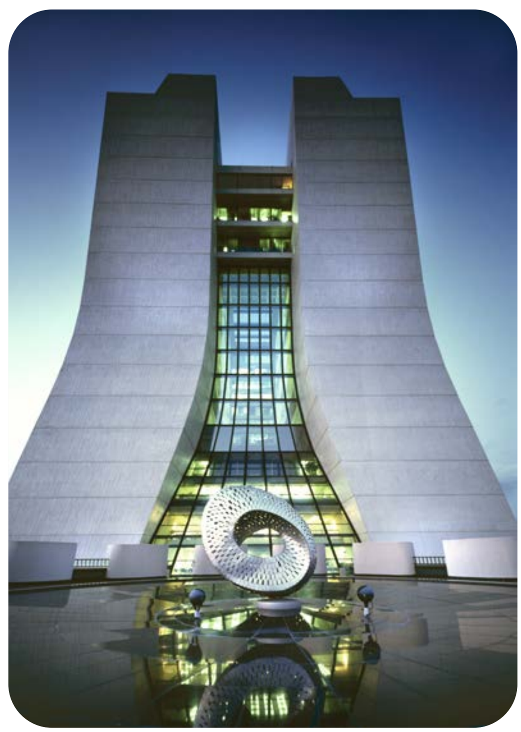

Figure 14: Image of Fermi site (source: interactions.org)

Fermilab is a member of the East West Corporate Corridor Association (EWCCA) as well as part of Illinois Technology and Research Corridor. Along this corridor, numerous international organizations, headquarters, companies, research, scientific, and educational institutions, medical centers, and many other points of interest are located (Fermilab, 2014).

Fermilab attracts visitors by hosting many special events, such as science lectures, music concerts, art exhibitions, cultural events, and public science lectures. In addition to public realm, Fermilab attracts jobs and funding through university partnership, world-class research, and innovative technologies specializing in high-energy particle physics (Fermilab, 2014).

Figure 15: Map of Illinois highlighting location of Fermilab

In 2013, Fermilab announced the new and improved version of their vision and mission statement. Their vision is to "inspire the world and enable its scientists to solve the mysteries of matter, energy, space and time for the benefit of all". Fermilab also outlined three mission statements. These include:

- Building and operating world-leading accelerator facilities.
- Performing pioneering research with global partners.
- Transforming technologies for science and industry.

(Nagel, 2013) (Anderson Economic Group, 2011)

Crash Course: NSCL 101

The National Superconducting Cyclotron Laboratory (NSCL) is located in East Lansing, Michigan on Michigan State University's campus. The facility became operational in 1965 from grant money awarded to MSU from the National Science Foundation

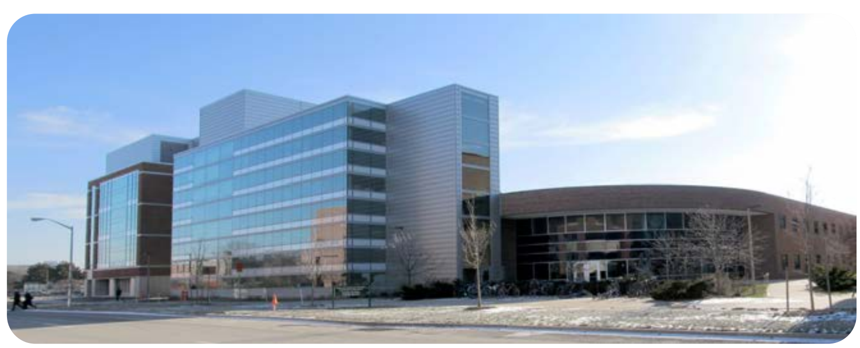

Figure 16: NSCL site (source: nscl.msu.edu)

(NSF). At the time, the laboratory was known as the MSU/NSF Heavy Ion Laboratory. In the late 1970s, the NSF awarded MSU with another grant, this time to build a Superconducting Cyclotron. After the appropriations bill was signed by Congress and President James Carter, MSU and the United States Department of Energy signed a contract in 1980, thus establishing the National Superconducting Cyclotron Laboratory. The superconducting cyclotron became operational on November 21st, 1981. Over the next decades, the NSCL continued to receive funding for new research. Projects included building a second independently operated superconducting cyclotron in the late 1980s, receiving money to merge the two independently operated cyclotrons in the late 1990s, and being selected as the location to host the new FRIB facility in 2008. Research done at the facility has produced findings in medical treatment and nuclear physics (Michigan State University, 2014).

At the NSCL, the main purpose of the lab is to study the nuclei of atoms. The accelerator is used to increase the speed of stable isotopes and collide the isotopes with other nuclei. After this collision, scientist can study rare isotopes that are not found naturally. The primary goal of this scientific endeavor is to unravel the mysteries that reside at the center of atoms, in atomic nuclei (Michigan State University, 2014).

Figure 17: Map of Michigan highlighting location of NSCL

6.0 Accelerating Economic Development

Overview

The FRIB has potential to profoundly impact the Greater Lansing Regional economy. In order to predict what kind of economic effect the FRIB may have on its surrounding region, a comprehensive analysis of similar facilities is needed. J-Lab, Fermilab, TRIUMF, and the NSCL are similar in nature to FRIB and were selected as case studies to measure potential impacts. The following section is an analysis of each case study facilities' economic impact on their respective locality. These facilities have the potential to make an economic impact through workplace development, innovation and technology transfer, and collaboration and partnerships.

6.1 Comparing Cases

The following table includes a comparison of a number of indicators across each of the selected case study facilities. Definitions for each indicator in Tables 5 and 6 are included in Appendix B. More qualitative analysis is provided in the remainder of this section. Table 6 assesses the presence of supporting activities that are able to facilitate technology transfer or represent a clear public interest. For any cell populated with "N/A", this means that the information was either not available or not applicable (e.g. outdated information) to the research being conducted.

In addition to the information in Table 5, a matrix style assessment of each facility was completed as well. The information in Table 6 is designed to be binary type questions, meaning the facility either met the variable or did not meet it. The purpose of Table 6 is to provide an idea of what sort of factors tend to be present (or not) for a facility of this size and scope.

Information for Tables 5-6 was found from the sources listed for each respective facility. A full list of sources can be found in the Appendices, under the bibliography subsection. In addition, supplemental information was provided by the contact persons from each case facility.

Indicators/Data Variables	TRIUMF	J-LAB	FERMILAB	NSCL
# Incubators in the	5	2	N/A	N/A

Indicators/Data Variables	TRIUMF	J-LAB	FERMILAB	NSCL
region				
# Spin-Offs (10 yrs.)	6	2	N/A	4
# Full-Time Employees (FTE)	340	720	1,757	240
# Patents (10 yrs.)	30	85	8	N/A
# Conferences (Annually)	Average 7-11 per year (34 conferences 2004-2008)	6	24	3-4
Visiting Researchers (Per yr.)	500 (10-15 per day)	1,250	2,300 (in year 2010)	200
Conference Attendees (Per yr.)	1,000 – 1,500	80 (not counting workshops)	1,581	300
Royalties? (10 yrs.)	$17,279,000 (FY2002-03 – FY2012-13)	$606,512 (8 year period)	N/A	$100,000
Operating Funding (Per yr.)	2013 ($86 million) 2014 est. ($74 million) 2010-15 est. ($382 million)	$100 million	2010 ($478.3 million)	$22.5 million

Table 5: Indicators for each Case Study Facility

Variables	TRIUMF	J-LAB	FERMILAB	NSCL
Intellectual Property Assistance	X	X	X	X
Partners/Public Private Partnership (PPP)	X	X	X	
University Partnership	X	X	X	X
Venture Capital Fund	X		X	

Table 6: Data Variables for each Case Study Facility

The following sections (6.2-6.4) explain the information depicted in Tables 5-6 in further detail.

6.2 Accelerating the Workplace

The FRIB will be a massive facility employing roughly 180 scientists, researchers, and support staff, along with an estimated 200 additional jobs outside of the facility in related industries over the next ten years (Anders, 2014). An influx of jobs to the Greater Lansing Region has the capacity to benefit the region's economy. To gain a perspective on how many direct jobs may be linked to the FRIB, an in-depth look into employment of similar facilities was conducted. Additionally, facilities of this nature may spawn numerous jobs indirectly. Indirect jobs may be produced to satisfy the needs of the facility and its employees. The following section provides direct and indirect employment impacts from the TRIUMF, J-Lab, Fermilab, and NSCL facilities.

For this section, criteria analyzed for each case study include full-time employment, part-time construction employment, universities and/or colleges in the region with high-technology concentrations, and some regional information on employment.

TRIUMF

There are about 340 staff employed at TRIUMF; in addition, about 150 other visitors, students, and researchers work at TRIUMF each day. Every year there are about 500 scientific visitors who come to TRIUMF for short periods of time to conduct experiments or research during the year (Communications, 2014).

More specifically, TRIUMF is in the process of constructing a new portion of their facility, known as ARIEL. The total cost of this upgrade is estimated at $62.9 million (Canadian dollars), with $30.7 being provided by the British Columbia Provincial government. Over 300 workers will be working part-time to build the tunnel and lab that will be used for this facility, leaving TRIUMF with 160 additional full-time employees upon completion (TRIUMF, 2008, p. 206)

Fermilab

Fermilab attracts a variety of talented people from all over the world. Based on The Economic Impact of Fermi National Accelerator Laboratory conducted by Anderson Economic Group, based in Lansing, Michigan, it is estimated that in 2010, Fermilab employed 1,757 full-time employees. In total, lab created a total of 4,529 jobs, including indirect jobs from local business located in Illinois and the majority of these jobs were in the eight-county Chicago region (Anderson Economic Group, 2011).

6.3 Accelerating Collaboration & Partnerships

Each particle accelerator facility serves as a focal point in attracting scientists from around the globe. The facilities often host conferences where the scientists and researchers may discuss their current research and generate networking opportunities. Such conferences have a great capacity to positively impact the local economy. Travelers to these conferences have basic needs such as food, lodging, and transportation. The following is data pertaining to conferences held by the four case study facilities. Knowing how many conferences each facility sponsors along with attendance figures can assist FRIB and Lansing to prepare for such events.

This section includes an assessment of conferences hosted, associated conference impacts, visiting scholars, and collaborative research projects completed for each respective case study, where information was available.

TRIUMF

TRIUMF operates within a large network ranging from academic, government, and industry partners across Canada and around the world. In Canada alone TRIUMF has 18 different university partnerships that work with about a dozen different public agencies. In addition to TRIUMF, Canada also has three complementary institutes that focus on subatomic physics, with different focuses including: the Perimeter Institute for Theoretical Physics, the SNOLAB and the TRIUMF for accelerator-based experiments, science and technology. In the summer of 2013, the three institutes began their work to form partnerships with a yearly international summer school, TRISEP, which encourages Canadian students to take part in the physics related studies. Internationally, TRIUMF attracts a lot of foreign investment. “Japan is contributing $4 million to a University of Winnipeg project at TRIUMF that is co-supported by the Canada Foundation for Innovation, Japan’s KEK laboratory is planning to install its first international office at TRIUMF, and agencies from the U.S., Germany, U.K., and Japan have invested $3.75 million in experimental facilities at ISAC” (TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008). TRIUMF has a strong network of over 75 universities, companies, research institutes, and global laboratories around the world.

There are many direct results of the partnerships that are formed with TRIUMF. Federal Minister of Finance, Jim Flaherty, has come to the conclusion that:

> TRIUMF has also forged highly successful partnerships with industry leaders in order to commercialize its scientific breakthroughs, and is recognized globally for its innovative work in the production of medical isotopes used for treating thyroid, breast and other cancers. It has helped to launch several spin-off companies and accelerate the growth of existing firms by sharing expertise, laboratory and research space, and jointly developing leading-edge research equipment. (Meyer, 2014)

Conferences and visiting researchers hosted by TRIUMF on a frequent basis, which attract scientists from across Canada and around the world, and which result in tourist spending in the Province. From 2004 to 2008 TRIUMF hosted a total of 34 conferences in BC, attracting more than 3,500 attendees. There is an average of seven-eleven conferences per year (Meyer, 2014).

TRIUMF also typically hosts 10 to 15 visiting researchers on any given day. Overall, TRIUMF management has estimated that total tourist spending in BC related to TRIUMF conferences and visitors averages at least $2.5 million per year (TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008, p. 7).

A direct result of the partnerships that are formed through the conferences is the recent alliance formed at TRIUMF between the International Linear Collider (ILC) and the Compact Linear Collider (CLIC). These colliders are two of the most innovative next-generation projects of their time. The projects will be conjoined with the Large Hadron Collider (LHC), located in Switzerland and France. TRIUMF has first-hand information on this “new organization to coordinate and advance the global development work for the Linear Collider Collaboration, and will take office at a meeting of the linear collider oversight committees at TRIUMF” (Collaboration/TRIUMF, 2013).

TRIUMF helps to organize workshops and conferences, and these events are of critical importance to the scientific community. Over recent years, TRIUMF has seen staff-reductions in the conference-services office. However, the facility still brings in a half-dozen international conferences to Canada annually (TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008, p. 458). See Table 7 for an overview of the estimated economic impact of these events on the region.

Year	2007/2008	2008/2009	2010/2011	2011/2012	2012/2013
Number of conferences	7	8	11	9	5
Economic Impact	$1,615,000	$2,318,375	$2,651,575	$952,850	–

Table 7: Estimated Impact of TRIUMF Conferences

(TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008)

For visiting scholars, TRIUMF offers the "TRIUMF House" as an interim living situation. In 2011, the TRIUMF House received a perfect score upon review by Tourism British Columbia (BC) in their annual assessment visit. The facility is renowned for its cleanliness and state of repair (TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008, p. 336).

Fermilab

According to during fiscal year 2010 there was an average of 1,000 users at Fermilab from institution outside of the State of Illinois. The visiting users combined for a total of 360,000 visitor days within the region (Anderson Economic Group, 2011). In 2013, Fermilab hosted 24 meetings/conference with a total attendance of 1,581 participants.

Collider Detector at Fermilab (CDF) is an experimental collaboration with sixty different institutions involved to study high energy particle collisions at the proton-antiproton collider (Fermilab National Accelerator Laboratory, 2014).

Fermilab has a partnership with Indiana-based Roark Industries Incorporated and Michigan-based Niowave, Inc. to develop new superconducting structures and electron linear accelerators.

Fermilab also runs the Office of Partnership and Technology Transfer (OPTT). They meet with the Fermi Site Office on a monthly basis for a formal discussion of Partnering Agreements and any other matters pertaining to the Partnerships Management System. The Partnering Management System is focused on establishing the policies, processes, and procedures for planning, executing, evaluation and improving performance, in accordance with the requirements of the contract.

In partnership with universities and laboratories worldwide, more than 4,600 scientists worldwide use Fermilab for their research. Of these, about 2,500 researchers, from 35 countries, collaborate on Fermilab experiments, including more than 1,500 scientists from 120 U.S. Institutions in 35 states (Fermilab National Accelerator Laboratory, 2013).

Fermilab has also worked with several private companies to develop specific components for their work:

- Advanced Energy Systems: A New York company that develops and sells accelerator-technology products. The firm has worked with Fermilab on the development of the lab's superconducting radio frequency accelerator technology.
- Pavac Industries, Inc.: It is a Canadian electron beam technology firm. Fermilab has been working with Pavac Industries to develop products suitable for use in particle accelerators.
- Euclid TechLabs LLC: It is a research and development company in Ohio. Fermilab has worked with Euclid to develop their technology for use in particle accelerators at Fermilab.

6.4 Accelerating Innovation & Technology Transfer

Research at the FRIB could present the Greater Lansing Region with exciting opportunities to capitalize on potential discoveries. Particle accelerators may create spin-off industries from the research discoveries at the facilities. Such spin-off industries can create many related high-technology sector jobs. Discoveries from the particle accelerator may also lead to patents filed and corresponding royalties received from those patents. Royalties gained may impact individuals and companies who make discoveries, along with MSU. The following section analyzes spin-off industries created from the case study facilities, where information was available. The number of patents filed and the amount of royalties grossed from the facility where information was available is presented. Discovering how like-minded facilities capitalize on innovation can help FRIB and the Greater Lansing Region to maximize potential economic gains. While all case studies have some type of innovation and technology programs in place, this section focuses on TRIUMF, as the most detailed information is available for this case.

TRIUMF

TRIUMF represents the heart of a growing advanced technology cluster in British Columbia focused on nuclear medicine and particle accelerator technology. TRIUMF's existence directly supports private industry in BC (e.g., MDS Nordion, Advanced Cyclotron Systems, PAVAC Industries, and D-Pace) as well as nonprofit agencies and organizations (e.g., BC Cancer Agency and Advanced Applied Physics Solutions, Inc.) (Inc., 2009, p. 2).

TRIUMF's leadership role in these collaborations keep BC scientists at the forefront of global science, attracts highly qualified personnel to BC to live and work, and provides opportunities for domestic firms to participate in the supply of equipment and apparatus required by these global projects. (Inc., 2009, p. 2)

In the past ten years there have been six substantial spin-offs that have formed as a result of TRIUMF. Collaborations such as these have brought over 500 visiting researchers per year to BC to conduct research (Meyer, 2014). They range from jobs related to nuclear medicine, nuclear and particle physics, and materials science.

TRIUMF realizes that certain individuals trained at TRIUMF (either students of professional) will go on to create technologies, launch businesses, and pioneer innovations. This type of development is often difficult to model and predict, and so a few noteworthy examples are included below.

1. Nordion, Inc., produces 2.5 million patient doses of medical isotopes from its TRIUMF-based manufacturing facility and its dedicated medical cyclotrons. Nordion's headquarters are in Ontario and has sales of $15-$20 million annually. This dedicated

Applied Technology Group employs roughly 30 full-time employees. The activity from Nordion provides a royalty revenue stream for TRIUMF as well as value to medical patients around the globe. Nordion and TRIUMF received the 2004 NSERC Synergy Award for Innovation that recognized its best practices between the commercial and public sector (TRIUMF Five-Year Plan, 187).

2. D-Pace, Inc. was cofounded by Morgan Dehnel in 1995 after earning a Ph.D. from the University of British Columbia (UBC) and research completed at the TRIUMF site. D-Pace began as an engineering design firm that worked with research facilities and private companies in the accelerator industry. Dehnel noted his company "owes its existence and almost all of its knowledge base to TRIUMF. This includes Ph.D. training, intellectual technology transfer in accelerator-related physics and engineering, technology license agreements, and business advice related to the licensed technology items. TRIUMF and D-Pace work together in a team effort."
3. Moe Kernani was trained as a physics Ph.D. at UBC and TRIUMF and he is now the Vice President of NetApp, Inc., a leading provider of enterprise data storage solutions. Kernani currently serves on the board of directors for the British Columbia Technology Industry Association. He has received a Business in Vancouver "Forty under 40" award for young professionals and was named the BC Technology Industry Association's Person of the Year in 2011.
4. Juergen Wendland was also trained as a physics Ph.D., his studies were completed at Simone Fraser University and TRIUMF. He currently leads a team of quantitative analysts in a financial software company in Surrey, BC called FINCAD.

(TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008, p. 188)

All of the innovative research being completed at TRIUMF leads to a number of patents and resulting royalties for the facility. See Table 8 for a

Commercial revenues flowing to TRIUMF during the 2008–2012 period are shown in Table 1.

	Total	2012–13	2011–12	2010–11	2009–10	2008–09
Royalties						
Nordion	4,879,360	580,745	999,812	1,546,033	1,019,872	732,898
D-Pace, Other	87,655	9,233	13,713	24,924	24,965	14,820
Subtotal	4,967,015	589,978	1,013,525	1,570,957	1,044,837	747,718
Other Income						
PIF & NIF	1,720,768	204,753	330,451	451,837	733,727	0
F-18 Production	1,688,320	39,600	3,300	493,760	490,196	661,464
Miscellaneous	689,886	293,134	94,652	112,114	69,447	120,539
Subtotal	4,098,974	537,487	428,403	1,057,711	1,293,370	782,003
Grand Total	9,065,989	1,127,465	1,441,928	2,628,668	2,338,207	1,529,721

Table 8: TRIUMF Commercial Revenue Estimates

summary of royalties and other revenue from 2008-2013. (TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008)

TRIUMF is also in the process of constructing the Advanced Rare Isotope Laboratory (ARIEL). TRIUMF's new facility will expand its studies and production of isotopes related to physics and medicine. The high-power superconducting electron accelerator is anticipated to "create 160 spinoff jobs in the private sector, universities and other research agencies - not to mention 90 person-years of employment during construction," according to BC Minister for Small Business, Technology, and Economic Development Iain Black. (Meyer, 2014)

Intellectual Property Assistance

TRIUMF has created a strict patent policy that persons interested in creating a patent must follow. The main purpose of the TRIUMF Patent Plan is to "stimulate innovation and invention, to encourage public use and commercial application of invention and, while doing so, to protect the rights of the inventor and TRIUMF" (TRIUMF, TRIUMF Patent Plan, 2004).

There are a series of steps the inventor must be approved of before receiving the patent including:

1) Must be a TRIUMF staff member
2) Those who are from one or more of the member associate universities must split their royalties by 50% to the inventor, 25% to the university and 25% to TRIUMF
3) Visitors to TRIUMF must follow TRIUMF policy
4) When a patent is submitted jointly, for example, by a member and an associated university, the two must cooperate on who will receive the royalties and patenting costs
5) The staff of the Technology Transfer Office must review the application wholly and only once they have approved the patent will it be official

Additionally, those applying for a patent must fill out a 'Detailed Invention Disclosure Form' that asks for detailed information about the invention including its purpose, detailed description, sketches of the invention, etc.

7.0 Accelerating Community Well-Being

Overview

The FRIB is a nationally funded, internationally significant, and could certainly be utilized for decades to come. The expected longevity and publicly funded nature of FRIB may task a facility of this type with potential civic duties. To become a fully engrained within the fabric of the Greater Lansing Community, the FRIB must provide community outreach via various outlets. This section provides insight on how the case facilities have had an impact on their respective communities, where information was available. While all case studies have some type of community well-being programs in place, this section focuses primarily on TRIUMF, as the most detailed information is available for this case.

TRIUMF

TRIUMF offers tours to a variety of groups as part of its Communications and Outreach work in the region. Tours provided are targeted at the following specific groups:

- General public: Tours are offered twice a week from September thru May and twice a day for the summer months of June to August
- Science: The lab conducts pre-arranged tours for university and college physics, chemistry or other related science students as well as for visiting scholars
- Students: Pre-arranged tours are available for elementary, junior high, and high-school students, along with university or college "non-science" students
- VIP: Senior management can conduct specially arranged tours for VIPs, review and advisory committee members, and media members

Category	2008-09	2009-10	2010-11	2011-12	2012-13
General Public					
# of people	475	1845	616	820	891
# of tours	143	150	179	208	214
# of guides	146	161	181	214	237
Science					
# of people	666	1004	1581	1184	1089
# of tours	45	55	83	91	78
# of guides	76	105	177	136	124
Students					
# of people	491	574	952	844	751
# of tours	23	26	37	47	35
# of guides	50	53	90	83	70
VIP					
# of people	356	198	190	97	99
# of tours	72	54	38	28	41
# of guides	92	63	52	28	42
Total					
# of people	1988	3621	3339	2945	2830
# of tours	283	284	337	374	368
# of guides	358	382	500	461	473

Table 9: Estimated Attendees at TRIUMF Tours

See table 9 for additional data on tours provided in each of the respective categories (TRIUMF, Five Year Plan 2010-2015 Building a Vision for the Future, 2008, p. 459)

Community and University: Working Together

TRIUMF exemplifies the immeasurable benefits of a national laboratory that works closely with the university community. The university partnerships create a symbiotic relationship of sharing of knowledge and capabilities with one another. Originally in 1968 TRIUMF was launched by three universities, today TRIUMF has grown to have 18 key university partnerships nationwide. The consortium of Canadian universities owns and operates TRIUMF. The consortium has a Board of Management, which directs the overall vision and direction of the laboratory. In 2008 the consortium formed the Policy and Planning Advisory Committee, which consists of university members, and presents detailed input on TRIUMF's planning and policy decisions (TRIUMF, Canadian University Partners & Owners, 2014).

TRIUMF offers innovative and advanced, high technological equipment that are exclusively found at the main TRIUMF facility, resulting in many partnerships. The scientists that work at TRIUMF are the main source of contact for other researchers fostering collaborative partnerships among Canadian researchers and between Canadian researchers and their international colleagues.

TRIUMF also provides salary support (in whole or in part) for about a dozen scientist residencies at Canadian universities. In addition, as an active research center, TRIUMF maintains an atmosphere that promotes intellectual activity through seminars, visitor programs, and workshops. Tying it all together is a management structure geared to maximizing the impact for Canada (TRIUMF, Canadian University Partners & Owners, 2014).

Member Universities:

- University of Alberta
- University of British Columbia
- Carleton University
- University of Guelph
- University of Manitoba
- Université de Montréal
- Simon Fraser University
- Queen's University
- University of Toronto
- University of Victoria
- York University

Associate Members:

- University of Calgary
- McGill University
- McMaster University
- University of Northern British Columbia
- University of Regina
- Saint Mary's University
- University of Winnipeg

Students that collaborate with TRIUMF universities work with the community by encouraging research related to post-doctorate fellowships, as well as offering training and research experience. “Between 2003 and 2008, 319 undergraduate students worked at TRIUMF and 104 Ph.D. and 203 M.Sc. degrees were awarded for work done at least partially at TRIUMF” (TRIUMF, Canadian University Partners & Owners, 2014). The partnerships that TRIUMF forms with its partner universities have set a solidified foundation for TRIUMF and are a huge component of the laboratories successes.

(TRIUMF, Canadian University Partners & Owners, 2014)

8.0 Findings & Recommendations

As the FRIB begins to come to fruition, consider these common findings across the completed case study analysis to determine what types of potential programs, policies, partnerships, or actions may be most beneficial.

8.1 Findings

The findings section represents an overview of general patterns, concepts, and themes that became apparent during the completion of this report. The following findings represent a synthesis of the most noticeable and potentially impactful ideas from sections 3.0-7.0.

Transfer Agent

Universities offer incredible value with their ability to act as a transfer agent. This role can move academic research toward real world impact. This became increasingly apparent in section 4.0, especially in the University of Waterloo (UW) and University of Central Florida (UCF) cases. The UW case is a wonderful example of knowledge transfer. Their innovative co-op program engages thousands of students annually. In comparison, UCF is a useful example of how technology transfer can be catalyzed at the university level. Both of these universities use their ability to transfer knowledge and ideas to the surrounding regional economy. Table 10 depicts findings from each case.

Knowledge Transfer	Technology Transfer
Provide R&D assistance to local firms	Creation of new jobs and industries
Exchange of tacit knowledge at both regional and global levels	Multiplier effect of adding new jobs
Facilitate entrepreneurship	Facilitating research-based commercialization
Attraction and retention of high quality students	Provision of support tools for start-up enterprises

Table 10: Key Elements of Transfer Agents

Proven Driver of Economic Growth

A particle accelerator facility can provide an incredible amount of impact on a regional scale. The similar facility case study analysis has illuminated some expected impacts and themes to consider for FRIB. Between the four case study facilities, expected impacts include 2-5 incubators required to enhance business acceleration in the region. In addition, 2-6 spin-off companies result every 10 years. In terms of actual employment considerations, 340-1,757 full-time employees are present, between the four cases. Conferences and visiting researchers are also significant impacts, with 3-24 conferences and 200-2,300 visiting researchers coming to each facility per year (these numbers are ranges between the four cases).

8.2 Action Strategy

As Greater Lansing Region stakeholders begin to develop a strategy for capitalizing on the FRIB, consider the following potential action items, associated timelines, and responsible parties (Table 11. The Responsible Party column is designed to provide an idea for the type of entity that is generally responsible for carrying out specific action-related tasks. The different potential parties identified are educational institutions, regional economic development organizations, and government entities.

Action Item	Responsible Party	Timeframe
Develop a branding / marketing strategy for the FRIB & Greater Lansing Region	Educational Institution, Regional Economic Development Organization	Short-Term (Less than 2 years)
Review existing regional incubator facilities and existing capacity, determine future demand	Regional Economic Development Organization	Medium-Term (2-5 years)
Hold a series of community meetings to receive input regarding FRIB and potential regional impact	Regional Economic Development Organization, Government Entity	Ongoing (for 5 or more years)
Establish an FRIB specific ongoing analytics and measurement plan with regional indicators of barriers and success	Educational Institution, Regional Economic Development Organization	
Hold Accelerator Task Force meetings to engage all interested stakeholders at a regional level	Regional Economic Development Organization	
Determine the feasibility of MSU and Lansing Community College (LCC) specific degree programs related to entrepreneurship, co-operatives, and accelerator technology	Educational Institution, Regional Economic Development Organization	

Table 11: Recommended Course of Action for Regional Stakeholders

8.3 Recommendations

This section explains the Action Strategies from Section 8.2 in greater detail. The analysis conducted throughout this report provided the basis for the development of the actions highlighted above. Recommendations for capitalizing on a high-technology anchor institution, especially one housed in a university setting, can be diverse and wide-reaching. Considerations for long-term success should consider partnerships, community engagement, branding and marketing, and workforce development. With this in mind, consider the following recommendations for establishing a compelling vision for the future of the FRIB at MSU. The following subsections follow the same order as the actions outlined in section 8.2.

Branding and Marketing

If the Greater Lansing Region hopes to become internationally recognized as a hotspot of innovation in high-technology, it must brand itself accordingly. In the University of Waterloo (UW) case study, it was clear that a brand can develop organically over time. UW has fostered a culture of entrepreneurship over decades of advanced thinking and flexible policies. The UW Co-operative vision is to "demonstrate innovative, global leadership in co-operative education and career development, and position Waterloo as a top choice for students and employers" (University of Waterloo, 2014). The result of such a culture is a willingness for companies and highly skilled individuals to be attracted to and retained within the Greater Waterloo Region. Institutional policies, brand development, cultural amenities, and attitude all have a significant impact on the perception of a given region. As such, stakeholders in the Greater Lansing Region must make a sustained effort to establish themselves as key players in the fields of advanced technology and particle acceleration.

Incubator Facilities

Educational institutions are known for employing new methods and conducting groundbreaking research. As such, there is a constant flow of new ideas and discoveries. This level of innovative activity suggests the need a strategic approach for moving new ideas from the laboratory to market-ready impact. While there are several steps from discovery to market including intellectual property issues, capitalization and production processes; one common approach to accomplish this goal is through the use of incubator facilities. The University of Central Florida

(UCF) case study showed that business incubators can provide significant return on investment for the surrounding region. Facilitating the growth of new companies within expanding industries can provide additional jobs and spending. The Greater Lansing Region already has a base of incubator facilities, but the addition of the FRIB within the region could result in increased demand or require more specific targeting of incubation facilities to meet the needs of accelerator technology. Regional stakeholders ought to determine whether or not the current incubator facilities can meet the needs of FRIB related enterprises, and if not, this gap must be addressed.

Community Engagement

While it may take a Ph.D. in nuclear physics to understand the inner workings of a structure like the FRIB, that does not mean community members have no role in such a facility's operation. The completed case study analysis has shown that community meetings, tours, and events can offer a stage for collaboration and partnerships to be cultivated. By increasing interaction between individuals who may not normally be related to the work being done at such a facility, there is opportunity for new approaches or ideas to be developed. In addition, community meetings can help to address public safety concerns related to living in close proximity to a nuclear research facility.

Ongoing Measurement

One common theme we noticed during the analysis of our case study facilities was that ongoing measurement of the impacts of each facility varied greatly from facility-to-facility, and was occasionally absent altogether. Measuring indicators such as full-time employment, spin-off industries, patents and associated royalties, operating funding, collaborations and partnerships, experiments completed, annual conferences hosted, visiting researchers, and a variety of others can provide a facility with some useful information of its impact on the surrounding region. Ongoing measurement can help explain what is being done, who is being effected, and any change in patterns over time. These are useful things to know in order to improve the effectiveness of the FRIB in an ongoing fashion and build a base of credibility in the prudent use of public resources.

Accelerator Task Force

The Accelerator Task Force, which our client has helped to organize currently exists as a committee of interested stakeholders around the development of the FRIB and related industries, such as manufacturing, education, medical technology, and others. The members of this committee have academic and professional experience in fields related to the FRIB. This intimate internal knowledge of the potential impact the FRIB may have on the Greater Lansing Region is invaluable to developing a strategy to move forward. With this in mind, the Accelerator Task Force may be best suited to discuss potential for future strategies and the best way to implement recommendations related to the FRIB and its ties to the Greater Lansing Region.

Accelerator-Specific Educational Programs

Just as UW has specific entrepreneurial and high-technology related educational programs to help support the high-technology industry cluster in the surrounding region, educational institutions in the Greater Lansing Region ought to help create the highly skilled, industry specific workforce that will help support the FRIB and related spin-offs. The region boasts a large network of educational institutions, including but not limited to Michigan State University and Lansing Community College. Industry and educational leaders have the opportunity to work together to figure out the best way to produce future employees that have the skills and desire to ensure that the FRIB and its related industries can expand and stay at the forefront of international best practices. The combination of targeted degree programs working with regional industries offer existing potential for the Greater Lansing Region as a whole.

8.4 Conclusion

As the FRIB begins construction and ultimately becomes operational in the early part of the 2020s, the Greater Lansing Region will experience significant change. Based on our review of similar cases, it is apparent that jobs, spin-offs, conferences, visiting researchers, and new discoveries will be injected into the region. In addition, we found that higher educational institutions offer an exciting opportunity for catalyzing the transfer of new ideas and technology within a region. In order to capitalize on the FRIB, regional stakeholders must plan carefully and think holistically. The FRIB accelerator has the potential to accelerate the impacts of human, physical, social, and economic capital around Michigan's capitol region in the decades to come.

9.0 Appendices

Appendix A: Bibliography

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Appendix B: Definitions for Tables 5, 6

Indicators/Data Variables Tables

Of Incubators: "an organization or place that aids the development of new business ventures especially by providing low-cost commercial space, management assistance, or shared services."

http://www.merriam-webster.com/dictionary/incubator

Of Spin-off Companies: "A spinoff is a new, separate, independently managed company created from a division of an existing company or organization."

http://www.spinoffprofiles.com/definition-of-spinoff

Of Full-Time Employees (FTE): Employees that work 40 hours or more in a single work week.

Patents: "protected by a trademark or a brand name so as to establish proprietary rights analogous to those conveyed by letters patent or a patent."

http://www.merriam-webster.com/dictionary/patent

Of Conferences Annually: Conferences with at least 100 attendees, held by the research facility per year.

Conference Attendees: Number of attendees total from conferences over 100 people.

Visiting Researchers per Year: Number of researchers not formally employed by the facility outside to complete at least one research related project.

Royalties: a sum of money paid to a patentee for the use of a patent or to an author or composer for each copy of a book sold or for each public performance of a work.

http://www.merriam-webster.com/dictionary/royalty

Operating Funding: The money required to cover operating expenses of a research facility.

Data Variables Table

Intellectual Property Assistance: Intellectual Property is the work of an intellect, inventor, mind as a result of creativity that the person has rights to and can patent. The Assistance would be outreach offices that the research facility has to help those who have intellectual property produced at the research facility obtain rights and a patent for their work.

Partners/Public Private Partnership (PPP): Other research facilities that are working together in collaboration with projects, conferences, visiting researchers, anything that relates to two or more research facilities that are in an alliance together. Public Private Partnership (PPP) "a business relationship between a private-sector company and a government agency for the purpose of completing a project that will serve the public."

http://www.investopedia.com/terms/p/public-private-partnerships.asp

University Partnership: A mutually beneficial relationship between the research facility and one or more universities. Is there a partnership between the research facility and a university or a multitude of universities?

Venture Capital Fund: "An investment fund that manages money from investors seeking private equity stakes in startup and small- and medium-size enterprises with strong growth potential. These investments are generally characterized as high-risk/high-return opportunities."

http://www.investopedia.com/terms/v/vcfund.asp