



ADVANCED MANUFACTURING INNOVATION CENTER (AMIC)

FOR THE ST. LOUIS REGION

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EXECUTIVE SUMMARY

In the fall of 2014, the Department of Defense, Office of Economic Adjustment (OEA) awarded a Defense Industry Adjustment Grant to the St. Louis Economic Development Partnership (the Partnership) to help the St. Louis Region diversify beyond dependence on defense spending, specifically linked to final assembly of the F/A-18, the E/A-18, and the F-15, three programs that, like the F-4 Phantom II back in 1979, are now poised to gradually transition out of production in coming years.

Partnership decisions in 2014 laid the groundwork for an emerging defense adjustment strategy through the nurturing of a regional coalition of manufacturing stakeholders, service providers, and associated businesses, known as the Regional Advanced Manufacturing Partnership (RAMP). This public private group has continued to meet since 2014 to provide critical input to the evolving process.

AECOM was first engaged by the Partnership in 2015 to support formulation of a regional defense adjustment strategy; this document identified clear action steps to support the emergence of an organized Regional Advanced Manufacturing Ecosystem for St. Louis.

The defense adjustment strategy called for:

- Expanded leadership and organizational capacity for an advanced manufacturing ecosystem, supported by obvious regional strength in the Plant and Life Sciences through organizations such as BioStl and Cortex,
- Pursuit of growth strategies, anchored by funding for manufacturing incubators, accelerators, and innovation facilities
- Expanded formal and informal conduits for manufacturing employment through apprenticeship and mentoring programs
- Establishment of regional leadership in metalworking and advanced materials
- Expanded linkage between entrepreneurship, IT, software development, and advanced manufacturing
- Export strategies to support defense contractor diversification

At the core of the 2015 recommendations was a clear intent to deliberately grow the St. Louis Manufacturing Ecosystem.

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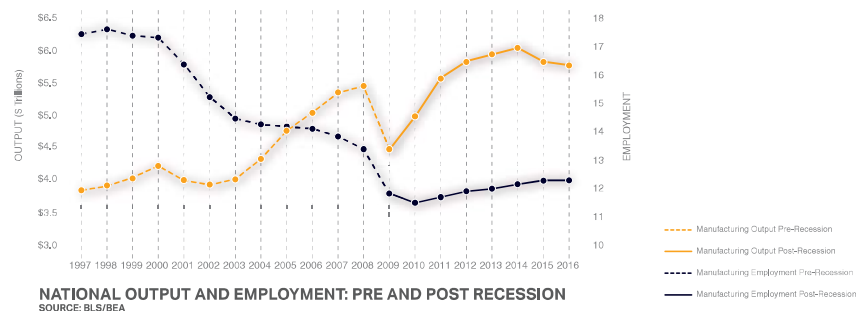
In the summer of 2017, as the logical extension of prior work, AECOM was engaged by the Partnership to prepare a master plan and financial sustainability strategy to establish an Advanced Manufacturing Innovation Center (AMIC) in the St. Louis Region, with the clear intent being a facility that can become the hub of leadership and programming to promote and encourage Advanced Manufacturing innovation throughout the St. Louis Region. The effort sought to support answers to the following critical path AMIC questions:

- What does industry need?
- At what do the regions industries excel?
- Who is the Champion?
- What manufacturing innovation model do we pursue?
- Who are other public, workforce, and higher education partners?
- Where does consequential funding come from?

- What about all that expensive equipment?
- Does “place” (i.e. a physical location vs a virtual location) matter??

Advanced Manufacturing Insights

US Manufacturing is growing robustly, but very different from what it was 10 years ago, with 2.5% annualized growth in output versus only 1.1% growth in employment. The graphic below reinforces a healthy increase in manufacturing output that has been sustained both before and after the 2008 Recession, despite a long run decline in employment. In large part, this is due to the use of capital goods in place of labor for manufacturing purposes. Using capital goods in place of labor generally leads to lower variable costs of production at the expense of higher fixed costs. As firms become larger and industries become more consolidated, preference for lower variable costs over lower fixed costs generally prevails, therefore capital goods will likely continue to replace labor, in economic terms,



As shown in the chart below, sectors including transportation (8.9%), plastics (4.5%), and chemicals (4.4%) experienced the largest annual increases in manufacturing output post-recession. While these sectors have rebounded strongly since 2010, food processing has been the primary US manufacturing sector to enjoy gradual steady growth over the past 20 years.

The now unfolding 4th Industrial Revolution has redefined our view of advanced manufacturing, with concepts such as big data, advanced materials and additive manufacturing moving to the forefront. Emergence of digitization has driven a parallel concern about Cyber-Security; a significant threat to businesses in an increasingly digital world. US Manufacturing is adding jobs for the first time since 2004, it should be emphasized that US manufacturers face two distinct disadvantages:

- US manufacturing workforce policy is pivoting, but how to replace retiring manufacturing workers is a question.
- While a majority of economic rivals maintain a defacto industrial policy, the US continues to pursue disparate and fragmented policies in support of manufacturing.

Innovation

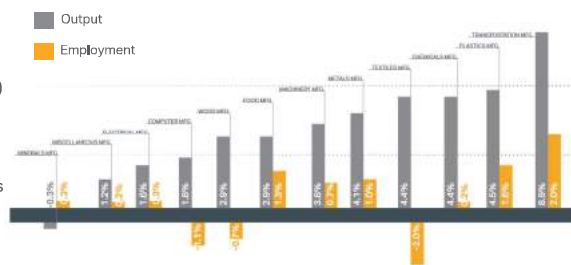
Since the 1980's, the pursuit of research and development (R&D) as drivers for innovation and economic development has been a recurring theme, with regions focused on the goal of attracting higher wage employment, spin-off development, and related economic value added. Expansion of R&D has been critical in creating industries that foster constant innovation. The St. Louis region understands this model, having perfected it in the plant and life sciences.

Innovation is a term that can take on different meanings when used in different contexts; however it fundamentally involves

the creation of a new process, idea, or product that proliferates into an existing environment or creates a new environment autonomously. Innovation comes about in one of two forms:

- Process Innovations allow tasks be completed "quicker, cheaper, or better." Examples could include reducing weight in car door panels.
- Revolutionary Innovations redefine or create a new product, process or idea. Examples include the invention of the internal combustion engine and chlorination of water.

Our experience reinforces challenges in pushing breakthroughs in basic and applied research into commercial success. This apparent gap between research and commercialization (referred to as the "valley of death") is a challenge to innovation. It is the intention of the AMIC to close this gap and accelerate economic development.

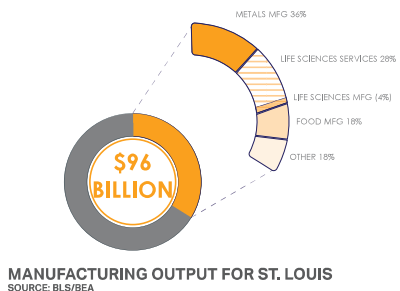
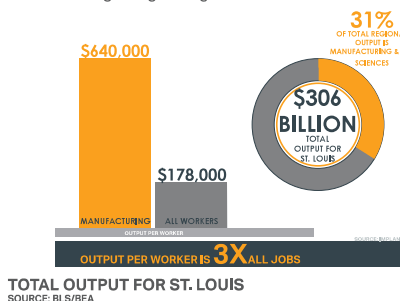


NATIONAL MANUFACTURING EMPLOYMENT & OUTPUT CAGR (2010-2016)
SOURCE: BLS/BEA

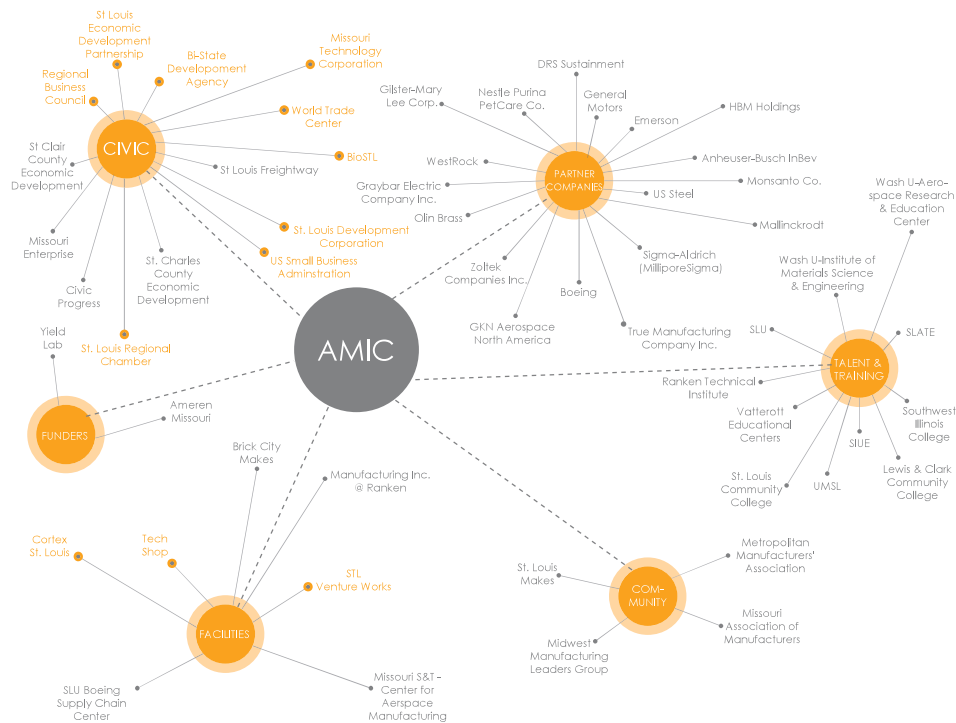
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For St. Louis, the AMIC conversation focuses on five points:

- Metal Fabrication, including aerospace, automotive, and tooling is highly concentrated in St. Louis. Metal Fabrication is the single largest regional cluster in terms of output.



- Substantive growth in manufacturing employment since 2010, at a rate faster than US averages, supported by dramatic recovery in local auto assembly (GM Wentzville) and defense aerospace.
- While aggregate defense spending remains below pre-sequester peaks, DoD spending for procurement of new F/A-18 and F-15 aircraft has increased, with an estimated \$4.8 billion in increased funding budgeted between FY 15 and FY 18. These increases do extend local defense aerospace capacity a few years into the future, buying local defense contractors additional time to approach new markets.
- While Missouri experienced growth in R&D Funding (4.4%), GDP (2.7%), employment (1.0%) and population (0.3%) annually between 2010 and 2015, it is apparent that statewide total funding for R&D (covering basic and applied research, pre-development and commercialization across private, federal, VC, and academic resources) remains below US average, with an estimated net gap of about \$4.5 billion, largely linked to below average local corporate and federal R&D spending.
- While the St. Louis region has defined itself as the center for plant and life science research, it is now clear that the regional economic footprint of metal sciences manufacturing (including automotive, aerospace, and metalworking) supports the single largest share of manufacturing output (36% of \$96 billion), but with a supporting ecosystem that remains in its infancy. The following graphic displays the network which can be improved with the addition of an Advanced Manufacturing Innovation Center in the St. Louis market.



ST. LOUIS MANUFACTURING ECOSYSTEM
SOURCE: BLS/BEA

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Industry Enablers

The AMIC conversation is intended to support companies, identify new markets and support development of technologies that link with the future of advanced manufacturing:

- **Advanced Materials/Additive MFG**– Stronger and lighter weight; Customization and improvements in product quality; enhancements to casting processes.
- **Logistics** - Improved transportation links and efficient supply chains
- **Data** - Cloud computing, Internet of Things, Big Data, and Analytics
- **Standards** - Industry standards, replicable processes and replaceable parts
- **Industrial Hardware** - Advanced sensors and semiconductors
- **Demographics + Infrastructure** - Aging population, obsolete infrastructure and urbanization

Industry Challenges

The AMIC conversation is intended to help companies overcome challenges, many of which are connected to data:

- **Business Challenges** - Finding and penetrating new markets, sustaining high quality, and remaining cost competitive
- **Continuous Improvement** – Customers consistently ask their suppliers to continuously improve their products. This pressure for process innovation (i.e. making parts “5% quicker, faster, and cheaper”) leads to a challenge, which is that after multiple years of “continuous improvement” companies tend to hit a point of inflection with a product where they need to fundamentally redesign a part. If smaller

firms can't compete, they may lose the business

- **Talent Development** – Managing manufacturing employee retirements and identifying new pathways for the next generation to participate
- **Technology Implementation** - Integration of software and hardware, interoperability across assembly equipment, and premature obsolescence of new equipment
- **Additive Manufacturing** - Tremendous potential and significant technical challenges; lack of standards, and how to work with new materials
- **Changes in Standards** - Adjust to new standards; ISO 9001:2015
- **Cybercrime** - Growing importance of data in manufacturing has security implications
- **Supply Chain Coordination** - Impact of technology on supply chains
- **Regulations** - Complying with the ever changing health and environmental regulations imposed upon industry

Recommendations

The following section outlines key findings for the conceptual master plan, the financial sustainability plan, and the branding plan for the future Advanced Manufacturing Innovation Center.

The intention of the St. Louis Advanced Manufacturing Innovation Center (AMIC) is a facility that can become the hub for leadership and applied research related to advanced manufacturing.

Recommendations focused on the role of a 501 (c)(3) non-profit structure for AMIC, governed by a board of directors. In general, 501(c)(3)s are organized and operated primarily for religious, charitable, scientific, and educational purposes.

The board of directors would play a crucial oversight role for AMIC, setting expectations and research priorities; a majority of board members should be from the private sector. Board members generally serve on a volunteer basis, and did not collect a salary at other innovation centers such as UI Labs or Lightweight Innovations for Tomorrow (LIFT). Board participation should include membership from:

- Major Manufacturers
- Small and Mid-Sized Manufacturers
- Defense Contractors
- Universities & Workforce Intermediaries
- Public Sector Economic Development Agencies
- Manufacturing Associations and Networks

An independent nonprofit governance structure can provide AMIC with the structural support it needs to promote growth and innovation in the St. Louis Region:

- 501(c)(3) organizations offer flexibility in their governance structures, and are empowered to craft their own governance policies at the institutional level.
- IRS oversight of 501(c)(3) organizations is intended to ensure that the respective institute is not in violation of tax exempt status, and oftentimes this oversight compels nonprofits to establish policies related to: compensation, conflicts of interest, fundraising, investments, record retention, and the establishment of a code of ethics.
- Independent governance structures provide more flexibility than dependent governance structures, and independent nonprofit structures are common among many innovation centers (e.g. DMDII, LIFT, CCAM, ICNC).
- Governance structures that organizations use are flexible as opposed to fixed, and should circumstances materially change at an organizational level, an entirely new governance structure can be adopted.

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Conceptual Master Plan

The AMIC will be a 21st century manufacturing building for the next generation of manufacturing workers. Key elements include:

- Need for a physical site that can support expansion is linked with the premise of "deliberate serendipity"; i.e. intentionally creating a location where physical proximity of people can drive innovation and research.
- The building form responds to the three key programmatic functions; high bay space, specialty labs, and workplace.
- The building form is to be flexible; arranging the programmatic features in modules that can be expanded or contracted as the facility design develops.
- As technology is evolving several manufacturing processes are becoming more streamlined. A physical innovation center for St. Louis will provide manufacturers with a zone to develop new and more efficient modes of manufacturing.
- A physical location can provide these manufacturers with the latest in equipment and processes that they may not have the access to otherwise due to financial reasons which will appeal to larger companies to leverage their existing R&D efforts.
- The appearance of the facility shall be engaging, exciting, and provide an outward expression of the research efforts conducted within to the community.

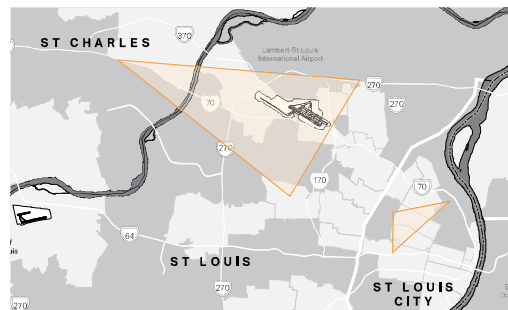
Through extensive case study research the following site drivers were established for the location of the facility:

- Affordable and available land, either vacant, or suitable for redevelopment to allow for current development and future growth. The AMRC in Sheffield has expanded to an industrial park of 100 acres.

- A site that can accommodate an existing or new 40,000-60,000 sf building and parking.
- A site that will remain zoned for industrial / manufacturing; Americas Central Port would be an example.
- A site that can be accessed by semi-trailer
- A site with physical proximity to partner companies, workforce training/ education, and urban core/ transit.

Across the St. Louis region, four types of sites were identified: Infill, Redevelopment, Academic/Workforce, and Industrial/ Aerospace.

In contrast with these sites we acknowledge that, the region is beginning to see the emergence of one Innovation Triangle anchored by CORTEX, the National Geospatial Agency, and Ranken Technical College. A second potential cluster could be anchored by Lambert-St. Louis International Airport, 39 North, and eastern St. Charles County.



Financial Sustainability Plan

Staffing: 10 To 20 People
Labor Budget: \$750K To \$1.5M
Total Operation Budget: \$1.5M To \$3.0M
Capital Costs: \$12-16M (Building And Site)
Operating Equipment: \$5M

- Initial funding requirements for innovation centers are largely dependent on the organizational structure employed by the institute, the innovation center model that the institute operates under, and the desired functionalities of the institute.
- Individual Manufacturing USA facilities have secured upwards of \$140 million in public and private funding.
- Financial sustainability plans can be implemented at the inception of an innovation center, with a target date for financial self-sufficiency and funding source distribution.
- The institute will need a public sector sponsor or champion (e.g. a Federal agency such as the Department of Defense, State/County/Municipal Government) to help foster the institute, while supplemental funding from private and academic sources is being developed.
- Within the St. Louis region, academic institutions such as Missouri University of Science and Technology, Washington University, University of Missouri St. Louis, St. Louis University and Webster University could serve as funding partners and research partners for the institute, providing in-kind support to the innovation center.
- Private sector funding for AMIC would likely begin with a core group of private sector sponsors who claim leadership positions within the institute. Over time, private sector

income streams can be developed from new memberships. The Manufacturing USA institutes have a propensity toward particular sources of funding (in the case of Manufacturing USA institutes public sector funding).

- Innovation centers that serve as a sub-unit of another institution, for example the AMRC at Sheffield, can adopt vastly different funding models than independent innovation centers, and these institutes may give up elements of their funding flexibility for more stable financing cash flows.

Branding Plan

- AMIC will have a generalized focus on advanced materials, additive manufacturing, and digitization. Clearly as the program evolves its focus could shift.
- By their very existence, innovation centers provide innovation as a component of their value proposition, providing society with a hub of innovation, dialogue, and technological improvement.
- In accordance with technological improvement, AMIC can serve as a critical link between technological and workforce improvements, giving the St. Louis workforce a bridge to learn the skills that are increasingly demanded by the manufacturing sector.
- As the facility develops, an annual symposium of world manufacturing thought leaders could lead to new research ventures and partners.

01

PROJECT INITIATION : ECONOMIC CONTEXT

Manufacturing across the world is entering into a new era, and St. Louis is situated in a unique position to shape manufacturing of the 21st century. An analysis of the economic backdrop of this change in manufacturing and the positioning of St. Louis reveal insights that are critical to the understanding of St. Louis in this turbulent manufacturing environment.

1.1 ADVANCED MANUFACTURING CONTEXT

Overview

The AMIC effort evaluates the current state of manufacturing in St. Louis squarely in context with generally understood definitions of “Advanced Manufacturing”, defined by the President’s Council of Advisors on Science and Technology as a family of manufacturing activities that:

- Depend on the use and coordination of information, automation, computation, software, sensing, and networking;
- Utilize cutting-edge materials, advanced processes, and emerging capabilities in the physical and biological sciences (nanotechnology, chemistry, and biology).
- Advanced manufacturing production is also Additive; products move through several assembly stages using third party logistics providers, linked by nimble supply chains.
- Are highly aligned with research and development activity and closely associated with workforces that are strong in science, technology, engineering, and math (STEM) fields; this point speaks to why workforce development must be at the core of any future defense adjustment strategy

While the technological enhancements that drive advanced manufacturing are recent, what has not changed is the important reality of end market competitive pressures, where customers are constantly asking suppliers to fabricate or redesign a part faster, cheaper, or lighter. This constant demand drives manufacturers to pursue capital investments to sustain incremental process improvements (i.e, efforts to make something slightly faster, cheaper, or lighter). Over time, it also leads to an infrequent number of far more profound and radical new product innovations, otherwise known as “industrial revolutions”:

- 1.0 Mechanization of production using water and steam power.
- 2.0 Evolution of mass production using electrical power.
- 3.0 Digitization and use of electronics and information technology to automate production.
- 4.0 Collective embrace of big data, logistics, advanced materials, lean manufacturing techniques, and the Internet of Things to create mass customization of production.

These radical changes are reflected in new power sources (the steam engine in the 1700s), new communications technologies (the telegraph in the 1800s and the internet in the 1980s), and new industrial processes (Haber-Bosch; extraction of ammonia from atmospheric nitrogen around 1910). While these innovations all eventually disrupted existing markets and created new opportunities, it still took many years to move from proof of concept to commercial marketability, a reality that remains true today, for example with 3D / Additive Manufacturing.

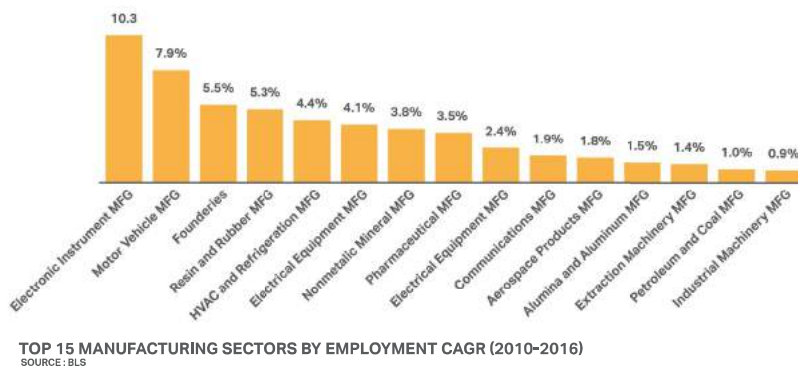
Our research highlights several distinctions about the now unfolding Industrial Revolution 4.0 related to “Advanced Manufacturing” that are critical for the St. Louis Region:

- Manufacturers are evaluating new enabling technologies (3D / Additive manufacturing) and advanced materials (powdered metals, composites, nano-tubes, adhesives) in their manufacturing processes as they pivot toward new and evolving end-market opportunities. While recent developments in additive manufacturing focus on companies such as General Electric “printing” commercial jet engine fuel nozzles, universities such as Missouri S&T are finding that additive manufacturing processes are still evolving, due to uncertain technical standards and variability across production.

- US recovery in manufacturing is on-going, linked in part by a weaker US Dollar, as well as to concepts such as “re-shoring” where manufacturing jobs are gradually being relocated closer to the US from overseas. In general, our experience shows that returning jobs tend to be in sectors that are specialized and advanced, supporting higher wages. Sectors where the manufacturing process remains more commoditized or where transportation costs are not a factor in the production process are seen as less likely for return in the short-term. What is surprising is that a surprising number of components are currently not made in the US; examples include small motors and optics.
- The unfolding revolution in energy costs is impacting sectors that rely on natural gas as a feedstock for production processes but also is sparking innovation in energy storage and renewables, as manufacturers seek to gain a measure of control over their utility bills.
- As quality expectations are already consistently high, companies are compelled to compete on price and contemplate purchase of capital equipment to increase capacity and reduce labor.
- US manufacturing workforce policy is pivoting, but how to replace retiring workers remains the big question.

Regional Manufacturing Growth

Several manufacturing sectors have experienced healthy employment recoveries since the Recession of 2008 in the St. Louis region, with several industries adding jobs at annual rates above 5%. The graphic below depicts the top 15 manufacturing sectors based on their annual employment growth between 2010 and 2016:



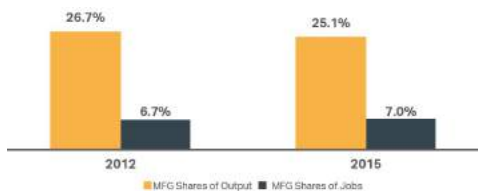
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1.2 ST. LOUIS MANUFACTURING

Introduction

The St. Louis region has historically been a consequential US industrial center. Specifically, a robust set of manufacturing industries, ranging from aerospace manufacturing to food manufacturing, hold sizable presence within the region, and these industries have helped to contribute to the St. Louis industrial spirit. Manufacturers in the region also field a remarkably productive workforce, as illustrated by the graphic below.



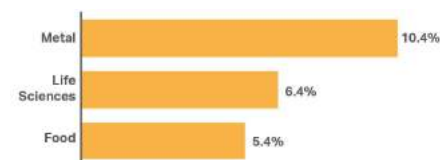
ST. LOUIS MANUFACTURING (TOTAL OUTPUT/EMPLOYMENT)

In both 2012 and 2015, St. Louis manufacturing workers produced a share of regional output that was over three times larger than their share of regional employment. Additionally, the importance of manufacturing to the St. Louis region is reinforced by the above graphic: over one in four dollars of output produced in the region was directly contributed by manufacturing in 2012 and 2015, and over one in twenty workers in the region were employed in a manufacturing establishment. Understanding the nature of this vital industry requires a more detailed level of analysis.

St. Louis is home to many different types of manufacturing including metal, food, and life science manufacturing among others. The three mentioned manufacturing types are among the most important to the region for different reasons.

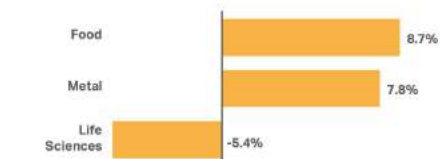
Metal Manufacturing

Metal manufacturing provided the largest amount of output out of all manufacturing types in both 2012 and 2015, and has produced either a majority or plurality of manufacturing output at various points in time. Metal manufacturing experienced the fastest annual increase in output between 2012 and 2015, as indicated by the graphic below:



Food Manufacturing

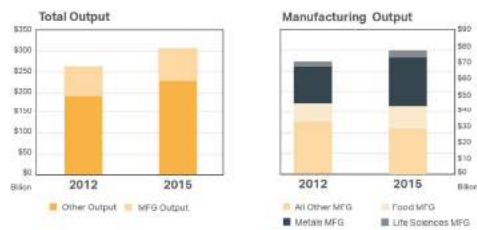
Food manufacturing is the second largest of the three focused manufacturing types in terms of output and employment, Food manufacturing served as a major area of employment growth in the St. Louis region between 2012 and 2015, and attained the fastest employment growth rate of the three focused manufacturing types over this time period:



At an 8.7% annual growth rate in employment, food manufacturing added jobs at almost three times the regional rate (8.7% vs. 3.1% for the region), reinforcing the economic benefits that are provided by food manufacturing.

Life Sciences Manufacturing

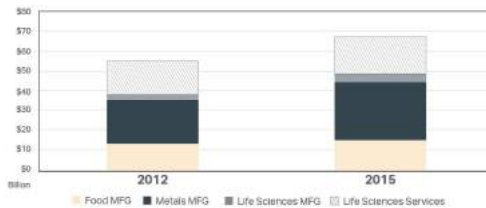
Life sciences manufacturing was one of the smaller manufacturing sectors in terms of output, and it experienced the fastest annual decline in employment out of all major manufacturing types. Life sciences manufacturing, which includes the production of medical and laboratory goods, is helped by the importance of life science services to the St. Louis region. Consider the series of graphics below:



GDP ANALYSIS: MANUFACTURING & MANUFACTURING TYPE
SOURCE: IMPLAN/ ST. LOUIS CHAMBER

The graphic above depicts manufacturing output relative to total output in the left two columns, and a breakdown of manufacturing output by the focused manufacturing types. Life science manufacturing has generally represented a smaller share of manufacturing output. However, when life science services are analyzed alongside life science manufacturing, the true potential of the industry can be realized.

The graphic below depicts the combined output impact of life science manufacturing and services against metal and food manufacturing:



FOOD, METALS, AND LIFE SCIENCE MFG OUTPUT COMPARISON
SOURCE: IMPLAN/ ST. LOUIS CHAMBER

When life science services are included in the impact calculus of the life science industry, the combined life sciences industry provided an output contribution equal to 76% of the metal manufacturing level of output in 2015. While the combined life sciences industry certainly plays a role in the St. Louis region, the impact of life sciences manufacturing is smaller when analyzed independent of life science services.

Conclusion

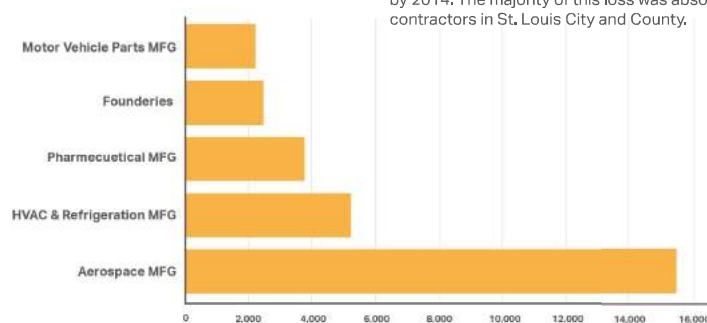
Metalworking, food, and life sciences manufacturing have provided the St. Louis region with a large component of its manufacturing output and employment and continue to provide the region with new opportunities for innovation and growth. While the life science industry has played a pivotal role in the recent growth of the St. Louis economy, the more historically rooted metal and food manufacturing industries have continued to play a central role in the St. Louis economy as well, but need support.

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Of particular note is the recovery of the automotive sector after past plant closures in 2006 and 2009. Annual employment gains of 7.9% since 2010 bode well for the health of the auto industry in St. Louis. Local positioning for the unfolding industry pivot to electrification will be important, in part because the St. Louis region has one remaining auto assembly plant, GM-Wentzville.

One concern for the St. Louis region relates to a dependence on aerospace manufacturing for an advanced manufacturing base within the region. In 2016, aerospace manufacturing held an employment level of approximately 15,500 workers, nearly 3 times the employment level of the next closest advanced manufacturing sector, HVAC and commercial refrigeration manufacturing. The graphic below illustrates the disparity between aerospace manufacturing and the next 4 largest advanced manufacturing sectors in the St. Louis region:



2016 EMPLOYMENT LEVELS OF THE TOP 5 ADVANCED MANUFACTURING SECTORS IN ST. LOUIS
SOURCE: BLS

As of 2016, aerospace manufacturing represented 34% of advanced manufacturing employment in the St. Louis region, while the top 5 advanced manufacturing sectors represented 64% of advanced manufacturing employment. As a result of the St. Louis region's advanced manufacturing base, relatively few industry sectors are ideally positioned to absorb workers in the short-term.

Local Impact - DoD Pull-Back/Sequester

Concern over loss of F-15 and F/A-18 production should be put in context with broader reductions in DoD spending following wars in Afghanistan and Iraq as well as "The Sequester", otherwise known as the set of automatic spending cuts put in place beginning in the spring of 2013 as a result of the Budget Control Act of 2012. These activities resulted in a significant decline in top-line defense spending in the St. Louis Region, falling from almost \$12 billion in annual spending down to less than \$6 billion by 2014. The majority of this loss was absorbed by defense contractors in St. Louis City and County.

Local Impact F-15 and F-18 Production

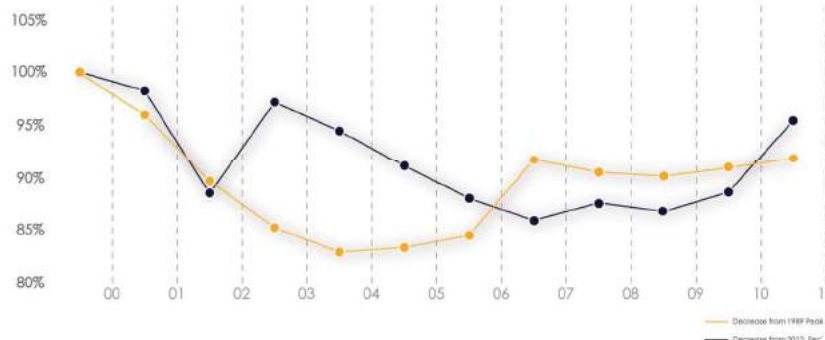
Conversations between DoD and the US Congress over the past 15 years have come to a head within the past 2 years over funding for new combat aircraft. Two structural issues are in play:

- Current transition from 4th generation fighter aircraft (F-15, F-16, F/A-18) to "5th generation fighter aircraft (F-22 and F-35)
- The "Fighter Gap"

The F-35 Lightning II (Joint Strike Fighter) program is intended to replace the F-16, A-10, and F/A-18. The F-35 is referred to as a "5th generation aircraft, incorporating stealth, enhanced maneuverability, advanced avionics and network

communications, engines, and airframe designs. Like any advanced weapons program, significant delays have occurred.

The program is now rapidly progressing through development of software and avionics systems, such that production can ramp up by 2019. The "Fighter Gap" is closely related to delayed ramp up in F-35 production as well as increased use of existing F/A-18 and F-15 aircraft in combat (particularly Navy and Marine Corps) over the past 10 years, with the result being that F/A-18s are "running out of hours" of airframe life at a faster rate. As a response, DoD has budgeted significant service life extension funding through FY 2018 and has increased procurement of new F/A-18s and E/A-18s to address the "Fighter Gap." Recent procurement announcements appear to have extended the life of production in St. Louis, arguably to 2020.



CHANGE IN DEFENSE OUTLAY FROM PEAK YEAR, 1989 AND 2012.
SOURCE: DOD

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Variables for the F-18 program include:

- Impact of foreign military sales, with customers weighing lower costs for F-18s in context with higher costs associated with more advanced technologies found in the F-35.
- Anticipated growth in need for the electronic warfare version of the F/A-18 (the E/A-18)

Variables for the F-15 program are notable:

- The F-15 is in a not-dissimilar situation, with current major overseas procurements for the Royal Saudi Air Force expected to keep the St. Louis production line open arguably through 2020.
- The Saudi F-15s now being assembled in St. Louis are reportedly a "more advanced" variant compared to existing USAF F-15s
- The US Air Force (USAF) has a similar "Fighter Gap" issue linked with constrained production of 5th generation F-22s as well as currently limited production of F-35s, even as mission requirements have generally increased. In the spring of 2016, Congress made a formal request of DoD about costs to restart F-22 production; this aircraft was produced in Georgia under a joint venture between Boeing and Lockheed-Martin.
- A key element of the F-35 program is greater communications between individual aircraft weapon

systems. As such, strategies that allow future F-15s to fly in combat with F-35s would require additional upgrades to F-15s.

In total, two points about F-15 and F-18 production in St. Louis are clear:

- While these aircraft represent roughly 25% of DoD aircraft production activity, the region continues to do other DoD Aerospace work. For example, several local contractors have contracts with Lockheed-Martin to support production of F-35. Also, while the Boeing-Lockheed Team was not awarded the Advanced Bomber contract, recent sub-contract announcements did include St. Louis-based operations for GKN to support with carbon fiber and composites. Lastly for St. Louis unfolding decisions related to the T-X trainer program to replace existing USAF training aircraft will be significant.
- Beyond volatility created by the political process and a close relationship to DoD procurement there is a clear sense that the F-15 and F/A-18 will eventually follow in the footsteps of other retired combat aircraft such as the F-4 Phantom and F-14 Tomcat. Defense contractors in the St. Louis Region need to be prepared for this inevitable transition.



US NAVY / USAF AIRCRAFT PROCUREMENT.
SOURCE: DOD

Indirect Purchases
Modifications of Existing Aircraft
New Aircraft

Challenges and Enablers to Manufacturing

Manufacturing in the 21st Century faces a consistent stream of new challenges and enablers that have the ability to drastically alter markets and shift opportunities. These challenges and enablers come in different forms, some of which have existed for centuries (e.g. challenges in running a business) and some of which could not have been imagined mere decades ago (e.g. cybercrime). For manufacturers, the ability to navigate a constantly changing industrial landscape will remain of paramount importance in the near future. Manufacturers who are able to capitalize on manufacturing enablers and mitigate manufacturing challenges have the ability to flourish in the new age of manufacturing.

Challenges to Manufacturing

Manufacturers across the globe are in the midst of facing challenges to their businesses, and these challenges come in different forms. Challenges that manufacturers face in 2017 are as follows:

- **Business Challenges** – Manufacturers often have difficulty in expanding their operations within their current market and discovering new markets that they can enter. Business development is further hindered by the administrative tasks that are required to operate a business (e.g. accounting, legal) that take resources that could be used for business development and instead must be used to administer the business. Manufacturers can face any type of business challenge, including difficulties in market penetration to accounting problems in a given tax year.
- **Continuous Improvement** – Competition amongst businesses has led to increased pressure on supply chains to operate more efficiently. As consumers continue to demand products with better quality and lower prices, pressure moves throughout the supply chain to suppliers who must

ultimately produce goods with better quality and lower price. An inability for suppliers to continually improve their products can lead to their supply chain partners finding new suppliers for their products.

- **Workforce Development** – As new technology replaces old tools and processes, workers must be equipped with the knowledge and skills to use this new technology effectively. Workforce development can give workers an opportunity to learn the skills they need to use these new technologies. Human capital investments such as workforce development can help create a technologically competitive workforce for communities.
- **Technology Implementation** – As technology becomes more sophisticated, adoption of new technologies may be required for businesses to remain competitive. For manufacturers new technology can make a world of difference in terms of production costs. Implementing new technology can be both costly and difficult for businesses due to the increasing complexity of this new technology. For example, implementing robotics into a production line requires that the robot be equipped with all of the hardware that is required to both perform its task and data, in addition to all of the software that is required for the robot to operate with any degree of precision. The software that the robot uses to carry out its instructions must explicitly give the robot instructions of how to handle workplace scenarios and therefore must be constantly maintained and updated to ensure accuracy and quality. Mere implementation of these intricate technologies can be difficult for businesses, and maintaining these new technologies can be even more costly. Manufacturers may face the challenge of technological implementation when they are forced to implement new technology unexpectedly to remain competitive, or when their new technology does not work as planned.

- **Additive Manufacturing**– While additive Manufacturing has generated significant cost savings linked to reduced inventories and enhanced methods for metal casting processes, it is clear that further research and investment will be needed for additive manufacturing to fully move beyond prototyping into production. Challenges relate limited industry standards for items fabricated through additive manufacturing as well as concern about the rapid pace of change which creates risks that new additive manufacturing equipment will become obsolete well before its cost can be amortized.
- **Changes in Standards**– Quality management standards, such as ISO 9001 created in 2015, place more stringent quality standards on industry, including manufacturers. Navigating through the legal waters involved in these regulatory changes can be challenging for companies, and a failure to comply with these standards can materially harm businesses. Manufacturers may face difficulties in navigating new quality management and environmental standards that are imposed upon them, particularly if their production processes materially conflict with these new standards.
- **Cybercrime**– Cybercrime poses a threat to all companies that have a digital footprint, and in an increasingly digitized world that includes nearly all manufacturers. People who engage in cybercrime steal intellectual property and sensitive information from businesses, and even bring the operations of businesses to a halt. To combat cybercrime, businesses must ensure that their networks are secured and that strong cyber defenses are in place to mitigate virtual attacks. As of February 2017, a Hiscox Cyber Readiness Report found that fewer than half of US businesses were prepared to deal with cyber attacks, indicating that many businesses still struggle to face this challenge. For manufacturers, cybercrime can lead to intellectual property theft or potential damage to their production process. For defense contractors, cybercrime has obvious national security implications.
- **Supply Chain Coordination**– Supply chains have become more complex, and in order to maintain total quality control and have a competitive edge, manufacturers may wish to work with other parts of their supply chain to increase efficiency and quality. Collaboration throughout supply chains can be difficult, particularly if supply chain members do not trust one another or if digital communication is not transparent throughout the supply chain. Manufacturers that struggle to communicate can be put at a competitive disadvantage and potentially create inefficiencies in their production process.
- **Regulations**– Manufacturers in the United States face challenges from an increasingly regulatory legal environment and volatility in regulation. Food manufacturers have experienced significant changes to their business practices since the passage of the Food Safety Modernization Act (FSMA) in 2011, which required them to develop strong safety protocols to combat food-borne illness. The FSMA also requires food manufacturers to audit their own protocols routinely, adding to the already challenging burden of food safety. Environmental regulations in the form of fuel efficiency standards have historically increased, causing increases in cost and flexibility to manufacturers. As the regulatory environment of the United States continues to become more complex and stringent, manufacturers will be challenged to play a game of keep-up with regulators.

Enablers to Manufacturing

While manufacturers face significant challenges to their operations, there are also several enablers to manufacturing that can be capitalized on by businesses to support their operations.

- **Logistics**- As supply chains become larger and serve wider areas, enhanced transportation links can connect these supply chains with greater efficiency. Sound logistics are essential when goods are produced in several different locations, and in an increasingly fragmented production landscape this benefit can be realized. Manufacturers can benefit from improved logistics through a more efficient supply chain and reduced costs.
- **Industrial Software**- Software packages have advanced significantly from early punch systems used to operate looms. Today, manufacturers have access to cloud computing and Internet of Things devices that can fully integrate their production processes. These new software products allow for improved efficiency of production processes (e.g. if a snag occurs somewhere along the production chain, every other point on the chain will know it immediately), and can reduce costs associated with production. Sophisticated software is also able to process significant amounts of data and churn out useful analytics that help the production process operate. Manufacturers can benefit from industrial software by creating more sophisticated robotic production systems that reduce costs and increase efficiency.
- **Standards**- While adopting new standards can initially disrupt business, industry standards can also allow businesses to operate in a more stable environment. For example, the introduction of standardized parts for production processes (e.g. 3D printing), can allow for the cost savings of replaceable parts and replicable processes to proliferate into these new methods as well. Manufacturers could benefit from the standardization of industrial parts, as these products would be less difficult to replace than in their current form.
- **Industrial Hardware**- New hardware that can be used for industrial processes opens the door to new production

techniques and methods. Sensor technology that can collect new types of data or more accurate data can allow for more automation to occur. Semiconductors that improve according to Moore's Law can double their processing speed every 2 years, leading to an exponential increase in processing power for industrial hardware. The use of new industrial hardware can help manufacturers implement cost saving processes and increase efficiency of production.

- **Demographics/Infrastructure**- Global population is growing, and is becoming older and more urban. As a result, businesses that are able to position themselves to appeal to these new demographic attributes of the population can benefit from these underlying changes. Infrastructure is outdated in many parts of the world, and as these existing infrastructure systems are repaired or replaced, transportation efficiency can improve. Manufacturers can benefit from new consumers in the marketplace, along with improved infrastructure in the places they operate in.

The Innovation Process

As capital equipment becomes more important to manufacturing, and the economy as a whole, increased importance must be given to innovation. Innovation is a term that can take on different meanings when used in different contexts; however it fundamentally involves the creation of a new process, idea, or product that proliferates into an existing environment or creates a new environment autonomously. Generally, innovation comes about in one of two forms:

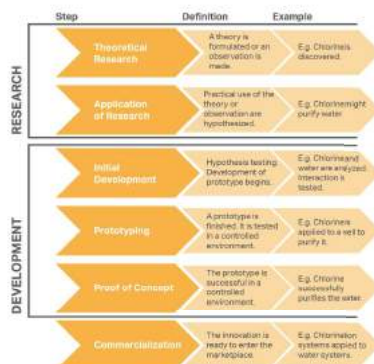
- **Process Innovation**- Innovations that allow tasks be completed "quicker, cheaper, or better." Examples could include lightening car door metals or pre-slicing meat before cooking food. These innovations proliferate into existing markets without materially altering them (i.e. other actors in the market do not need to adapt to their creation).

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- **Revolutionary Innovation**- Innovations that overhaul or create a new product, process or idea. Examples include the invention of the internal combustion engine, the Jacquard loom, and chlorination of water. These innovations can either proliferate into existing markets and materially alter them, or alternatively create new markets themselves.

Both process and revolutionary innovations are generally not developed at a single instance of time. Rather, these innovations are often developed over a period of time and after completing a series of different steps. These steps can be referred to as the innovation process. The innovation process is closely related to the traditional scientific method, but has been adapted to accommodate the entire R&D process as well as post-development proliferation of the innovation. The following steps are included in the innovation process:



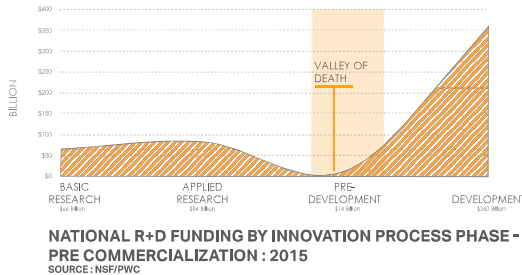
Innovations will progress through the innovation process in different orderings and time frames. For example, process innovations will generally not require basic or applied research, as the theories and products that are being improved are already established and understood. In contrast, process innovations will oftentimes occur in either the development or commercialization phases of the innovation process, as improvements can be made to the design of an innovation or its delivery to users.

Alternatively, some innovations may invert steps in the process, such as observing the application of an idea prior to knowing anything about the cause of the application (e.g. building boats out of materials that are observed to be buoyant prior to knowing anything about the material or testing it). In general however, innovations will follow the innovation process and move through each step of the process, potentially several times, until the innovation is finally commercialized.

The R&D portion of the innovation process generally includes the first 4 steps. Basic and applied research types form the research component of R&D, while initial development and prototyping form the development component of R&D. For innovations to survive the innovation process, the innovation must receive support through every node of the innovation process.

The Challenge of Innovation

Successfully moving innovations from a theoretical state to a practical application is difficult to achieve. R&D funding is one challenge to innovation. In recent years, R&D funding has been most available for innovations in either a theoretical state or a practical application (research or development). However, few resources have been allocated to activities that transfer research into development. The graphic below depicts R&D funding at each phase of the innovation process, pre-commercialization:



1.3 MISSOURI INNOVATION

Overview

Since 1821, Missouri has fostered innovations and innovators within its borders. Innovators who were pioneers in their fields, such as astronomy's Edwin Hubble and biology's George Washington Carver, were raised in the State that has been referred to as the Gateway to the West, and the pioneering spirit of Missouri has continued into the contemporary era.

Historically, Missouri has commanded a respectable amount of R&D activity, though has not been one of the top 10 States conducting R&D in recent times. Despite this fact, since the 2008 Recession, Missouri has generally experienced positive trends for R&D funding, with total funding growing at 4% per year (in contrast to the 5% annual growth rate for R&D funding nationally). Overall, Missouri has the potential to be a hub of innovation within the Midwest Region, and possesses the human capital to foster innovations within the State. An analysis of R&D funding within the State of Missouri allows for further insights into the State's innovation landscape to be acquired.

R&D Funding Trends

Metric	2010	2015	CAGR
Population	5,988,927	6,076,204	0.3%
Employment	2,658,400	2,796,900	1.0%
GDP	\$255,865,000,000	\$292,718,000,000	2.7%
R&D Funding	\$4,464,770,500	\$5,545,616,100	4.4%

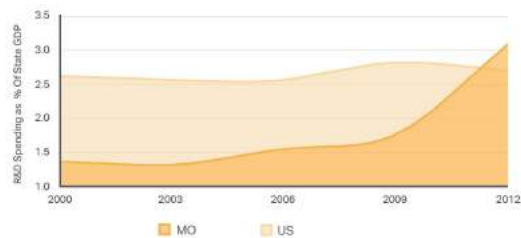
GROWTH RATE COMPARISON: 2010-2015 MISSOURI
SOURCE: US CENSUS, BLS, BEA, & NATIONAL SCIENCE FOUNDATION

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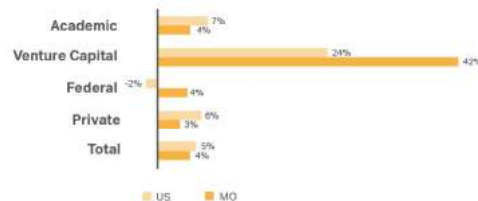
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As a State, Missouri has experienced growth since 2010, with increases in the State's population, employment level, total GDP, and total R&D funding. Notably, the annual growth rate for R&D funding within Missouri has outpaced the growth of population, employment, and GDP within the State, a trend that bodes well for the cultivation of a healthy innovation environment in the future. The previous table depicts the annual growth of each of these economic metrics within Missouri.

The State of Missouri experienced an increase in non-venture capital R&D funding as a percentage of State GDP after the 2008 Recession. The increase in R&D funding in Missouri occurred even as national funding levels for R&D decreased slightly, which bodes well for Missouri's R&D potential. The chart below depicts the R&D funding that the Federal Government, private sector, and academic institutions provided for R&D as a percentage of GDP:



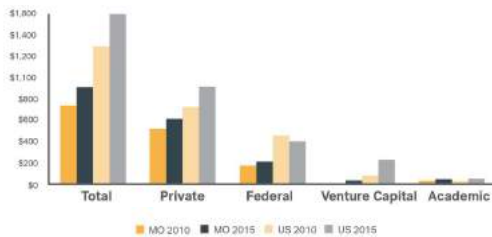
With venture capital included, Missouri's total R&D funding growth rate was slightly below the US growth rate. The chart below depicts the annual change in funding provided by each source within the United States and Missouri:



NOTE: *PRIVATE TOTAL IS BASED OFF OF 2009, NOT 2010 DUE TO DISCLOSURE

The graph above illustrates that funders of R&D within Missouri have provided different levels of R&D funding than funders nationally have in recent years. For example, Federal funding for R&D within the State of Missouri increased at an annual rate of 4%, while nationally the Federal Government cut funding for R&D by 2%. In contrast, private sector actors increased R&D funding in Missouri at an annual rate of 3%, half of the national rate of 6%.

While Federal and private sector organizations constitute a majority of R&D funding in both Missouri and the United States, the funding trends of these organizations differed greatly between the two geographies. Different sources of funding have a tendency to support different phases of the innovation process; therefore the distribution of R&D funding can provide insights into the nature of innovation in a given area. A per capita analysis of R&D funding in Missouri and the United States reveals further insights about R&D funding in both geographies:

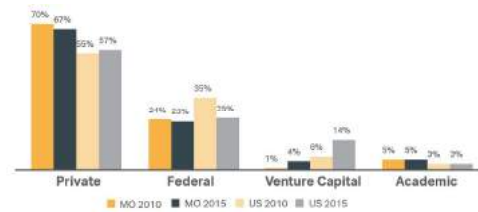


NOTE: *PRIVATE TOTAL IS BASED OFF OF 2009, NOT 2010 DUE TO DISCLOSURE

PER CAPITA R&D TOTALS*
SOURCE: NATIONAL SCIENCE FOUNDATION, US CENSUS, & PWC

The graph above indicates that on a per capita basis, Missouri has deviated from national R&D funding levels since the 2008 Recession. Between 2010 and 2015, the total per capita gap in R&D funding between Missouri and the United States increased from \$550 to \$700, although total per capita funding in both geographies increased over the same time period. Notably, a large gap existed between per capita venture capital funding in Missouri and in the United States, which contributed to the lower total R&D funding level for Missouri. Proportionally, the sources of R&D funding within Missouri contribute vastly different shares of total R&D funding than these sources do nationally.

The graph above indicates that private sector organizations in Missouri provided a larger share of total R&D funding than private sector organizations did nationally. In contrast, venture capital funding in Missouri represented a significantly smaller share of total R&D funding compared to the national share, and the gap between Missouri and the United States has widened since 2010.



R&D SOURCE OF FUNDS (%): MISSOURI & UNITED STATES
SOURCE: NATIONAL SCIENCE FOUNDATION, US CENSUS, & PWC

The Federal Government and academic institutions within Missouri provide similar shares of R&D funding as in the United States nationally. Fundamentally, R&D funding within Missouri has increased since 2010 at a rate that closely mirrors the national rate, however Missouri has not possessed as large of a per capita R&D funding pool to grow from. As a result, Missouri has been unable to match or surpass the national per capita levels of R&D funding between 2010 and 2015.

On a per capita basis, the Federal Government, private industry, and venture capital organizations have not provided the same level of support to Missouri that they did across the United States, while Missouri's academic institutions have provided a similar level of per capita support for R&D to academic institutions nationally. The distribution of Missouri's R&D funding in 2015 presents several opportunities for the State to enhance its innovation environment.

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If each source of funding within Missouri provided the same per capita R&D funding as US sources did in 2015, Missouri would have had an additional \$4.2 billion to use on R&D.

The chart below depicts the potential R&D funding that could have been used in Missouri if each source of funding provided a per capita level of support that matched the United States nationally.



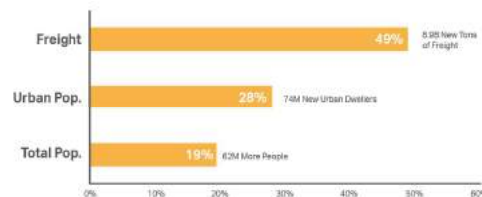
MISSOURI TOTAL R&D FUNDING & MISSED OPPORTUNITIES (2015)
SOURCE: NSF & PWC

A thorough understanding of where resources flow from in Missouri's innovation environment can help provide insights to continually foster innovation across the State. Leveraging all of the State's resources to engage in innovation has the potential to help Missouri don the mantle of innovation hub of the Midwest.

1.4 ADVANCED MANUFACTURING AND LOGISTICS

Overview

Basic demographic shifts are expected to create new opportunities between 2015 and 2045. It is estimated that an additional 62 million people will call the United States home, and 74 million additional people will reside in an urban or suburban environment. The projected increase in population, in conjunction with the projected increase in urban dwellers, is expected to increase the demand for freight over the same time period. By 2045, an additional 8.9 billion tons of freight are projected to flow through the United States. The following graphic depicts the total percentage change of each of these metrics between 2015 and 2045: Manufacturers are in a unique position to help supply new goods demanded by America's burgeoning population. By continuing to improve the manufacturing industry, American manufacturers can maintain their global competitiveness in the future.

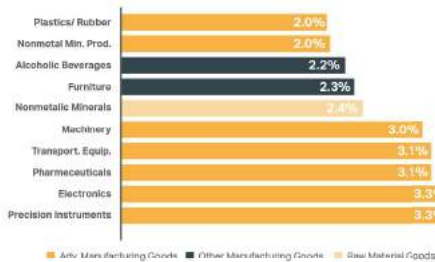


POPULATION, URBAN DWELLING POPULATION, AND TOTAL FREIGHT TONNAGE PERCENTAGE CHANGE (2015-2045)
SOURCE: UNITED NATIONS & DEPARTMENT OF TRANSPORTATION (FREIGHT ANALYSIS FRAMEWORK)

St. Louis Freight & Logistics

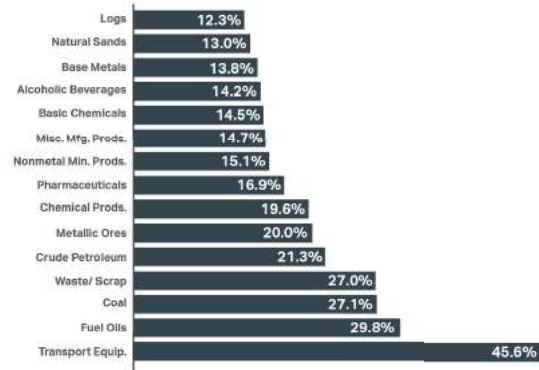
As a hub of manufacturing within the Midwest, St. Louis is well positioned to capitalize on the anticipated increase in national population and urbanization, as well as the resulting increase in freight throughout the country. An analysis of forecasted freight flows to, from, and within St. Louis through 2045 shows a positive freight trend for manufacturers.

The graphic below illustrates that of the top 10 freight commodities expected to increase the fastest between 2015 and 2045, 7 of them have the ability to be generated through advanced manufacturing at current capability levels. For St. Louis, the ability to service large quantities of freight using advanced manufacturing in the future could generate income for the region through value-adding processes.



CAGR FOR FREIGHT TONNAGE TO, FROM, AND WITHIN ST. LOUIS: 2015-2045
SOURCE: DEPARTMENT OF TRANSPORTATION (FREIGHT ANALYSIS FRAMEWORK)

In recent years, St. Louis has represented a large proportion of freight flows by value and tonnage that flow through two of the nearby States that surround it (Illinois, Missouri, and Iowa). By value, significant proportions of the Three-State area's transportation equipment, fuel oils, and coal were transported from, to, and within St. Louis in 2015. The graphic below depicts the top 15 freight commodities based on the St. Louis share of total three State area value in 2015:



TOP 15 FREIGHT COMMODITIES BASED ON ST. LOUIS SHARE OF 3 STATE AREA VALUE (2015)
SOURCE: DEPARTMENT OF TRANSPORTATION (FREIGHT ANALYSIS FRAMEWORK)

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1.5 INDUSTRIAL POLICY

Industrial policies have been used throughout the world since before the Industrial Revolution. Historically, these policies were best represented by mercantilist economic systems, which made use of trade barriers and large domestic investments in infrastructure to support domestic industry. By the 20th Century, many of the holdover policies from the mercantilist era were abandoned, and new types of industrial policies emerged. In the contemporary economy, a wide array of industrial policies exist throughout the world, although the United States is one nation that notably does not have a formal industrial policy. In general, industrial policies are aimed at improving the competitiveness of domestic industry, oftentimes promoting innovation and workforce development in the process.

Different policy tools are employed around the world to attain the goals of the national industrial policy, including the use of:

- Direct subsidies to industry
- Tax incentives for industry
- Long-term financing provisions
- Trade protection mechanisms
- Development of public goods

While having an industrial policy is not a requirement to compete in the global economy, setting a national industrial policy can help to level the playing field between American industry and foreign industry. The only common attribute of industrial policies is that they seek to improve the competitiveness of domestic industry, and therefore allows industrial policies to be crafted in any way that each nation sees fit. Detailed analysis of several different industrial policies can provide examples of the types of tools that can be used in an American industrial policy.

In addition to the lack of a formal industrial policy, the United States is one of a few countries that formally opposes offset agreements for certain types of heavy industry, notably the defense and aerospace industry. Offset agreements can be thought of as import stipulations that foreign companies must oblige by in order to export their products to the domestic country. For example, if an Italian defense contractor sold 50 fighter jets to the Indian military for \$500 million, the Indian government may require the contractor to offset their export to 10%. In this scenario, India would offer the Italian contractor a list of programs that the contractor could perform in order to offset the export. The offset activities could include using an Indian manufacturer to produce spare parts equal to \$50 million (10% of the export value, or could generate \$50 million in foreign investment into India.

The U.S. government has maintained an official policy against offset arrangements. The issue has been debated by individuals who support and oppose offset arrangements, however for nations that are not reliant on foreign imports for military purposes (the US ranked 15th in arms imports in 2016, but 1st in arms exports), the impact that offsets could have has been questioned.

1.6 MANUFACTURING USA CONTENT FINDINGS

The Manufacturing USA network was created in 2014 under the Revitalize American Manufacturing and Innovation Act (RAMI). The Network was initially envisioned as a group of public-private centers where businesses could connect with public sector entities, and academic institutions to develop new technologies and processes used in advanced manufacturing. The Act included within its scope the goals of:

- Increasing American manufacturing competitiveness

- Stimulate US leadership in advanced manufacturing research, innovation, and technology
- Transition innovative technologies into scalable, cost-effective, and high performing manufacturing capabilities
- Facilitate access by manufacturing enterprises to capital-intensive infrastructure
- Accelerate development of an advanced manufacturing workforce
- Facilitate peer exchange of and documentation of best practices in addressing advanced manufacturing challenges
- Leverage non-federal sources of support to promote a stable and sustainable business model without the need for long-term federal funding
- Create and preserve jobs

The Manufacturing USA network of innovation centers is one of the products of the RAMI Act. As of 2017, 13 innovation centers were official Manufacturing USA Institutes, and in total over 1,100 organizations are involved with all institutes. Analyses of the Manufacturing USA Network from Deloitte and the Government Accountability Office yielded a series of findings on the Manufacturing USA Network.

Manufacturing USA Setup

Manufacturing USA centers are created as public-private partnerships, and each institute has a specific Federal Agency sponsor. Until 2017, the Departments of Energy, Defense, and Commerce, were eligible to sponsor institutes within the Network. At each institute's inception, public funding totaling at least \$70 million was allocated to the institute over 5 years, matched by private member funding in the amount of \$70 million or more (i.e., the cost share ratio between private and public

sources had to equal 1:1 or higher).

After their creation, these institutes are given a large degree of autonomy with respect to their institutional policies, and each institute can craft its own membership structure and research programs. Each institute in the network has an area of focus (for example lightweight metal research at LIFT in Detroit), and all of the research that occurs at the given institute relates to the area of focus in some aspect. Manufacturing USA institutes are equipped with technologies that are needed for advanced manufacturing production and research, and also contain spaces for companies to engage in corporate work. While financial self-sufficiency within a 7-year period is one of the goals that these institutes have, the actual path forward is less certain.

Benefits of Manufacturing USA Institutes

Manufacturing USA institutes are designed to provide members with incentives that encourage them to join the network. Members of Manufacturing USA facilities gain access to different benefits depending on their level of membership within the institute, with higher ranking members securing more rights from membership than lower ranking members. The highest ranking members of each institute hold influence over the research agenda of the institute and governance that oversees the institute, while lower ranking members gain access to members-only data, assistance in navigating government contracts, and the ability to participate in research and development projects.

Workforce training occurs at Manufacturing USA centers, providing the local population with the ability to gain new skills and knowledge that can help them compete in the increasingly technological economy.

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Area for Improvement

The Manufacturing USA Network is still an idea in its infancy, and as a result contains room for some improvement. The Government Accountability Office believes that allowing more inter-agency collaboration between Federal agencies that sponsor institutes and non-sponsoring agencies can help to maximize the impact that Manufacturing USA centers provide. Other areas for improvement that have been highlighted by Deloitte include a need for less rigid membership regimes as well as incorporating inter-institute competitions into practice. Among institute sponsors, there was concern about their respective institute's becoming financially independent of the Federal Government within 5-7 years, indicating some concerns about the long-term sustainability of the Network. The concerns centered on both the magnitude and length of Federal financing.

Since the Manufacturing USA Network is relatively new, there is a limited amount of data that can be used to place the Manufacturing USA Network. As these institutes become more mature, the goals of the initiative can be properly evaluated against current performance.

1.7 INTERNATIONAL INDUSTRIAL POLICY

European Industrial Policy

The European Union (EU) maintains an industrial policy that consists of 6 sub-policies that are aimed at increasing the competitiveness and promoting the wellbeing of European citizens (European Commission). The 6 component parts of European Industrial policy are as follows:

- Single Market & Empowering People
- International Dimension (Trade)

- Innovation
- Investment
- Going Digital
- Circular and Low Carbon Economy

The EU attempts to directly support European industry through direct intervention and action. For example, the EU created the European Cybersecurity Research Competence Centre to support the creation of cybersecurity capabilities across Europe. The creation of European wide agencies to directly engage in research or production is an example of this direct intervention.

Another example would be the EU anti-subsidy trade policies which are in effect across Europe (European Commission). Under the EU's International Dimension program, European businesses who feel that their foreign competitors are supported by their own national governments are entitled to petition the EU to levy customs duties on these foreign products. If the EU deems the complaint legitimate, the EU can impose a 5-year import tariff on the product to level the trade playing field. Through a combination of direct domestic support and elements of foreign protection, the EU is able to support industry with its industrial policy.

Russian Industrial Policy

The Russian Federation is another example of a foreign competitor to the United States that has adopted an official industrial policy (Russian Presidential Executive Office). Russian industrial policy does not use direct intervention in the economy to support industry, but rather indirect or supplemental support for Russian businesses. Financial support for Russian industry can come in the form of subsidies for R&D or industrial construction, refinancing of loans, tax incentives, and government loans for

industrial development, Emphasis with Russian industrial policy is placed almost exclusively on the construction, improvement, or acquisition of capital goods used for industrial production, and the Russian state does not provide subsidies for non-investment purposes.

One policy tool that is highlighted under Russian industrial policy is referred to as the Special Investment Contract. Special Investment Contracts are contracts that are awarded to Russian businesses that attempt to modernize an existing industrial production facility or create a new one. Under the terms of the Special Investment Contract, the Russian business is guaranteed to receive long-term incentives from the Russian state. The Russian government does not contribute any funds directly to these contracts, and provides these incentives in the form of tax incentives. As a result, the Russian government cannot claim any legal right to facilities and products resulting from these contracts (CMS).

Australian Industrial Policy

Australia maintains an industrial policy that is aimed at increasing the competitiveness of Australian industry, particularly for small businesses (Parliament of Australia). In Australia, there is a tax R&D offset that allows Australian industry to invest larger pools of resources into R&D for tax benefits. Additionally, a network of government-supported innovation centers is maintained across the country. The overall industrial policy of Australia is organized as a series of different programs.

Indian Industrial Policy

The Department of Industrial Policy & Promotion oversees industrial policy in the nation. Indian industrial policy has five main goals (Government of India: Ministry of Commerce & Industry):

- Maintain sustained growth in productivity

- Enhance gainful employment
- Achieve optimal utilization of human resources
- Attain international competitiveness
- Transform India into a major partner and player in the global arena

In order to achieve these goals, the Indian industrial policy is heavily focused on deregulation of the Indian economy, and seeks to encourage market forces to foster growth. Two industries are specifically reserved for public sector investment: rail operations and atomic energy. Other than these two industries, private sector investment is encouraged to promote industrial competitiveness.

South African Industrial Policy

South African industrial policy is focused on promoting labor-absorbing industrialization, broadening industrial participation and increasing national competitiveness. South Africa maintains a very broad industrial policy that has several different parts including:

- Development and maintenance of support programs for automotive, metal, agricultural, textile, and apparel manufacturing
- Create manufacturing jobs
- Develop a strategic tariff regime and clampdown on illegal/substandard imports
- Encourage state infrastructure spending
- Limit collusion and price fixing domestically

Advanced Manufacturing Innovation Center

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- Encourage value adding activities and mineral beneficiation
- Support renewable industry development

Activities in South Africa are undertaken for each part of the industrial policy. A wide array of tools is used by the South African government for each part of its industrial policy, including economic interventionism, infrastructure investment, tariff reform, industrial financing, and workforce development. South Africa tracks the success of its program by the number of industrial jobs retained or created within the nation, quality of life, and by the health of industry sectors.

1.8 INNOVATION MODELS

Maker Spaces

Maker spaces are facilities that provide businesses with equipment that they may need for production. Research and production is not carried out by these innovation centers. Generally speaking, there are two main types of maker spaces: basic maker spaces and enhanced maker spaces. The type of maker space that is used by the facility can determine the level of support that is offered to the members of the facility.

- **Basic Maker Space-** Basic maker spaces are the most basic type of maker spaces. Facilities that use the basic maker Space model can provide businesses with access to equipment that they need. One example of an innovation center that used the basic maker space type is Tech Shop. The benefits of using a basic maker space facility are that they require fewer resources to construct and are less costly to operate. The basic maker space model does not offer as many support resources as other types of facilities, and therefore may not be optimal when extensive business support is needed.

- **Enhanced Maker Space-** Enhanced maker spaces provide businesses with more resources than basic maker spaces, but do not provide business support services that are offered by other types of facilities. Enhanced maker spaces generally provide businesses with access to equipment they may need as well as small private spaces that can be used for work (e.g. office space, desk space). One example of an innovation center that uses the enhanced maker space type is MHUB located in Chicago. Enhanced maker spaces are relatively low cost to operate (although more expensive than basic maker spaces) and can provide businesses with access to the equipment they need. However, enhanced maker spaces do not provide businesses with support services that may be needed to grow their business, and they do not offer private spaces where companies can operate their business.

Industrial Incubator Space

Industrial incubators provide more services and amenities to businesses than maker spaces do. Industrial incubator spaces provide businesses with access to equipment they may need, along with private spaces to operate their businesses and business support services to help companies operate. One example of an industrial incubator space is the Industrial Council of Nearwest Chicago (ICNC), which does not have membership tiers, and rather charges a rent like fee to businesses that use its facility. Industrial incubator spaces can be helpful when the innovation center wishes to expand existing companies.

Innovation Center Models

An innovation center is a facility that can provide all of the benefits that are provided by maker spaces and industrial incubators, and additionally engages in research and production at the institutional level (i.e., the innovation center employees actively participate in research and production). There are three main types of innovation centers. Each type of innovation center provides the same general benefits to members; however these different types have vastly different organizational structures.

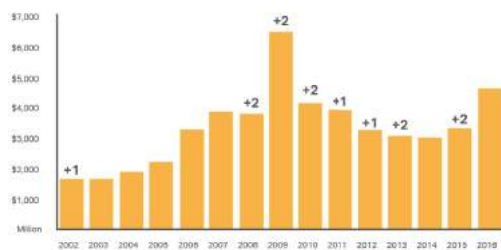
- **Academic Based-** Academic based innovation centers are innovation centers that are founded by academic institutions. The founding academic institution may hold either complete ownership of the Innovation center or may hold a majority stake in the facility alongside several other partnering organizations. Tiered membership systems are often implemented at academic based innovation centers, and each tier of membership offers different benefits to facility members. Membership fees are collected based on the tier of membership that is purchased. The AMRC at Sheffield University is an example of an academic based innovation center. Academic based innovation centers can be ideal when there is an academic institution willing and able to help start the innovation center and a maker space model is insufficient for the objectives of the founder.
- **Hybrid-** Hybrid innovation centers are innovation centers that are founded by any combination of private, public, or academic institutions. There is not a specific type of institution that is required to create these innovation centers, and ownership of these facilities is generally organized into a non-profit structure. Tiered membership systems are often implemented at hybrid innovation centers, and each tier of membership offers different benefits to facility members. Membership fees are collected based on the tier of membership that is purchased. The Commonwealth Center for Advanced Manufacturing (CCAM) is an example of a hybrid innovation center. Hybrid innovation centers can be ideal when there is not a large government or academic institution available to help start an innovation center, and a maker space type is insufficient to meet the objectives of the founder. Hybrid innovation centers often lack the institutional support that academic or government based innovation centers have, and therefore may be more dependent on revenue from membership dues and other contribution sources.
- **Government Based-** Government based innovation centers are innovation centers that are founded by government institutions. A government agency is required to sponsor the innovation center, after which point a non-profit governing body is established to operate the facility. Tiered membership systems are often implemented at government based innovation centers, and each tier of membership offers different benefits to facility members. Membership fees are collected based on the tier of membership that is purchased. The Lightweight Innovations for Tomorrow (LIFT) Institute is one example of a government based innovation center. Government based innovation centers benefit from large amounts of government financing at their inception, and therefore generally have a larger pool of resources flowing into the organization at their inception. However, government based innovation centers can be difficult to create if government agencies are unwilling or unable to create an innovation center in the requested location (i.e., specific locations for innovation centers may be preferred by government agencies).

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Boeing Research and Technology Consortia

Beginning with the opening of the University of Sheffield AMRC in 2001, Boeing has encouraged the development of a global platform of 14 innovation centers in support of aerospace manufacturing, working collaboratively with government and universities. While in most cases Boeing has not funded the construction and operation of these facilities, they do participate / support research efforts. The following chart places the openings of these facilities in context with Boeing's overall R&D spending trajectory since 2002. As the chart shows, a majority of these facilities have opened since 2010. Boeing R&D activity grew significantly beginning in 2008 related to development of the 787 and 747-8 programs. R&D trends for 2016 point to growth as well. Geographical location and details in regards to the Boeing Research Centers can be found on page 118 in the Appendix.

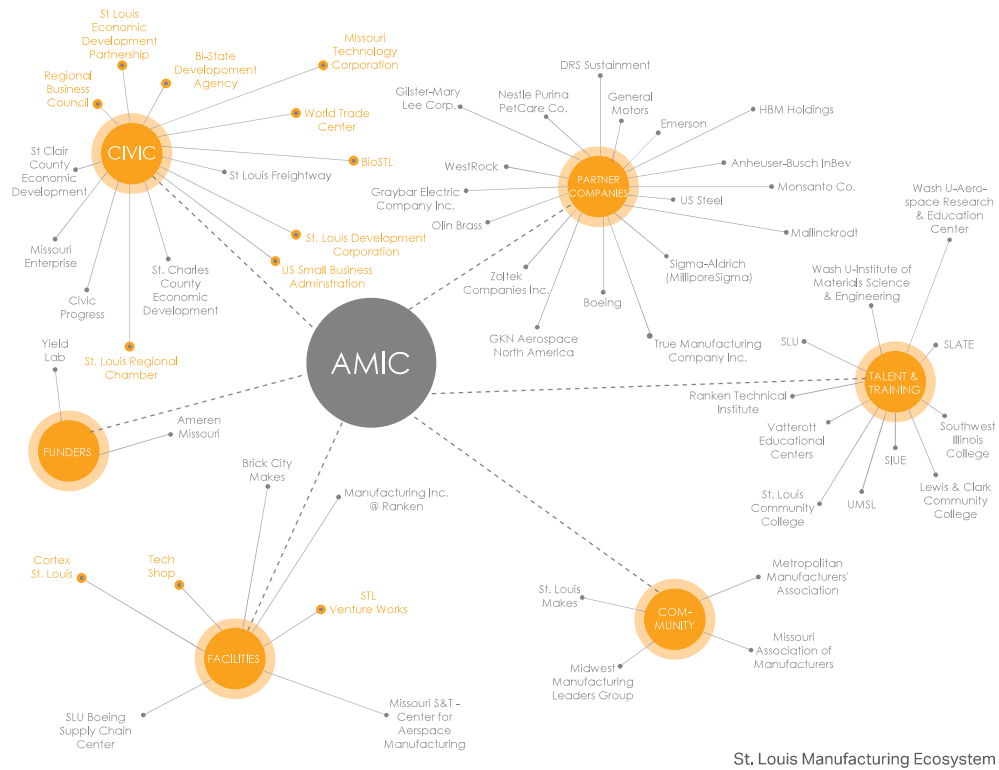


BOEING RESEARCH AND DEVELOPMENT SPENDING
SOURCE: BOEING FINANCIAL STATEMENTS

- Advanced Manufacturing Research Center (AMRC)
- Integrated Vehicle Health Management Centre (IVHMC)
- Digital Manufacturing Research Center (DMRC)
- Advanced Forming Research Centre (AFRC)
- Aviation Services Research Centre (ASRC)
- Boeing Cyber Analytics Center (BCAC)
- Boeing Research & Technology (BR & T)
- Canadian Composites Manufacturing R&D Inc. (CCMRD)
- National Centre for Aerospace Innovation Research (NCAIR)
- Sustainable Bioenergy Research Consortium (SBRC)
- Center for Cabin Air Reformative Environment (CARE)
- Thermoplastic Composites Research Center (TPRC)
- Collaborative Research Center for Manufacturing Innovation (CMI)

Manufacturing Ecosystem

The region has spent 20 years investing in plant and life sciences and technology, and is now reaping the rewards for a focused strategy. In comparison, the current manufacturing ecosystem is highly fragmented. The following graphic displays the network which can be created with the addition of an Advanced Manufacturing Innovation Center in the St. Louis market.



St. Louis Manufacturing Ecosystem

Advanced Manufacturing Innovation Center

02

ORGANIZATIONAL DEVELOPMENT : INTERVIEWS, VISIONING, & STRUCTURE

The AMIC facility master plan was anchored by stakeholder interviews as well as detailed case study research of existing innovation center concepts. Findings are used to shape the masterplan and financial sustainability for AMIC.

2.1 INTERVIEWS AND VISIONING

Organizational Development

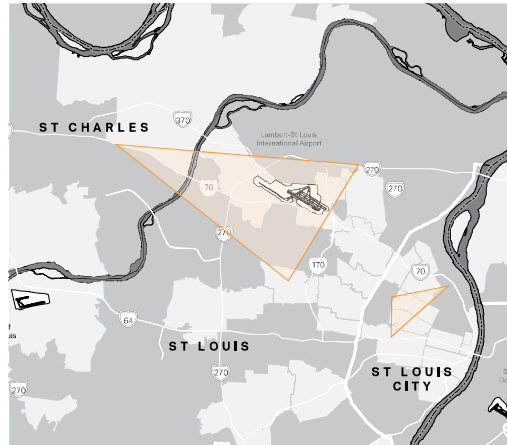


Interview Insights

While manufacturing is gradually being transformed by additive manufacturing, the path forward is uncertain.

- Additive manufacturing is allowing companies to move beyond prototyping and directly into production work, which is changing how manufacturers interface with suppliers, improving quality and shortening lead times.
- While larger companies are actively studying additive manufacturing, small and mid-sized manufacturers are not getting sufficient exposure to this new approach. Training is essential for the next generation of workforce in the industry; apprenticeships are seen as one pathway.
- Assess the role of workforce intermediaries, including Ranken Tech and their current initiative, Manufacturing Inc., as well as emerging networks, including St. Louis Makes, Midwest Manufacturing Leaders, and the SLU Supply Chain Center.
- Small and midsized manufacturers may not know what they don't know about new market opportunities and in general lack the resources to fund significant R&D investment.
- The Manufacturing USA program remains a work in progress, several facilities are now approaching the end of their initial 5-year startup period with an uncertain path to financial sustainability.
- While federal support for the Manufacturing USA program is currently somewhat uncertain, DoD continues to face an array of R&D needs associated with maintaining older aircraft, and managing a pivot into advanced materials and the digital realm.

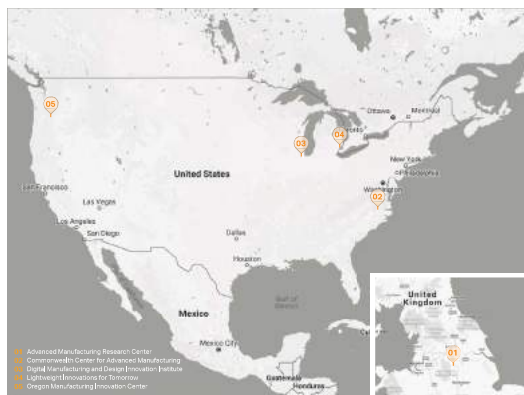
- The analysis identified several key intangibles that impact the path forward for AMIC, BioStl, Missouri S&T, SLU, and the Wash U Aerospace Research & Education Center could play a larger role in the future of this facility. In addition, other entities are also positioned to play a role.
- While there are a number of locations that could be suitable, it seems apparent that region is beginning to see the emergence of one Innovation Triangle anchored by CORTEX, the National Geospatial Agency, and Ranken Technical College. A second potential cluster could be anchored by Lambert-St. Louis International Airport, 39 North, and eastern St. Charles County.



2.3 CASE STUDIES

Five critical case studies were established as examples of Innovation Centers around the world. The case studies were evaluated based on the following criteria:

- Site Location and Zoning
- Programmatic Elements
- General Sizing
- Research Focus
- Organizational Structure
- Funding



01
Advanced Manufacturing Research Center (AMRC)



02
Commonwealth Center for Advanced Manufacturing (CCAM)



03
Digital Manufacturing and Design Innovation Institute (DMDII)



04
Lightweight Innovations for Tomorrow (LIFT)



05
Oregon Manufacturing Innovation Center (OMIC)



	Advanced Manufacturing Research Center (AMRC)	Commonwealth Center for Advanced Manufacturing (CCAM)	Digital Manufacturing and Design Innovation Institute (DMDII)	Lightweight Innovations for Tomorrow (LIFT)	Oregon Manufacturing Innovation Center (OMIC)
Location	Sheffield, England, U.K.	Disputanta, VA, U.S.A	Chicago, IL, U.S.A	Detroit, MI, U.S.A	Scappoose, OR, U.S.A
Project Cost (\$)	\$9.3 million	\$17.6 million	\$31 million	\$8 million building and upgrades \$50 million equipment and installation	\$4.2 million
Building Gross Area (sf)	48,000 sf	62,000 sf	94,000 sf	100,000 sf	33,816 sf
Construction Cost/ sf	\$192	\$210	\$329	\$80	\$124
Public Funding	100%	28%	100%	50%	50%
Private Funding	0%	72%	0%	50%	50%
University Partners	University of Sheffield	Old Dominion University University of Virginia Virginia Commonwealth University Virginia State University Virginia Tech	Iowa State University Northwestern University University Illinois-Chi University Illinois-Urb University of Michigan	University of Michigan EWI Worldwide Ohio State University	Oregon Tech Institute Oregon State University Portland State University
Corporate Partners	Boeing Rolls-Royce	Rolls-Royce Siemens Canon	Dow General Electric Rolls-Royce	Boeing General Electric Alcoa	Boeing
Building Program	High bay space, specialty manufacturing labs, lobby, open office, and conference rooms	High bay space, laser powder bed fusion lab, laser powder deposition cell, wet and dry labs, workspace, meeting space	Town hall, digital manufacturing floor, collaborative engineering space, open workspaces, cafe/social hub, conference rooms	High bay space, open office, closed office, conference rooms, and collaboration spaces	High bay space, open office, general workspace, and meeting rooms
Research Focus	High performance machining, milling and composites	Manufacturing systems, surface engineering, and coatings	Systems engineering, future factory, product development, and digital design	Melt processing, powder processing, thermo-mechanical processing, novel/ agile processing	Industrial manufacturing

Advanced Manufacturing Innovation Center

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CASE STUDY 01**Advanced Manufacturing Research Center
Sheffield, UK**

Founded by the University of Sheffield, in association with companies such as Boeing and Rolls-Royce, the Advanced Manufacturing Research Centre (AMRC) sets new standards for manufacturing research facilities worldwide.

Architect: Bond Bryan Architects London

Focus Industries: High-performance machining of specialist alloys, low-volume high-value assembly, large composite material machining, and provides design/ structural testing services

Completion: Phase I 2008, Phase II 2011

Cost: £8 million \$9.3 million

Construction Type: New Construction on a Reclaimed Brownfield Site

Building Area: 48,000 sf

Building Program: High bay space, specialty manufacturing labs, lobby, open office, teaming space, conference rooms

Number of Employees: 2,000 engineers and apprentices. The center also provides 800 member companies with access to training and innovation

Site Considerations: During the early phases of design an expansive site with adequate room for growth was selected. The site is located approximately 6 miles outside the city center of Sheffield. This building was the site for a entire future innovation campus.

The AMRC is owned by an academic institution, the University of Sheffield. The organizational structure is based on a tiered membership fee offering different companies varied membership options based on their needs. Their marketing and branding strategy is oriented around the University.

Marketing and Branding Strategy:

Tag Line: "AMRC helps manufacturers of any size to become more competitive by introducing advanced techniques, technologies and processes."

The character of the institute is described as helping manufacturers become more competitive. There is not a mention of turning ideas into profits like at CCAM, and rather the site mentions engaging in research projects. The idea of turning ideas into profits is not explicitly expressed anywhere on the about us section This institute appears to be selling competitive research and collaboration as its quality of life contributions.

Brand: AMRC offers members a way to collaborate and engage in meaningful research projects to help them become more competitive. Manufacturers of any size are welcome, and manufacturers can choose to be either a temporary member on one project or make a long term commitment.

Value Proposition: Meaningful research that helps manufacturers

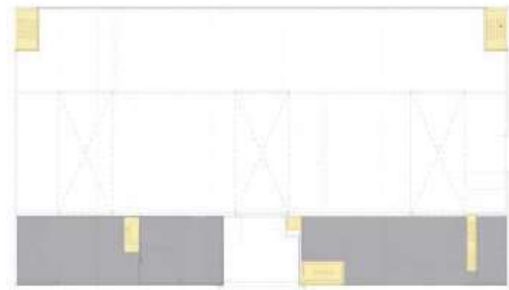


Organizational Development





GROUND FLOOR



MEZZANINE FLOOR



FIRST FLOOR

- High Bay Heavy Equipment Labs
- Open Workstation Environment
- Enclosed Team/Meeting Rooms
- Circulation/ Exhibit Space
- Core and Support Areas

Advanced Manufacturing Innovation Center

PHOTO SOURCE: PERKINS + WILL RESEARCH JOURNAL



PHOTO SOURCE: BOND BRYAN ARCHITECTS

Advanced Manufacturing Innovation Center



Advanced Manufacturing Innovation Center

PHOTO SOURCE: GOOGLE EARTH PRO

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CASE STUDY 02

Commonwealth Center for Advanced Manufacturing Disputanta, VA

"The CCAM project presented an opportunity to develop a unique architectural and planning solution at the intersection of laboratory and factory, and to make a contribution to the renaissance of high-technology manufacturing in the United States," said Paul Harney, AIA, LEED AP, Associate Principal at Perkins+Will.

Architect: Perkins + Will

Focus Industries: Surface Engineering (a specialty in material science that pertains to the coatings and other surface manipulations of materials that alter their fundamental properties)

Completion: October 2012

Cost: \$17,600,000 (project cost) \$14,300,000 (construction cost)

Construction Type: New Construction

Building Area: 62,000 sf

Building Program: High Bay Space, Laser Powder Bed Fusion Lab, Laser Powder Deposition Cell, Wet & Dry Labs, Open Workspace, Seminar & Meeting Rooms, Visualization Lab, Computer Lab, Metrology Lab

Site Considerations: During the early phases of design an expansive site with adequate room for growth was selected. This site is located around 30 minutes from the closest city center,

Marketing and Branding Strategy:

Tag Line: "CCAM delivers innovative solutions for manufacturing better products."

The character of the institute is described as an applied research center where different groups can come together to pool their talents and resources and turn an idea into a reality. There is a focus on turning ideas into profit affordability, indicating that it takes a pragmatic look at innovation (instrumental value- applied research and development heavy). This institute appears to be selling the transition from ideas to products as their quality of life improvement, along with collaboration.

Brand: CCAM offers members an affordable way to convert their ideas into something tangible, and bring the tangible product to the marketplace. It casts a wide research net and provides "deep technical expertise".

Value Proposition: Conversion of ideas into tangible products



Organizational Development





Advanced Manufacturing Innovation Center

PHOTO SOURCE: PERKINS AND WILL

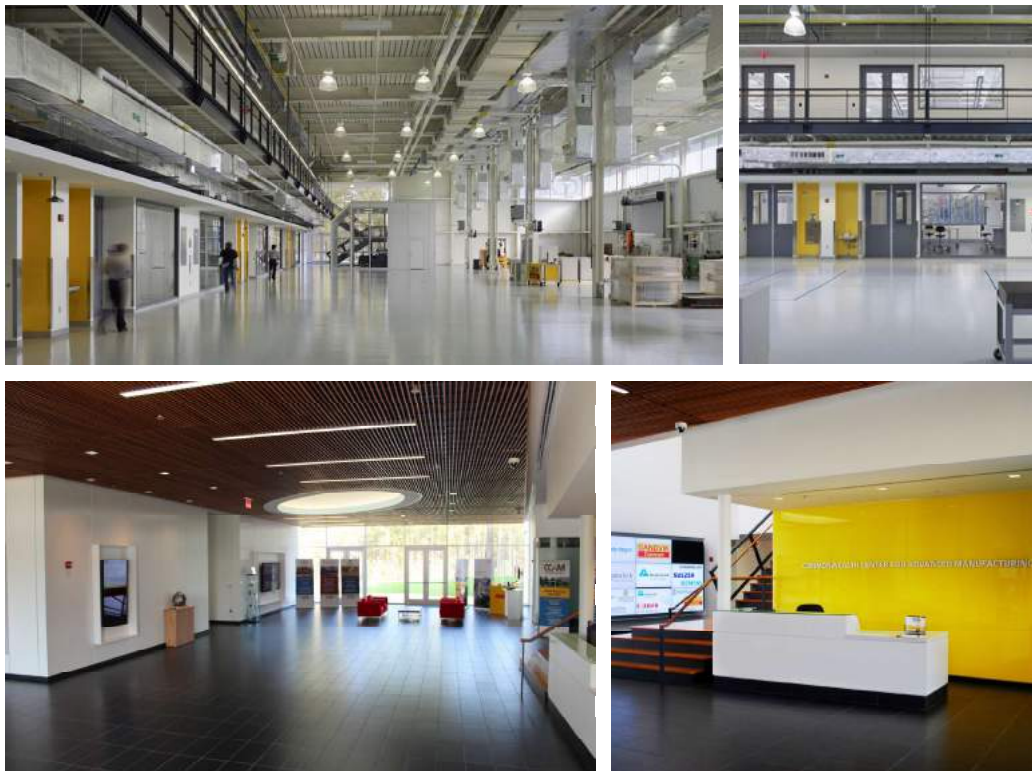


PHOTO SOURCE: PERKINS AND WILL

Advanced Manufacturing Innovation Center



Advanced Manufacturing Innovation Center

PHOTO SOURCE: PERKINS AND WILL

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CASE STUDY 03

Digital Manufacturing and Design Innovation Institute Chicago, IL

"Intended to unite industry, academia, and government under one roof, the lab enables UI (University of Illinois) Labs to develop real-world solutions for tomorrow's most important economic and cultural challenges."

Architect: SOM

Focus Industries: Design, Product Development, and Systems Engineering, Future Factory, Agile, Resilient Supply Chain, and Cybersecurity in Manufacturing

Completion: October 2015

Cost: \$96 million in state and federal funding received for the project, the building was purchased for \$31 million

Construction Type: Adaptive Reuse (1965 factory originally designed by Booth Hansen)

Building Area: 94,000 sf (one third of the building is dedicated for future growth)

Building Program: Town Hall (Entrance), Digital Manufacturing Floor (22,400sf), collaborative engineering space, two open workspaces, a cafe/social hub, and permanent staff office, conferencing, and boardroom spaces

Site Considerations: An older factory building was selected with close proximity to the city center of Chicago and close proximity to partner companies.

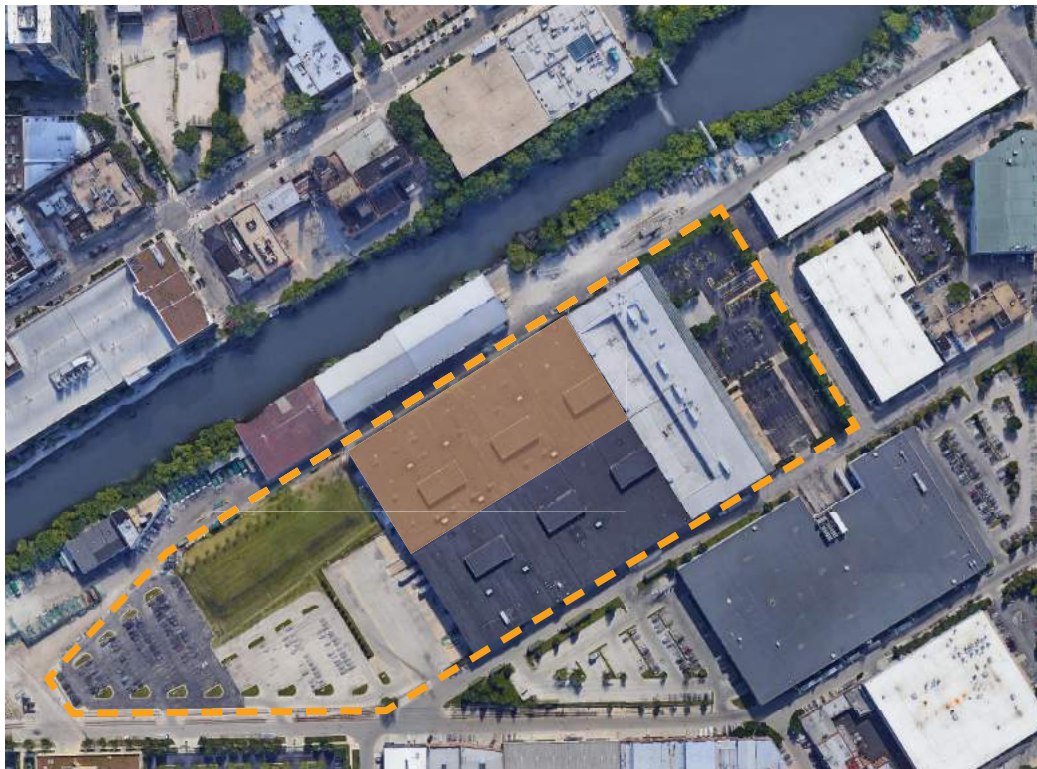
Marketing and Branding Strategy:

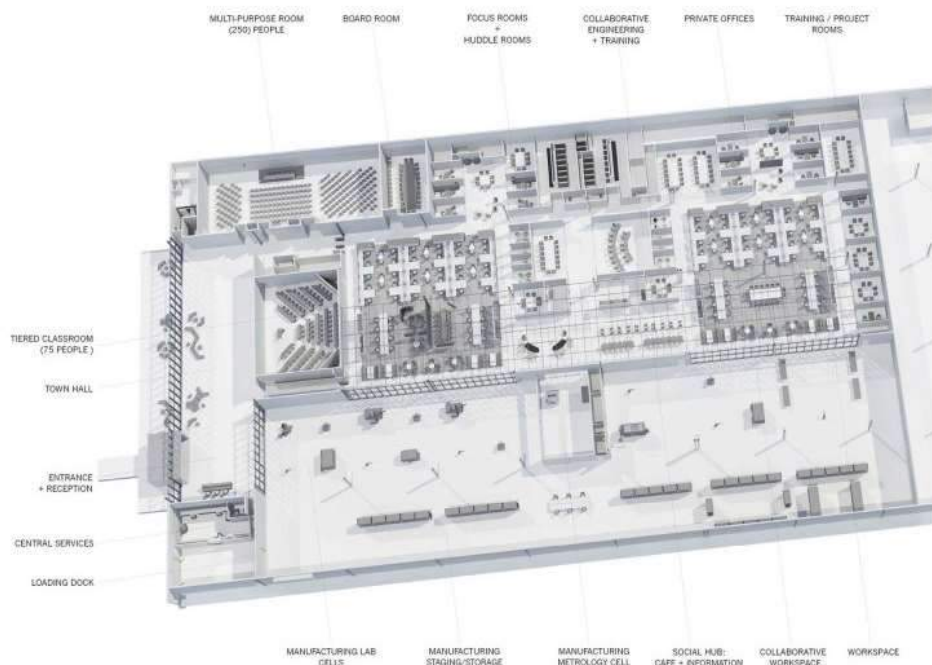
Tag Line: "UI Labs is a trusted guide to innovation for courageous leaders with a mandate to redefine the futures of their industries."

The character of this institute is another one that has a discrete goal. The goal is to promote the digitization of innovation. It is essentially the same as LIFT in practice, although there is not a workforce component for this institute. Instead, the public good is related to technological preparedness (e.g. cybersecurity). This institute appears to be selling technological innovation and collaboration between academic and private sources as its quality of life contributions.

Brand: UI Labs creates a partnership between universities and industry to help create new digitized world. Manufacturers benefit by creating a digital environment to compete in and strengthen the technological capabilities of manufacturing

Value Proposition: Increase use of technology and increase the quality of technology that is used





Advanced Manufacturing Innovation Center

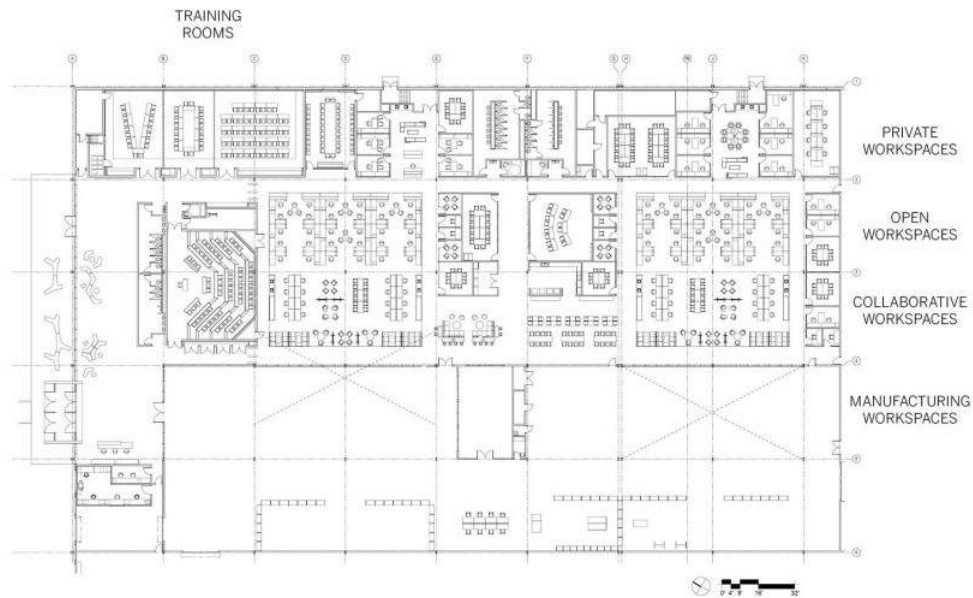
PHOTO SOURCE: SKIDMORE, OWINGS, AND MERRILL



PHOTO SOURCE: SKIDMORE, OWINGS, AND MERRILL

Advanced Manufacturing Innovation Center

GROUND FLOOR PLAN



Organizational Development

Advanced Manufacturing Innovation Center

PHOTO SOURCE: SKIDMORE, OWINGS, AND MERRILL

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CASE STUDY 04

Lightweight Innovations for Tomorrow Detroit, MI

"The Institute will provide IAM (Institute of Advanced Manufacturing) members the opportunity to learn how to work with lightweight materials for employers in the automobile, aerospace, light and heavy ground vehicles, small boat and large ship, rail, and defense manufacturing industries. Lightweight manufacturing is not only cheaper, but is being used to make cars up to 40 percent lighter and armored vehicles that can withstand a roadside bomb but also be airlifted by a helicopter."

Focus Industries: Aerospace, Melt Processing, Powder Processing, Thermo-mechanical Processing, Novel/Agile Processing

Completion: 2015 (Office Headquarters) and expected completion of 2018 for High Bay Renovations

Cost: \$148 million DOD Grant

Construction Type: Adaptive Reuse

Building Area: 100,000 sf

Building Program: 84,000 sf High Bay and 13,000 sf Office Space including six conference rooms varying in size between 2-80 person capacity.

Marketing and Branding Strategy:

Tag Line: "LIFT... is a public private partnership to develop and deploy advanced lightweight materials manufacturing technologies, and implement education and training programs to prepare the workforce."

The character of this institute is one that has very discrete goals. The goal of the institute is to engage in research on lightweight metals, as well as workforce development. The emphasis is not on companies, but rather on research. This institute appears to be selling workforce training and technological innovation as its quality of life contributions.

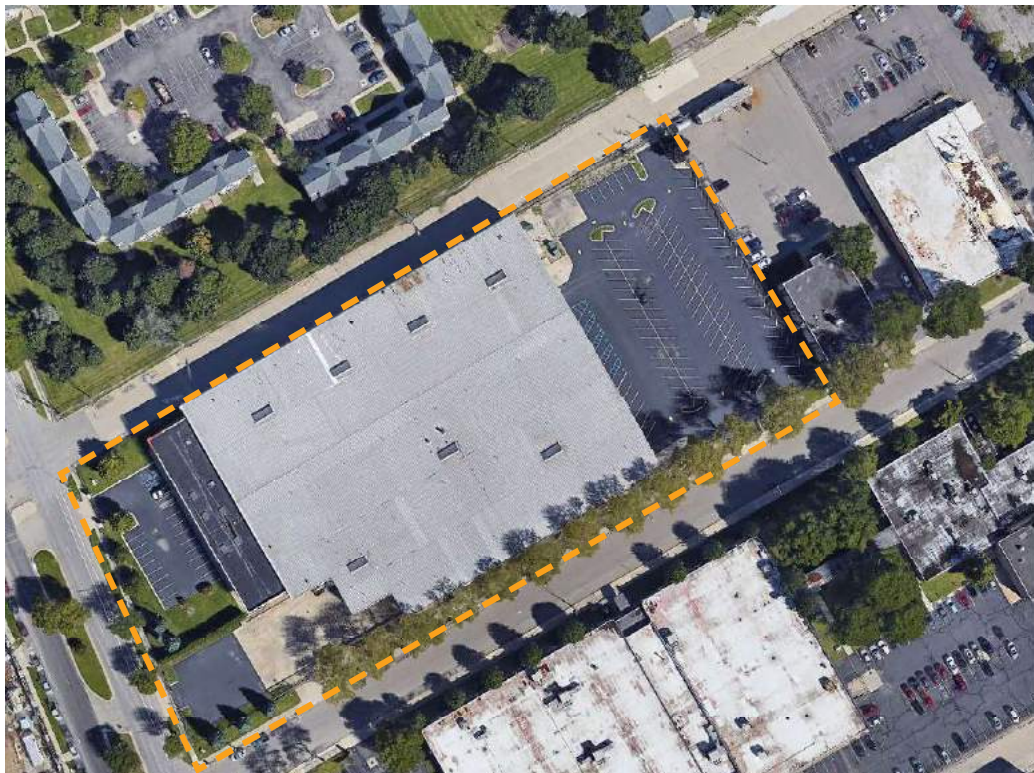
Brand: LIFT offers members a way to help innovate in lightweight materials and assist in developing a workforce for tomorrow. All manufacturers benefit from a capable workforce, and lightweight producers benefit from improvements in lightweight technology.

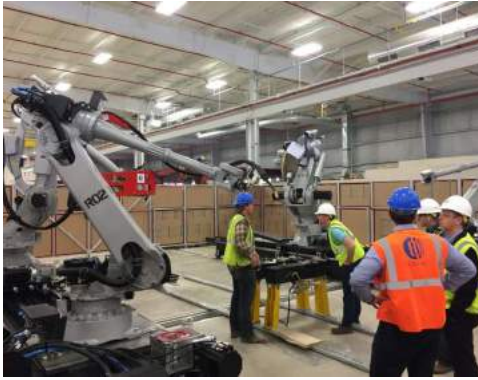
Value Proposition: Improve lightweight materials/technologies and develop the workforce of tomorrow

Organizational Development



Organizational Development





Advanced Manufacturing Innovation Center

PHOTO SOURCE: MANUFACTURING USA AND LIFT

CASE STUDY 05**Oregon Manufacturing Innovation Center
Scappoose, OR**

This facility is currently in the early development phase, therefore there is not as much background information as the previous case studies.

"OMIC builds on Oregon's long-standing reputation as a leading metals, machinery and manufacturing hub," said Chris Harder, director of Business Oregon. "The partnership – a collaborative effort between industry, academia and government – lays a foundation for long-term job creation, skill development and advanced technology in the state, while immediately increasing the competitiveness of local companies."

Focus Industries: Industrial Manufacturing

Completion: Expected completion 2017

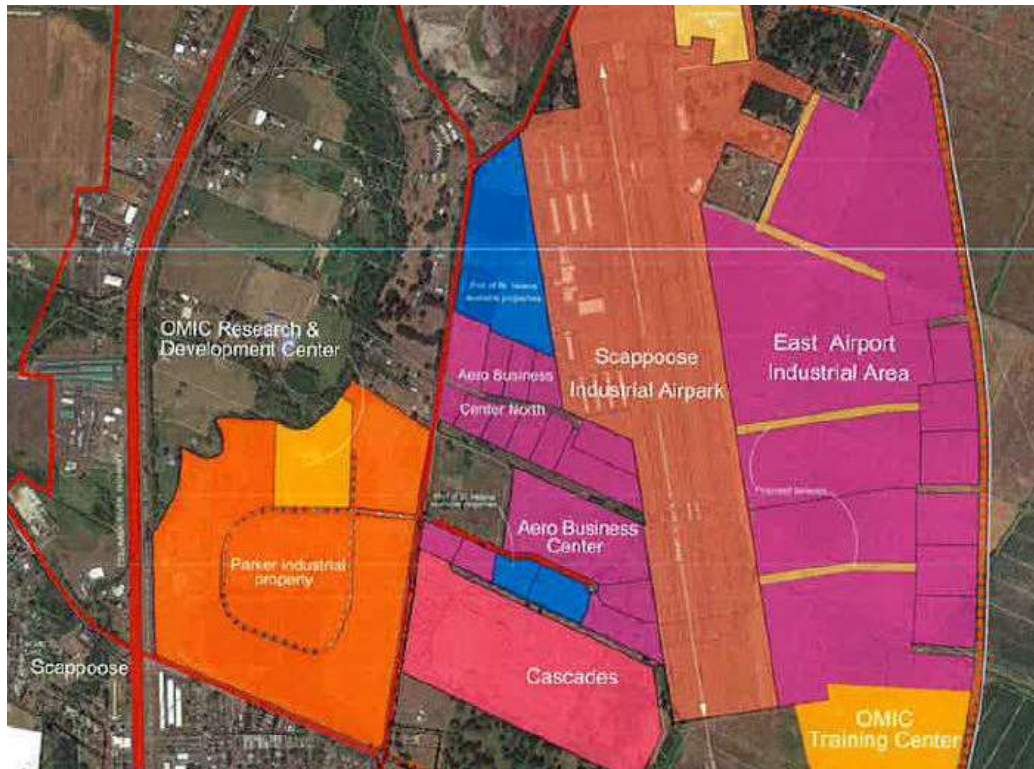
Cost: Building \$4.2 M

Construction Type: Adaptive Reuse

Building Area: 34,000 sf

Building Program: High bay space, specialty manufacturing labs, lobby, open office, teaming space, conference rooms

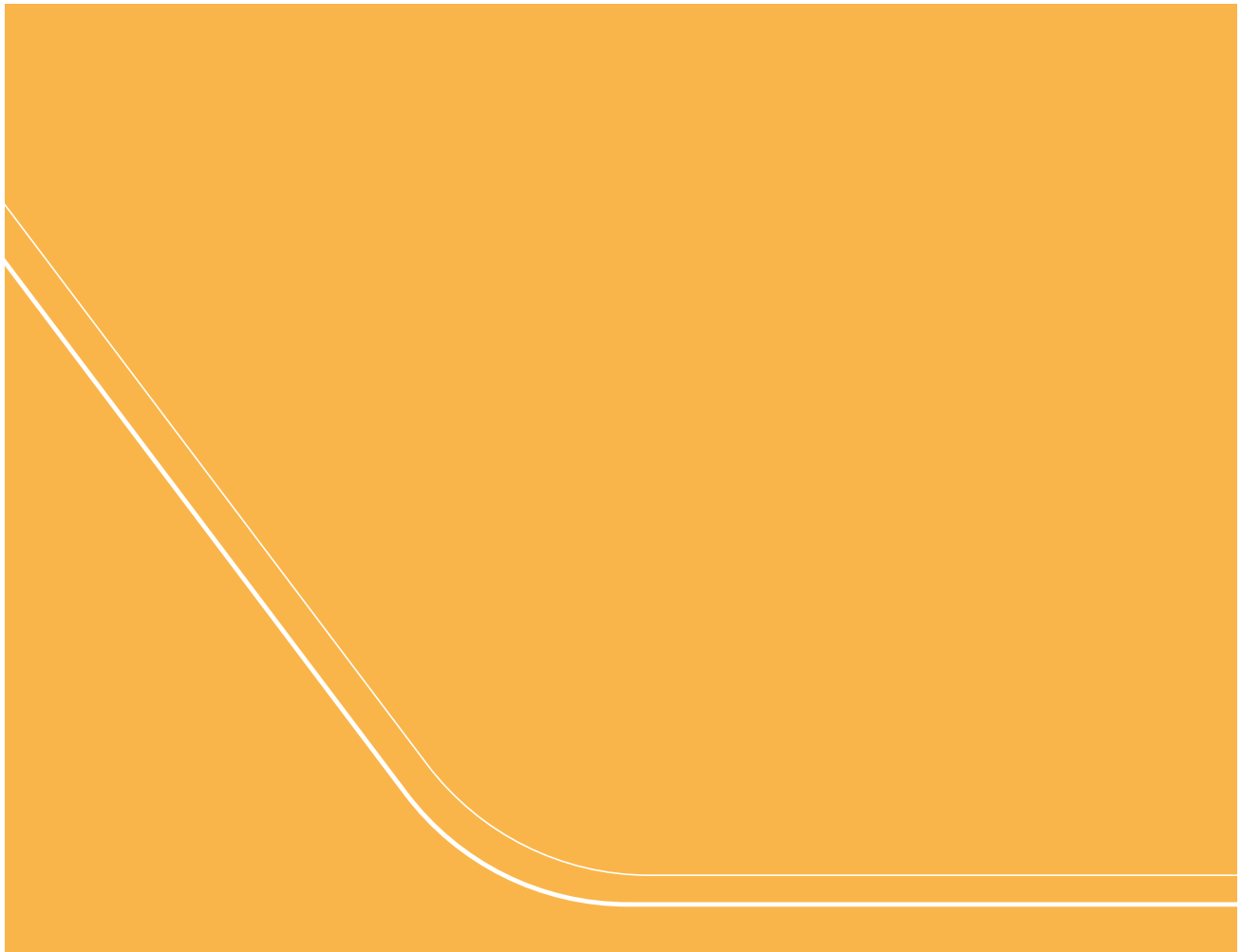
Site Considerations: 10.18 acres in a reclaimed gravel quarry located within the city of Scappoose urban growth boundary and the enterprise development zone just outside city limits





Advanced Manufacturing Innovation Center

PHOTO SOURCE: PORTLAND COMMUNITY COLLEGE



03

CONCEPTUAL MASTER PLAN : GENERAL LOCATION, CONFIGURATION, & NATURE OF THE FACILITY

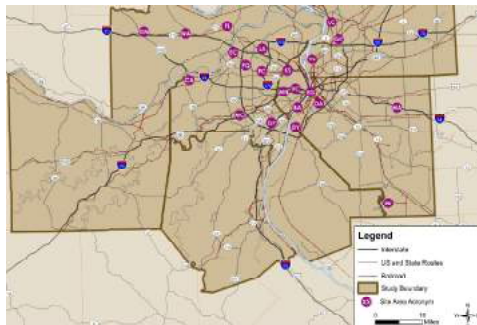
The Advanced Manufacturing Innovation Center will be a 21st century manufacturing building for the next generation of manufacturing workers. The following outlines potential site areas, programmatic configurations, and overall vision of the facility.

3.1 GENERAL SITE INVESTIGATIONS

The site conversation for AMIC beings with context afforded by the breadth of the St. Louis industrial Market, which supports more than 270 million square feet of manufacturing, warehouse and distribution space, as shown in the map on the following page.

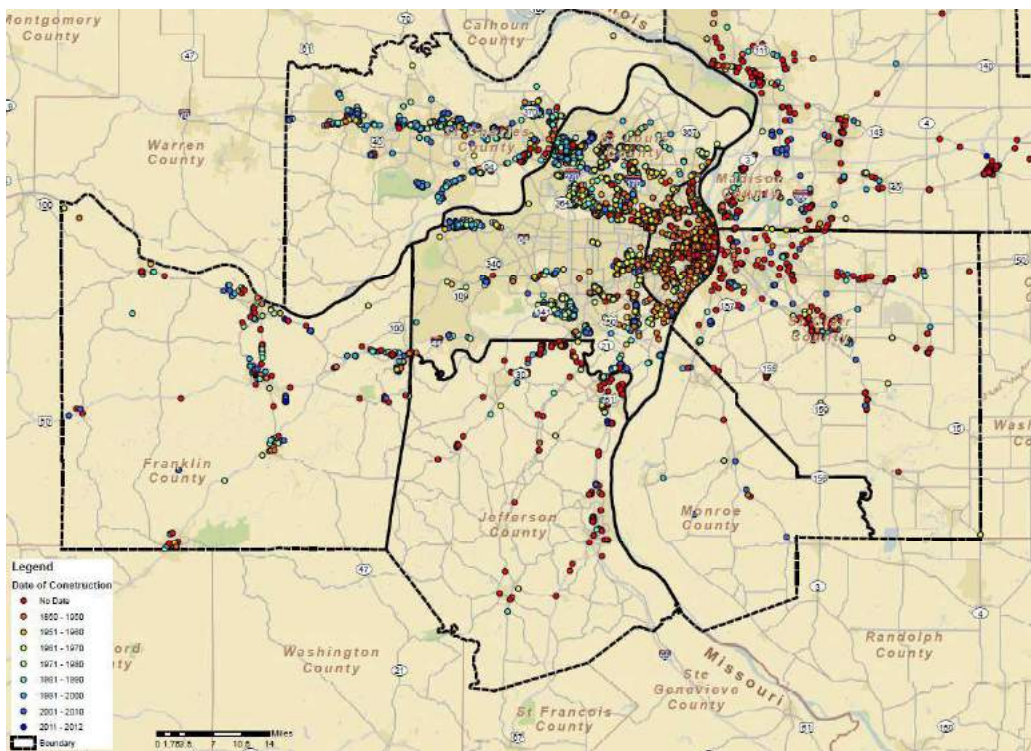
As part of work on the St. Louis Regional Freight Study, completed for East West Gateway, AECOM completed a deep dive into the regional industrial market and identified 23 specific industrial districts where a majority of the region's inventory is concentrated. As part of this study, we also learned that a large percentage of the region's industrial space (60%) is concentrated in buildings that are less than 25,000 square feet.

The study drilled down into 23 specific areas in the Region where transportation modes align with industrial land use, assembled from groups of Transportation Analysis Zone (TAZ) blocks. For each area, we identified core metrics related to total industrial space, employment, train counts, truck counts, crashes, and similar factors. The following map summarizes the locations of these 23 areas; labels for each area are in the following table.



Acronym	Site Name	Acronym	Site Name
BA	Broadway- Arsenal	LA	Lambert Airport
BH	Broadway- Hall	LC	Lewis and Clark North
CA	Chesterfield Airport	MN	Manchester 44
DA	Downtown Airport	MC	Meramec 44
DY	Dupo Yard	MA	MidAmerica Airport
EC	Earth City	PQ	Page- 270 Quadrant
EG	East Industrial Gateway	PC	Page Corridor
FL	Fountain Lake- Elm Point	PK	Port Kaskaskia
GC	Gateway Commerce	TN	Route 3 North
GM	GM Plant	VC	Vandeventer- Choteau
GP	Green Park	WA	West 70- Arrowhead
KS	Kingshighway- 70		

The AMIC site conversation also reflects specific challenges related to industrial development in St. Louis County, where several larger industrial districts overlap a number of municipalities. Examples include Earth City (4 municipalities) and Lambert Airport (11 municipalities).



INDUSTRIAL INVENTORY BY DECADE OF CONSTRUCTION
SOURCE: AECOM/ COSTAR

Advanced Manufacturing Innovation Center

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Site Name	No. of Municipalities Interested	Site Area (Acres)
Earth City	4	12,700
East Industrial Gateway	8	7,500
Meramec 44	4	3,800
Green Park	3	800
Page Corridor	8	2,700
Lambert Airport	11	8,400
Route 3 North	3	13,300
Gateway Commerce	3	2,800
Downtown Airport	5	3,500
MidAmerica Airport	5	8,100
Lewis and Clark North	4	7,600
Dupo Yard	3	10,800

Site Criteria determined by Case Studies

- Affordable and available building and land
- Site that can accommodate an existing or new 40,000- 60,000 sf building and parking
- Adjacent to land or buildings that can be re purposed for industrial growth

- Zoned for industrial/ manufacturing and can be zoned as an innovation district
- Site that can be accessed easily by semi-trailer
- Local government support/ access to financial resources
- Physical proximity to partner companies
- Physical proximity to workforce training/ education programs
- Physical proximity to urban core/ transit

Location Categories:

- Infill-** Includes sites such as Cortex, SLEDP Grand, SLEDP Wellston, and Brick City Makes which are located within a largely developed urban area in the city of St. Louis. These sites face certain challenges due to density of the urban environment,
- Redevelopment-** Includes sites such as NGA which are located within a redeveloped brownfield site and will be rezoned for alternative uses to propel progress in the area.
- Academic / Workforce-** Includes sites such as Ranken, St. Louis University, St. Louis Community College, and Washington University. These sites benefit from close proximity to researchers and students who specialize in innovative manufacturing techniques,
- Industrial / Aerospace-** Includes sites such as East St. Louis, GM Wentzville, and Airport North which already have a well-established industrial or aerospace presence. These sites are presented with several benefits such as ease of access to the site, zoning, and adjacency to potential manufacturing partners.

Infill



39N
Monsanto



CORTEX



FOX PARK
Brick City Makes

Redevelopment



ST LOUIS PLACE
Ranken



ST LOUIS PLACE
NGA



WELLSTON

Advanced Manufacturing Innovation Center

Academic/ Workforce



FLORISSANT VALLEY
Louis Community College



EAST ST LOUIS
East St. Louis Community
College



GRAND CENTER
St. Louis University

Industrial/ Aerospace



EAST ST. LOUIS
East St. Louis Airport

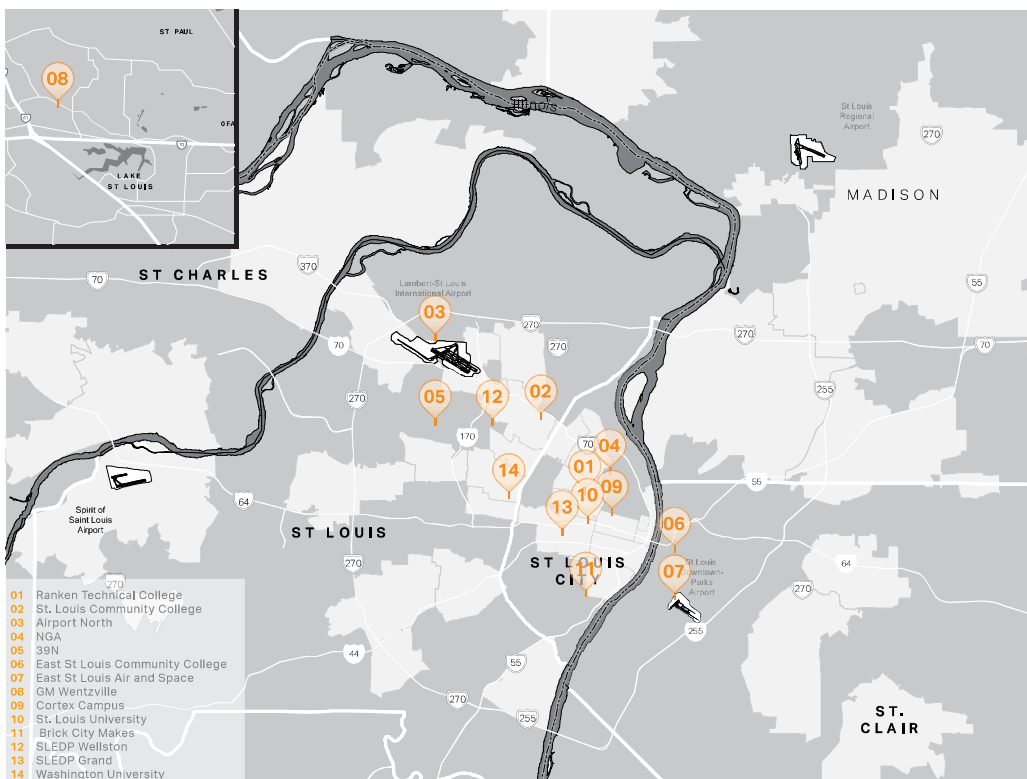


WENTZVILLE
GM



AIRPORT NORTH
Boeing

Advanced Manufacturing Innovation Center

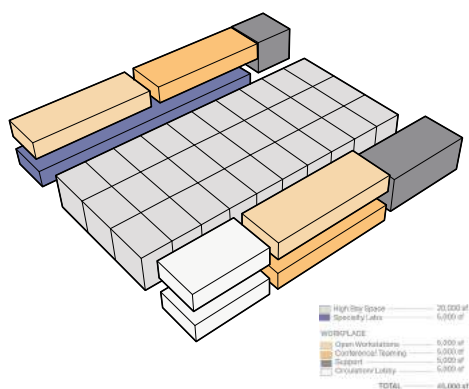


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3.2 GENERAL CONFIGURATION AND PROGRAMMING

Building Program

Several building configurations were considered to maximize efficiency and create the most flexible and dynamic space for the innovation center. The following options depict programming studies based on the case study models introduced in the previous section.



Option 1: Split

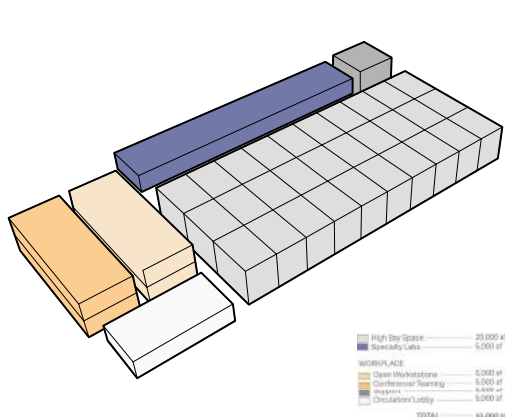
Using the AMRC in Sheffield as a precedent, this option explores placing the specialty labs in the high bay space with the office and conference room flanking the high bay. This creates an opportunity for circulation above the high bay that could be used as a viewing area for demonstrations and exhibits.

Pros:

- + Ability to stack program due to the similarity in size between the office and the specialty labs
- + Opportunity to have shop floor on display for partners and donors
- + More integrated working and shop space

Cons:

- If additional space is required for the high bay, limited to expansion in linear direction



Option 2: Separated

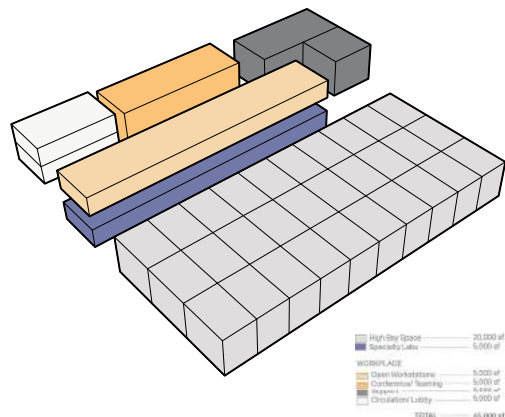
Using LIFT as a precedent, this option explores placing the office and conferencing towards the front and the high bay space near the back.

Pros:

+ Ability to stack program due to the similarity in size between the office and the specialty labs

Cons:

- Lack of integration between the office and the high bay space
- Lack of display space for guests and future donors



Option 3: Stacked

Using the CCAM in Virginia as a precedent, this option explores stacking the specialty labs and offices orienting the high bay space towards the back of the facility.

Pros:

+ Ability to stack program due to the similarity in size between the office and the specialty labs

Cons:

- Lack of integration between the office and the high bay space
- Lack of display space for guest or future donors

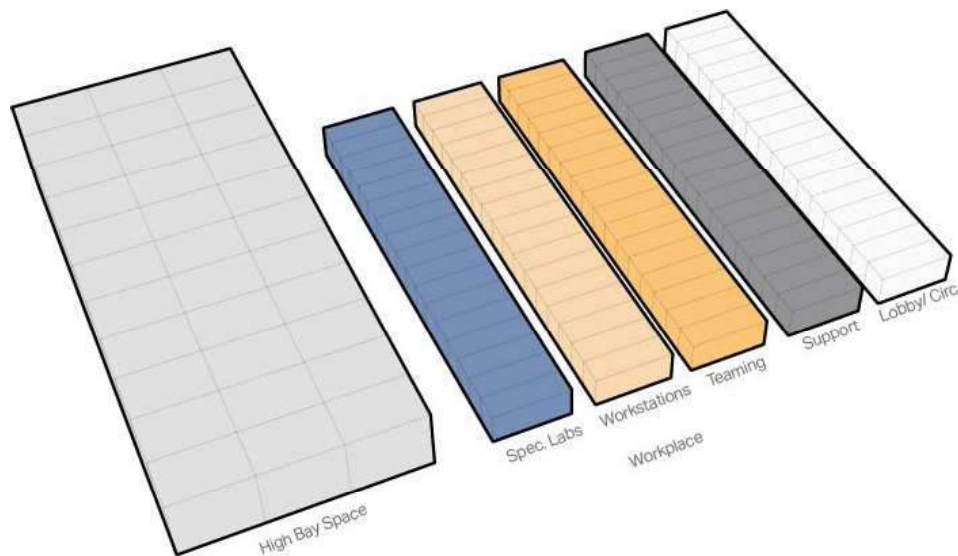
3.3 BUILDING PROGRAM

The space program was developed to accommodate adequate space for advanced manufacturing prototype and development facilities. The space program and description are as follows:

- High Bay Space to accommodate large-scale manufacturing equipment. This space will have a minimum of 24' clear to the underside of structure and have the necessary infrastructure for production equipment. This is meant to be a shared space. **15,600 square feet**
- Specialty Labs are assignable to lab partners for specific development or research activities. Four labs are anticipated, each approximately 1,000 square feet. Labs will provide the basic infrastructure needed to support multiple types of manufacturing equipment, including electrical power, data connections, compressed air, water, and gases. These labs should be located on the first floor with a controlled environment. **4,200 square feet**
- Digital Labs are focused on electronic or computer-based projects or solutions. Four are anticipated, each approximately 1,000 square feet. They will be provided with electrical power and the capability to support a network to run equipment. The Digital Labs could be located on the second floor. **4,200 square feet**
- Office space supports both open office functions, such as workstations, but also open collaboration and enclosed conference, and instructional space. **10,000 square feet**
- Support space, which includes the building lobby, rest rooms, locker rooms, break area/social hub, mother's room, storage space, loading dock and staging area, circulation space, and spaces for building mechanical and electrical equipment, as well as telecom and data accommodations. These spaces will be spread throughout the facility. **8,000 square feet**

Total Projected Space Requirement: 42,000 square feet

3.4 SPACE AND FUNCTIONAL PROGRAM



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3.5 GENERAL NATURE OF THE FACILITY

Conceptual Design

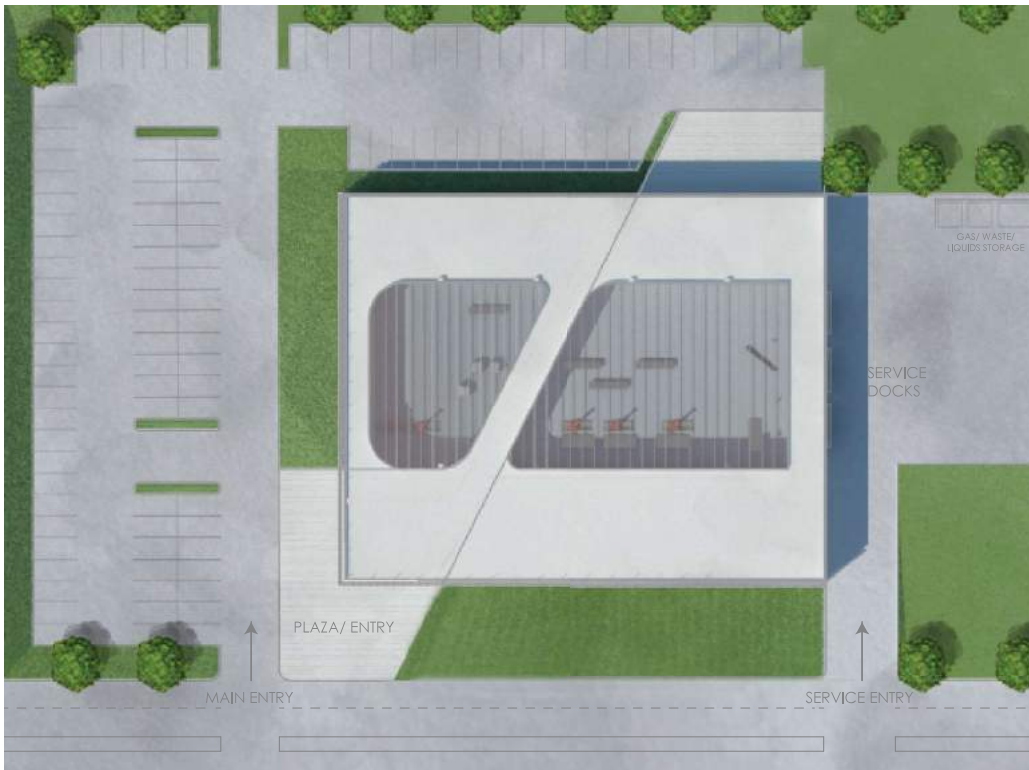
The design concept locates the high bay space in the center of the building. It is flanked two levels of Specialty (ground floor) and Digital Labs (second floor) on one side, with two floors of office space on the opposite side. Support spaces will be located throughout the flanking spaces. This concept keeps the high bay space central to the facility, and also supports expansion to its rear, assuming the selected site could support a larger building. The concept provides straightforward circulation and easy identification of the spaces. The second floor includes a bridge across the high bay space that would provide a unique observation point of the ground floor activities by residents and visitors alike.

Building structure and enclosure is meant to be simple and straightforward. The two-story building would be steel framed, enclosed with a combination of tilt-up concrete panels for lab areas, and glazed curtain wall for public and office area. Two sides of the building would receive a metal screen over the curtain wall, with the screen "cut away" to identify the building entry. It creates visual interest, and can act as a shading device for the glazing. During the day, it will create patterns of light and shadow on the building's facade; at night, when the building is lit from within, it will create those patterns on the adjacent surfaces.

The most dramatic feature of the building is the large expanse of translucent skylight material on the roof, which is meant to flood the high bay space with natural light. Looking from the building entry to the high bay area, people will be drawn to it by the daylight and sense of openness created by this feature.

Interior construction will be painted gypsum board over light-gauge steel framing. In high-traffic or utility areas, protective wall covering may be added. The lab, office, and meeting/collaboration spaces will receive acoustical tile ceilings and LED lighting. LED lighting will also illuminate the high bay space, with its exposed structure and mechanical systems. The high bay and specialty labs will have sealed concrete floors. Public areas, including the building entry, rest rooms, locker rooms, and the break area/social hub will receive porcelain tile flooring; office, collaboration and meeting spaces will be carpeted.

The generic site plan shows the footprint of the 42,000 square foot facility, along with vehicular access and parking for 112 cars, based on an estimate of current requirements. The site will be landscaped and will provide truck access to the service doors/loading dock of the building. In addition, we have shown locations on the site to support gas inventory that may be needed for work in the AMIC, as well as an emergency generator. These elements will be adapted to the selected site, as appropriate.

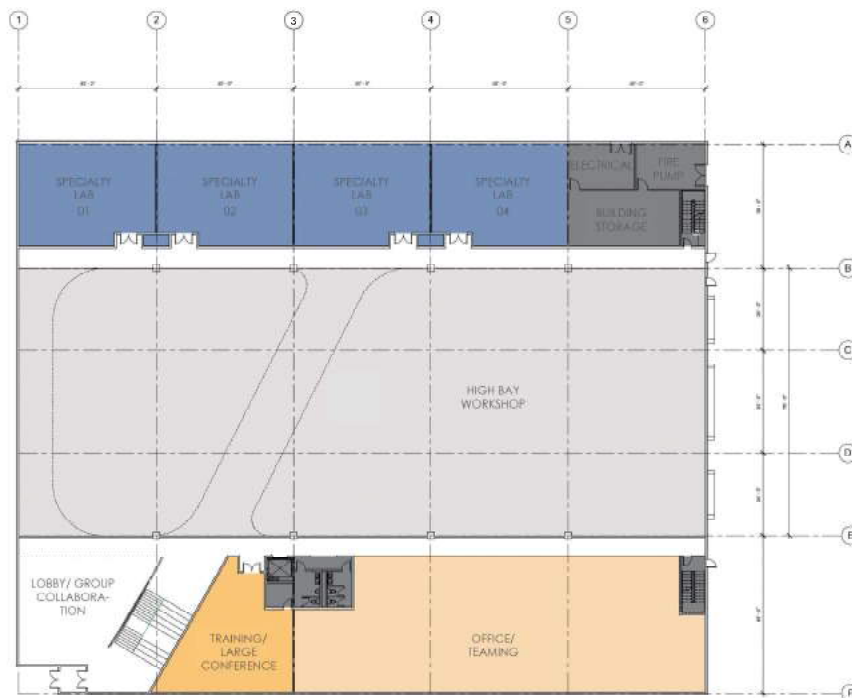


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LEVEL 01 FLOOR PLAN

Conceptual Master Plan



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EXTERIOR VIEW



MATERIAL STUDIES

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LOBBY VIEW



HIGH BAY VIEW

04

FINANCIAL SUSTAINABILITY PLAN : COST ESTIMATE, FINANCIAL PLAN, AND FUNDING SOURCES

Sustainable operations require a stable and healthy financial infrastructure. Analysis of the financial nature of innovation centers, as well as potential financial and marketing plans for AMIC can provide footing for a financially sustainable institute.

4.1 BUSINESS MODEL - ORGANIZATION

Governance Structure & Organization

The following sources were considered:

- Form 990
- AMRC Overview Brochure
- National Network for Manufacturing Innovation Program: Annual Report February 2016
- UI Labs Annual Report 2015
- Key Private Bank: Governance of 501(c)(3) Organizations: Understanding the role and responsibilities of board members
- Foundation Group Inc: How to start a 501(c)(3) Nonprofit
- USA.Gov: Starting a Nonprofit Organization

Introduction

The organizational structure adopted by innovation centers is largely dependent on the objectives of each facility, as well as the technology and industry sectors that engage with the center. Manufacturing USA Centers are organized into independent non-profits that are founded as public private partnerships. In contrast, the Advanced Manufacturing Research Centre at Sheffield with Boeing officially operates as a component of the University of Sheffield. As a result, the organizational structure of AMIC can be crafted to the needs of the founding members.

Theoretically, it is possible for innovation centers to operate under any governance structure legally permissible in the United States. However, there are generally two governance structures that have been used for innovation centers in other locations:

1. Independent Institutes (e.g. CCAM, LIFT, DMDII, ICNC)

2. Dependent Institutes (e.g. AMRC)

A thorough analysis of each type of governance structure used by other innovation centers can provide insights into the governance structure that is optimal for AMIC.

4.2 GOVERNANCE STRUCTURES

Independent Institutes

Within the United States, nonprofit institutions are formed in nearly every sector of the economy and for different purposes. Many of these nonprofit institutes are formed as 501(c)(3) organizations, which are given tax exempt filing status pursuant of the US Internal Revenue Code. 501(c)(3) organizations can include public charities, private foundations, and private operating foundations, which each have their own unique governance regulations associated with them.

For example, public charities oftentimes must have boards of directors composed of unrelated individuals who are separate from management positions within a given nonprofit. Private foundations, in contrast, can consist of boards of directors from a single family (in the case of family foundations). 501(c)(3) organizations are often incepted for religious, scientific, educational, or other public service uses, and therefore the objectives of the institute generally must align with these broad categories of activities.

While all 501(c)(3) organizations contain the same tax exempt status, these nonprofits can be organized under completely different governance regimes including nonprofit corporations, trusts, LLCs, community chests, or other unincorporated associations. As a result, the leadership of these 501(c)(3)s can vary wildly, and completely different bylaws can be enacted upon the institute's creation. For 2017, the IRS did not mandate any particular governance policies to 501(c)(3) organizations, and in contrast these organizations may choose to write their own bylaws to govern their institutes. However, the IRS does strictly monitor the activities of 501(c)(3) organizations to ensure they are not performing activities that violate their tax exempt status. As a result, the boards of directors at most 501(c)(3) organizations consider creating policies related to each of the following activities within their organizations:

- Compensation
- Conflicts of Interest
- Investments
- Codes of Ethics
- Record Retention
- Fundraising

As it is possible for 501(c)(3) organizations to violate the conditions of their tax exempt status, strong board policies that ensure compliant behavior can help to both protect individual board members from violating IRS regulations, and also help prevent the organization from falling out of compliance. Board members who fail to act in good faith to the organization and with respect to governing IRS regulation can face criminal or civil penalties pursuant to either Federal or State law.

Independent nonprofit governance structures carry with them a number of benefits that members can take advantage of. The most significant benefit of an independent nonprofit structure is the flexibility of activity that is provided through this structure. Provided that the institute is not performing nefarious or non-compliant activities, the institute is free to pursue revenue streams and projects that the institute wishes to pursue. In contrast, independent nonprofits do not receive the same level of legal protection or resource pools that dependent institutes may receive, and this can be a drawback to using the independent nonprofit governance structure.

Numerous innovation centers in the United States operate under the independent nonprofit governance structure including:

- CCAM
- LIFT
- DMDII
- ICNC

The flexibility that is provided by the independent nonprofit governance structure is bolstered by its adoption of different types of innovation centers. For example, relatively lean innovation centers, such as ICNC which operates as a maker space, as well as LIFT, DMDII and ICNC which operate as fully functional research centers, all operate under this structure. The flexibility that is provided by this governance structure renders it a strong potential candidate for AMIC.

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Dependent Institutes

In contrast to independent nonprofits, it is possible for innovation centers to adopt governance structures that are dependent, or component units, to larger established entities. For example, the AMRC at Sheffield is a dependent institute to the University of Sheffield, or in other words is officially a part of the University of Sheffield. While dependent institutes such as AMRC oftentimes have their own board of directors and can adopt different governance structures, these institutes are always subject to the decision of their parent organizations.

Dependent institute governance structures generally provide more stability to institutes than independent governance structures provide, as dependent governance structures have a parent organization that can support and protect the institute. In contrast, flexibility can be constrained in dependent institutes, as the will of the parent organization overrides the will of the dependent institute.

Successful innovation centers, such as AMRC, have adopted dependent governance structures that have enabled them to fulfill their institutional objectives with large levels of external support. For AMIC, finding a suitable parent organization, such as the St. Louis Economic Development Partnership or Washington University, would be required in order to use a dependent governance structure.

AMIC's Governance Structure

For the St. Louis AMIC, any governance structure that aligns with the institute's objectives can be adopted by the institute. The choice of governance structure is not fixed and can be changed in accordance with institutional or environmental changes that occur. For AMIC, an independent nonprofit governance structure would allow AMIC to craft its own governance policy and develop a set of institutional rules and controls to attract new members. As a result, an independent nonprofit structure could provide



ORGANIZATIONAL STRUCTURE
SOURCE: AECOM

AMIC with the flexibility it needs to achieve its institutional objectives to a greater degree than a dependent structure would.

AMIC could utilize the above non-profit governance structure in operation once it becomes an established institution, with each part of the structure fulfilling a specific role:

- The Board of Directors- Similar to the Board of Directors of a for profit entity, AMIC's Board of Directors could be responsible for overseeing the operations of AMIC and providing oversight of the paid management of the institute. In accordance with traditional non-profit models, members of the Board of Directors would generally not serve in management positions within the institute. The Board would likely meet at least annually to make material governance decisions for the institute.

- **Executive Committee-** The Executive Committee of AMIC could fulfill the governance role that the Board of Directors serves when the Board of Directors is not in session. Day-to-day decisions that would require board member approval could be determined by the Executive Committee in order to ensure efficient operations within the institute. Consequently, the Executive Committee would have to be sanctioned by the Board of Directors in order to empower the Executive Committee to make these decisions.
- **Supplemental Committees-** Similar to the Executive Committee of AMIC, additional committees could be formed to make decisions on matters of particular importance. For example, the Finance & Compensation Committee of AMIC could be empowered to make decisions related to the financial health of AMIC or employee compensation. The Nominating & Recruiting Committee could be empowered to make decisions regarding members, ranging from member acceptance into AMIC to membership level changes. All supplemental committees would need the same authorization from the Board of Directors that the Executive Committee receives.
- The President, or Chief Innovation Officer, of AMIC could serve as the head manager of the institute, and would fulfill roles similar to a for-profit CEO. The President would be responsible for the day-to-day management of the institute, and would answer directly to the Board of Directors or their agents on the Executive Committee. As the Chief Innovation Officer of AMIC, the President would be tasked with ensuring that the innovation vision set out by the Board of Directors is accomplished within AMIC.
- **Departmental Directors-** Management responsible for individual tasks within AMIC could be delegated to different directors within different departments of the institute. These directors would answer to the President of the institute and would be responsible for ensuring that the objectives of the Board of Directors are carried out within their respective departments. These potential departments include:
 - **Marketing-** Responsible for promoting the research and activities of AMIC to the public and attracting new candidates for membership within the institute.
 - **Finance-** Responsible for overseeing the financial health of AMIC and managing financial resources that the institute possesses.
 - **Operations-** Responsible for overseeing projects and activities pursued by AMIC and organizing members and employees of the institute to engage in these respective projects and activities.
 - **Talent-** Responsible for securing and retaining human capital (i.e. employees) that are required for AMIC's operations and administration.
 - **Technologies-** Responsible for overseeing R&D conducted by AMIC and securing the necessary capital goods (i.e. machinery) that are needed for operations.

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4.3 FINANCE - CONCEPTUAL COST ESTIMATE

AMIC Sources of Funding

The following sources were considered:

- Form 990
- US Government Accountability Office: Advanced Manufacturing: Commerce Could Strengthen Collaboration with Other Agencies on Innovation Institutes
- Deloitte: Manufacturing USA: A Third-Party Evaluation of Program Design and Progress
- Industrial Council of Nearwest Chicago: About Us

Core Findings

A review of innovation center funding has yielded the following findings:

- Innovation center funding is dependent on several factors, and three of the most important factors are the model, organizational structure, and maturity level of the innovation center.
- Maker spaces and industrial incubators generally secure funding from program or investment revenues, while innovation facilities generally receive larger proportions of funding from external contributions.
- Innovation centers that are organized as independent entities (e.g. nonprofits) generally have more flexibility when securing funding, while innovation centers that are organized as subunits of an established entity (e.g. university owned) have more dependable funding streams.

- The age or maturity of innovation centers can skew the funding mix that the institute receives, with new innovation centers receiving significant portions of their funding from public or nonpublic contributions, and older innovation centers receiving more funding from their institute's activities

For innovation centers of all types, external funding can form anywhere from a small proportion to an absolute majority of revenue that the center receives. Regardless of the magnitude of revenue that funding represents, understanding what factors influence innovation center funding can provide helpful insights into the administration of innovation centers.

Funding that innovation centers are able to secure is largely a function of several different attributes that the innovation center has. Specifically, funding for innovation centers can be thought of as a function of three different attributes:

1. The innovation center model that the institute follows
2. The organizational structure that the institute uses
3. The maturity level of the institute

These three attributes can be thought of as variables that help to determine how much funding an innovation center is likely to receive. Innovation centers can generally acquire funding from four primary sources:

1. **Public/Government Contributions:** moneys that are allocated to the innovation center through some publicly funded mechanism (e.g. restricted grants) initiated by a public sector entity
2. **Other Contributions:** moneys that are provided to the innovation center in the form of contributions or gifts from some non-government entity (e.g. universities, corporations)

3. Program Revenue: moneys that are generated from the activities of the innovation center (e.g. membership fees, money from services rendered)

4. Other Revenues: moneys that are generated from non-operational activities that the innovation center engages in (e.g. investment income, gains on sale of assets, fundraising)

An analysis of each of the three attributes that determine funding that the innovation center receives can provide insights into the sources of funding that innovation centers receive.

4.31 FUNDING CRITERIA

Innovation Center Model

When an innovation center is created, one of the key variables that influence the funding that the institute receives is the innovation center model that the institute is founded under.

Innovation centers that operate as maker spaces or industrial incubators generally do not receive as much funding from contributions as innovation facilities do. While some public money, and occasionally private or academic funding, is provided to maker spaces and industrial incubators, these sources of funding generally do not constitute a majority of the institute's funding. Instead, maker spaces and industrial incubators generally receive larger proportions of their revenue from institute members in a landlord like relationship (i.e. the innovation center effectively collects "rent" from its members in exchange for use of the innovation center's assets). The Industrial Council of Nearwest Chicago is an example of this "rent" revenue component, and the institute received over half of its revenue from this landlord like relationship in 2015. Maker spaces and industrial incubators have the opportunity to collect revenues from other sources (e.g. financial instruments, sale of

assets); however these innovation centers generally do not have the ability to collect revenue from the rendering of services, as these centers do not engage in research as an institute.

Innovation facilities, in contrast, generally receive larger contributions from public, private, or academic organizations. The type of innovation facility that is founded can help determine the balance of public, private, and academic funding that is secured by the institute. Manufacturing USA centers, for instance, receive public funding from the Federal Government alongside some contributions from non-public entities (e.g. nonprofits and corporations). An academically founded innovation facility generally receives larger sums of funding from academic institutions than other innovation facilities. In addition to funding from contributions, innovation facilities can extract revenue from membership fees (similar to the "rents" collected by maker spaces and industrial incubators) as well as service revenue that can result from the activities of the institute. The innovation center model that is used by the innovation center can play a significant role in determining the institute's source of funding.

Organizational Structure

The organizational structure that is adopted by innovation centers can play a significant role in determining the funding that the institute is able to secure. Innovation centers that are founded as nonprofits, for example, are generally able to secure funding from each of the four sources described in the introduction. There is no legal impediment that prevents nonprofits from securing public and nonpublic contributions, program revenue, or other revenue. Innovation centers that operate as component units of another entity, for example a university owned innovation center (e.g. AMRC), may be able to receive more funding from academic sources in exchange for some revenue limitations (e.g. investment activities, sale of assets).

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A funding divergence emerges when the organizational structure of the innovation center is accounted for. Generally, there is a tradeoff between flexibility and stability that emerges depending on the organizational structure used by the innovation center. Innovation centers organized as independent entities have a large degree of flexibility with regard to their funding; however they also may not have a guaranteed source of funding that they can continually depend on. In contrast, innovation centers that are organized as a sub-unit of another entity (e.g. an academically or publicly owned dependent innovation center) may have dependable access to certain revenue streams but face obstacles extracting revenue from other methods. The organizational structure that innovation centers are organized under can help determine what sources of funding are easily accessible to the institute, and which are not as dependable for the institute.

Maturity Level

The maturity level, or age, of innovation centers is the third significant attribute that helps to determine the sources of funding that the institute secures.

Generally, innovation centers that are in their infancy require significant amounts of external support to operate (i.e. contributions from public and nonpublic entities). New innovation centers may have a small member roster and relatively few passive income streams, and as a result a large plurality or majority of the institute's funding may come from contributions. As innovation centers age and secure increased membership levels, institutes may begin to experience a shift from contribution dominated funding, to program and other revenue dominated funding.

Manufacturing USA facilities are examples of innovation centers that extract revenue from different sources depending on the age of the institute. Institutes in the Manufacturing USA network were envisioned to attain financial sustainability within 7 years

of the first distribution made to the innovation center. In other words, by the 7th year of operation, one financial goal is for the Manufacturing USA institute to secure more funding from program and other revenue, and receive a smaller proportion of funding from public contributions. Generally, the age of the innovation center can contribute to the balance of funding that is provided by external contributions and revenues generated by the institute itself. As innovation centers age, the proportion of funding that is secured from program and other revenues generally increase at the expense of funding from contributions.

Funding Takeaways

While most innovation centers can alter their funding strategy to meet the needs of their institute, there are certain attributes of innovation centers that can lead to funding biases of different kinds. An understanding of the innovation center model that is being employed by the institute, the organizational structure that the institute operates under, and the maturity of the innovation center can provide useful insights into the natural sources of funding that the innovation center may gravitate towards. Playing to the strengths of the innovation center's attributes can help improve the financial health of the institute.

4.32 FIVE YEAR FINANCIAL PLAN

Sources Considered: Form 990

Introduction

Financial sustainability is often desired by innovation centers and their founding members. Manufacturing USA innovation centers, for instance, are tasked in their objectives with achieving de facto financial self-sufficiency within their 7th year of operation. In order to achieve a sense of financial sustainability, early stage financial planning should be undertaken to construct a solid financial base for the innovation center to build off of.

For AMIC, an initial five year financial plan that strives for financial sustainability should consider the following financial considerations:

1. Service Policy- What services should be offered by AMIC to best preserve financial health?
2. Partnerships- How should AMIC leverage its relationships to secure revenue streams?
3. Financial Framework- What types of costs should AMIC be prepared to deal with in its infancy?

In addition to these financial considerations, the financial nature of innovation centers should also be considered so as to develop a financial plan that utilizes all of the advantages that innovation centers possess and mitigate as many financial threats as possible. An analysis of the financial nature of innovation centers, followed by the three financial considerations for AMIC can provide useful insights on cultivating a solid financial structure for AMIC.

The Financial Character of Innovation Centers

For many innovation centers in the United States, a nonprofit structure is used to operate the center. Manufacturing USA centers, the Industrial Council of Nearwest Chicago, and Commonwealth Center for Advanced Manufacturing are examples of nonprofit innovation centers. For these centers, a traditional "breakeven" analysis on research projects does not carry the same applicability to the centers as it might at for profit research laboratories. At their core, innovation centers do not engage in research to generate a profit, but rather to provide technological innovation to society. The same is true of the business services offered by some innovation centers. As a result, the financial character of innovation centers does not include a traditional gross profit margin that can be used to provide financial

sustainability.

In contrast, one could think of innovation centers in the context of four distinct financial flows:

1. Fixed Costs- Costs that the innovation center carries in order to operate the facility.
2. Variable Costs- Costs that the innovation center carries to carry out research, development, and provide support services to members.
3. Institutional Revenues- Revenues that are generated by the innovation center in the form of membership fees, investments, or other revenue streams that the innovation center controls.
4. External Revenues- Revenues that are derived as funding from external organizations.

Financial sustainability for innovation centers could include a regime where institutional revenues are great enough to cover the fixed costs of the institute, and where any surplus of institutional revenues and external revenues are used to fund research, or the variable costs, of the institute.

The Industrial Council of Nearwest Chicago (ICNC), which has existed since 1967, is an example of an innovation center that has a large degree of financial sustainability under this definition. In 2015, the program service revenues of ICNC totaled \$581,000, while the salaries and occupancy expenses of ICNC totaled \$524,000.

If salaries and occupancy are considered fixed costs of operation, ICNC would be financially sustainable under the definition of financial sustainability described above. Any excess revenues, either institutional or external, could then be used to fund

research or other services that the institute wishes to provide. Unlike for profit institutes which would ordinarily require institutional revenues to cover fixed and variable costs in the long-run, innovation centers should strive to generate enough institutional revenues to cover their fixed costs and use all remaining resources for its research or objective purposes. With the financial character of innovation centers more refined, it is possible to analyze each of the financial considerations of innovation centers for AMIC.

4.34 FINANCIAL CONSIDERATIONS FOR AMIC

Service Policy

For innovation centers, including AMIC, institutional policies about the sector or industry that research will be focused on can improve financial sustainability. For AMIC, declaring a formal focus on metals or additive manufacturing could provide the institute with important control over fixed costs. To illustrate this point, consider the impact that a lack of sector focus could have on the fixed costs of AMIC. If different types of physical capital are required by different sectors, these additional pieces of machinery could significantly compound fixed costs for AMIC without providing a material increase in the institutional revenue of AMIC. By declaring a specific sector of focus, AMIC could maximize the use of specific machinery types and have more control over the fixed costs of the institute.

Similarly to a sector focus, AMIC could also provide a similar focus in terms of the types of research that it carries out as an institute. For example, AMIC could declare that it would focus its efforts on "pre-competitive research" in order to maximize the dollar impact that its spending would provide. By focusing on similar types of research, AMIC could reap the benefits of spending optimization and perform more activities with fewer resources than would otherwise be needed.

Endowment

Financial sustainability at innovation centers can be achieved through the construction of passive income streams that the innovation center can count on in order to fund its operations. In order for investments to provide such income streams, financial capital must be allocated to different investment instruments, such as securities or real estate. An initial endowment of money that the institution receives can be used to seed these financial investments in order to generate internal revenue for the institution.

AMIC could help to create internal revenue streams to fund its fixed costs by allocating some of its initial funding money towards an investment portfolio. In years when AMIC operates with positive net income, some of this net income can be reinvested into the financial portfolio of AMIC, increasing the overall size of this income stream. For many innovation centers, investment income generally forms a small component of total revenue (less than 1%), however through careful planning, saving, and investment, this income stream can be developed at AMIC to sustain the innovation center well beyond its initial funding periods.

Partners

For AMIC to be financially sustainable and carry out its research effectively, seeking out partners that are able to assist the institute can be critical. Partners are important to both AMIC's ability to generate institutional revenues (in the form of membership fees) and also to access external revenue from outside entities. A strong partnership network for AMIC could include:

- A private sector champion and several partners
- One or more universities
- One or more workforce intermediaries

These partnerships are strategic partnerships that could serve two purposes:

1. To provide revenue opportunities for AMIC to support its operations
2. Provide cost control measures through expertise provided by these partners

With respect to the first benefit that strategic partnerships have, a strong partnership network provides AMIC with a deeper fee collecting bench and with more access to external revenue. A private sector champion that is able to advocate for AMIC could be crucial in securing external revenue that is needed to fund the research activities at AMIC. Higher levels of institutional revenues could allow AMIC to increase its fixed or variable costs, while higher levels of external revenue could allow AMIC to increase its variable costs without adversely affecting financial sustainability.

In addition to the revenue benefits associated with a strong partner network, the second benefit speaks to the cost benefits associated with developing strong partnership links. Securing partners that are able to provide expertise on research projects can remove the need for AMIC to use institutional cost on another source of this expertise. For example, if a unique skillset is required to complete one of AMIC's projects that would require outsourcing a knowledge worker, a partner that can provide access to a knowledge worker either in-kind or through a partnership can reduce the overall costs of AMIC. These cost reductions free up resources for AMIC and can allow for variable costs to be used for other purposes.

AMIC, similarly to other innovation centers like AMRC or CCAM could benefit greatly from a strong partnership network. These partnership links can provide the flexibility and resources that are needed to ensure financial sustainability.

Phase I Financial Framework

The financial framework that is employed by innovation centers, particularly in their early phases such as AMIC, can be critical to developing strong financial fundamentals in the long-run. For AMIC, the following financial framework could be used for the initial phase of operations:

- Staffing: 10 to 20 People
- Labor Budget: \$750,000-\$1,500,000
- Total Operating Budget: \$1,500,000-\$3,000,000
- Capital Costs: \$12,000,000-\$16,000,000 (building)
- Site Costs: unknown
- Operating Equipment: \$5,000,000

All are subject to change

4.35 MARKETING & BRANDING

Sources Considered: 39 North Master Plan

Introduction

As an institute, AMIC is far more than a physical space where companies can conduct research. Rather, the AMIC brand is one that provides opportunities for collaboration, innovation, and empowerment both within the St. Louis Region and potentially across the globe. As a result, the AMIC brand and branding strategy should reflect both what utilitarian benefits can be derived from participation and support of the institute, as well as how these utilitarian benefits proliferate to different clusters of society. An analysis of the AMIC brand (i.e. value propositions) and branding strategy can provide useful insights to help capitalize on all of the value that can be created at AMIC.

4.4 AMIC VALUE PROPOSITION

AMIC, as an innovation center, has the ability to provide many different benefits to different segments of society. These benefits are manifested in the value propositions of the institute. Value propositions are statements that inform individuals and organizations that interact with a given entity how the products or services of the entity solve a problem or create value for the user. AMIC has the potential to contain three impactful value propositions to all who come into contact with it:

- Collaboration
- Innovation
- Empowerment

Individuals and organizations that interact with AMIC may choose to interact with AMIC to capitalize on any one of the institute's value propositions, and some of these individuals and organizations may receive more value from AMIC than they intended to receive. Each of the value propositions that AMIC possesses contain different benefits for different users of the institute. Generally speaking, there are four primary groups who could interact with AMIC:

1. Companies (members and non-members)
2. The General Public
3. Governments
4. Universities

An analysis of each value proposition in detail can reveal the specific benefits that can be rendered to each of these primary groups.

Collaboration

Collaboration is one of the three value propositions that AMIC can present. Generally speaking, collaboration involves bringing

individuals and institutions together in a constructive as opposed to destructive way. The group that is brought together under the banner of collaboration may choose to collaborate in different ways (e.g. discussion of a topic, working towards a common goal, allocating resources to a common cause), but the key differentiator that makes collaboration unique is that the group that is collaborating is always engaged in a constructive environment. AMIC, through its physical structure, services offered, and institutional aura has the ability to deliver collaboration to its users and society, and provide net benefits to quality of life through collaboration. For each primary group, the collaborative environment can come about in different ways.

Companies

Companies receive the value of collaboration through AMIC in numerous different ways. For companies that are members of AMIC, the following opportunities depict some of the ways that companies receive value from AMIC's collaboration:

- Communicating with other companies in the collaborative spaces of AMIC's structure.
- Create new partnerships with other AMIC members of non-member industry players
- Acquire intellectual property through AMIC that would otherwise be unavailable

Membership at AMIC bestows upon companies the ability to collaborate with other companies in ways that otherwise would be logistically difficult in a competitive landscape. Through the physical structure of AMIC, the collaborative aura of the institute, and the institutional projects that are pursued by the institute, collaboration is delivered to all member companies, regardless of their level of membership or company resources.

For companies that are not members of AMIC, there are also opportunities to derive collaboration from AMIC. These external companies can benefit from collaboration in the following ways:

- Industry or trade associations that hold membership at AMIC provide all of their industry members with a voice at AMIC, allowing more companies to work together indirectly through AMIC.
- Partnerships that are created at AMIC can create new opportunities for companies outside of AMIC's target industry to support these new partnerships- which are created as a result of AMIC's collaborative value proposition.

For companies both with membership at AMIC and those without membership at AMIC, collaboration can be delivered to all companies that have some interaction with the AMIC. For companies, the ability to collaborate within a network of other individuals and institutions with similar objectives can provide utilitarian value to companies that would otherwise not be available.

General Public

The public, specifically within the St. Louis Region but also across the globe, can receive value from AMIC's collaborative environment in different ways as well. For the public, the collaborative value from AMIC manifests in two different ways: direct collaborative value and indirect collaborative value. Specifically, the public of the St. Louis Region can derive both direct and indirect value from AMIC's collaboration, while people outside of the Region are more likely to derive indirect value from AMIC's collaboration.

The direct value that the public gains from AMIC's collaboration value proposition can be thought of as ways that individuals

within the public realm are able to directly interact with AMIC. The general public can receive direct benefits from collaboration by:

- Receiving the ability to volunteer and work on meaningful research projects with others who are interested in the project's subject matter.
- Network with potential employers who are connected to AMIC's research in some way.

In addition to the direct value that the general public receives from AMIC's collaboration, indirectly the public across the world can benefit from the collaboration of businesses through AMIC. When businesses collaborate, new opportunities for employment and growth can present themselves, and these macroeconomic benefits can provide opportunities both within the St. Louis Region and beyond.

Governments

The public sector, from the St. Louis Region to the Federal level, can also receive value from the collaboration that AMIC offers. Similarly to the general public, there are both direct and indirect benefits that can be derived from the collaboration value

Universities

Universities across the world can reap benefits from AMIC's collaborative value proposition in numerous different ways. AMIC offers universities a unique opportunity to network and build relationships with non-academic institutions, both private and public. These relationships can be leveraged to provide:

- An ability for universities to pair their students and faculty with AMIC members to work on meaningful research and network with potential employers and partners
- Direct communication between universities and other AMIC members to ensure to align member goals with one another

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Innovation

As a research center, AMIC can provide innovation as one of its value propositions. Innovation is a broad term that can take on different meanings when used in different contexts; however it fundamentally involves the creation of a new process, idea, or product that proliferates into an existing environment or creates a new environment autonomously. Innovation provides value in numerous ways including:

- Cost- through more efficient production methods.
- Quality- through improved functionalities, precision, or ease of use.
- Discovery- through the scientific method of observation and experimentation.
- Growth- through providing new opportunities to society.

Through each of the four benefits detailed above, innovation creates value for companies, the general public, governments and universities.

Companies

Companies that are both members and non-members of AMIC benefit from AMIC's innovation value proposition in numerous different ways. Companies have historically invested in research and development to capitalize on the benefits of innovation, and AMIC provides an avenue for companies to maximize their investment in R&D.

For companies that are members of AMIC, value from innovation is created by:

- A maximization of R&D funding through AMIC's pooling of innovation resources.

- The ability to contribute to meaningful research on new subject matter that can benefit the entire industry.
- Assisting in the creation of open source material that can be continually improved by AMIC and industry players

For companies that are not members of AMIC, value from AMIC's innovation manifests as innovations generated by AMIC proliferate outside of the AMIC membership circle. For example, as research is monetized by AMIC members, the resulting technology can be licensed or proliferate to external members. These external members could then enjoy the benefits created by the innovation similarly to AMIC members.

General Public

Globally, innovation has long been linked to increasing consumer value. For example, the creation of innovations such as the Jacquard loom and the steam engine allowed for clothing and travel costs to be drastically reduced and increase access to these goods within the marketplace. In a similar sense, the public can derive similar benefits from AMIC's innovation. Specifically, the public, both within the St. Louis Region and outside of the Region, can benefit from AMIC's innovation through:

- Decreased prices of consumer goods
- Improved quality of consumer goods
- Access to new types of goods that were previously inaccessible
- Advances in the standard of living

To illustrate the potential benefits that the public receives from AMIC's innovation; consider the impact that improved equipment has on company costs. As company equipment improves in quality, average total costs of this equipment tend to decrease

in the long run. A portion of that cost savings is passed on to consumers of the company's products, who are able to enjoy increases in quantity and decreases in prices resulting from this technological innovation. AMIC, through its innovation value proposition, has the ability to deliver quality of life improvements through innovation to the general public.

Governments

Governments have the ability to derive value from AMIC's innovation similarly to companies and the general public. Historically, governments across the world have encouraged technological innovation as a method to secure economic growth in the long run. Securing long run economic growth generally leads to higher overall quality of life amongst the inhabitants of a given country, and also provides the government of the respective nation with a larger tax base.

AMIC allows governments to both directly and indirectly play a role in and benefit from innovation in ways that would be significantly more difficult without AMIC. These direct and indirect roles include:

- Direct- the ability for governments to directly influence and contribute to meaningful research projects.
- Indirect- positive economic growth associated with technological innovation

Government institutions that wish to directly derive value from AMIC's innovation may opt to become members of the institute and both direct and contribute to technological innovation at AMIC. For example, the Department of Defense may wish to improve a specific military technology and can attempt to improve this technology with the help of other AMIC members. Alternatively, improved economic growth resulting from technological innovation can provide all levels of government

with an expanded tax base and an overall higher quality of life.

Universities

Universities can derive value from AMIC's innovation value proposition in numerous ways. For universities, research that occurs at AMIC has intrinsic value, and can also serve as a launch pad for other avenues of research (e.g. creating new metalworking technologies or discovering new applications for metals built upon research performed at AMIC).

Universities that are members of AMIC receive value from AMIC's innovation by:

- Allowing universities to participate in applied research and development (two activities that universities generally are not as focused on compared to basic research) directly with private and public sector partners
- Providing universities with access to intellectual property that is developed at AMIC

For universities, innovation that is provided by AMIC can open the door to new areas of basic research and give universities new technologies to conduct research with. All universities across the globe can benefit from new scientific discoveries, and as a result can benefit from the insights provided by AMIC's research.

Empowerment

The third value proposition that AMIC can provide to each of the 3 primary groups relates to empowerment. Individuals and organizations derive utility from empowerment because it allows for new opportunities and more freedom than were previously available. Empowerment is strongly linked to the concept of negative liberty- which refers to a freedom from impediments. Individuals who are empowered as opposed to not empowered have the ability to do things that other individuals do not. For example, individuals who are skilled and knowledgeable about

welding are empowered to become welders if they choose to be, while individuals who lack these skills face an impediment that can prevent them from becoming a welder if they wanted to become one. AMIC has the ability to empower all three primary groups in different ways, creating new opportunities and expanding access to already existing opportunities.

Companies

AMIC can provide empowerment to companies that are both members of AMIC and those that are not members of AMIC.

For companies that are members of AMIC, empowerment can be accessed in numerous different ways, such as:

- Exposure to students and other individuals who are prospective hires of the company at a significantly reduced cost.
- Access to capital goods at the AMIC center that allow the company to innovate and produce in ways they could not without access to these capital goods.
- Mentorship and other professional services from AMIC staff that can help with business development and administration.

By providing access to tools and services as an institute, AMIC can provide value to member companies through empowerment.

For companies that are not members of AMIC, empowerment is primarily derived from AMIC's workforce training capabilities. Companies that are not members of AMIC can benefit from a more skilled workforce that is trained at the AMIC facility, and they are empowered by this increase in human capital.

General Public

The general public can receive empowerment from AMIC in

numerous different ways, however one of the most significant forms of empowerment that AMIC can deliver is workforce training or knowledge.

As manufacturing becomes more technological, new skills are required by the manufacturing workforce. Learning these skills can be difficult, especially for workers who have been displaced by these new technologies. AMIC can empower these workers by giving them an environment where they can both learn the skills they need to perform these new jobs and build a resume for themselves. Value from educational empowerment can be delivered to the public of the St. Louis Region and give workers the freedom to learn skills they previously did not have the opportunity to learn if they choose to do so.

Governments

Governments can derive benefits from AMIC's empowerment value proposition in a number of different ways. For governments in the St. Louis Region, AMIC empowers governments to directly provide workforce training alongside private partners. For example, while it may be difficult for a municipality in the St. Louis Region to compel a group of private employers to engage in workforce training simultaneously, AMIC contains a group of private companies who are willing to work with the local workforce for a mutually beneficial arrangement- workforce training in exchange for work services.

AMIC empowers governments in the St. Louis Region to develop apprenticeship programs, job fairs, and other workforce training regimes without the need for immense public sector coordination alongside private industry. The removal of this coordination impediment can allow local governments to more directly encourage workforce development in their communities.

Universities

Universities can be empowered by AMIC in a number of different ways, such as acquiring a greater ability to turn basic research into commercial products. It can be difficult for basic research in university settings to be transferred to the marketplace as a commercial product, however AMIC can empower universities with the resources they need to convert research into tangible products. Startup companies that are founded at AMIC could take the research conducted at AMIC (backed by its university members), and bring the product into the marketplace. By providing universities with potential private sector investors and entrepreneurs, AMIC can empower universities with a greater ability to commercialize their innovations.

Additionally, AMIC can empower universities by giving them access to technology that the university may not have access to on its own. For example, AMIC could provide universities with access to industrial 3D printing technology that could allow for theoretical ideas to be tested in a laboratory or practical setting. Universities can benefit from empowerment that is provided by AMIC, and can use this empowerment to help create technologies that benefit the entire globe.

As an institute, AMIC has the ability to provide a multitude of different benefits to the St. Louis Region and potentially to the world. These benefits manifest themselves in utilitarian quality of life improvements that can directly benefit different groups of people. Fundamentally, AMIC can provide value to these groups in the form of collaboration, innovation, and empowerment, among others, and these value propositions distinguish AMIC from other places of research. These value propositions form the public identity of AMIC, and can allow AMIC to stand out in the St. Louis Region and potentially across the world.

AMIC Financial Framework

AMIC's financial framework can be viewed as a function of the institute's attributes and initial resources. For example, the membership fees that AMIC generates can be considered a function of the total number of members that AMIC has, as well as the fees that are levied upon members. Revenue can be altered by either changing the total number of members or the fees that members must pay. To analyze the financial character of AMIC, a financial template was developed in an attempt to capture the impact that different institutional attributes would have on AMIC's finances, as well as how different financial strategies could theoretically impact the sustainability of AMIC.

The financial template consisted of 13 input sections where different numeric values and assumptions could be inputted by the user. These initial values and assumptions allowed for the generation of a conceptual income statement for AMIC. These 13 input sections ranged from selecting a time frame to calculate an inflation rate (to make inflation adjustments to costs of AMIC) to inputting the number of employees in specific industry sectors that work at AMIC. As the user completes each input section, the income statement of the template is updated to reflect user inputs.

The financial template can be calibrated to generate a conceptual income statement for several years of operation, and for the sake of this analysis was calibrated to calculate a total of 7 years. The reasoning behind generating 7 years of incomes statements for AMIC was that the first 2 years would represent non-operating years (i.e. planning and construction years), with 5 years of operation simulated afterwards by the template. Once the user has finished entering all of their inputs into the template, a conceptual income statement is generated in the following format:

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Income Statement								
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
		Planning	Construction	Operating	Operating	Operating	Operating	Operating
REVENUES	Grants	\$2,000,000	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000
	Membership Fees	\$750,000	\$836,000	\$976,000	\$1,387,000	\$1,489,000	\$1,594,000	\$2,039,000
	Investment Income	\$20,000	\$29,000	\$36,000	\$37,000	\$38,000	\$39,000	\$41,000
	Total Revenues	\$2,770,000	\$2,365,000	\$2,512,000	\$2,924,000	\$3,027,000	\$3,133,000	\$3,580,000
EXPENSES	Labor	\$41,000	\$92,000	\$124,000	\$527,000	\$610,000	\$622,000	\$634,000
	Building	\$0	\$0	\$262,000	\$267,000	\$272,000	\$277,000	\$282,000
	Interest	\$578,000	\$578,000	\$578,000	\$578,000	\$578,000	\$578,000	\$578,000
	Contract Services	\$0	\$0	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000
	Total Expenses	\$619,000	\$670,000	\$2,464,000	\$2,872,000	\$2,960,000	\$2,977,000	\$2,994,000
Net Income		\$2,151,000	\$1,695,000	\$48,000	\$52,000	\$67,000	\$156,000	\$586,000

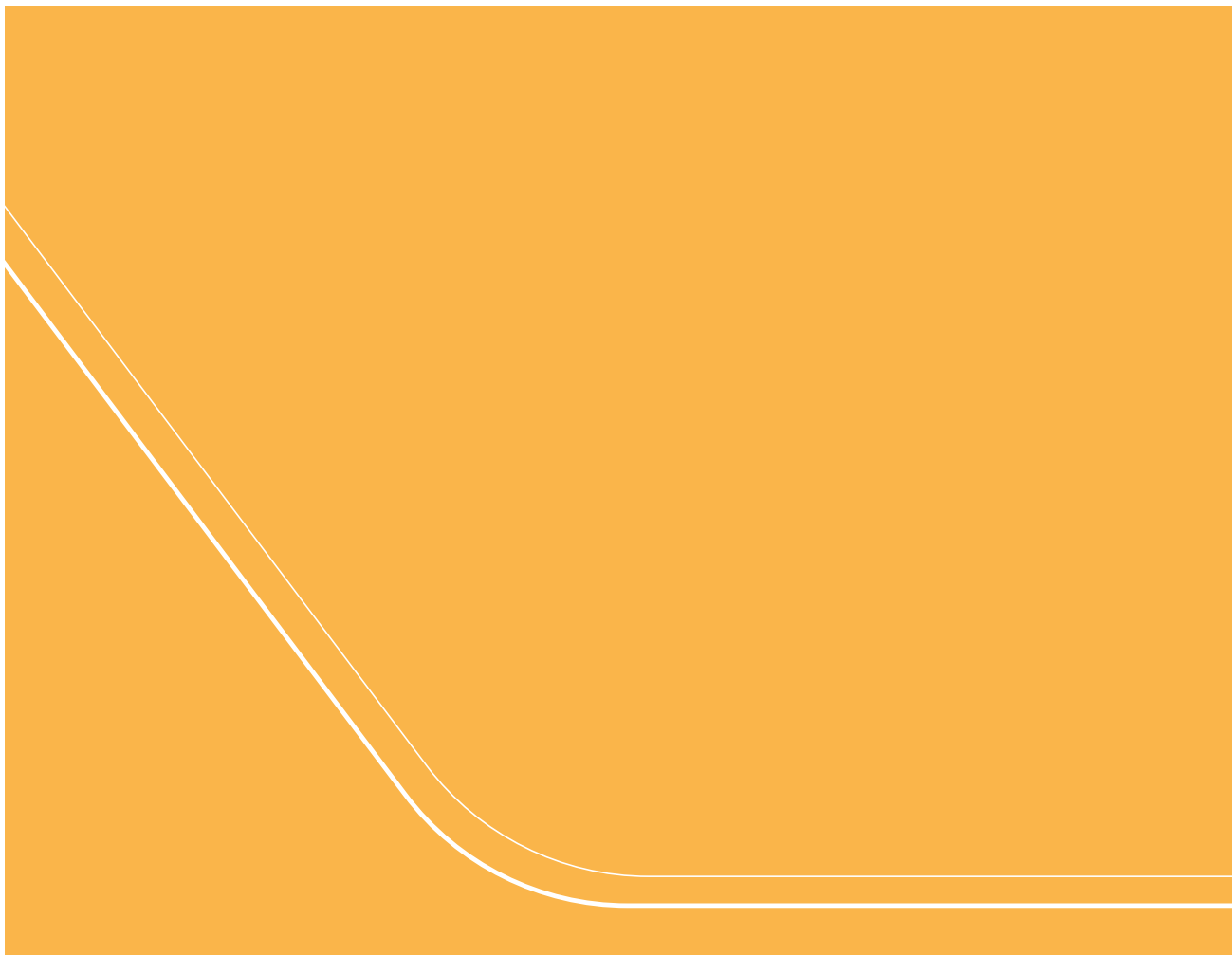
*Excludes depreciation and other non-cash expenditures. Estimates are conceptual.

External Revenue Internal Revenue Fixed Costs Variable Costs

Each line item of the income statement was based on line items from the Form 990s of other innovation centers (CCAM, LIFT, DMDII, and ICNC). The revenues and expenses listed on the above income statement are also intended to be consistent with the definition of financial sustainability outlined in this document. External revenues are highlighted in green while internal revenues are highlighted in yellow, which allow the user to examine how dependent AMIC could be on external revenues based on the user's input. Likewise, expenses can be classified as fixed or variable, consistent with the definitions used to define financial sustainability.

Analyzing AMIC's finance using this template can allow the user to simulate how different assumptions could impact AMIC's financial sustainability. For example, the user can simulate the effectiveness of using membership fees to fully fund fixed costs of the institute, or instead simulate how much AMIC would need to accumulate in investments to supplement any membership losses.

The table on the previous page depicts an income statement generated by the template based on assumptions about AMIC. Values used to generate this income statement were based on midpoint values presented in this report (e.g. building size, cost), and based on midpoint values from the financial statements of other innovation centers (CCAM, LIFT, DMDII). The midpoint values were based on common sized financial statement analysis (i.e. the financial statements of other innovation centers were viewed proportionally to generate input values for AMIC). For this income statement, grants that AMIC received were assumed to fund research for the institute (contract services).



APPENDIX

INTERVIEW CONTACTS

Appendix

Name	Organization
Leroy Stromberg	Alberici Construction
Keith Ridgway	AMRC
Antonio Santos	BioMerieux
Ben Johnson	BioSTL
Ray Freim	Bi-State Development Metro
Peter Hoffman	Boeing
Darryl Davis	Boeing Phantom Works
Martin Kaiser	Bugeye Technology
Ed Monser	Emerson
Keith Guller	Essex Industries
Charles Gascon	Federal Reserve Bank of St. Louis
Milton Fulghum	Flight Safety International
Jon Sonju	GKN
Satya Veerapaneni	GM Wentzville
David Boulet, Ph. D.	IMEC
Steve DeBretto	Industrial Council of Nearwest Chicago
John McDonnell	James S. McDonnell Foundation
Bill Fienup	mHUB
Dusty Cruise	Missouri Enterprise
Henry Wiebe, Vice Provost	Missouri University of Science & Technology
Steve Tupper	Missouri S&T, Military Education and Research Liaison

Name	Organization
Douglas Bristow, Ph. D.	Missouri S&T, Director, Center for Aerospace Manufacturing Technologies
Joseph Newkirk, Ph.D.,	Missouri S&T, FASM, Professor Materials Science & Engineering
Elizabeth Smith,	Missouri S&T, Chief of Staff, Office of the Chancellor
Ming Leu,	Missouri S&T, Ph.D., Director, Intelligent Systems Center
Richard Wlezien, Ph. D.	Missouri S&T, Vice Provost and Dean, College of Engineering and Computing
Dr. Phil Singerman	National Institute of Standards and Technology
Stan Shoun	Ranken Technical
Joe Bannister	St. Louis Economic Development Partnership
Ginger Imster	St. Louis Economic Development Partnership
Ken Olliff	St. Louis University
Amy Breuer	St. Louis University
Cindy Mebruer	SLU; Boeing Supply Chain Center
Mary Lamie	St Louis Freightway
Steve Long	St. Louis Community College
Dr. Jeff Pittman	St. Louis Community College
Marc Bowers	St. Louis Makes / Brick City Makes
Jerry Stauder	Stauder Technologies
Tom Swip	Swip Systems
Steve Epner	The Startup Within
Ramesh Agarwal, Ph. D.	Wash U, School of Engineering & Applied Science
Brian Clevenger	Yield Lab

INNOVATION CENTER TYPES

Metric	Basic Maker Space	Enhanced Maker Space	Industrial Incubator Space	Government Based Innovation Facility	Hybrid Innovation Facility	Academic Based Innovation Facility
Example Center		MHUB	ICNC	LIFT	CCAM	AMRC
Ownership	Non-Profit	Non-Profit	Non-Profit	Non-Profit	Non-Profit	Academic
Organizational Structure	Subscription Fees	Subscription Fees	Flat Fee	Tiered Membership Fee	Tiered Membership Fee	Tiered Membership Fee
Cost	Low	Low	Medium	High	High	High
Location Flexibility	High	High	Medium	Low	Low	Low
Initial Requirements	Low	Low	Medium	High	Medium	High
Support Capabilities	Low	Low	High	High	High	High
Research Capabilities	Low	Low	Low	High	High	High
Production Capabilities	Low	Low	Low	High	High	High
Institutional Support	Low	Low	Low	High	Medium	High

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REVENUES

ADVANCED MANUFACTURING INSTITUTE REVENUES (2015)

Example Center	LIFT	CCAM	DMDII	ICNC
Government Grants	\$5,630,418	\$0	\$28,095,523	\$108,327
Program Service Revenue	\$350,000	\$4,262,339	\$3,221,792	\$581,116
Other Revenue	\$2,004,607	\$1,990,453	\$1,002,140	\$121,505
Total Revenue	\$7,985,025	\$6,252,792	\$32,319,455	\$810,948

Source: Form 990

ADVANCED MANUFACTURING INSTITUTE EXPENSES (2015)

Example Center	LIFT	CCAM	DMDII	ICNC
Salaries & Wages	\$440,533	\$2,715,940	\$4,485,688	\$321,216
Occupancy	\$453,308	\$1,530,112	\$1,557,062	\$203,056
Other Expenses	\$4,855,824	\$3,966,399	\$10,737,281	\$216,033
Total Expense	\$5,749,665	\$8,212,451	\$16,780,031	\$740,305

Source: Form 990

ADVANCED MANUFACTURING INSTITUTE REVENUE PER EMPLOYEE (2015)

Example Center	LIFT	CCAM	DMDII	ICNC
Government Grants	\$1,407,605	\$0	\$550,893	\$7,738
Program Service Revenue	\$87,500	\$88,799	\$63,172	\$41,508
Other Revenue	\$501,152	\$41,468	\$19,650	\$8,679
Total Revenue	\$1,996,256	\$130,267	\$633,715	\$57,925

Source: Form 990

ADVANCED MANUFACTURING INSTITUTE EXPENSES PER EMPLOYEE (2015)

Example Center	LIFT	CCAM	DMDII	ICNC
Salaries & Wages	\$110,133	\$56,582	\$87,955	\$22,944
Occupancy	\$113,327	\$31,877	\$30,531	\$14,504
Other Expenses	\$1,213,956	\$82,633	\$210,535	\$15,431
Total Expense	\$1,437,416	\$171,093	\$329,020	\$52,879

Source: Form 990

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BOEING RESEARCH AND TECHNOLOGY CONSORTIA

Advanced Manufacturing Research Centre (AMRC)

A maker space is an innovation center classification that can offer resources and support services to businesses to help the University of Sheffield AMRC helps manufacturers of any size become more competitive by introducing advanced techniques, technologies and processes. Founded in 2001 in Sheffield, England, AMRC now has eleven core capabilities including structural testing, additive manufacturing, microscopy and virtual reality.
<http://www.amrc.co.uk/pages/about>

Integrated Vehicle Health Management Centre (IVHMC)

IVHM is the transformation of system data on a complex vehicle or system (such as a luxury car or a commercial airplane) into information to support operational decisions and optimize maintenance. The Cranfield University IVHMC delivers generic IVHM solutions from our research. Established in 2008 in Cranfield, England, IVHMC supports commercialization, reducing time to market and combine technology, business and technology transfer solutions.
<https://www.cranfield.ac.uk/centres/throughlife-engineering-services-institute/integrated-vehicle-health-management-ivhm-centre>

Digital Manufacturing Research Center (DMRC)

The DMRC is an institution in the faculty of mechanical engineering at the University of Paderborn. Opened in 2008 in Paderborn, Germany, DMRC projects focus on additive manufacturing technologies for end-use part production purposes.
<https://dmrc.uni-paderborn.de/>

Advanced Forming Research Centre (AFRC)

The University of Strathclyde AFRC is a globally-recognized centre of excellence in innovative manufacturing technologies,

R&D, and metal forming and forging research. Founded in Renfrewshire, Scotland in 2009, AFRC collaborates with all types of organizations: from global OEMs all the way through to local manufacturing companies.
<https://www.strath.ac.uk/research/advancedformingresearchcentre/aboutus/>

Aviation Services Research Centre (ASRC)

ASRC is an industry-led non-profit making organization established by The Hong Kong Polytechnic University (PolyU) in 2013. The aim of ASRC is to develop new or improved aviation service technologies and processes applicable to industry. The ASRC business scope covers aviation service research, manpower development, and business information exchange.
<http://www.asrc.hk/about.html>

Boeing Cyber Analytics Center (BCAC)

Established in 2015 in Singapore, BCAC brings advanced cybersecurity capabilities and services to its partners in the region. The center helps train and equips cybersecurity professionals, perform advanced analytics and serve as Boeing's regional cybersecurity center of excellence.
<http://boeing.mediaroom.com/2014-09-22-Boeing-to-Open-First-Cyber-Analytics-Center-Outside-the-US-in-Singapore>

Boeing Research & Technology (BR&T)

King Abdullah University of Science and Technology BR&T organization collaborates with the University on a number of major research projects in advanced materials, combustion quenching, solar power optimization and industrial water treatment. Established in 2009 in Makkah, Saudi Arabia, Boeing technology leaders are currently working with KAUST researchers on purifying manufacturer water and the development of unique mechanisms for the analysis of flame quenching physics.

[https://www.kaust.edu.sa/en/news/kaust-and-boeing-renew-mra-\(2\)](https://www.kaust.edu.sa/en/news/kaust-and-boeing-renew-mra-(2))

Canadian Composites Manufacturing R&D Inc. (CCMRD)

CCMRD is an industry-led not-for-profit consortium with a mandate to develop and demonstrate advanced composite manufacturing technologies in Canada. Founded in 2010 in Winnipeg, Canada, CCMRD brings together major aerospace companies and small-to-medium sized enterprises to develop and transform the latest technical and academic knowledge into practical solutions that will enhance Canada's global competitiveness.

<http://www.ccmrd.ca/>

National Centre for Aerospace Innovation and Research (NCAIR)

The IIT Bombay NCAIR is a collaborative consortium of the Indian aerospace manufacturing sector providing research and technology to its members with a vision to create a world class aerospace manufacturing ecosystem in India. Established in 2010 in Mumbai, India, it serves as a catalyst for collaboration between industry, academia, research & development organizations, and government with an aim to provide economically viable and sustainable solutions to the Indian aerospace manufacturers.

<http://ncair.in/about/organisation>

Sustainable Bioenergy Research Consortium (SBRC)

The Masdar Institute of Science and Technology SBRC was established in Abu Dhabi in 2011 as a not-for-profit research consortium to advance the aviation industry's commitment to sustainable business practices by developing technology with the promise of producing a clean, alternative fuel supply.

<https://sbrc.masdar.ac.ae/>

Center for Cabin Air Reformatory Environment (CARE)

The Tianjin University CARE develops technologies in aircraft cabin environments, advanced materials, computer science and industrial designs. Established in 2012 in Tianjin, China, CARE deepens its partnership with the university on aircraft cabin air environment research projects.

http://www.boeing.com/resources/boeingdotcom/company/key_orgs/boeing-international/pdf/chinabackgrounder.pdf

Thermoplastic Composites Research Center (TPRC)

The University of Twente TPRC is a not-for-profit organization active in the thermoplastic composites industry. Founded in 2012 in the Netherlands, TPRC aims to enable a more widespread use of thermoplastic composites (TP) by eliminating technological barriers. TPRC believes in TP as the material for lightweight manufacturing in large volumes for a broad range of end use markets.

<https://tprc.nl/about-tprc/>

Collaborative Research Center for Manufacturing Innovation (CMI)

The Institute of Industrial Science at the University of Tokyo established CMI in 2013 for the purpose of developing innovative manufacturing technologies for fuel-efficient aircrafts using materials of high specific strength and rigidity. The center's research promotes advanced manufacturing processes and systems, such as high speed machining of CFRP and titanium alloy, NDI and repair of CFRP, robotic machining and sealing, and the hot forming and welding of titanium alloy.

https://www.iis.u-tokyo.ac.jp/en/research/departament_center/cmi/

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SAMPLE BALANCE SHEET

	Non-Profit Balance Sheet	Beginning of Year	End of Year		Non Profit Income Statement	Value
		A	B			
Assets	Cash/Cash Equivalent			Revenue	Government Grants	
	Contributions Receivable				Other Contributions	
	Accounts Receivable				Program Revenue	
	Inventories				Revenue from Services	
	Prepaid Expenses				Investment Income	
	Property, Plant, Equipment				Total Revenue	
	Accumulated Depreciation			Expenses	Grants Paid	
	Investments				Wages	
	Intangible Assets				Benefits	
	Other Assets				Administrative Expense	
Liabilities	Total Assets				Interest Expense	
					Depreciation Expense	
	Accounts Payable/Accrued Expenses				Total Expenses	
	Grants Payable				Net Income	
	Deferred Revenue					
	Bond liabilities					
	Secured Notes and Mortgages					
	Unsecured Notes and Mortgages					
Net Assets	Other Liabilities					
	Total Liabilities					
	Unrestricted Net Assets					
	Temporarily Restricted Net Assets					
	Permanently Restricted Net Assets					
	Paid in Capital					
	Retained Earnings					
	Total Net Assets					

