USDOT Region V Regional University Transportation Center Final Report

NEXTRANS Project No. 129UMY2.1

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphical Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions

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Disclaimer

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TECHNICAL SUMMARY

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Title

Mapping New Mobility Business, Innovation, and Employment Opportunities in Michigan: Developing a Data-Driven Graphical Platform for Assessing and Advancing Industry Cluster Development and Entrepreneurship Opportunities in Urban Regions

Introduction

Across regional economic development leaders and policy makers, the concept of clustering has grown in importance as a framework for structuring economic growth and resurgence (Muro & Katz, 2010). Cluster identification is most often treated as a comparative evaluation through juxtaposition of existing conditions within a boundary area relative to other competing areas (Porter, 1998). A central aim of this project is to develop visualization methods and tools that can inform decision making regarding the nurturing of emerging clusters, and more specifically, to develop visual tools for identifying which components and factors are present or lacking in a region, and which could be developed in order to reengineer, catalyze, or grow a cluster. The project aims to produce visualizations to assist decision-makers is assessing what elements associated with potential New Mobility economic cluster formation are present within a region and which might be absent, constitute an opportunity space for development, and could be assembled around specific initiatives given the right investment and support. To undertake this, the project uses the conceptual framework of scenario planning to position the work as a way to open up new vistas to the future of a region's economic development from the existing conditions of the region, not merely to diagnose and evaluate existing conditions. Visualization techniques developed through this project include geospatial mapping, historical mapping, relational mapping and combinatory mapping. Potential scenarios associated with the New Mobility economy in Southeast Michigan are utilized to test and explore the application of techniques developed through this project.

Findings

Historical case studies were utilized to prototype the visualization techniques for three existing economic clusters associated with the New Mobility economy including the Southeast Michigan Advanced Battery Cluster, Northeast Ohio Polymer Cluster and the Saguenay Aluminum Cluster. Through each of these examples, and the review of economic theory associated with cluster development the authors developed strategies to visualize both regional characteristics that are explicitly geospatial, and those that elude spatialization (relational mapping). In preparing descriptive visualizations of the historic conditions surrounding cluster formations, a language of visualization was developed and prototyped with stakeholder feedback on issues of legibility and their capacity to present and account for information to assist in the evaluation of cluster potential. A range of conditions including regional economic foundations, extant regional assets, and emerging regional assets can be assembled as combinatory mapping methods through which the presence of anticipated cluster actors can be assessed. Relational mapping techniques to assess untraded relationships in order to evaluate potential catalysts for cluster development are both more difficult to visualize and a subject around which data availability, reliability and granularity present numerous challenges. In both instances, the role of Institutions for Collaboration (IFCs) are central in assembling self-identifying cluster participants, aggregating solicited data to assist with overcoming the challenge of incomplete data sets and facilitating contact and dialog around potential catalyzing projects.

Recommendations

- As the phenomena of economic clustering is inherently related to issues of colocation, and related to several core factors that are explicitly geospatial including economic foundations, extant regional assets and emerging regional assets, geospatialization through cartographic visualization of a range of these issues can enable new apprehension of the regional context for economic development in this realm.

- Culturally there is a high degree of cartographic literacy across the capacity sets of many individuals, hence the most familiar types of mapping (geospatial) undertaken within this project were those most easily understood and interpreted across stakeholder participants. In order to be effective, broad legibility is important to facilitate discussion and decision-making across groups of multi-disciplinary composition.

- Existing traded relationships across firms within the economic sectors comprising a cluster constitute an important characteristic in describing the underlying economic conditions that indicate potential cluster strength. In defining these traded relationships significant challenges exist in assembling detailed, complete and interchangeable data to enable the production of meaningful visualizations of economic exchange and are limited to existing available data sources. Soliciting more robust reporting of relations between regional actors through entities such as IFCs or in partnership with firms associated with the emerging cluster could assist with overcoming this challenge.

- Multiple factors associated with the emergence of economic clusters are tied to untraded relationships between key actors within the opportunity space defining sector activity. Tools for visualization of the social networks that surround these contexts exist, however, a key challenge is to identify available datasets that would enable the building of such models. While increasingly, the phenomena of social media platforms and self-reporting of such relationships is becoming available, further work is required to assemble, parse, analyze and visually report these interactions in order to inform geospatial and traded dimensions of cluster mapping.

- The geospatial mapping practices developed through this project rely on data assemblage, geocoding through GIS based software platforms and post-processing in graphic design software packages in order to produce static maps (images) that represent the assembled data in a particular graphical format for a specific moment in time (data specific). New modes of mapping that sit on top of dynamic, open online large scale geospatial platforms (such as Google Earth), and that are driven by self-reported sourcing of the database content have the potential to disrupt the limitations of the static map, and address aspects of data availability – especially for emergent system participants. Such platforms constitute an import next-generation format for work of the kind undertaken in this project.

- In both economic cluster theory and case studies, the central role of Institutions for Collaboration (IFCs) in aggregating membership, producing awareness and facilitating cluster development are of great importance and often constitute a central catalyst in cluster formation and development over time. For regions aiming to foster specific clusters, and in the case of current interest in the New Mobility Economy within Southeast Michigan, the presence of such an entity or entities is important. An IFC focused on questions of the New Mobility economy could undertake key activities related to aggregating membership, promoting catalytic projects and connecting membership across sectors. This role is all the more important due to the wide range of often disconnected industry sectors that are implicated in many New Mobility projects regardless of scale.

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1.0 Introduction and Overview

1.1 Project Context and Background

A panoply of new services, products, technologies, and design opportunities are emerging to supply New Mobility related solutions for an increasingly complex world. This recent transportation evolution related to rapid worldwide urbanization and shifting cultural, economic, environmental, and demographic trends is currently creating unique business and employment opportunities and generating innovative new business models for sectors as diverse as information technology, manufacturing, energy, service and retail, tourism, real estate, logistics, urban design, architecture, infrastructure. It is also generating new meta-opportunities that connect these industries and economic sectors as clusters to supply seamless door-to-door systems for moving people, moving goods, and moving less more sustainably locally and abroad.

Michigan business, civic, education, labor and political leaders recognize that the state possesses tremendous assets and expertise related to the emerging global New Mobility market-space, and are actively supporting this economic shift. In a 2002 report on building a new mobility cluster in the Toronto region, a wide range of industries including telecommunication, ITS, real estate, IT, transport operations and services, tourism, and more were all considered part of the then multimillion-dollar New Mobility Industry Cluster (ICF Consulting & Moving the Economy, 2002). In January 2012, Business Leaders for Michigan (BLM), with support from McKinsey Consulting and The Brookings Institution Metropolitan Policy Program, released the Michigan Turnaround Plan, assessing Michigan's strategic economic opportunities and naming growth in the New Mobility space as one of the state's leading opportunities for jobs and economic growth (Business Leaders for Michigan, 2012). New Mobility systems and products bring a range of innovative transportation systems and solutions together with IT to move people and goods more sustainably and efficiently, and at the same time to move toward more sustainable and livable communities, competitive regions, and revitalized economies. Corporate leaders led by Bill Ford, Chairman of Ford Motor company, and organized through BLM, are working to identify and support the key actions, policies and practices that can create conditions for Michigan to become, in Bill Ford's words, the "Silicon Valley" of New Mobility (Howes, 2012).

This is a complex evolution to understand and advance, and, while global in nature, its opportunities are regionally specific. Recently, there have been increasing efforts to understand the various layers of these new integrated transport systems, referred to as the New Mobility Grid (in particular infrastructure, modes, technologies, services and amenities and how they relate to each other), less activity and fewer tools exist to support understanding and advancement of industry, enterprise growth, economic development, and employment opportunities related to this shifting transportation context. Both the gap and the need for such tools are particularly pronounced in the context of

Southeast Michigan (SEM); an economy particularly affected by this shifting transportation landscape in both direct and indirect ways.

1.2 Project Goals

Across regional economic development leaders and policy makers, the concept of clustering has grown in importance as a framework for structuring economic growth and resurgence (Muro & Katz, 2010). This project is fundamentally embedded in this discourse and accepts as its premise the potentials that clusters have for regional economic development – that is, the geographic co-location of interrelated actors which cooperate around a specific specialization or specializations through which competitive advantage is derived for the involved actors and thus the region through job creation, increased tax base, infrastructural investment, and strategic advantage with respect to related areas of specialization over other competing regions. Cluster identification is most often treated as a comparative evaluation through juxtaposition of existing conditions within a boundary area relative to other competing areas (Porter, 1998). A central aim of this project is to develop visualization methods and tools that can inform decision making regarding the nurturing of emerging clusters, and more specifically, to develop visual tools for identifying which components and factors are present or lacking in a region, and which could be developed in order to re-engineer, catalyze, or grow a cluster. The project aims to produce visualizations to assist decision-makers is assessing what elements associated with potential New Mobility cluster formation are present within a region and which might be absent, constitute an opportunity space for development, and could be assembled around specific initiatives given the right investment and support. To undertake this, the project uses the conceptual framework of scenario planning to position the work as a way to open up new vistas to the future of a region's economic development from the existing conditions of the region, not merely to diagnose and evaluate existing conditions.

Recent cluster mapping projects such as the *U.S. Cluster Mapping Initiative* (2014) are primarily focused on identifying and quantifying existing national-level industry clusters and regional specializations through comparative data spatialization related to economic factors. This project has aimed to develop graphical tools to better understand where clusters could form given the desire and investment to do so from industry, government, research institutions, and other regional stakeholders. Our methodology builds graphical tools based upon the process of a competence audit, defined as the "mapping of competitive advantages of the region, identifying the competencies of the participating companies/organizations, and determining the gaps that exist" (Andersson, Sylvia, Serger, Sörvik, & Hansson, 2004, p. 79). We have developed a series of visual techniques that map existing regional-scale cluster competencies, or the physical and non-physical assets that may foster clustering opportunities. This includes the geospatial distribution and density of firms across relevant industries, traded and untraded relationships between firms and other regional actors, and the regional economic foundations that underlie existing clusters and which may support future cluster development. In addition, through analysis of a series of historical case studies, we have developed modes of visualization that aim to facilitate the reverse engineering of existing and formalized New Mobility clusters, in order to better understand which industries might be implicated in the New Mobility—especially identifying those that might exist outside of normative expectations; which regional foundational issues are critical to formation; and how, when, and with which instruments cluster-catalyzing interventions were made relative to instances of emergence and formation. Through the various visualization processes and techniques, our aim is to point towards new tools that might enable informed decision-making and risk assessment in assessing emerging sectors, while helping to identify the places where strategic actions might be taken to promote regional advantage within emerging economic opportunities associated with the New Mobility space.

In general, the suite of visualization tools developed in this project aims to fill an important analysis gap for understanding existing and emerging industries and enterprises surrounding New Mobility. These tools may help to produce more informed decision-making and innovation by governments, large business, entrepreneurs and other innovators by integrating diverse sets of data and interrelations that operate within the 'blind spots' of individual sector participants. In attempting to identify visually specific existing assets such as firms, concentrations of firms by industry type, economic foundations, and linkages between firms that already exist, and in turn showing where there are absences or gaps, the sets of tools outlined in this report will be of value to those interested in growing strategic linkages towards new cluster initiatives generally and a new mobility industry cluster in Southeast Michigan specifically. We see this effort to visualize the existing field as a fundamental first step for future cluster initiatives that might be established. Overall, this work has direct implications for local and regional governments seeking to promote regional economic development, employment, entrepreneurship and sustainable communities; leaders of large and medium sized business seeking to understand new major market opportunities; entrepreneurs, venture capitalists, foundations, and social enterprises currently moving in to the New Mobility space; and NGO's and academics focused on sustainable transportation, livable cities, and sustainable economic development. While there is a specific Michigan-based component to this work that addresses Region V specifically, the project has attracted partners to this work, including Business Leaders of Michigan, Next Energy, Michigan Economic Development Corporation, Detroit Works, Ford Motor Company and over fifty private and public sector participants outside of the region such as the University of San Paulo, Scottish Enterprise, Scottish Smart Mobility, the Institute for Competitiveness (India), and KPMG LLP/ Harvard University. As a methodology and way of working through visualization this project presents a scalable platform and approach to be tested in other regions nationally and globally.

1.3 Report Overview

The following report is structured as a series of six successive sections that outline and report on work undertaken through this project. *Section 2.0: Background to Economic Clusters* provides an overview of economic cluster theories and interdisciplinary perspectives associated with cluster development that inform specific aspects of the visualization efforts of the project. It describes a series of three historic case studies that were undertaken to both test the validity of clustering concepts and provides concrete examples that are used to develop initial project visualizations. This section articulates how the project was conceived, developed, and executed, focusing specifically on the conceptual importance of agglomeration and clustering, scenario thinking, the ways in which the cluster concept informs data collection strategies in the context of emergent, and yet undefined, contexts and the different typologies of visualization and their relation to scenario thinking. *Section 3.0: Typologies and Methods of Mapping* outlines a range of considerations and techniques explored in the visualization efforts of the project including a discussion of the scenario planning techniques utilized in the economic mapping of the New Mobility economy in Southeast Michigan. *Section 4.0: Visualizing New Mobility Economic Opportunities in Southeast Michigan* describes specific data based methodologies, constraints and techniques deployed in developing cartographies and visualizations for the region. It also includes a discussion regarding limits to available data and future considerations that might inform related work. *Section 5.0: Stakeholder Input and Process Development* outlines the process of stakeholder consultation enabled through U-M-SMART's Global Professional Network. *Section 6.0: Mapping Possible Clusters: A Scenario Approach* describes the strategy deployed to outline three possible cluster-catalyzing processes and includes combinatory maps developed to support assessment and discussion of those scenarios. The final section outlines conclusions and recommendations regarding the advancement of future work related to this project and strategic next steps to be undertaken in advancing data-based visual techniques to assist with the development of New Mobility economic clusters.

2.0 Background to Economic Clusters

2.1 Introduction to Clusters

Many experts agree that access to knowledge and information plays a decisive role in the development and competitiveness of firms and regional economies in today's complex and evolving global economy. At the heart of this discussion is the idea of economic clustering as a means to create efficiencies, reduce barriers of access to ideas, and spark innovation within a given region. The concept of clustering goes beyond more basic economic concepts such as the agglomeration of industries, whereby the concentration and specialization of firms in a geographic area produces external economies of scale. In a cluster economy, there are added dimensions of interaction and cooperation that link a diverse network of local actors and facilitate flows of intellectual and social capital. In this section, we outline the conceptual frameworks that underpin this project. We first summarize the key ingredients of clusters and the processes of cluster formation as described in Andersson, Serger, Sörvik, and Hansson's *The Cluster Policies Whitebook* (2004); we then expand those definitions by describing our own findings from case studies of three existing clusters related to the concepts of New Mobility from within the Great Lakes Megaregion. We close the section with a discussion of the importance, challenges, and some effective methods of analyzing cluster economies that inform our approach to their visualization.

The concept of economic clustering has developed from early theories of agglomeration, which economists and geographers used to explain specialized concentrations of economic activity as early as the 1820s (Thünen, 1826). Whereas agglomeration focuses exclusively on the co-location of firms, clustering is concerned with not only the proximity of similar firms, but also the traded and untraded linkages between diverse regional actors which produce competitive and cooperative advantage through economies of scale and scope, knowledge spill-over, and shared marketing activities. Michael Porter (1998) defines clusters as "a geographically proximate group of interconnected companies and associated institutions in a particular field linked by commonalities and complementarities" which include agglomerations of firms as well as a network of governmental, research, training, commercial, and other institutions and organizations. In *The Cluster Policies Whitebook*, Andersson, Serger, Sörvik and Hansson (2004) build upon Porter's definition, describing clusters as:

> *"Spatial concentrations of specialized multiple actors linked through competition and cooperation in response to specific local and global market demands supported by a range of legacy frameworks, such a regulator environments, R&D activity, social capital, and various infrastructures."*

Malmberg, Sölvell, and Zander (1996) add that clusters "are made up not only of physical flows of inputs and outputs, but also by intense exchange of business information, know-how, and technological expertise, both in traded and un-traded forms," clearly emphasizing the information exchanges that distinguish clusters from mere geospatial agglomerations of actors.

Andersson et al. (2004) identify seven key elements of a cluster: geographical concentrations of actors, specialized activity, the types of actors present, the nature of dynamics and linkages between cluster actors, the development of a critical mass of actors, the structural character and development of the cluster, and the measure of innovation the cluster produces. A cluster's viability and health also depend on the general cultural, political, economic, legal, and regulatory environment in the region, as well as the availability and capacity of transportation, energy, and communication infrastructures. Each cluster is unique and not all of the above elements will be present in a given cluster; however, these elements serve as a useful framework for assessing regional competencies and clustering potential. The following sections discuss these cluster elements and characteristics with respect to the mapping and visualization efforts of this project.

2.1.1 Geographical Concentrations of Firms

Geospatial co-location of firms and other related actors is the basis of every cluster. Andersson et al. (2004) outline a number of reasons for why firms benefit from co-location, categorizing these into "hard and soft aspects." Hard aspects of co-location include primarily operational benefits such as access to natural resources, infrastructure, and other unique local assets; access to specialized local supply chains, labor pools, and customer bases; the ability to produce greater economies of scale and scope; and lower transaction costs and greater ease in transferring knowledge. Because of these hard aspects, the co-location and interrelation of firms and other local actors "can serve to enhance efficiency, underpins productivity growth and raises innovativeness, especially due to better access to knowledge, ideas, and skills" (Andersson et al., 2004, p. 20).

While the hard aspects of co-location have much in common with older theories of agglomeration, it is the "soft aspects" that distinguish the contemporary ideas of clustering in knowledge-based economies. Soft aspects of co-location tend to relate to forms of social capital, especially interpersonal networks and the informal exchange and accumulation of information. Social capital can lead to positive effects for co-located actors by facilitating cooperation, informal exchanges of tacit knowledge, the pooling of risk, the sharing of values. Social capital and other soft aspects of co-location may promote innovation and creativity in a region or among members of a social network. However, Andersson et al. (2004) point out that social capital can also lead to social immobility and exclusion, and may therefore hinder regional development in some cases.

The actors, assets, and relationships implicated in this discussion of hard and soft benefits of co-location inform the underlying principles determining specific content prioritized in the visualizations undertaken within this project. Geospatial mapping is utilized to capture and locate geospatial assets, where the depiction of material and economic flows between actors is approached through the depiction of connections between assets with

Hard benefits	Geospatial Asset	Relationships / Flows
- The availability of specific natural resources or other unique local assets. Soil, climate, location of raw materials, energy endowment (forests, waterfalls), waterways, natural ports, etc. - Opportunities for lowering transaction costs especially in accessing and transferring knowledge. - Economies of scale and scope may be optimized most effectively by a limited number of efficient-scaled plants in a given geographical area. - Specialization of supply from factor markets with respect to labor, financial capital, technology sources, management and entrepreneurial resources, and raw materials may be facilitated within a specific area. - The means for accessing and sharing information on market and technology change may become more effective within a given area. - The interplay with local customers triggers learning processes and more sophisticated demand. - Ability to access and availability of transportation, energy and communication infrastructure to meet customer demand	- Natural resource reserves. - Availability and skill of workforce. -Knowledge centers, for example universities. - Distribution and concentration of firms - Financing opportunities in the form of financial service firms, VC funds, tax benefits (in the form of Special Economic Zones, Renaissance Zones, SmartZone) - Existing infrastructural assets including roadways, railways, airports, ports, pipelines, electrical transmission lines, power generation locations and international crossings.	- Traded relationships between firm (Supplier, Customer, Partner, Joint Venture). - Formalized information/ knowledge sharing agreements between firms.

Figure 1: Hard benefits of co-location, associated geospatial assets and relational networks.
(Adapted from The Cluster Policies Whitebook)

Soft benefits	Geospatial Asset	Relationships / Flows
- Informal exchange and the accumulation of tacit knowledge. - Development of networks of trust	- "Special Meeting Places", Chamber of commerce, libraries, university campuses, sport arenas, logistical hubs, lunch restaurants, bars, cafés, festivals, churches, beaches, schools, community institutions, social incubators, business incubators. - Quality of workplace environment. - Quality of living conditions to encourage face-to-face encounters.	- "Cafeteria Effect." Social networks between individuals through private relationships developed via informal channels. - Professional Bonds. Social networks between individuals through professional contexts such as Membership to artisan and commercial associations, labor associations, community-based institutions, company boards, alumni associations / previous post-secondary education, and workforce turn over.

Figure 2: Soft benefits of co-location, associated geospatial assets and relational networks.
(Adapted from The Cluster Policies Whitebook)

assignment of the weight of relationship as an attribute of the link. Non-traded relationships are approached through the development of relational mapping across a number of methods discussed in section 3.2.3.

2.1.2 Cluster Specialization

A common trait of clusters involves the concentration of shared specialization across actors within a core sector or industry. However, in an evolving economy, traditional industry classifications and categories are being challenged with more value being placed on the potential for knowledge spillover, mutual learning, and experimentation towards innovation and new markets. According to Andersson et al. (2004), diverse, cross-industry participation within clusters can lead to innovation and greater competitiveness than clusters that are limited to a single traditional sector. Indeed, many of traditional industry categories, such as those defined by the North American Industry Classification System (NAICS), cannot capture the breadth of new fields like telematics, biotech, and New Mobility. In many cases, the specificity of sector categorization fails to adequately describe the breadth of capacity and potential that resides within companies beyond core capacities with which they self-identify. Clusters that form around these emerging economic domains may pull together a wide variety of geospatially proximate, yet previously unrelated industries, and may not self-identify as part of the emerging economy they are enabling. In clusters spanning multiple traditional industry classifications, as with the New Mobility space, a major challenge lies in identifying the full range of implicated industries and sectors, technological domains and IT-related enhancements that might catalyze new products, services and cluster development. Industries that might have the most meaningful or disruptive participation in the cluster may not perceive the emerging opportunity, and it may be difficult to predict which complimentary industry types will be of greatest importance within a nascent formation (Figure 3).

2.1.3 Multiple Actors

While the firms, institutions, and other organizations directly participating in core industries constitute the most obvious component of a cluster, there are also other supporting actors that are fundamental to cluster development and prosperity. The *Cluster Initiative Greenbook* divides cluster actors into five main types (Sölvell, Lindqvist, & Ketels, 2003): 1) firms, organizations or companies, 2) government at all levels through multiple departments, agencies, and policies, 3) financial institutions 4) the research community, including universities, colleges, research and development activities, and 5) institutions for collaboration (IFCs). IFCs connect the other four actor types and often perform activities on behalf of the larger cluster including information gathering and dissemination, networking, lobbying, export promotion, and branding (Figure 4).

Governmental agencies establish the general macroeconomic policy and legal environments within which

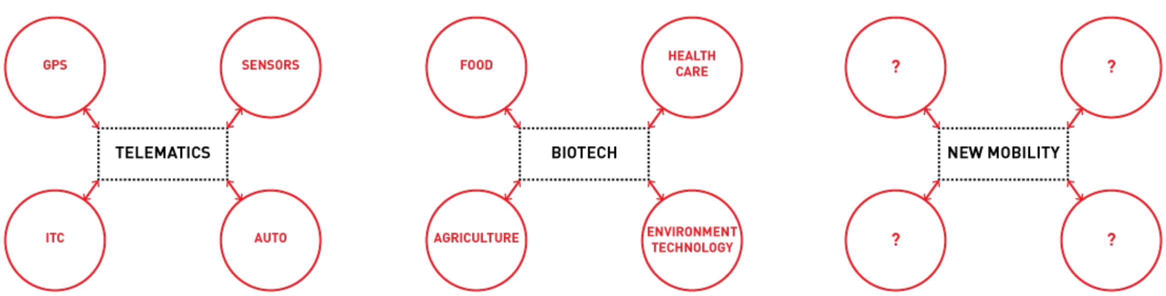

Figure 3: The core activity of a cluster may link seemingly unrelated industries.
(Adapted from The Cluster Policies Whitebook)

cluster participants must operate and which shape them to some extent. Additionally, governments can develop and advance microeconomic policy (including regional, small and medium sized enterprise (SME), investment attraction, and science and innovation policy) that "lubricates" the development and maintenance of a cluster. Universities play an important role in cluster development due to their education and research mandates, and also because of the beneficial relationships they may form with the private sector in the form of knowledge spillover, spin-offs, and new innovation associated with technology transfer. IFCs promote the interests of the cluster to member actors and encourage and facilitate the involvement of actors outside the cluster. IFCs range from informal, unstructured associations to formal, highly institutionalized with due-paying members; these organizations may form as entirely new entities, or arranged by established actors such as "chambers of commerce, industry associations, professional associations, trade unions, technology transfer organizations, quality centers, think tanks, university alumni associations," as well as non-governmental organizations (NGOs), many of which also are important for developing social capital (Andersson et al., p. 24). Within the New Mobility landscape, other actors might emerge as IFCs including foundations, NGOs and Accelerators.

A key challenge within the mapping and visualizations of this project has been to develop effective ways of addressing the five actor types within regional depictions. Geo-location of individual entities, Representation

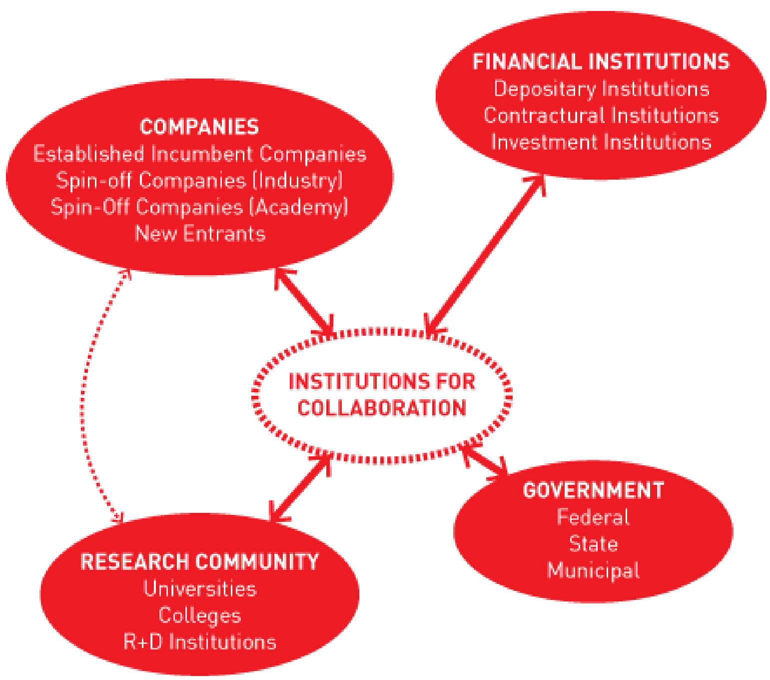

Figure 4: Five Mayor Actor Groups Comprising an Economic Cluster.
(Adapted from The Cluster Policies Whitebook)

through scalar techniques to depict economic impact and employment present notational challenges. Key considerations and the general approach to visualization of actors within cluster mapping are presented in Figure 5.

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2.1.4 Cluster Dynamics and Linkages / Cluster Competition and Cooperation

Central to the theory of economic clustering is the premise that a cluster is more than the sum of its individual parts, and to fully understand a cluster one must understand the traded and untraded linkages that exist between the various actors within the cluster as well as in other geographic areas beyond the regional boundary within which it is operating. In order to develop a case for where a cluster might be formed, it is important to understand the existing linkages and interrelations between actors, the nature of those connections, the sectors they bridge, and the intermediaries involved.

This project focuses on two categories of relationships between actors: traded and untraded. Traded relationships are the intra- and inter-regional input-output factors of production that occur between companies in the form of customer, supplier, partner, subsidiary, or joint venture relations, often as contractual agreements or monetary exchanges. Untraded relationships comprise the social networks between actors which facilitate cooperation and the formal and informal exchanges of knowledge. These untraded or soft connections can result in traded relationships down the road (Storper, 1995; Kruse, 2008). Kruse (2008) writes,

> *Looking at the cross-company cooperations, untraded interdependences become even more important as they often precede and influence the traded interdependencies. When a company is searching for an external partner to complete the process of value-adding, there normally is more than one candidate. Which one of the potential partners the company will choose in the end depends not only on the offered price but also on trust and therefore personal relationships. A well-developed untraded interdependency can therefore lead to a traded interdependency. (p. 40)*

Visualizing these traded and untraded relationships helps to reveal which industries are already successful at spanning between sectors and which individuals are participating in these networks across industry classifications. Understanding the existing connections within a region reveals relationships where cooperation and trust might already exist and where further efforts might need to be directed, should specific connections be desired that are not yet established.

While a critical mass of actors is important for the development of a cluster this is not a significant constraint when developing and building tools to identify the cluster competency of a region—that is, the availability and presence of assets that contribute to possible clustering. Visualization will, by its very nature, assist experts in identifying whether or not there is a critical mass of actors. While not exact or prescriptive, a critical mass of actors can be understood as having multiple actors representing companies, research institutions, government, and financial institutions, and enough actors in each category that the full gamut of skills and

ACTOR	VISUAL	QUANTITY
COMPANY - Single entity based on NAICS classification	- Scaled point based on address of headquarters and/or branch office	- Revenue in USD - Number of Employees - Revenue in USD per Employee
RESEARCH INSTITUTION - Research University - College(non-research focus) - Government Facility - Private/Independent R&D Center -Public-Private Joint Research Venture	- Scaled point based on address	- Research expenditure - Number of researchers - Research expenditures per Employee
FINANCIAL INSTITUTIONS - Depository Institutions: banks, credit unions, mortgage loan companies - Contractual Institutions: Insurance companies -Investment Institutions: Investment Banks, brokerage firms, venture capital firms, private equity firms	- Scaled point based on address of head office and/or branch office	-Assets in USD (where available)
GOVERNMENT - Federal - State - Municipal	- Legislative boundary - Special Economic Zones (as the geospatialization of microeconomic policy)	N/A
INSTITUTES FOR COLLABORATION Chambers of commerce, industry associations, professional associations, trade unions, technology transfer organizations, quality centers, think tanks, university alumni associations, non-governmental organizations.	- Boundary of geographic zone of interest - Incentivized or specially developed zones (Innovation districts) - Point based on address of head office	N/A

Figure 5: Five major cluster actors and associated modes of representation and quantification undertaken through project visualization.

knowledge required to compete around a given specialization are present. Because this project is intended to produce visual products that enhance understanding through their representation of information in novel formats, a key issue is the communication of the range and density of actors within a given area. Depending on the goals of those interrogating the visualizations, different densities of actors will suggest different strategies for developing the regional economy.

2.1.5 Cluster Formation

While every cluster is unique in their composition and how they are organized to carry out specific activities, there are certain accepted stages in the process of cluster formation. Andersson, Serger, Sörvik and Hansson (2004) note that "Many clusters evolve spontaneously and take shape gradually over extended periods of time, with more conscious actions –cluster initiatives –developing at a particular stage when parts of the foundations are already in place” (p. 74). They outline three main processes of clustering: engineered clustering processes, organic clustering processes, and re-engineered clustering. Engineered clustering processes prioritize top-down intervention to initiate clustering: developing existing social capital to produce buy-in for the cluster idea, maintain and develop trust building mechanisms, produce a cluster vision and strategy, and under take action through policy driven cluster initiatives. Organic clustering processes are bottom-up approaches to clustering that see multiple actors developing networks of collaboration, building tight regional linkages and joint strategies. Over the course of development, relationships are formalized and proactive cluster action is taken.

The re-engineered cluster is the most salient with regards to New Mobility cluster potential in Southeast Michigan. This process of cluster formation is a hybrid of the organic and engineered processes, in that clusters already exist but are hindered by broken linkages between actors, structural imbalances, or other factors. In these cases, existing clusters are augmented or reorganized through “corrective action” such as “reestablishing key linkages, dismantling or breaking adverse rigidities, or through the communication of a new vision and strategy for the development of the cluster” (Andersson et al., 2004). Southeast Michigan is currently home to strong legacy firms and existing clusters which might constitute candidates for ‘re-engineering’: The U.S. Cluster Mapping Project identifies clusters in automotive, transportation, metalworking, upstream metals, marketing, and business services, while The Detroit Regional Chamber of Commerce includes clusters in defense, health care, information technology and global logistics (U.S. Cluster Mapping, n.d.; Detroit Regional Chamber, n.d.).

For this project we accept that, regardless of regional interest in producing a New Mobility cluster, whatever new clusters are promoted or fostered will need to emerge from a combination of foundations that are already regionally established – from the existing actors, relationships, individuals, histories, infrastructures –as well as new initiatives and actors. Muro and Katz (2010) write, “clusters can’t be created out of nothing and cluster initiatives should only be attempted where clusters already exist” (p. 6). As such the visualizations developed through this project establish the regional milieu of emergent and legacy actors, conditions and relationships within which cluster formation and cluster initiatives might occur and be situated; the antecedent moment to cluster formation as identified by Sölvell et al. (2003).

2.2 Case Studies: Assessing Existing New Mobility Clusters

In the first phase of this project, we conducted a historical case study analysis of three existing and mature industry clusters, all of which are contained within the Great Lakes Megaregion: the Michigan battery cluster, the Ohio polymer cluster, and the Saguenay, QC aluminum cluster. Although many historic and emerging industry clusters exist in North America and worldwide (Muro & Katz, 2010), these three cases were selected because of their geographic proximity to Southeast Michigan; their similar legacies as once-dominant manufacturing centers amidst an evolving, increasingly technology and service-oriented national economy; and their common ties to a nascent New Mobility economy. These case studies provided valuable real-world insight on the types of ‘ingredients’ and conditions that may contribute to cluster formation in regions in general, and which could be used as a lens through which to view cluster formation in Southeast Michigan around New Mobility in particular. Each of the three case study clusters was composed of a varying mix of elements, ranging from anchoring legacy institutions to abundant natural resources to direct government intervention. Synthesizing these unique cases, identifying their limits, and addressing their gaps, through visualization, allowed us to build a general checklist of possible regional assets and catalysts to search for in order to assess the cluster-forming potential of any region, around any primary activity. This case study research also allowed us to locate information sources, develop search strategies and criteria, improve methods of organizing and analyzing data, and test tools and techniques

Figure 6: New Mobility Economic Cluster Case Study Locations: Saguenay Aluminum Cluster, Michigan Battery Cluster, Ohio Polymer Cluster.

for effective visualization of the data. Most importantly, the case studies enabled us to test the efficacy of utilizing various visualization techniques to depict elements already understood to represent economic cluster activity.

2.2.1 Southeast Michigan Advanced Battery Cluster

The Southeast Michigan Advanced Battery Cluster is the youngest and least developed of the three clusters reviewed as case studies, but also has the closest geographic and participant-actor overlaps with a possible New Mobility cluster in Southeast Michigan. The trajectory of the battery cluster reveals the special importance of national and state funding and policy efforts as a primary driver of regional cluster formation, and the necessity of existing and emerging markets to drive demand beyond initial seed or stimulus funding.

Intensive, coordinated development of an officially recognized, battery-specific cluster in Michigan dates to 2005, when the Michigan Economic Development Corporation (MEDC), the State of Michigan's marketing and business development arm, identified advanced battery manufacturing as the most promising industry to promote in order to revive the state's lagging manufacturing sector (Wessner, 2012a; Wessner, 2012b). However, other latent actors in this emergent cluster were already involved in battery research and production dating at least to the 1970s. Southeast Michigan's most prominent asset is the anchoring presence of a well-established, tightly networked automotive manufacturing industry; according to a 2010 Brookings report, the region is home to 330 automotive R&D centers and 65,000 engineers, all closely integrated into a regional supply chain of automotive equipment manufacturers and suppliers (Muro & Katz, 2010). These actors already formed a powerful automotive cluster and conducted sometimes collaborative, but often competitive, battery research for drivetrain applications. Directed funding from the US Federal government in the 1980s and further Federal and state support in the mid-2000s provided the impetus for leveraging and combining the region's assets and promoting the development of a more collaborative battery-specific cluster. The advanced battery cluster has also benefited from the participation of a major local research institution, the University of Michigan, which collaborates on battery research, trains battery specialists, and generates innovative spin-off companies.

Undertaking this case study served this project in two ways. The first was that it revealed the influence of coordinated top down policy decisions between the Federal and State governments and industry investment towards catalyzing and engineering a cluster around a specific industry activity. Undoubtedly, the auto manufacturing industry, even with its steep decline, remains a significant actor in Southeast Michigan, and any new cluster activity was bound to be related to automotive technologies and advanced manufacturing. However, advanced battery manufacturing was almost exclusively undertaken in Asia, meaning that in order to grow an advanced batteries cluster in Southeast Michigan, an industry of strategic importance to auto manufacturing, talent and companies that did not exist, or existed in a very nascent state, would need to be produced from scratch or attracted from other regions.

To achieve this Michigan focused on developing "a comprehensive strategy that included investment in R&D, generous tax incentives, extensive training programs for engineers and skilled production workers, and public-private partnerships that brought together universities, industry, government agencies, and the U.S. Army – a large potential customer for high-performance, energy-saving rechargeable batteries," as well as grants and loans directly to companies which leverage matching funds from the Federal government made available through the American Reinvestment and Recovery Act of 2009 (Wessner, 2012a, pp. 445-446). Another significant finding was the role that legacy agents had in shaping this new cluster, not as direct participants on the production side of cluster activities, but in producing demand and funding research initiatives of start-up companies in conjunction with the Federal government. The U.S. Advanced Battery Consortium LLC is one such example as a government-industry partnership between the U.S. Department of Energy and the United States Council for Automotive Research LLC (USCAR), a technical collaboration between the Ford Motor Company, General Motors, and Fiat

Chrysler Automobiles. While there has been success in attracting advanced battery manufacturing to the state of Michigan, the assembly of batteries is only part of the supply chain, and it has been identified that to be more competitive in global markets a U.S based supply chain need to be established; domestic firms supply raw materials to finished products (Wessner 2012c, pp. 23 – 25).

While much of the initiative focused on strengthening the supply side of the equation –ensuring enough skilled engineers, skilled production workforce, the attraction of companies through tax incentives to the region, and the funding of research through grants and loans – there was also significant work to stimulate demand. Increasing the availability of charging stations for hybrids and plug-ins, boosting consumer uptake of electric vehicles through tax credits, using foreign trade policies to open up new markets, and using large government agencies, such as the U.S. Department of Defense and U.S. Army, to procure new technologies all contribute to ensuring that there is a significant market, whether they are domestic or global, for advanced battery technologies (Wessner, 2012c). This points to a very active engineering of a cluster through policy, albeit leveraging the support, knowledge, and the active participation of legacy clusters, around the field of advanced batteries manufacturing.

The second insight resulting from this case study was the development of the hybrid actor-network timeline that tracked many of the historic and foundational linkages associated with battery technology outside of the regional confines of the battery cluster. While the specific cluster initiative initiated by the MEDC was initiated in 2005, many of the companies, organizations, joint partnerships, institutions and policies/legislation, which participate in and shape the Southeast Michigan Advanced Battery Cluster, have a much longer legacy within the region and outside. Starting with the companies that are active in the cluster, we worked backwards in time through the hybrid actor-network timeline to reveal the founding moments and evolutions of specific companies as well as the changing nature of their relationships to other actors.

2.2.2 Northeast Ohio Polymer Cluster

Another cluster with historic ties to Great Lakes automobile manufacturing is the Northeast Ohio Polymer Cluster. While this cluster originally formed as a result of the rise of rubber manufacturers in Akron, the current cluster has thrived in large part due to the high degree of investment in, and participation of several regional research institutions via technology transfer activities that have spawned advancement of the cluster.

Northeast Ohio—and the city of Akron in particular—has a legacy as a major rubber-related manufacturing center dating to the turn of the twentieth century, thanks in part to its well-developed transportation infrastructure and geographic proximity to both automobile manufacturers in Detroit and to coal and hydro-power resources to the south. The presence of rubber tire leaders such as BF Goodrich, Goodyear, and Firestone led not only to a concentration of rubber manufacturing capacity, but also to the development of strong research and training institutes which could supply their need for specialized expertise and constant materials innovation. Regional universities like the University of Akron, Kent State University, and Case Western Reserve became global leaders first in rubber research, and then branched into other, more advanced synthetic polymer fields, such as research in liquid crystals at the Liquid Crystal Institute founded in 1965 at Kent State University (Liquid Crystal Institute, n.d.). Although rubber manufacturing has largely disappeared from the region, polymer technologies and manufacturing has grown and the institutions that the rubber industry helped to create and finance, such as the research universities listed above, have continued to sponsor the economic health of the region, and have persisted as knowledge centers and as important contributors to the local talent pool. These institutional assets have been joined more recently by public-private research partnerships like the Edison Polymers Innovation Center and the Ohio BioProducts Innovation Center that facilitate the integration of academic and industry research trajectories. As a result of advanced polymer innovations evolving regional industry beyond its rubber roots, the local production of top talent in polymer sciences, and active investment and knowledge-sharing partnerships between area companies and research institutions, a new cluster in Northeast Ohio around advanced polymers has developed out of the legacy of its now diminished automotive and tire manufacturing clusters.

In addition to the presence of research institutions developed through funding from legacy actors, which promotes cutting edge research and innovation, the case study of Northeast Ohio revealed two other important factors for the development of clusters specifically involved in the development and commercialization of new technologies; the role of IFCs in the form of industry associations, and the importance of having a complete supply chain in place from which to draw upon in sponsoring new activities within the cluster.

PolymerOhio, Inc. is a significant actor not only in Northeast Ohio but across the entire state, strengthening the polymer industry in Ohio. PolymerOhio, Inc. is an industry association that provides services to their membership of small- and medium-sized manufacturers, integrating multiple actors in multiple industries into a network around polymers.

> *PolymerOhio, Inc. is a non-profit organization comprising a team of seasoned, highly skilled manufacturing technology professionals who help polymer industry companies grow more profitably through a mix of services and resources that significantly improve how they develop, commercialize, manufacture and distribute innovative products. Our members have benefits through joining the Network (PolymerOhio,* n.d.*).*

Benefits that PolymerOhio, Inc. offer to their network include 1) access to high quality personnel through the PolymerOhio Professional Network and partnership agreements, 2) business growth assistance, 3) workforce develop programs to help firms get their employees trained on new processes, 4) assistance with the identification of new markets and new customers, 5) the identification of new technologies, processes or products that companies can implement to help grow their business and 6) the provision of low-cost access to high-cost software that is used in the polymer industry through the Manufacturing and Polymer Portal (PolymerOhio, n.d.). As clusters are constructions which help to promote innovation through the adjacencies of specific industry actors, IFCs generally, and PolymerOhio, Inc. specifically, help to bring actors together, strengthen their positions, and advocate for the collective body of participants. As part of the Ohio Manufacturing Extension Partnership (Ohio MEP) (a program which is funded by the State of Ohio with matching funds from the National Institute of Science and Technology), PolymerOhio, Inc. existing within a much large ecosystem of IFCs known as the Ohio Edison Technology Centers (EWI, BioOhio, CIFT,EMTEC, Polymer OH and TechSolve) as well as FastLane and the Appalachian Partnership for Economic Growth (APEG) all of whom are working to strengthen and grow Ohio manufacturing across a range of industries (PolymerOhio, n.d.; Ohio: Development Services Agency, n.d.). This points to the importance of not only establishing an IFC to coordinate and advocate for a single cluster, but to the possibility of establishing cross cluster collaboration between IFCs within a region to promote diversity and the growth and evolution of the region as a whole.

Another important insight from Ohio polymer cluster case study, is the importance of having a complete supply chain within a region to support the industry cluster. This can be latent within a region, with new connections needing to be made, or through attracting new companies to fill existing gaps. IFCs as well as municipal, state, and federal governments have an important role to play in ensuring the continued strength of a cluster, not only in research and development, but throughout the entire supply chain. As part of their strategy PolymerOhio helps to support and identify opportunities and connections between research and development, processors, chemical/polymer manufacturers, compounders/formulators, product manufacturers, consumers, and post-consumers (Barber, 2011). It is important, therefore, to not look exclusively at one part of an industry, for example manufacturing, but to understand how the whole supply- and value-chain can be leveraged towards fostering specific regional industry clusters. This case study reinforces the importance of IFCs in promoting all aspects of cluster development including their role in reinforcing full-spectrum supply chain presence.

2.2.3 Saguenay Aluminum Cluster

A third, highly-developed cluster exists in Saguenay, Quebec, where private companies constituting a mature but declining aluminum processing cluster were the main forces behind reorganizing and redirecting the region’s existing assets toward new objectives.

Saguenay’s aluminum industry originally developed as a result of the region’s abundant hydrological resources and related hydroelectrical potential, which ensured a cheap and plentiful source of electricity required for the energy-intensive processes of aluminum smelting and refining. Like the Akron rubber cluster, the Saguenay aluminum cluster prospered during the early and mid-twentieth century thanks to the strength of American manufacturing concentrated around the Great Lakes; and like the polymer cluster, the aluminum cluster struggled with the gradual departure of that manufacturing base. The Saguenay aluminum cluster's survival was dependent on a single dominant actor, global aluminum giant Rio Tinto Alcan (RTA). Though itself struggling with overseas competition and aging capital assets and workforce, RTA assumed a highly active role in supporting and reinvigorating the surrounding cluster than did the anchor manufacturers in Southeast Michigan or Northeast Ohio. In 1984, RTA directly contributed half of a $10 million venture capital fund to support innovative small- and mid-size businesses in a range of aluminum-related fields. Since then, RTA has continued to fund regional research ventures, support smaller specialized businesses—in some cases selling off its unused plants and facilities to new businesses—and cooperating with government authorities to launch initiatives that benefit both the aluminum industry and the region. Significant finds from this case study are the role of a New Mobility project catalyzing new industry relationships towards specific solutions, and the role that national governments play in the development of clusters.

The Saguenay case study revealed the example of how a proposed New Mobility project can catalyze new partnerships and business opportunities, drawing together participants from both inside and outside the cluster. In 2007, the city of Montreal released a transportation plan that called from the reduction of automobile dependence and featured a self-serve bicycle rental system (Ville de Montréal, 2007, p. 81). To meet this demand Stationnement de Montréal, the company that regulates parking operations in Montréal, was given the original mandate to design and operate this new system, and subsequently created the Public Bike System Company (PBSC) (Public Bike System Company, n.d.). PBSC brought together aluminum cluster participants Rio Tinto, which provided funding to the project as the title sponsor as well as aluminum for the bicycles, and Cycles Devinci, a boutique bicycle manufacturer located near Rio Tinto's factories, with Montréal companies 8D Technologies, who provided the system controls and developed a smartphone application to locate available bicycles, Michel Dallaire, an industrial designer who's company designed the aluminum bicycle and docking infrastructure, Robotics Design, who developed the "bike dock" and locking mechanism, and Marrow Communications, who implemented the commutation strategy (Public Bike System Company, n.d.; Robotics Design, 2009). This integrated team not only developed and implemented Montreal's BIXI system, but PBSC also went on to provide new bike-share systems in New York, London, Madrid, Chicago, Toronto, and many other large cities around the world. The example of BIXI and its relation to the broader aluminum cluster provided a key cautionary lesson to the projective visualization dimensions of this project – in depicting the agents included within visualizations of the cluster, it is important to project near-future projects and demand potentials. Limiting the search strictly to know cluster participants related to aluminum manufacturing and known demand via traditional manufacturing supply chains, it would be easy to miss the emergent global demand for urban New Mobility products and services and its potential impact on Canadian aluminum smelting, as well as those information and communication technology, robotics or designs companies that might be implicated in new products of services.

While the example of BIXI shows how regional assets can be mobilized to catalyze regional actors, and points to a possible role for specific New Mobility projects working to catalyze industry clusters, of great significance in the formation of the Saguenay aluminum cluster is the role of the Canadian Federal Government. As previously stated, the Saguenay region is a world leader in aluminum production, anchored by Rio Tinto Alcan. However, with increased global competition region began to struggle, due to a weakness in performance and competitiveness when turning aluminum into value-added products (National Research Council Canada, 2009a). The National Research Council Canada (NRC) report on NRC Technology Cluster Initiatives describes the situation – "With Alcan positioned in the Saguenay (sic) and facing political pressure to sustain regional employment, and a range of smaller firms engaged in activates related to aluminum production, opportunities were sought to enhance regional potential. Aluminum transformation was selected as a cluster orientation" (National Research Council Canada, 2009a, p. 19). The NRC Technology Cluster Initiatives seek to develop innovative technology clusters across Canada through supporting research and development (R&D) in Canadian companies, and forging links between Canadian government, academic institutions, and the private sector, especially sector small and medium enterprises (SMEs) (Organization for Economic Co-operation and Development [OECD], 2007, p. 146).

The primary efforts of the NRC towards the development and support of regional clusters is through 1) incubation and start-up support, 2) Research Associate and Post-Doctoral programs which facilitate the availability of high quality personnel (HQP) as well as through supporting other training initiatives, 3) providing access to technology knowledge, strategic advice and seed capital through NRC-Canada Institute for Scientific and Technical Information and (NRC-CISTI) and NRC-Industrial Research Assistance Program (NRC-IRAP), 4) sustained research partnerships and 5) the development of regional innovations (OECD, 2007, p. 147). However, one of the most significant ways that the NRC Technology Cluster Initiatives contributed to the development of clusters was through investing in cluster infrastructure in the form of facilities and equipment that was made available to cluster stakeholders, and in the case of Saguenay, the construction of the National Research Council Aluminum Technology Centre (NRC-ATC) (National Research Council Canada, 2012). The NRC-ATC is the centerpiece of the Saguenay aluminum cluster and is the nucleus around which R&D, HQP, and innovation networks develop. The NRC-ATC is specifically focused on providing assistance to manufacturers of aluminum parts or equipment or equipment intended of the transportation industry with respects to aluminum manufacturing processes, technology development, and commercialization (National Research Council Canada, n.d.).

2.2.4 Summary of Significant Data Fields from Case Studies

These three industry cluster case studies reveal a great deal about the types and combinations of regional assets that may promote or inhibit successful cluster development. Existing natural resources such as navigable bodies of water or energy potential have historically played an important role in determining the location of a cluster. Transportation and energy infrastructure often develop alongside growing industry clusters, adapting to the needs of existing industry anchors, and attracting new industry participants who benefit from well-developed regional networks. Mature industries in an area also lead to increased clustering by concentrating specialized workforces and capital assets, competing and collaborating with each other, supporting specialized institutions and innovations in the field, and promoting a favorable economic climate that benefits the entire industry. Strong regional institutions sponsor advanced research, attract talent from elsewhere and graduate well-trained specialists who may remain in the area, produce spin-off enterprises, and attract funding from government, industry, and independent sources. Finally, catalysts like government policies and funding programs, independent grant-making organizations, nonprofit interest groups, business incubators, venture capital, and the movement of industry giants and legacy players can help sustain the development of emerging clusters, or disrupt the structure and alter the trajectory of a stagnant mature cluster. In summary, these cluster ingredients are:

- Natural resources and infrastructure, including energy resources, topography and hydrology, and transportation and power infrastructure;
- Extant regional industries, including primary and secondary industries, their supply chains, support industries, and other industries which may drive demand;
- Extant regional institutions, including research universities, government institutes, private and independent R&D centers, and public-private research partnerships;
- Investments and catalysts, including government funding programs, regional development policies, business development initiatives, independent grant-making organizations, nonprofit organizations, and capital investment sources.

Case study findings have been utilized to develop methods for locating and aggregating information to describe this range of asset typologies that might add to any region's potential for forming a cluster in any emerging economy. However, these case studies have also presented challenges to selecting the correct assets and anticipating their value to cluster formation. A major limitation has been the historical nature of our cases: we can easily identify with the benefit of hindsight the elements that already participate in clusters, but it is more difficult to assess elements which could participate but currently do not. For example, innovative products like LCD technology and advanced plastics from Ohio's polymer cluster today are in high demand in portable electronics and biomedical applications; these industries have direct ties to the rubber and tire industries which helped to initially create the Ohio polymer cluster. These new industries and technologies would have been inconceivable in the heyday of Akron's rubber barons—how can we predict which industries in the future will benefit from another industry's innovations today?

Another challenge lies in the broad range of possible industries implicated in the New Mobility compared to the relative specificity of our case study clusters which all center on a single, well-defined, core specialization. The New Mobility economy potentially spans multiple industries, though exactly which ones is not always clear—in fact, the paradigm of New Mobility has the potential to profoundly affect many industries. Furthermore, if New Mobility constitutes a new kind of industry, rather than just a specialization which assembles many industries, it's relationships with older, better established, more clearly delineated and classified industries, through NAICS, for example, is constantly evolving. While it might be argued that New Mobility might constitute a proper industry or economic sector, requiring a unique NAICS number, in this project we position New Mobility as a field or specialization around and in which discrete industries participate. Therefore, in assessing the potential for forming a New Mobility cluster in Southeast Michigan or in other regions, the goal of this project has been to be as inclusive as possible when surveying a region's existing assets and creating the roster of potential participants, especially concerning which industries might be implicated.

To further address the challenge of mapping regional cluster potential beyond what already exists, it is important to identify possible catalytic or near-future projects that may bring together existing entities which may not be primary cluster participants, prompt the reorganization of established clusters, or which may facilitate or directly generate new participants. In order to better anticipate these sorts of future game-changers in the context of New Mobility in Southeast Michigan, as well as other regions, regional planning documents and proposed projects have been included as part of our research; we have also included catalysts like start-up business incubators, venture capital firms, philanthropic organizations, and business development zones and innovation districts as potential hot spots for future cluster activity.

2.3 Catalytic and Near Future Projects

Clusters develop from the cooperative and competitive linkages between geographically co-located actors to create a competitive advantage for the firms assembled around a common field or initiative locally, nationally, and internationally to fulfill market-demand. This project supposes the possibility of a New Mobility cluster in Southeast Michigan, mainly due to the strong presence of legacy automotive manufacturing but also because of conditions in the region that have provided an opportunity for the players to reimagine how people will connect and goods moved within the region. The role of catalytic New Mobility projects or infrastructures, in their various forms, is two-fold. First, these projects have direct benefit to the companies involved in their delivery; the projects have the potential to reposition the utility and potential application of existing skillsets and to promote cooperation between regional actors and spur innovation towards the development of new products, possibly opening up or inventing entirely new markets. Second, these projects produce indirect benefits to the firms participating in their supply. In the case of a New Mobility cluster, producing New Mobility products and services for the local market may improve the underlying economic condition or attractiveness of the entire region, resulting in positive feedback loops that stimulate the further development of the cluster itself. For example, New Mobility projects might raise regional quality of life, allowing the region and cluster members to attract and retain a talented workforce (Florida, 2004). New Mobility projects can also increase connectivity within the region, raising the potential for face-to-face encounters and knowledge exchange between its inhabitants, improving supply chain efficiency between local producers, and maybe even reducing the need for travel through better technology solutions like tele-working, tele-medicine, etc. These indirect benefits of participating in fulfilling local demand contribute not only to economic success of the individual firms but also fostering the development of human and social capital within the region as a whole. Therefore, when considering what elements a region's assets are comprised of, it is also imperative that one also understands the suite of near future projects within a region that might serve as a catalyst towards future clustering and the field around which actors and industry alike might be assembled.

Non-physical relationships, especially interpersonal relationships within a cluster, can also produce tangible benefits for cluster participants—the challenge is how to detect and visualize them. In a preliminary relational analysis of our three case-study clusters, we identified webs of intra-regional relationships at the NAICS industry level, that is, any instance where a company in one industry reported a trading relationship, joint venture, or other partnership with another company in a different industry.

We also became aware of the importance of—and difficulty of evaluating non-traded relations—personal connections between companies and between industries. In Saguenay for example, Groupe Sotrem-Maltech, a small manufacturer of niche aluminum products, has had an advantage in negotiations to purchase a closed Rio Tinto casting plant, since the Sotrem representative is a former RTA executive familiar with the plant and presumably the RTA representatives. That personal connection strengthened the collaborative bond between two companies, in a way that is much more difficult to detect and visualize than, for example, a reported financial transaction or a highway physically linking their factories. During the case study phase of this project, we have relied mainly on anecdotal evidence and case-by-case research of individual actors to identify non-physical and untraded relationships. However, to develop a repeatable method of data collection and visualization we have had to move beyond the anecdotal evidence of connections to a dataset which is more readily accessible and from

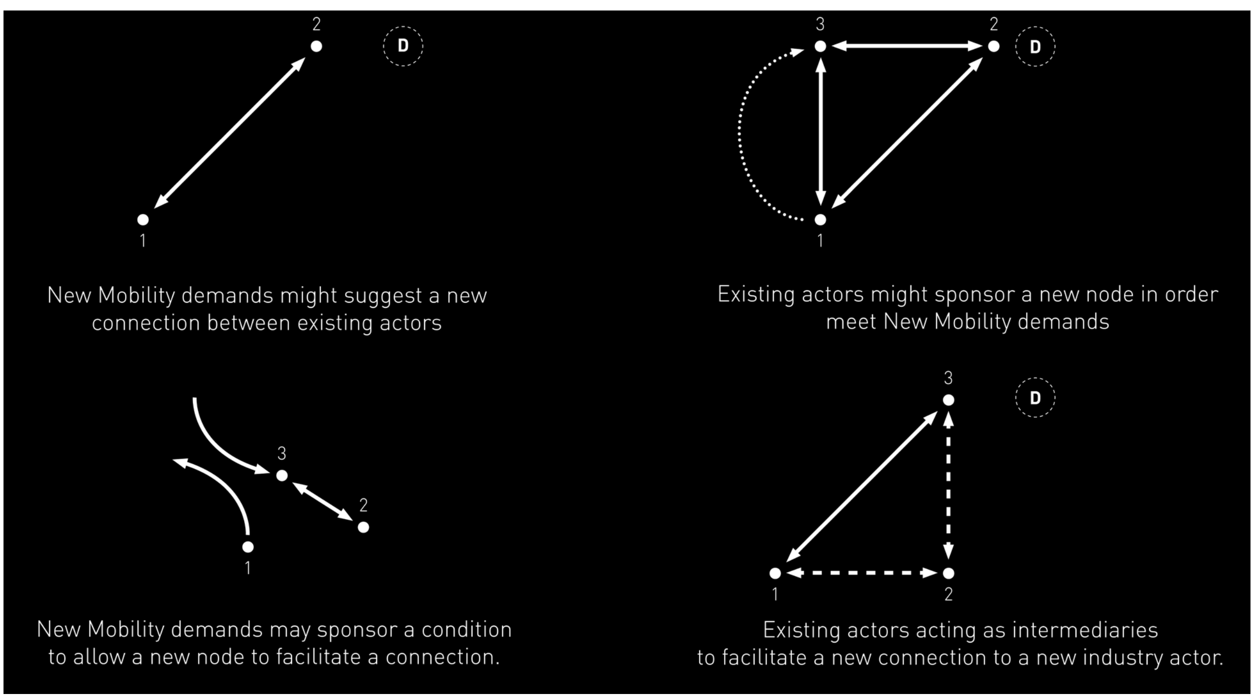

Figure 7: Interaction Models for Cluster Formation: Where New Mobility demand might reshape relations towards cluster formation or intensification.

which more predictable forms of data can be queried and downloaded in a methodical way.

2.4 Regional Asset and Cluster Component Summary

Every cluster is unique, yet all are constituted by a similar set of actors, are concentrated around a specific field in a specific geographic area, and have formed overtime in response to specific demands. To understand or advance the specific specialization of potential cluster it is crucial to know what components are present, what is in place to support the growth of the regional economy and what components might be nascent in the region but not visible or part of dominant legacy cluster and therefore may escape inclusion or scrutiny. Organized under the headings regional economic foundations, extant regional assets, and emerging regional assets, Figure 8 outlines a summary of cluster components, actors, and legacy infrastructures which would be implicated in any re-engineering of existing clusters, and the emerging assets which might help to reconstitute or catalyze their development. While not exhaustive of all possible assets, the table below helps to establish a basic set of data required to visualize the geospatial and relational terrain of regional economies towards cluster development. This

Regional Economic Foundations	**Extant Regional Assets**	**Emerging Regional Assets**
Labor Force: Education level attained, skills possessed, training institutions Financial Institutions: Banks, credit unions, mortgage loan companies, Insurance companies, Investment Banks, brokerage firms, venture capital firms, private equity firms Government: Legislative boundaries General Business Climate: Special Economic Zones, SmartZones Research and Development Climate: Number of patents	Legacy Companies Existing Infrastructures: Roadways, railways, airports, pipelines, electrical transmission lines, power generation stations, international crossings "Special Meeting Places": Chambers of commerce, libraries, university campuses, sports arenas, logistical hub, lunch restaurants, bars, cafés, festivals, churches, beaches, schools, community institutions, social incubators, business incubators Professional Networks / IFCs: Industry associations, commercial associations, labor associations, community-based institutions, alumni associations, technology transfer organizations, think-tanks, non-governmental organizations, business accelerators Research Institutions / Research Community Natural Resources: Soil, climate, location of raw materials, energy endowment, waterways, natural ports Traded Relationship Between Regional and Non-Regional Companies Regional Untraded Networks / Social Capital	Emerging Companies: State-ups, spin-offs Near Future Infrastructure Projects: Transit, internet connectivity, recreation, logistics Near Future Real Estate Projects: New districts, new public projects

Figure 8*:* Regional assets and cluster components.

framework has formed the primary roadmap for data collection and assemblage in the project.

3.0 Typologies and Methods of Mapping

In the previous section we have outlined how the concept of clustering has been understood and used as well as the fundamental theoretical and functional framework for the project. In it we established the privileged position of cluster-based thinking in microeconomic policy and regional development, the benefits of clustering to firms through the competitive advantages that they produce and the innovation which they enable, and the major components and actors which make up a cluster and which serve as the building blocks for subsequent clusters in a region. In this section, we outline the ways in which the information pertaining to cluster components is mobilized in the development of mapping and visualization techniques, how they assist in the understanding and development of regional economic clusters, and the instrumental nature of visualization when it comes to making strategic decisions; this is the core of this project. The section begins with a survey of other cluster mapping and visualization initiatives, most of which are reactive in their understanding of existing clusters and positions our approach to visualization and mapping relative to practices of scenario thinking. We then discuss the role of visualization as a tool in projective practice and future scenario development and present generally the three mapping techniques used in this project; geospatial, historical and relational mapping. Here the strength as well as biases of the three methods is highlighted and cases presented to describe the applicability of each. The section concludes with a discussion of how the previous three techniques, specifically the relational and geospatial mapping, become instrumental in a combinatory mapping process at the regional scale and a summary of the stakeholder engagement that was sought throughout the process of visualization development and the feedback that was received.

3.1 Mapping and Visualizing Clusters

Mapping, as a form of retroactive data visualization and as a projective activity for future action, remains confined to fairly standardized methods of representation with the domain of economic development particularly around the concept of clustering (U.S. Cluster Mapping, n.d.-a; European Cluster Observatory, n.d.). In the context of the United States, the most prominent of these efforts related to cluster mapping is the US Cluster Mapping Initiative (USCMI). This initiative, led by Harvard Business School's Institute for Strategy and Competitiveness, is a national economic initiative that compiles open data records to aid public- and private-sector assessments of the "competitive landscape" of regional economies and to help "reinvent and modernize economic development strategies" (U.S. Cluster Mapping, n.d.-a). This information is available to local officials and private enterprises through an online tool.

The USCMI focuses on defining cluster categories across the nation though algorithm-based processes, standardizing clusters and allowing comparison across regions. The resulting web-based tool "provides a broader data infrastructure that covers cluster presence and performance, as well as several types of data about regional economic performance, business environment quality, and regional characteristics" (U.S. Cluster Mapping, n.d.-a). While this tool is extremely useful for understanding which regions specialize in which areas currently, and helps to put firms and IFCs in contact with other cluster practitioners, the macro view of these microeconomic units does not present the granularity needed to understand the range of potential cluster actors, the underlying regional assets, or the inter-firm relationships that exist towards re-engineering clusters. Put another way, while the USCMI is helpful in identifying current regional strengths relative to the national economy, it does not present those foundational conditions or the full scope of actors (i.e. those that might be outside of the dominate clusters) that might be implicated and mobilized in the development of future regional clusters. The micro and qualitative mapping of this project compliments the macro quantitative mapping of the US Cluster Mapping Initiative. The macro view enables policymakers to understand how the region fits with the rest of the country, while the micro view clearly lays out the individual building blocks in the region (down to the scale of individual firms and people) which might be utilized to organize and reorganize economic development opportunities to re-establish cluster advantage or establish new cluster initiatives. The work of this project is intended to be complimentary to, and assist in filling some of the identified gaps that exist within tools such as those produced by the USCMI.

Our methods of visualization through mapping are developed from a lineage of thinking derived from Ian McHarg's "ecological method" that utilized a series of layered maps to understand a region through an analysis of its underlying geological, hydrological, biological and constructed systems (McHarg, 1969). For McHarg, this multivalent and interrelated understanding of place as part of evolutionary process enabled a designer to interpret, determine, and predict compatible land uses, as well as make projections for planning settlements that consider demand, logistics, and economics (McHarg, 1967). At the regional level we have developed visualization tools across three different dimensions of clustering that allow for the various structures and actors, which constitute and underpin a cluster to be isolated as a series of layers. Geospatial, historical, and relational mapping techniques allow for not only the analysis of existing clusters, as in the case studies undertaken in this project, but can reveal what the significant elements and actors are present within a region, and allow for the physical and relational assets of a region to be apprehended, evaluated and assessed. Each mapping technique allows for specific categories and subcategories of data to be isolated from one another so as to allow for the categorization of existing cluster components or for the isolate pieces to be reassembled into a new cluster form. Through a process of isolation and recombination, in a dynamic and pluralistic way, new directions and futures might be afforded for regional economic development outside of or as an enhancement of the current situation through the existing assets, both physical and relational, that are present in the region.

3.2 Mapping Techniques

Through our initial review of cluster economic theories, case study review and data collection phases we identified a number of elements which contribute to cluster formation, and have tested out ways to search for and visualize those ingredients. In our three case studies, we found that cluster formation closely depends on the characteristics of their existing industry, institutions, and infrastructure; their development is also encouraged by a range of financial, political, institutional and social catalysts. The geospatial significance of these regional assets and catalyzing agents became clearer as we experimented with various techniques of mapping and relational diagramming for each case study. Through the application of methods developed in the case study phase, we have refined our case-study visualization attempts and developed a suite of cluster-visualization techniques using GIS and relational mapping software that will be discussed in Section 4. Since a large part of our case study research was historical or retroactive in nature, have also tested out techniques for time-based visualizations of regional and cluster development that examine issues beyond the regional boundary in question and prior to key moments in the cluster formation. We believe that these techniques are useful for understanding not only the history of existing clusters, but also for analyzing and projecting the trajectory of emerging ones. The time-based visualization techniques used thus far will require further development beyond the scope of this project, but should be considered to be important contributing visualization models of the cluster-mapping toolkit.

3.2.1 Geospatial Mapping

The primary visualization method used across all aspects of the project is that of the geospatial map. This method of mapping allows for the capturing, storing, manipulating, viewing, analyzing and representation of geospatial data. Utilizing Geographical information systems (GIS), simple spatial analysis allows for individual entries (features) in a data set to be visualized by plotting their geospatial references. These references, such as geographic coordinates or address, allow for points to be located in coordinate space and projected based on either a geographic coordinate system or a projected coordinate system. Features can be translated into form of a point coordinate (X,Y) or a field associated to a known statistical area, such as census tracks or counties. While a range of GIS platforms are available, the proprietary platform ArcGIS (including ArcMap and ArcCatalog) developed by ESRI (Environmental Systems Research Institute) was used primarily for this project and coupled with imaging capacities of Google Earth Pro. Once created, data is assembled as a series of layers which are utilized to produce the overall map. Final graphic design of the maps is refined in Adobe Illustrator allowing for more graphic precision than that native in the ESRI suite, and therefor more control over the information being communicated.

The technique of geospatial mapping is primarily used to communicate the geographic location and concentration of specific assets; the firms, institutions, infrastructures, legislative zones, and demographics of a region. Different methods were deployed to test a range of formats that aim to clearly catalog and present existing assets in relational space. One challenge was to represent the geography in a way that could be easily recognizable while allowing the different entities to be clearly marked and identified. Due to the ubiquity of satellite aerial images (in GPS navigation, Google Maps, and Bing Maps for example) it was accepted early on that aerial images would form the backdrop against which subsequent information would be layered.

Within the case study evaluations, the importance of available resources in founding legacy industries within the region became legible. This observation is linked to the related inclusion of a broader set of underlying regional assets including physical infrastructures that enable and anchor subsequent clustering. As a result, datasets spatializing these assets were gathered as part of the analysis and in subsequent data sets for the SEM region. Figure 9 illustrates a regional composite of hydroeletrical capacities aggregated from 1910-1960 relative to the siting of key RioTinto Alcan smelting facilities.

With respect to the formation of future New Mobility industry economies, there is a lack of certainty in terms of which industry types will be central or required in order for cluster formation to be effective, and it is simultaneously clear, that depending on the nature of New Mobility products in play, that the landscape of industry types itself would be variably composed. As a result, in the case study reviews, an important aspect of the data classification was to parse crudely a range of industry types for classification, so as to begin to image the range of participants within a given cluster from a typological perspective. Geospatial assets are coordinated with icons representing primary, secondary and tertiary manufacturing sectors, as well as transportation related sectors and supporting industries. Figure 10 illustrates the generalized range of actor types, and the relationship

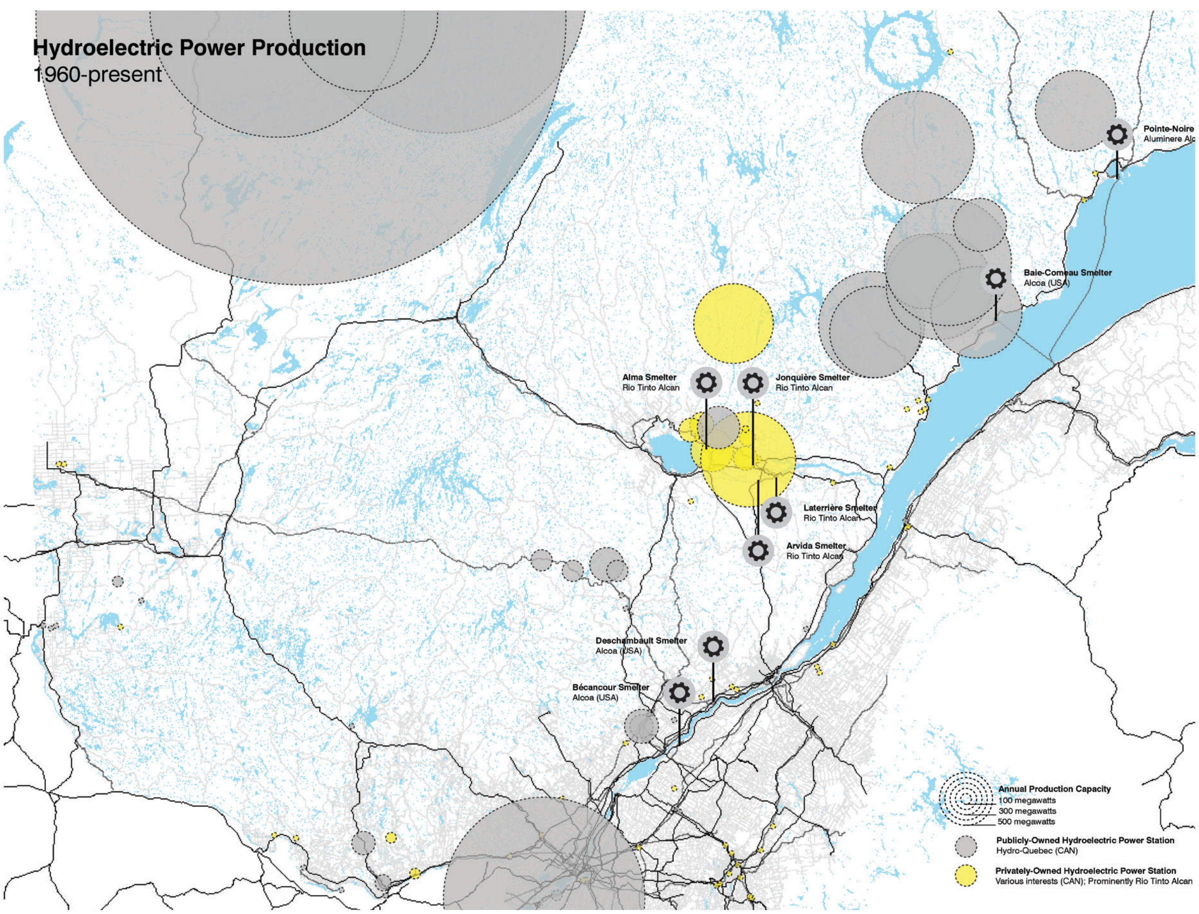

Figure 9: Hydroelectric Energy Capacity Map: Quebec Facilities Development 1960-present. Public and Private power generation sites relative to key Rio Tinto Alcan installations in the Saguenay Region.

Figure 10: Simplified Industry Type Classifications. For initial characterization of industry types, we utilized a simlified model to characterize sector types. Color based condifications inform early geospatial and relational mapping studies. Beyond transportation sectors, a range of primary material, technology and service industries are implicitly required to deliver New Mobility solutions.

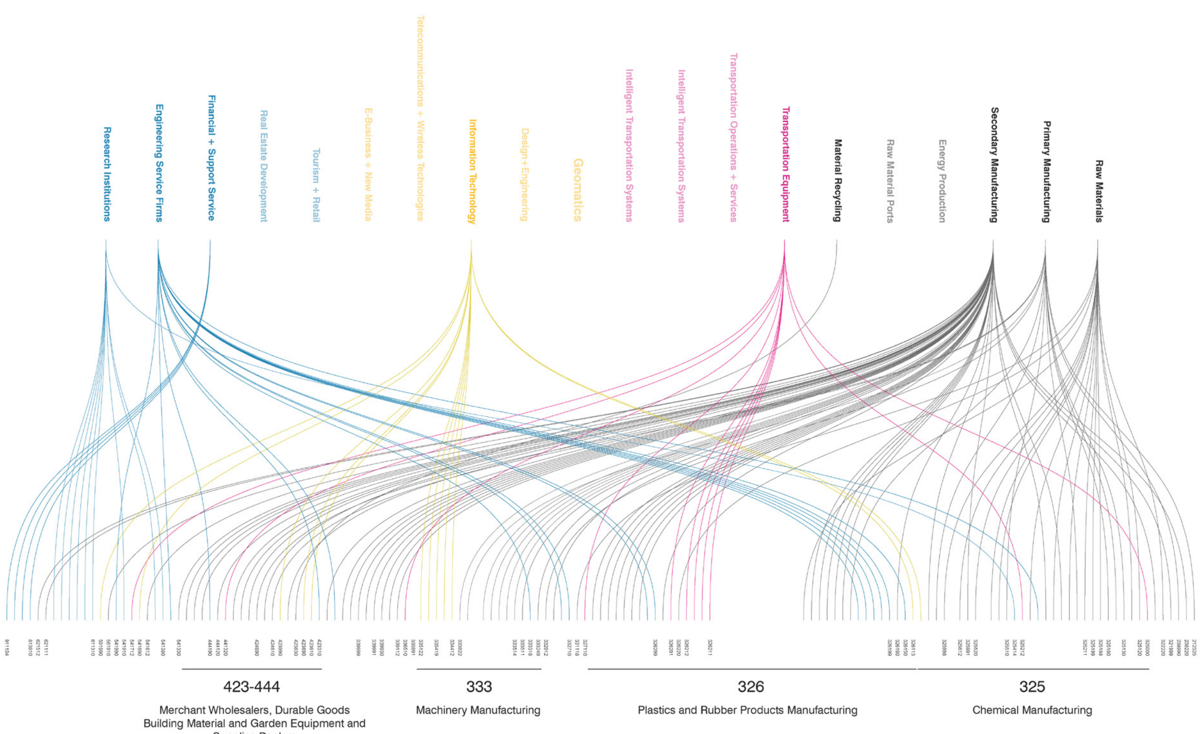

Figure 11: Codified Actor Legend and Classification Sorting Model: (Case illustrated is for the Northeast Ohio Polymer Cluster).

of these categorizations to the more granular detail of NAICS code-base identification. This process extended to other mapping techniques, where the codification of these existing industry types remained at a coarse level, and was color codified so as to understand primary relationships. Figure 11 presents an early visualization of the actor network comprising the Saguenay aluminum cluster.

Building on these techniques, we began to experiment with alternate and hybrid forms of geographic depiction. Figure 12 presents two different strategies for the presentation of cluster actors. The representation on the left shows the geography of southeast Michigan as a perspectival aerial. The major drawback of this type of map is that the information of each of the individual points is obscured due to the overlapping of points as the images recedes. The image on the right of Figure 12 presents a promising strategy. As a hybrid between a geospatial map and a variation on a circular layout graph typically deployed in social network mapping. This type of map allows for the representation of both the location of specific entities as well as the classification of those entities by major industry. However, the lines connecting entity name to specific location point, and the number of crossings that these lines create, make the map difficult to fully apprehend. While it is effective at presenting the complexity of regions multiple industries, it does not serve the purpose of isolating entities towards understanding the multiple components of a cluster, particularly beyond those assets related to companies or single point features. Because of these drawbacks it was not pursued beyond initial tests.

The mapping technique deployed for the majority of final geospatial file assembly allowed for different layers of information to be presented sequentially rather than in aggregate on one map. This strategy allows for

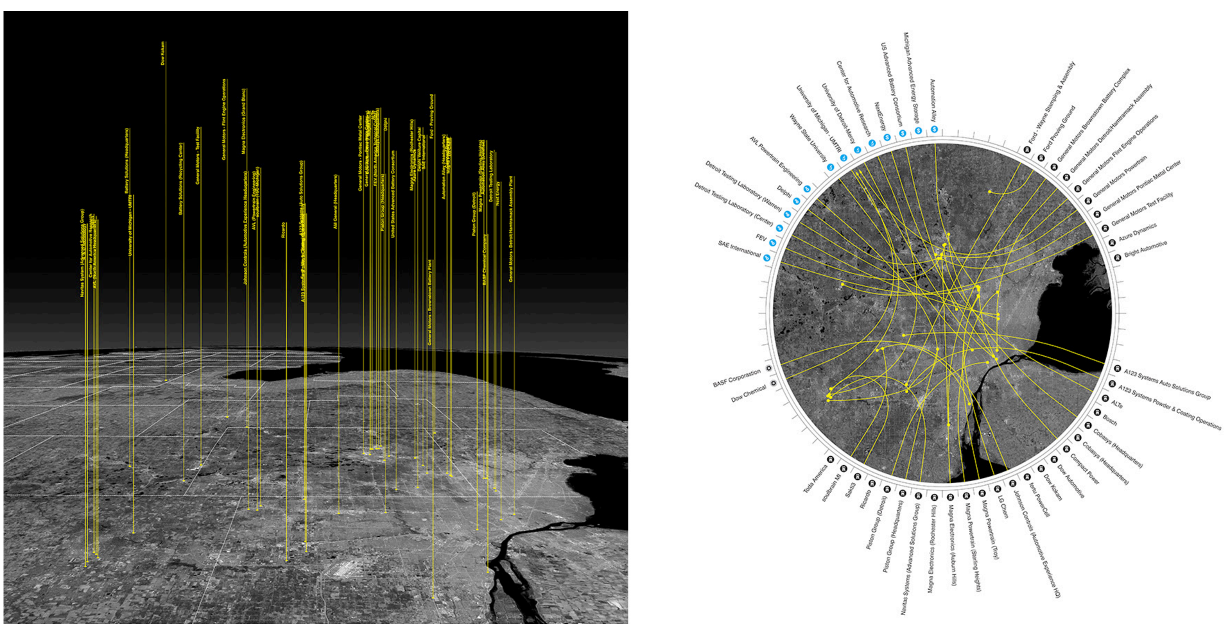

Figure 12: Southeast Michigan Battery Cluster: Geospatial Testing. (left) agents assembled and tagged geospatially relative to perspectival view across region surface. (right) agents assmbled, tagged with codified icons organized by industry classification codes.

specific information to be prioritized and for more diverse categories of information to be presented through a similar technique; for example the presentation of features as points, lines, and fields. This mapping technique is used to present companies, institutions, existing infrastructural assets, and near future projects – all aspects of economic clustering where co-location is critical and where geospatial tagging and presentation is of importance in assessing potential cluster agents.

The process of data collection was not linear and was informed through an iterative process and included stakeholder feedback as a way to confirm the veracity of our methods as well as the data that has been assembled. Through the process of developing the case studies various actors were identified that began to expand the industries which where initially theorized as constituting a New Mobility cluster (Gollub, Bialowas, Jones, Lo Zielinski et al. 2002). This expanded list (X), as defined by their NAICS code, served as the first set of inputs to identify companies in southeast Michigan (Y). This list was then used to identify the customers, suppliers and partners participating in the region (Z), and their NAICS codes served as the input for the next query of southeast Michigan companies (Y). Through this process stakeholder input was sought to help identify gaps, and industries that were missing from potential cluster descriptions. These processes and checks eliminate bias as to what should

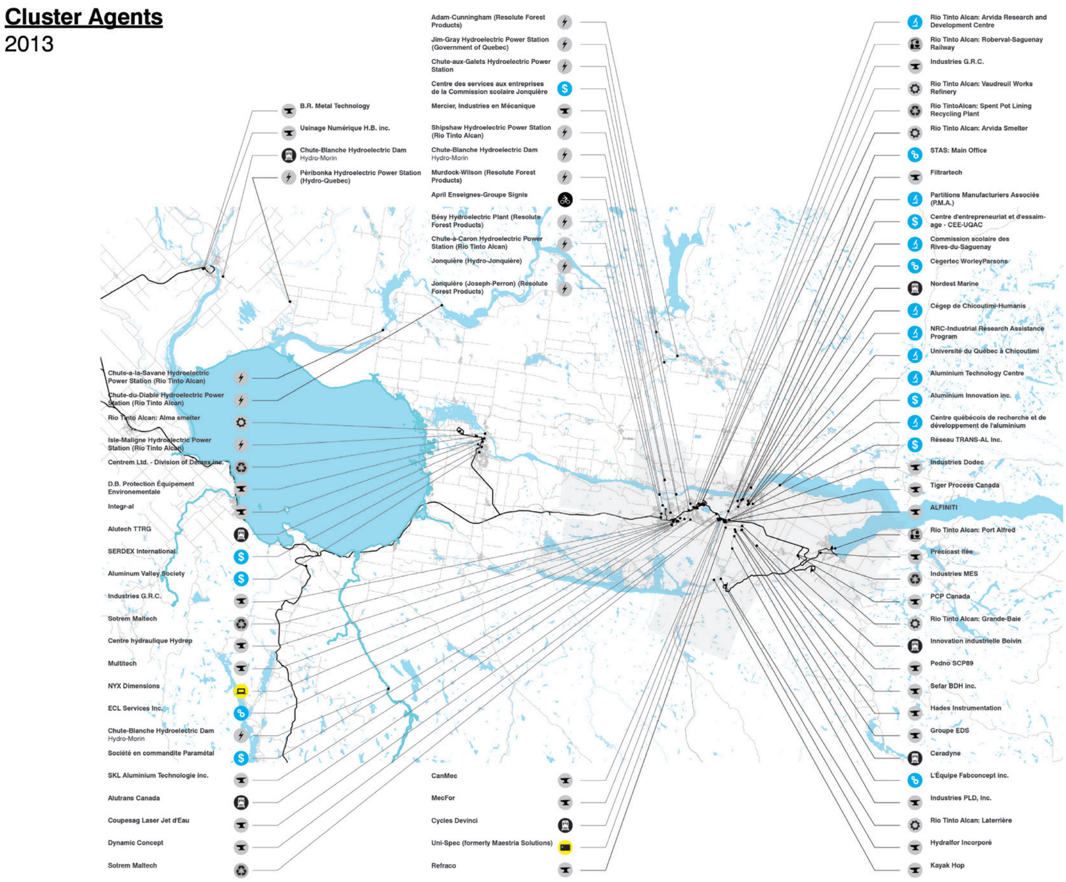

Figure 13: Typical geospatial map depicting Saguenay regional distribution of cluster agents, labeled and codified by industry sector and cluster roles.

constitute a New Mobility industry towards identifying a range of actors and assets that could constitute a New Mobility industry cluster. In mapping the SEM context, we developed detailed multi-industry maps using the granularity of individual NAICS codes as opposed to the simpler versions of the case studies reduced to a legend of icon types and color combinations to describe sector groupings more broadly.

3.2.2 Historical Mapping

The development of methods to map historical time relative to cluster development was primarily used in the context of the cluster case studies undertaken of the Saguenay aluminum cluster, the Ohio polymer cluster, and the Michigan battery cluster. These various methods were developed to understand at which point in the development of a specific cluster which types of actors were present, what infrastructures were developed or developing, the concurrency of cluster development and global events and the industry demands which they produced, the historical evolution of regional legacy firms and their relationships to other firms, at which point in the cluster's development certain initiatives where introduced, and at which point and in which conditions the cluster was formalized. While it is known that the past economic activities and legacy firms play an important role in present and future cluster development, these tools helped to create an understanding of the larger arc of development and which legacy components have lasting effects on the regions development, which drop way, and the significant of the various types of actors, infrastructures, and initiatives over time. Visualizing clusters in this way allows them to be placed in their macro-economic and historical contexts. The timeline-based diagrams developed are variations on non-geospatial visualizations: a composite timeline, and a hybrid actor-network timeline.

Historical geospatial techniques allow for regional assets to be represented based on the founding, establishment, or construction date of a group of assets. This type of visualization helps to understand how certain assets are developed concurrently or which assets precede other regional actors. By looking at the region as a palimpsest of historical development, the present condition is more firmly rooted in the past and reveals a region's longer process of development. This long view of the region speaks to the degree of long-term vision that is required for cluster development. It helps to reveal that regional development trajectories are long ingrained in past decisions and which historical decisions resonate and help to direct the present. It speaks to which assets have had a long-term influence in the region, and subsequently which might be harder to depart from, and those that are less well entrenched. The geospatialization of regional development in this way shows not only the establishment of assets but also where those assets are established relative to other assets in space and possibly when co-location is important and when it is not in order to capitalize on these assets. (Figures 9 and 13 constitute this type of mapping but are presented in the context of this report as static graphical images).

The composite timeline allows for the contextualization of regional development generally and regional

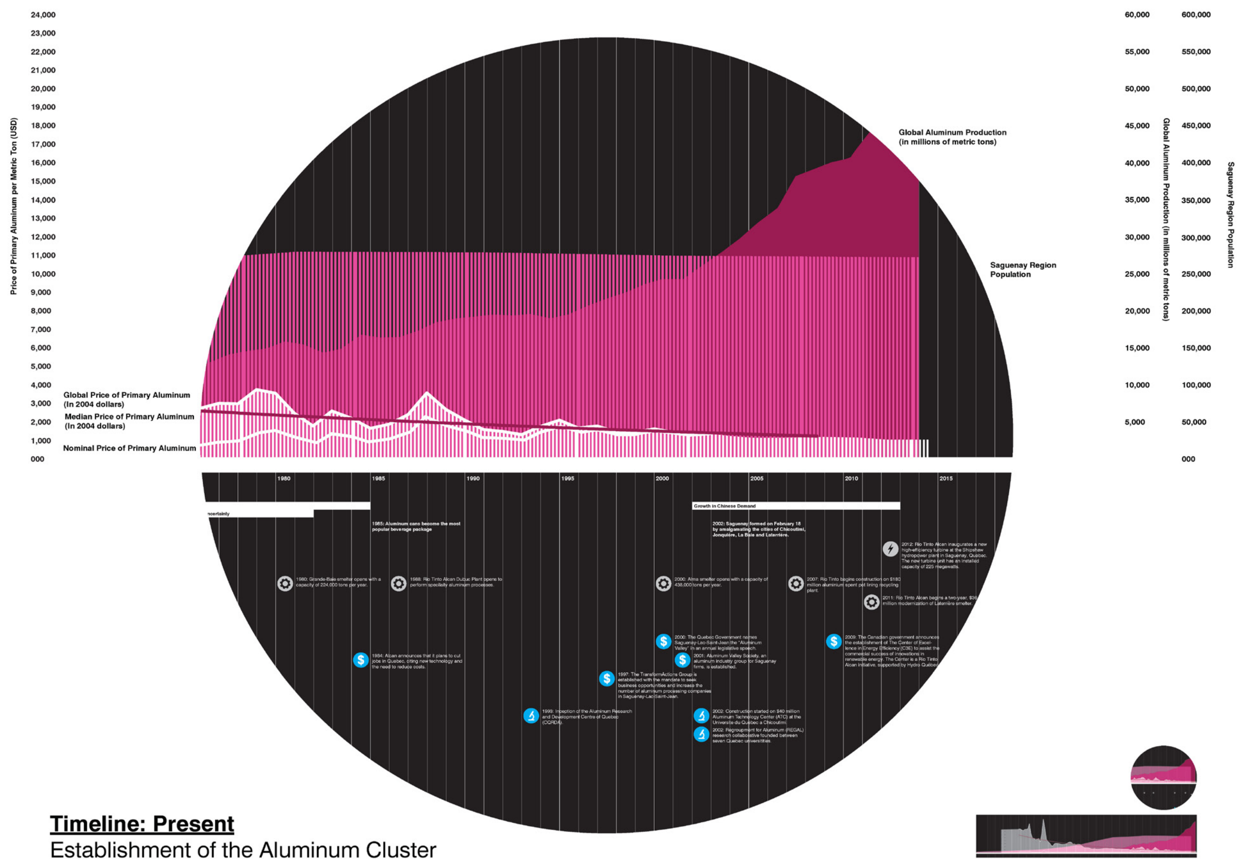

Figure 14: Composite timeline mapping tracking historical events in the formation of the Saguenay Aluminum Cluster over time. Overlay of specific industry events codified by actor type (bottom of detail) relative to histroic timeline depicting cluster formation relative to time and global unit price of aluminum as commodity.

clusters specifically relative to global events and global economic trends, regional demographics and regional clusters initiatives. This type of visualization helps to position the cluster in a macroeconomic and historical context, shows the significance or not of global events that help to produce or reduce demand, and when and in what forms regional actor respond.

While the previous historical mapping techniques focus on the regional and global contexts of cluster development, the hybrid actor-network timeline focuses on inter- and intra-firm development within a specific regional over time. The hybrid actor-network timeline shows the dynamism of firms over time in a similar way as the other historical mapping techniques show the dynamism of the region and its development. If regions can be viewed as a layered assembly that build on their strength, change directions, and reaffirm priorities over time, then so too can the firms that help to constitute them. The hybrid actor-network timeline allows one to track the establishment of firms, their connections to other firms and entities in the form of joint partnerships, the reconstitution of firms through mergers and acquisitions as well as the sale of assets, the introduction of policy/legislation, the establishment of institutions and organizations, and how all of these components related to one

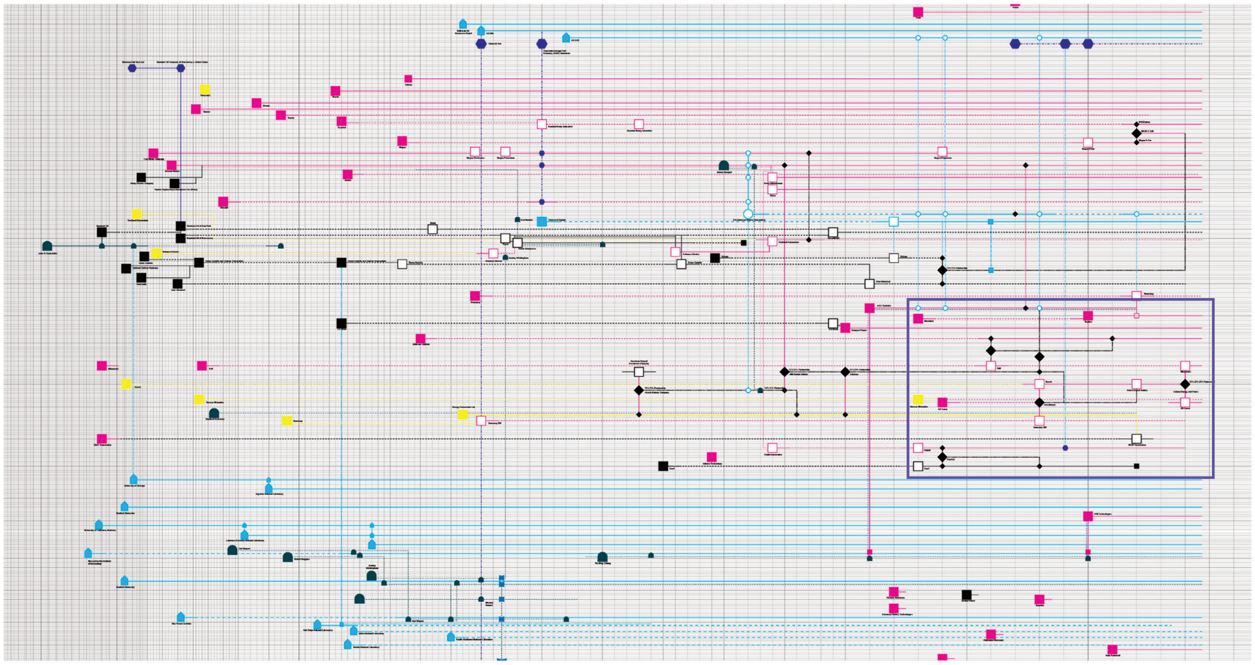

Figure 15: Actor Network Timeline – Southeast Michigan Battery Cluster (Historic Development) - Research related partnerships and enterprise start-up historic timeline USA 1970-2012. This time based notation outlines various forms of collaboration, research project funding, partnerships and new enterprise start-ups between Energy firms, bBattery start-ups, national OEMs and other actors around specific initiatives linked to lithium-ion battery innovation and business enterprise.

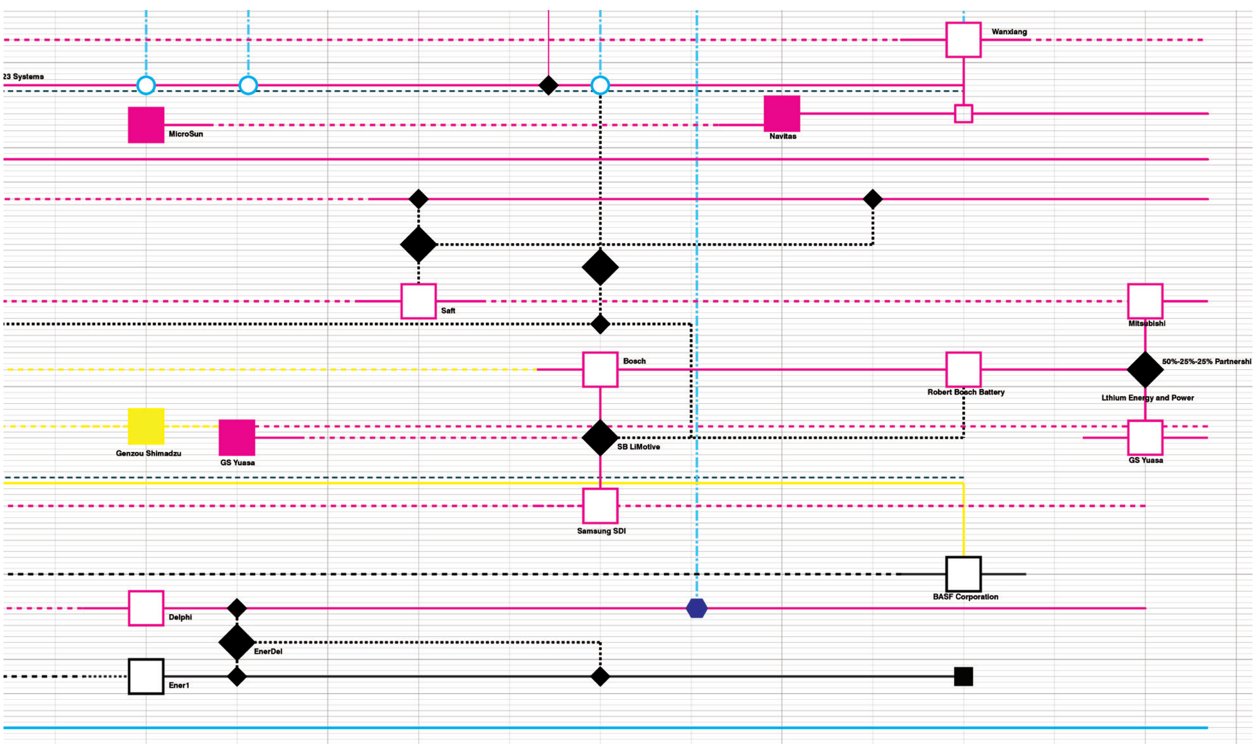

Figure 16: *Detail*: Actor Network Timeline – Southeast Michigan Battery Cluster: Partial history of Cobasys, a companythat partnered with both GM, and more recently A123 systems. It was bought by SB LiMotive, a joint enture between Samsung and Bosch. When Bosch dissolved the SB LiMotive partnership, it retained control of Cobasys' former assets in Michigan. Soon after, Bosch partnered with Mistubishi and GS Yuasa. The notational code refers to actor type, realtionship type and joint ventures.

another and evolve over time.

In aggregate, these methods act as visual repositories and diagrams of a historical research method. Whereas other techniques used in this project rely much more heavily on data collected by third parties and its reassembly and combination with other data into specific datasets, the data used for the historical mapping relies much more on the use of case studies and analysis of specific regional and firm histories. One limitation of this research based process is that the diagrams require long periods of time in which to assemble information and data points. As a result, they are specifically useful as supporting documentation to detailed historical analysis, in order to apprehend a situation within a given region, but on the other hand, are not necessarily as useful as a projective tool – to be utilized in the scenario based projective work the project aimed to support. As a result, we concluded that these visualizations were useful elements of the cluster-mapping toolkit, but were limited in their applications to a context of highly detailed time-based analysis.

3.2.3 Relational Mapping

As stated previously, clustering is more than just the co-location of firms in a geographic area, but is the co-location of interconnected firms in a geographic area cooperating around a specific economic field. Therefore, understanding where connections either occur or do not is important to predicting where a specific cluster might form, or potentially where to focus initiatives that may aid in establishing new connections and trust.

Through the case study analysis, we experimented with the concept of a non-geospatialized non-time based relational format that could depict the relationships between entities in the cluster, provide information as to the nature of their respective activity type within the cluster, and describe the nature and strength between individual actors relative to our understanding of the cluster's activities. This method is referred to as cluster network diagrams. An early comparative representation was developed for the Saguenay aluminum cluster. Several principles were developed in this representational type. In this model, a network diagram is produced to represent the range of actor types recognized to be present in the specific cluster. Sub categories of enterprise are identified where specific actors fill certain roles, and the traded (known traded) relationships between sub sectors are identified via vectors between sub-sector types. The resulting diagram (see Figure 17), constitutes a crude description of the range of actors and entities comprising the cluster defined coarsely by industry sector and sub-sectors, as opposed to individual agents. To illustrate the impact of a near catalytic project relative to the network, the example of the BIXI system development is utilized. In the adjacent description, the entities whose business enterprise entered partnerships to produce the bikeshare system are highlighted, as are the facilitating agencies and existing traded relationships that were known to impact the transaction. This model of visualization is intended to assist in catalyzing awareness regarding the potential for catalytic projects on the one hand, and to recognize the potentially disruptive impact of such projects on a range of agents within the cluster on the other. In this early visualization study, the value of traded relationships are not coded by weight (fiscal value), and the value of known

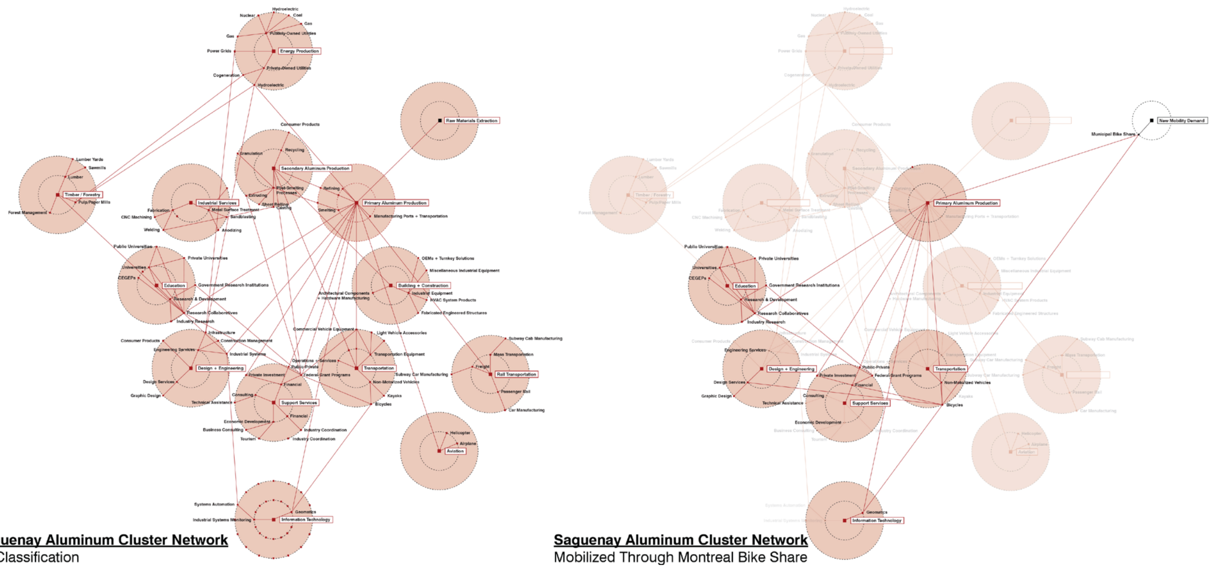

Figure 17: Comparative relational mapping: Saguenay Aluminum Cluster. (left) generalized aggregation of cluster industry participants organized by sector. (right) illustration of sectors engaged through the development of the BIXI bike share program. This technique illuminates unexpected actors brought together by a New Mobility initiative and assist in illustrating cluster relations between legacy, extant and emerging firms.

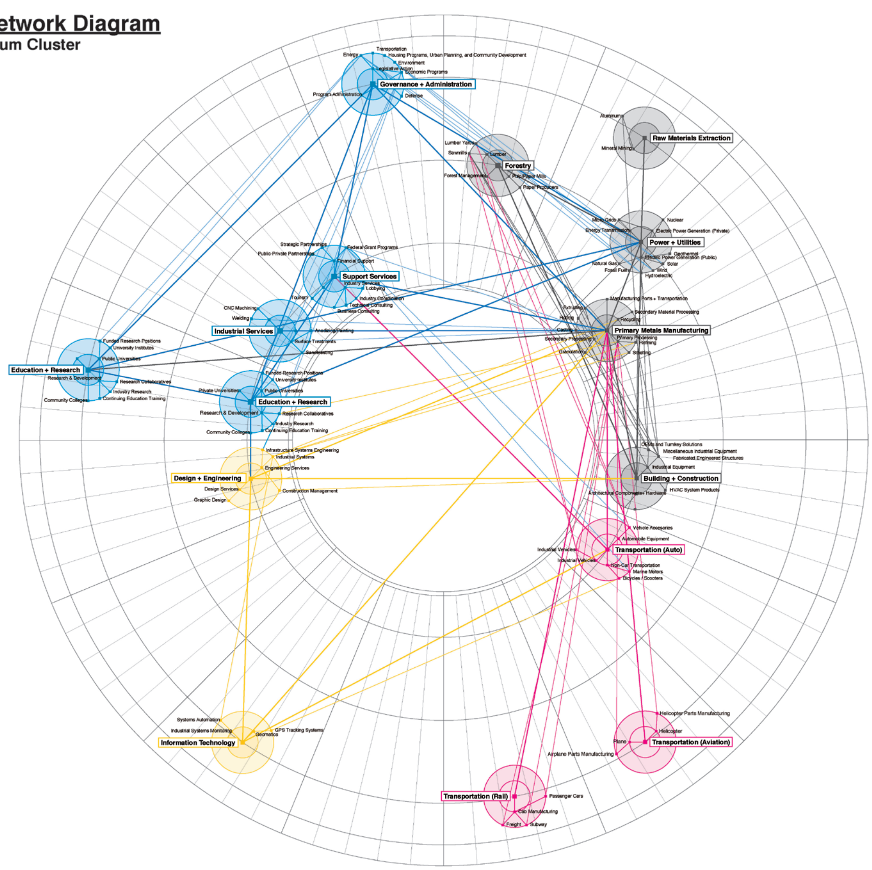

Figure 18: Saguenay Aluminum Cluster: Relational Diagram.

non-traded relationships (ie: connections between pivotal figures within institutions, companies and other agents), is reported as a vector of equal weight whose primary purpose is to generate inclusion of entities within the network where traded relationships do not exist, but where other forms of association are present and understood to be meaningful.

A second format of relational mapping aimed to pair the graphical color and icon-based notational codification developed for the initial geospatial mapping (Fig 10) with preliminary cluster network diagrams in order to produce a more explicit depiction of the range of entity types within a given cluster and to produce comparable representations of the clusters examined in the case studies. One intention was to understand the nature and differentiation of the composition, range of agent types and weighting of specific types of actors through a visualization that would deliver a range of levels of communication across different time scales of apprehension. In these visualizations (developed for each of the case study clusters) a circular organizational structure is utilized. Color assignment is predicated on the primary sector categorization simplified from the NAICS code assignments. Three concentric rings that move from the inside of the circle to the outside and organize the location of specific agents defined by (i) agents active within the cluster and proximate to the region, (ii) non cluster specific entities that are within the region, but not recognized as active within the cluster, but that contributed to its formation, and (iii) industries located outside of the cluster region, but that were formative in its development (global actors). Relational vectors between actors are further color-coded to depict the thematic nature of the primary traded relationship between actors related to the core activities of the cluster. Figures 18, 19, and 20 depict these visualizations for the case study clusters. While each reveals much about the nature of primary relationships within the cluster, and develops a standardized mechanism through which to begin to describe traded relationships within a cluster, these visualizations had not yet begun to include detail about the value, nature, or directionality of the forms of exchange between sectors, nor individual actors within the cluster. Subsequent relational drawings developed with specific data regarding SEM were subsequently developed to address these information gaps.

In developing these tools to support a deeper understanding of what might constitute an emerging economy (where the specific players are not yet identified) and with quantification, understand and present traded and untraded relationships within a region we subsequently utilized graph-drawing techniques, specific different variations of node-link diagrams and related layouts were developed. To map the two different classifications of relationships we focused on two unique ways to define traded and untraded relationships. These definitions, which aid in the production of two unique datasets, also allow them to be brought into relation with one another to produce a hybrid visualization of traded and untraded relationships simultaneously. The datasets that are produced relative to these three categories is then visualized using Gephi, and open source relational visualization tool (https://gephi.org/). The specific layouts utilized for each subsequent visualization and their respective datasets are discussed below and are depicted relative to data assembled through the project for SEM.

The mapping of traded relationships focuses on plotting the public, private and holding companies as

Relational Network Diagram
Southeast Michigan Battery Cluster

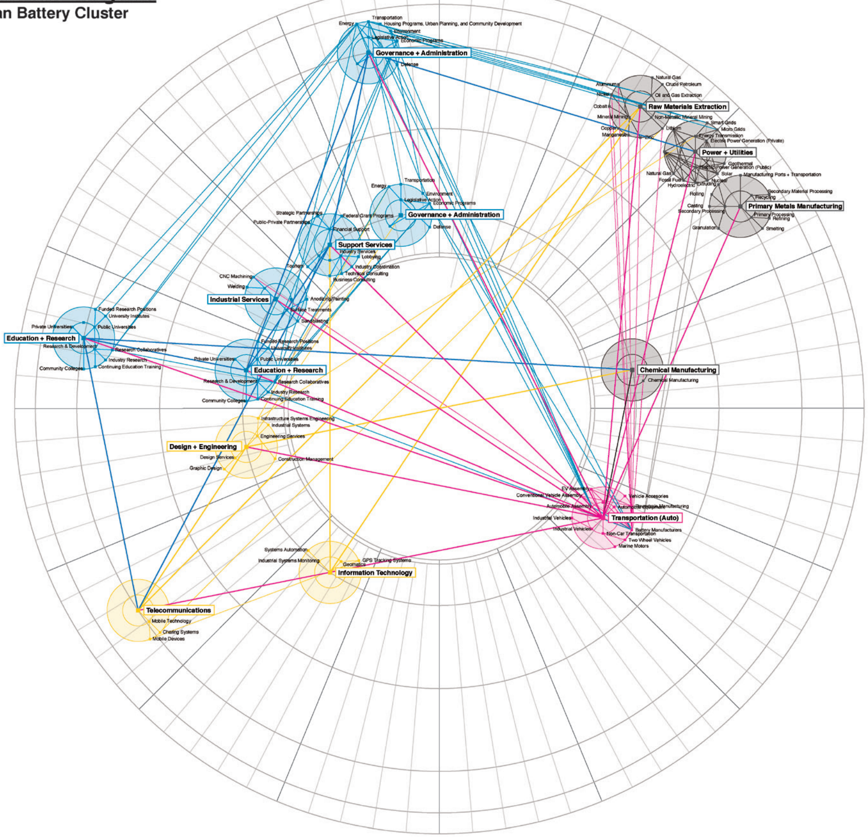

Figure 19: Southeast Michigan Advanced Battery Cluster: Relational Diagram.

Relational Network Diagram
Northeast Ohio Polymer Cluster

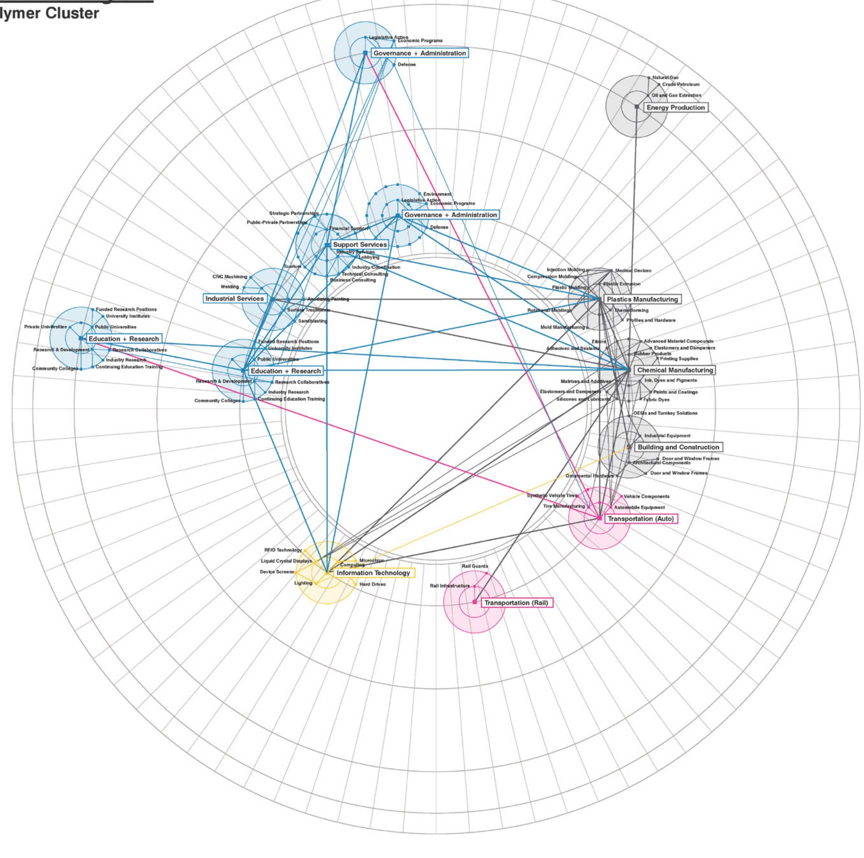

Figure 20: Northeast Ohio Polymer Cluster: Relational Diagram.

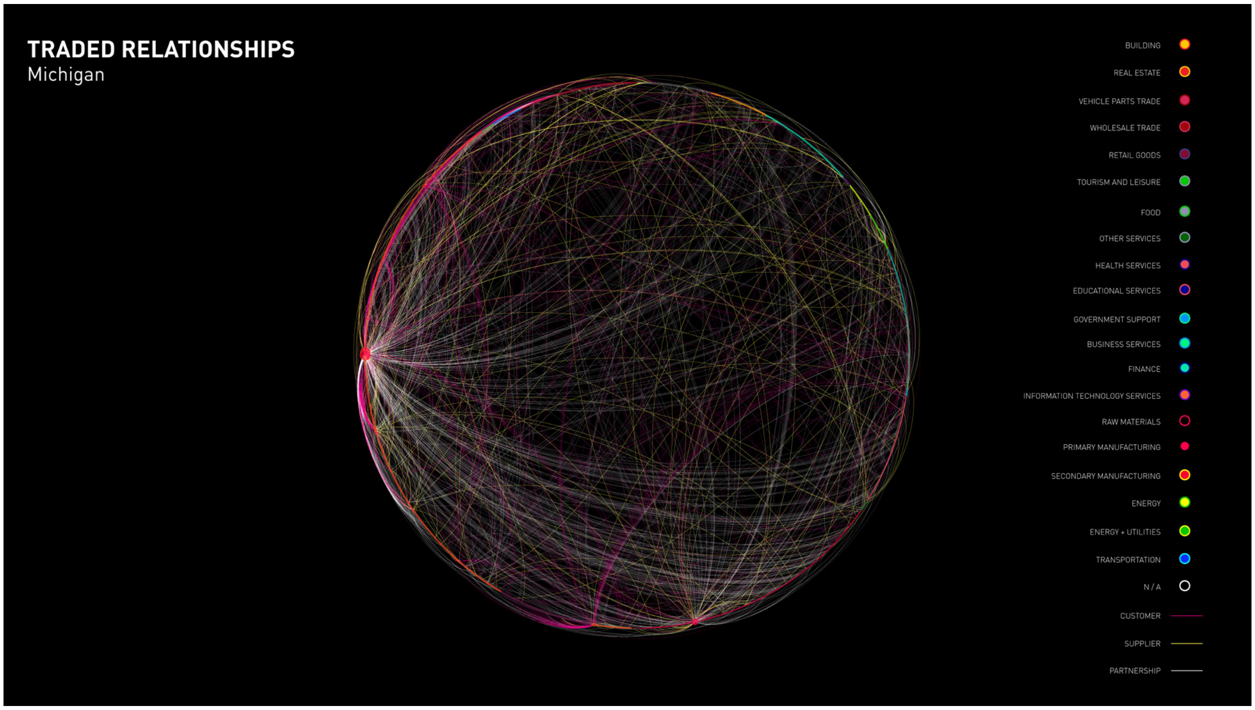

Figure 21: Traded Relationships. Existing New Mobility economic exchanges between frims within Michigan: Chord Diagram, indicating codified industry sectors arrayed to perimeter as characterized as nodes. Exchanges classified as suppliers, customers, and partnerships. Each node on the diagram perimeter indicates a publically-traded firm accessed via OneSource database. Values of exchange are not available to weight relationships.

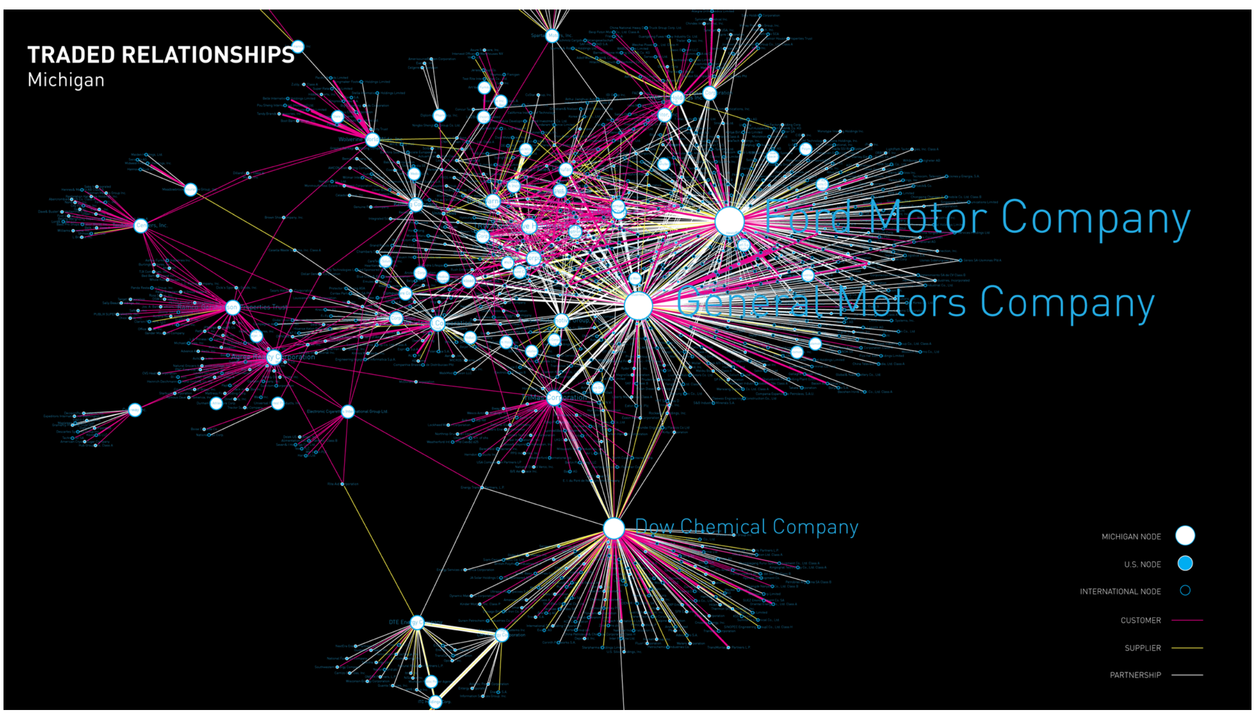

Figure 22: Traded Relationships. Existing New Mobility economic exchanges between frims within Michigan: Branching Diagram, indicating codified industry sectors arrayed as a three-dimensional network of nodes. Node sizes increas with number of partners. Exchanges classified as suppliers, customers, and partnerships. Each node on the diagram perimeter indicates a publically-traded firm accessed via OneSource database. Relationships are unweighted in terms of value.

well as joint ventures and subsidiary companies in a given geographic area and their regional, national, or global partners, customers, and suppliers. Each of these entities is identified by a unique code, in this case a CUSIP (Committee on Uniform Security Identification Procedures) code or where not available a FactSet ID number. The specifics of how these entities were collected and unique codes identified will be covered in section 4.2 *Data Collection Limitations, Gaps, and Next Steps*. Each unique company is then represented as a node and where a relationship between two nodes exists a line, or edge, is drawn. These edges are then characterized by the nature of the relationship between the two nodes as either a partner, customer or supplier relationship. A perimeter-based node diagram is illustrated by Figure 21. Figure 22 uses a branching structure to help clarify hierarchies and

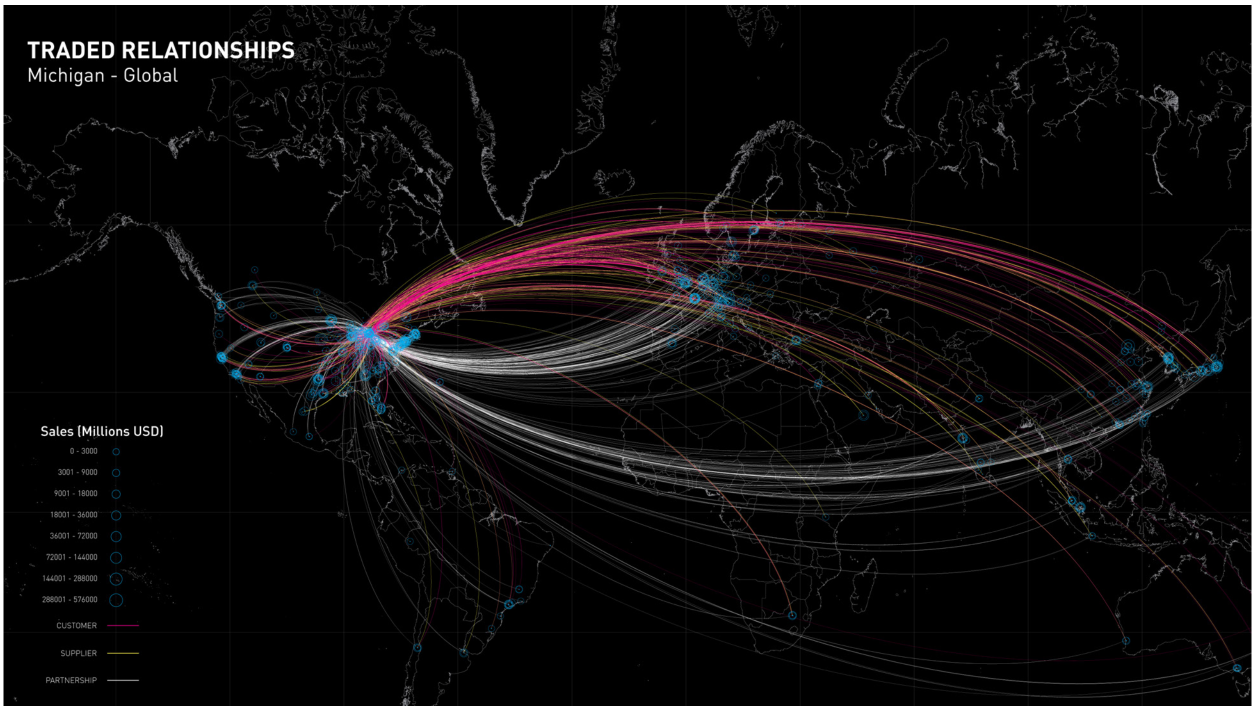

Figure 23: Traded Relationships: Michigan / Global. Existing New Mobility economic exchanges between frims within Michigan and global trading partners. Indicating codified industry sectors arrayed as a geospatial world map. Exchanges classified as suppliers, customers, and partnerships. Each node on the diagram perimeter indicates a publically-traded firm accessed via OneSource database. Nodes are scaled relative to total annual sales.

giving prominence to nodes with a greater number of transactions. Figure 23 illustrates a hybrid approach where the relational content of traded relationships is depicted over a geospatial map.

Mapping untraded relationships is more challenging than mapping traded relationships, mainly due to the availability of data and the lack of reliable, quantifiable data with which to assess and weight relations. While the traded relationships between publicly traded companies are more readily available and formally expressed in dollar values of formats of exchange, the informal relationships between firms through their employees or representatives are much harder to track. It is certainly impossible to fully represent the myriad of possible connections that *could* exist. It is, however, an extremely important aspect of clustering that needs to be accounted for, and in many cases, the personal relationships that exist are the grounds for trust building which creates the foundation from which clusters of cooperation emerge. In the specific instance of a New Mobility economy and cluster, we anticipate that, similar to the BIXI example from the Saguenay region, new assemblages of companies that develop in response to an emerging market opportunity will be fostered through pre-existing interpersonal relationships, dialogue and trust. Beyond the scope of this current project, but of interest to this area of work, is the potential to scrub and utilize data contained in social networking platforms such as Facebook and LinkedIn which could be beneficial in revealing the nature of social networks that exist between companies and key individuals within these companies. Even these would not present the complete picture, as face-to-face exchanges often occur in non-recorded contexts.

To overcome these challenges we have conceptualized two proxies, so to speak, to visualize untraded relationships. The first is using the technique of geospatial mapping described above to visualize all of the "special meeting places" as outlined in Figure 2. While not specifically showing what connections are made and between what companies, isolating "special meeting places" begins to represent the number of opportunities for connections to be made. Of course the number of meaningful connections cannot be equal or directly proportional to the number of "special meeting places," however, the presence or not of opportunities for informal connections to be established could play a significant role in creating untraded relationships and thus is worth understanding as part of the suite of regional assets. Similarly, at the intra-firm level networks are difficult to establish. However,

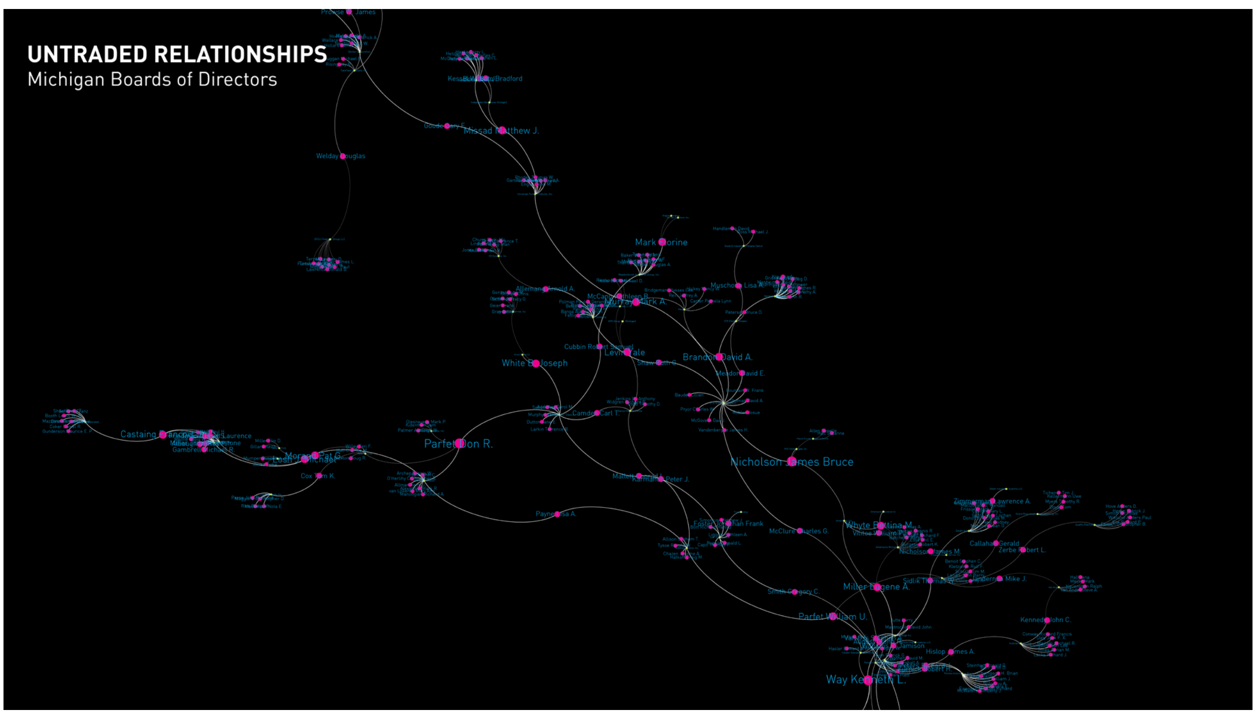

Figure 24: Untraded Relationships: Michigan Boards of Directors in New Mobility sectors. Social Netwrok modeling indicating connections between boards of firms sharing director members. Individual names scale as the frequency of number of positions held and related board member network grows in number of connections with other board members.

while not perfect, one set of data is available which helps to describe the untraded relationships that exist within the region. As one example of such locations, we have utilized the concept of the ‘boardroom’ as a site for meaningful interactions between key corporate decision makers that may foster untraded relationships. The second proxy for untraded relationships is mapping the boards of directors of public, private, holding, joint venture and subsidiary companies, while not showing the intra-firm relationships, does begin to speak of the untraded relationships between firms. In the same manner as the mapping of traded relationships, each unique firm is identified by their unique CUSIP or where not available a FactSet ID, and each unique person is identified by their assigned FactSet ID; collectively these are referred to as nodes. These nodes are then plotted and where a relationship exists a line is drawn between then. This method shows which boards are isolated and unconnected, and which boards are highly connected to one another. Significantly it shows which individuals are “keys” to multiple companies, acting as the primary link between different boards. When companies are identified by which industry they participate in, we can see which “key” individuals are active on multiple boards within the same industry space and which are acting as bridges between various industries. In terms of where clusters might form, this latter type of connection is very important as these individuals might be leveraged to help produce cooperation between two unlikely partners. While this dimension of the project is highly speculative, the concept suggests that within an effort to visualize the cultural contexts surrounding cluster development, the work to describe, visualize and create awareness around assessing key actors that may help to catalyze an economic cluster is valuable to the overall effort, and that approaches to data and information visualization could be instrumental in strategic decision making.

The final potential for relational mapping would develop a hybrid between the traded and untraded relational mapping described above. Because each visualization is developed from the same database platform, nodes and edges as identified by the same set of unique identifiers, the traded set of relations can be brought into relation with the untraded relationships between boards of directors. This has the potential to reveal the places where untraded relationships might have turned into monetary or traded relationships or where specific relationships that are based on trade then materialize as well as untraded relationships. While not causal, this type of visualization could reveal specific individuals which might be significant in developing an industry cluster around a specific activity. One impact of such combination is the potential to weight the relative power or potential impact of specific actors as a result of pairing the number of connections with the relative amount of capitalization they participate within. However, this type of evaluation has the bias of reinforcing existing perceptions that it will be the ‘most powerful’ individuals operating within the most robust corporate contexts that would be most significant. In the case of disruptive start-up activities, this may be far from the truth. While the efforts undertaken within this project to develop models for how we might visualize untraded relationships, this area of research constitutes significant challenges at both the conceptual level (which special meeting places and individuals matter most?), and at the level of data aggregation and social network analysis (which data sources are most useful in indicating the nature of meaningful relationships and their relative weighting within interpersonal social networks?). What is of great interest to future work is the potential for ‘big data’ related studies that might combine multiple data sources and attempt the visualization of relationships as part of visually enabled assessments associated with economic cluster analysis and development.

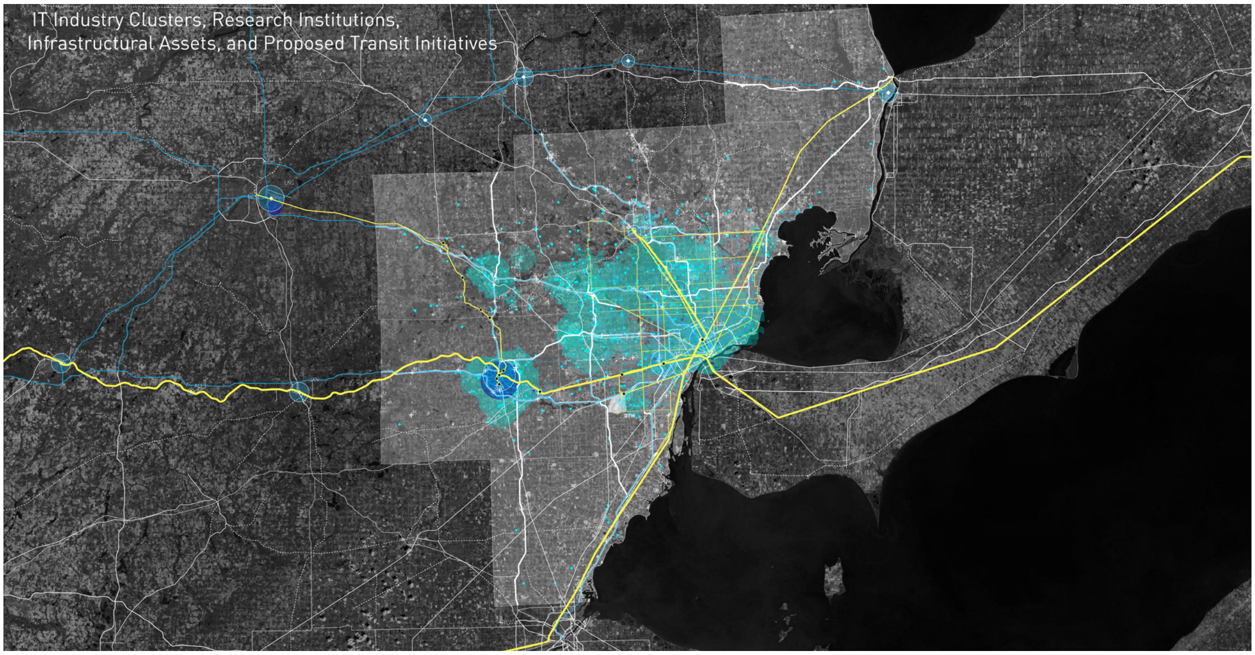

Figure 25: Combinatory Mapping Exemplar: Autonomous Vehicle Initiatives: SEM. Mapping aggregates IT-related industry concentrations, Dominant roadway networks with related pilot safety proposals, and proposed near-future transit related initiatives related to AV implementation. U-M MTC cited at U-M node is a key incubator site.

3.2.4 Combinatory Mapping

Combinatory mapping attempts to account simultaneously for a range of the factors and actors associated with potential cluster initiatives to be visualized simultaneously as a specific scenario, and geospatially within the boundary of regional consideration. As a result of the centrality of 'catalytic projects' in both case study evaluation and economic cluster literature of historic examples, the process of combinatory mapping begins with an evaluation of the near future catalytic projects within the region, a specific demand, around which a cluster might form and which will help contribute to the hard benefits of co-location in the region. The specific demand and associated products are then evaluated relative to other known value-chains that produce similar products. This analysis allows for specific NAICS codes to be identified in the process of delivering a specific product and isolated for within a given region. The identified industries are then mapped geospatially relative to existing infrastructures and implicated demographic statistics. Industries with strong regional presence are identified as well as those required industries needed for a particular New Mobility product or solution which might have a weaker presence or no presence at all. Additionally, those implicated industries are isolated in both the traded and untraded relational mapping to show where connections at the firm level already exist which could be leveraged towards fulfilling specific demands or where new connections are needed between nodes. Depending on the specific demand, this process may reveal expected or established relationships, it may reveal new unexpected potentials, or it may reveal gaps where new efforts might be focused to establish new connections. These combinatory and curated mappings at both the geospatial (see Fig 25) and relation level are directly tied to the process of scenario thinking – they create imaginaries of what might be and where one might direct their efforts rather than predictive tools of what will be or what even what is becoming. These mappings act as suggestions or prompts around which further discourse may be assembled, helping to enable decision making in one direction or another. They are intended to produce an image of what 'could be' from the conditions that already are present and to draw into apprehension the range of geospatialized actors and agents that might participate in the resulting activity stemming from a given proposal.

3.3 Visualization as Scenario Thinking Tool

In addition to the cluster concept, another important conceptual framework developed through this project is that of scenario thinking, also known as the scenario method or scenario planning. Herman Kahn, a military strategist and systems theorist, is widely credited with inventing scenario thinking in the 1950s as a way to improve strategic analysis and decision-making within the military in the face of uncertain futures. This way of thinking emerges directly from how we see, understand, and produce knowledge relative to our world around us. Scenario planning—seeking a middle-ground between rational, scientific forecasts and subjective, imaginative predictions—is a mode of critical speculation on the workings of a complex and uncertain world which seeks to improve our ability to make strategy decisions about social, political, and economic futures (Salewski, 2012, p. 20). The primary questions driving this research project are projective: "what if there was a new mobility industry cluster in Southeast Michigan, how might we develop it, and what might it look like?" Therefore, scenario thinking provides an important framework for how we might begin to think about the region's "possible future" and the plausible paths toward that future given the current status quo (Salewski, 2012). In Think*ing about the Unthinkable,* Kahn writes:

> *…one must remember that the scenario is not used as a predictive device. The analyst is often dealing with the unknown and unknowable future.… If a scenario is to be plausible, it must, of course, relate at the outset to some reasonable version of the present, and must throughout relate rationally to the way people could behave though it is important not to limit oneself to the most plausible, conventional or probable situations and behaviors. (Kahn 1962, p. 145)*

A combination of scenario thinking and the physical and relational mapping techniques described earlier add a potentially valuable tool to the domain of regional economic development policy because they help establish the ground from which regional futures might emerge. Scenario visualizations highlight existing potentials and opportunities and suggest diverse outcomes that might be reached. Visualization is therefore viewed neither as a predictive tool ("this will happen") nor as a diagnostic tool ("it is what it is") but rather as a tool to present the constituent parts of the region's economic make-up as a way to open up what the region might become.

Through a very precise collection and mapping of a region's current physical and non-physical assets, new economic development trajectories might be identified, produced, around which consensus and political will might be catalyzed. As such, our approach to these questions, hybridizing of cluster theories, mapping techniques, and scenario planning, aims to produce a set of related visualizations that may enable policy leaders and decisions makers through new ways of looking at and understanding the present towards different potential economic development paths for a region's future.

4.0 Visualizing New Mobility Economic Opportunities in Southeast Michigan

4.1 Mapping the Emergent New Mobility Cluster in Southeast Michigan

Widespread adoption of Geographic Information Systems (GIS) and the rapidly growing availability of public geospatial datasets make it possible to gather, parse, recombine, geocode, and map extremely large quantities of complex spatial and relational information. Dynamic, multilayered GIS and data-driven maps have developed into much more powerful as navigational tools, accessible to increasingly map-literate public. Maps can also be powerful analytical tool that allow researchers, designers, policymakers, and entrepreneurs to identify patterns and opportunities within large, complex, and dynamic systems. This chapter outlines how the methodologies and datasets have been developed, refined, and tested in the context of Southeast Michigan.

4.1.1 Geographic Extents

One of the initial challenges of mapping the geospatial distribution of extant regional assets was determining the appropriate geographic boundaries of the study. Ideally, these boundaries are treated as flexible and elastic, since regional systems and economies participate in global economic systems and material supply chains and are not usually confined to well-defined geographic or political borders. That said, regional systems do constitute boundaries of specific differentiation when understood through the lens of economic ecology as Self-Organizing Holarchic Open Systems: hierarchically organized, nested systems that operate through the self organizational principles of complexity (Kay, Regier, Boyle, & Francis, 1999). Within this context of global systems, the construct of the megaregion is increasingly understood to constitute a boundary of systemic extent within which tightly coupled sub-regional economies operate. In the case of Southeast Michigan, we understand that this region's economic footprint and extended network participates within the broader framework of the Great Lakes Megaregion (Thün, Velikov, Ripley, & McTavish, 2015). However, given the dominance of State based structures and localized policy and economic drivers, that consideration of Southeast Michigan within a framework of SOHO systems constitutes a meaningful boundary for examination, while recognizing, that limiting systemic examination to this extent will inevitably exclude network components with potentially substantial effects on economic cluster development. Furthermore, there are multiple definitions of what constitutes Southeast Michigan, none of which fully capture the extents of regional economic and infrastructural systems. Ultimately we selected the seven member counties of the Southeast Michigan Council of Governments (SEMCOG) as an acceptable limit for this phase of study. The choice of using the SEMCOG boundary served the project in two ways. First, SEMCOG is an intergovernmental agency that supports coordinated regional efforts around environmental resources, transportation, communities, and economic development. (SEMCOG, 2015) The choice of the SEMCOG boundary represents an entity that can help to coordinate policy and regional New Mobility projects around developing which could nurture New Mobility clusters and that supports the development of strong regional economic foundations. Second, the relatively constrained geographic area helped in facilitating our search for information and to limit our datasets to a manageable size relative to the primary project aim of developing visualization tools. Thus, the primary collection area for regional assets information is comprised of the three Detroit metropolitan counties of Wayne, Macomb, and Oakland, plus the counties of Livingston, Monroe, St. Clair, and Washtenaw, which all fall within the Detroit-Ann Arbor-Flint combined statistical area (CSA). The study excludes Genesee and Lapeer counties and the Flint metropolitan area; Ingham County and the Lansing metropolitan area; Lucas County and the Toledo, OH metropolitan area; the Windsor, ON metropolitan area; as well as primarily rural Jackson and Lenawee counties. Where possible, we have extended maps of infrastructure networks beyond SEMCOG borders in order to illustrate their connectivity with other regions; we have also shown major research institutions whose main campuses lie outside of SEMCOG counties, since these institutions might have large areas of influence which include the SEMCOG region.

4.1.2 Regional Economic Foundations

The overall economic foundations of a region significantly contribute to producing an environment that can promote the presence of the necessary components that comprise industry clusters. This project maps conditions in Southeast Michigan which are important for supporting clusters: the availability and proximity of human capital, the level of education attained, location of training institutions, availability of financial capital through venture capital and other funding agencies, and the level of innovation already present in the region. Mapping these factors help to visualize whether a region possesses a sufficient foundation to support a cluster and may reveal where further actions are required to ready the ground in sponsorship of cluster initiatives.

Our geospatial and relational cluster visualizations are founded on an assembled series of regional datasets that catalog the existing industry, institutional, and infrastructural assets in Southeast Michigan. This study examined a wide range of existing assets, both physical and non-physical, which have the potential to contribute to the development of an emergent New Mobility industry cluster in Southeast Michigan. These assets might also be leveraged in order to advance the New Mobility agenda of greater social access and connectivity in the region. These assets have been characterized as:

- Industries which may produce goods, technologies and services related to the New Mobility;
- Institutions which may produce knowledge, provide catalysis and support for emerging New Mobility enterprises, and facilitate connections and partnerships between potential New Mobility cluster actors;
- Infrastructure which provides the physical and spatial framework for the development of New Mobility systems, and a potential apparatus for the delivery of New Mobility services.
- Catalytic agents which could constitute a new product or solution around which regional actors might assemble.

By mapping these four categories of regional assets, synthesizing and layering them to create combinatory cartographies of Southeast Michigan, it is possible to identify patterns in geographic distribution, gaps in service sheds, and latent and emergent hot-spots of regional New Mobility activity. In some cases, these patterns and potentials are immediately apparent; in other cases, more advanced spatial statistical analysis is required to reveal the most useful cartographic narratives. The following sections will describe the progress of data collection to date, data-collection methodologies, and limitations of the compilation process. A comprehensive list of the data sources for the construction of the datasets developed for this project is contained in Appendix 2: Comprehensive List of Data Sources.

4.1.2.1 Existing Industries

The largest area of data assembly undertaken within this study is the dataset and map set of existing industries in Southeast Michigan. Using the *OneSource Global Business Browser* online database, we generated comprehensive custom lists of Southeast Michigan companies that included company name, street address, NAICS 2012 code, number of employees, annual sales, total assets, ownership type, and corporate parents. We systematically compiled company data by NAICS classification; out of a total 1,066 total NAICS codes, we identified 513 which are likely to include key New Mobility activities based on our understanding of this emerging area of enterprise. 188 of these were identified in our earlier case studies and 468 industry codes were added based on current literature review of the New Mobility space, and an analysis of supporting industry types. The definition of the New Mobility is quite broad and still evolving and the 513 industries identified may not constitute a complete list of all industries which could be related to New Mobility activities. However, we believe they do represent the industries and sectors likely to comprise the core of a New Mobility cluster. Also, not every company captured in those NAICS codes is guaranteed to participate in a New Mobility cluster. However, we have attempted to achieve greatest possible depth and inclusiveness within those key industries in order to maximize our sample of individual potential cluster participants and generate as complete a picture of the existing regional economic terrain as possible. To date, we have completed searches for 422 industries of interest, identified 367 industries existing in Southeast Michigan, and collected information for 58,056 individual companies. From that dataset, we have mapped and analyzed 26,290 individual companies across 301 unique industries anticipated to be part of the New Mobility economy in the Southeast Michigan region.

To visualize the geospatial distribution of existing New Mobility-related industries in the region, individual companies were geocoded and mapped based on their registered street addresses as a means to account for and location respective primary spatial assets. Once point locations were established for each company, the points were scaled by company size relative to their own industry or sector. To determine the relative size of a company, we used the US Small Business Administration (SBA) Table of Small Business Size Standards Matched to North American Industry Classification System Codes as a starting point; this table provides NAICS code-specific cutoffs based on revenue, assets, or number of employees, depending on the industry, to determine whether or not a company qualifies as a small business (U.S. Small Business Administration, 2014). Cutoffs for ‘very small’, ‘medium’, ‘large’, and ‘very large’ were determined based on the maximum and minimum sizes of companies in that industry and the distribution of firm sizes within that range. These size categories were assigned a common dot size, and this symbology was applied for all companies and industries in the dataset. Although this method of representing size categories makes it impossible to determine very fine-grained or absolute values (for example, comparing the number of employees between two similarly-sized companies or determining the company with the greatest revenues of any company), it is useful for making quick, visual assessments of a company’s position within its own sector, subsector, and industry (for example, a small architecture firm versus a large architecture firm), as well as for comparing the relative dominance of firms in dissimilar industries (a large architecture firm versus a large auto manufacturer). Each industry was color-coded by its larger industry family (i.e. primary manufacturing, secondary

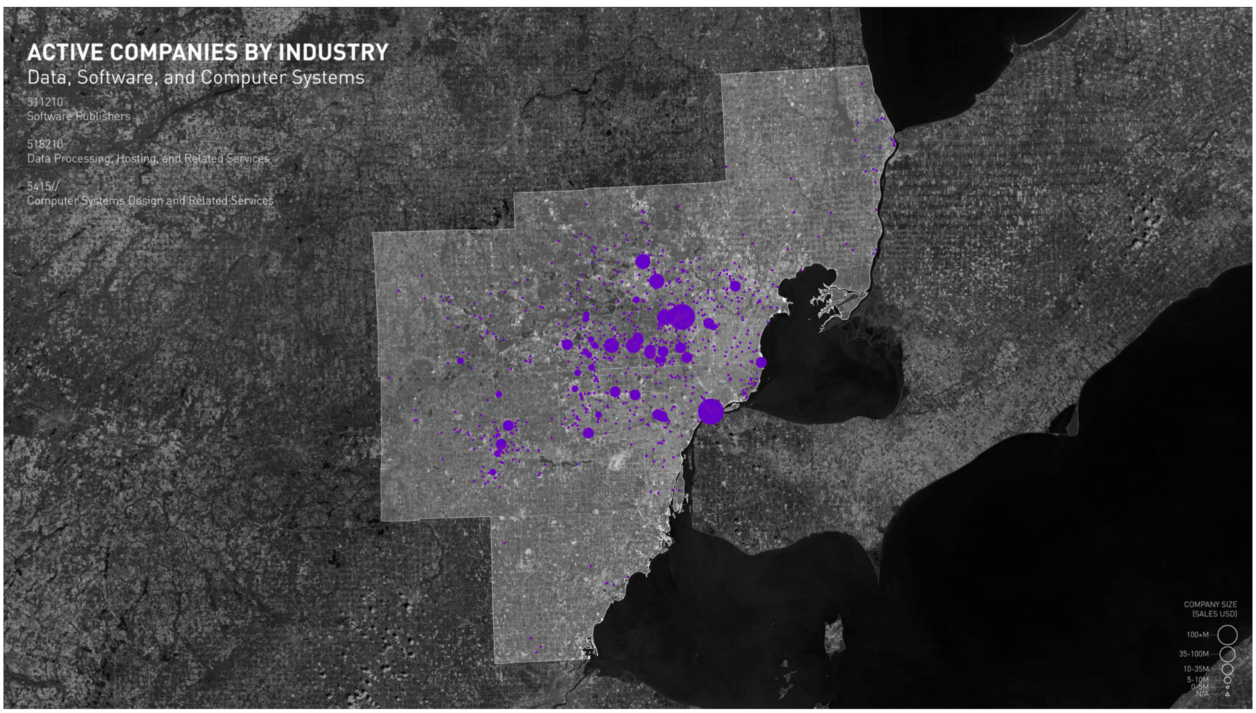

Figure 26: SEM: Existing Industries: Data, Software and Computer Systems. Assembled point data for NAICS industry codes of 511210: Software Publishers, 518210: Data Processing, Hosting, and Related Services, 5415//: Computer Systems Design and Related Services. Points scaled relative to annual gross sales attributable to specific real estate assets.

manufacturing, transportation services, IT services, etc.).

Geospatial point maps can be a useful tool for producing insights on their own; however, sometimes relevant patterns of distribution or activity are not apparent without further statistical and spatial analysis (Figure 26). In addition to mapping each potential New Mobility industry as a field of geolocated and scaled points, we

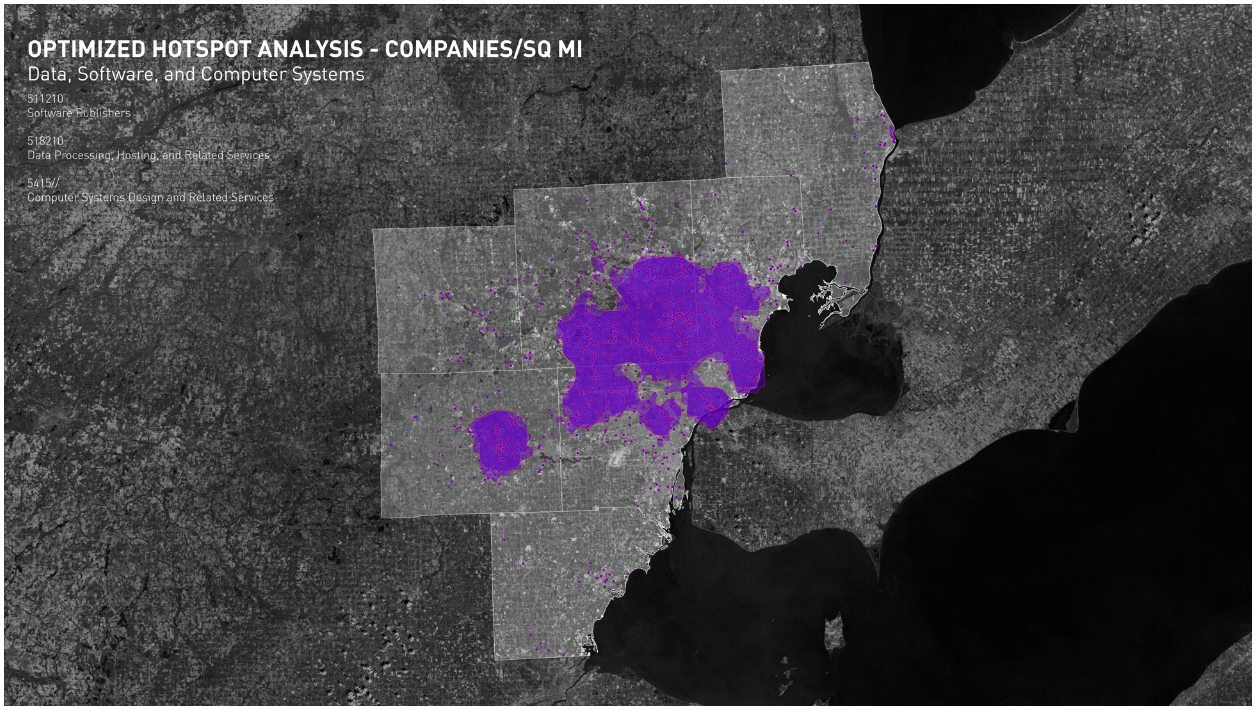

Figure 27: SEM: Existing Industries: Data, Software and Computer Systems: Optimized hotspot analysis I: for NAICS industry codes of 511210: Software Publishers, 518210: Data Processing, Hosting, and Related Services, 5415//: Computer Systems Design and Related Services. Area assessment based on weighted evaluation of companies/sq-mi.

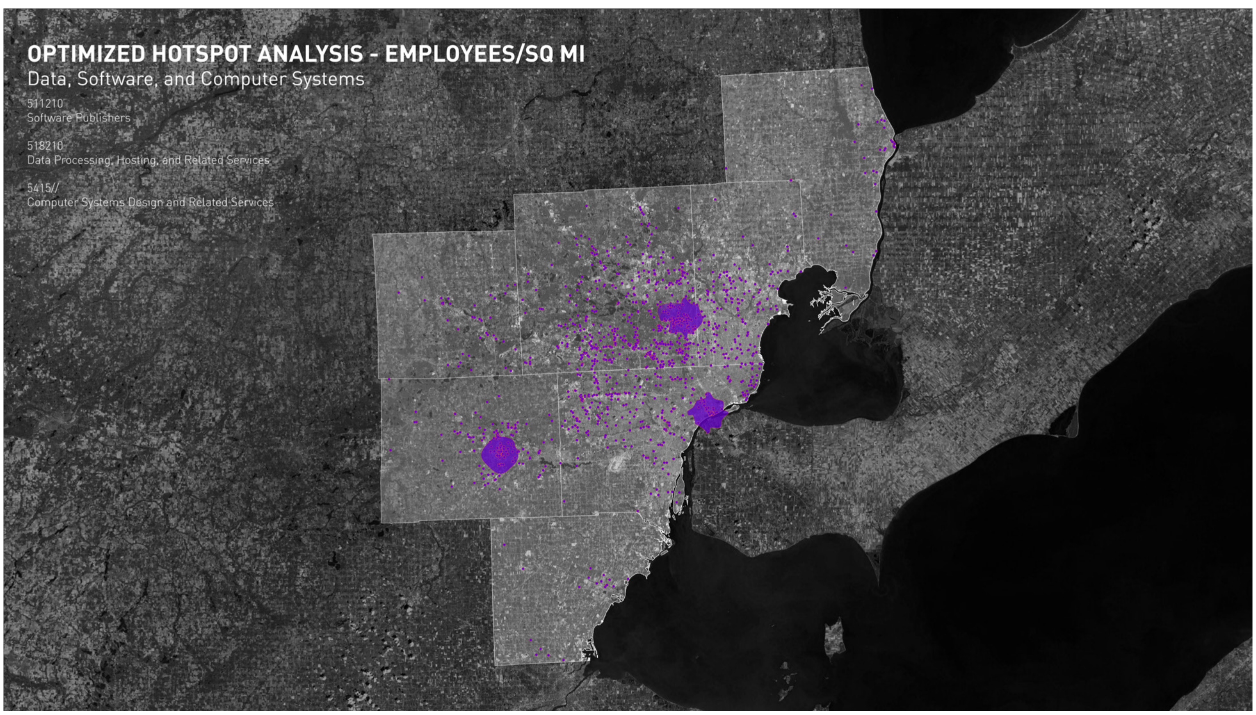

Figure 28: SEM Existing Industries: Data, Software and Computer Systems: Optimized hotspot analysis II: for NAICS industry codes of 511210: Software Publishers, 518210: Data Processing, Hosting, and Related Services, 5415//: Computer Systems Design and Related Services. Area assessment based on weighted evaluation of employees /sq-mi.

produced statistical hotspot and cluster maps for consolidated groups of similar industries. Using ArcMap GIS software, we first collapsed all company points and scalar information into a uniform grid of one-square-mile parcels, to represent the geographic density of companies per square mile and employees per square mile for each industry group. Next, we conducted an optimized hotspot analysis as well as a cluster and outlier analysis using the spatial statistics tools included in ArcMap 10.2. The “hotspot analysis tool” calculates a Getis-Ord Gi* statistic for each dataset feature; this statistic is a Z score, or number of standard deviations away from a null hypothesis of complete spatial randomness (CSR) for the distribution of features. The “cluster and outlier analysis” tool generates an Anselin Local Moran’s I statistic for each feature, a statistic comparing the probability-values of CSR between neighboring features; it can identify clusters where are a number of neighboring features share similarly low probabilities of CSR. We ran each analysis for both companies/sq-mi and employees/sq-mi for 25 New Mobility sectors to produce geospatial maps of likely industry co-location in Southeast Michigan (see Figures 27, 28). These maps alone do not definitively identify existing industry clusters, but rather highlight areas where there are high geographic concentrations of firms, a key prerequisite for industry clustering, as discussed in 2.1.1 *Geographical Concentration of Firms*. These visualizations aid in primary assessment of industry presence and scalar significance within the region.

4.1.2.2 Industry Relational Dataset

A second, parallel industry dataset cataloging traded and untraded relationships between companies and between company board members was constructed using data from FactSet. Initial relational visualizations

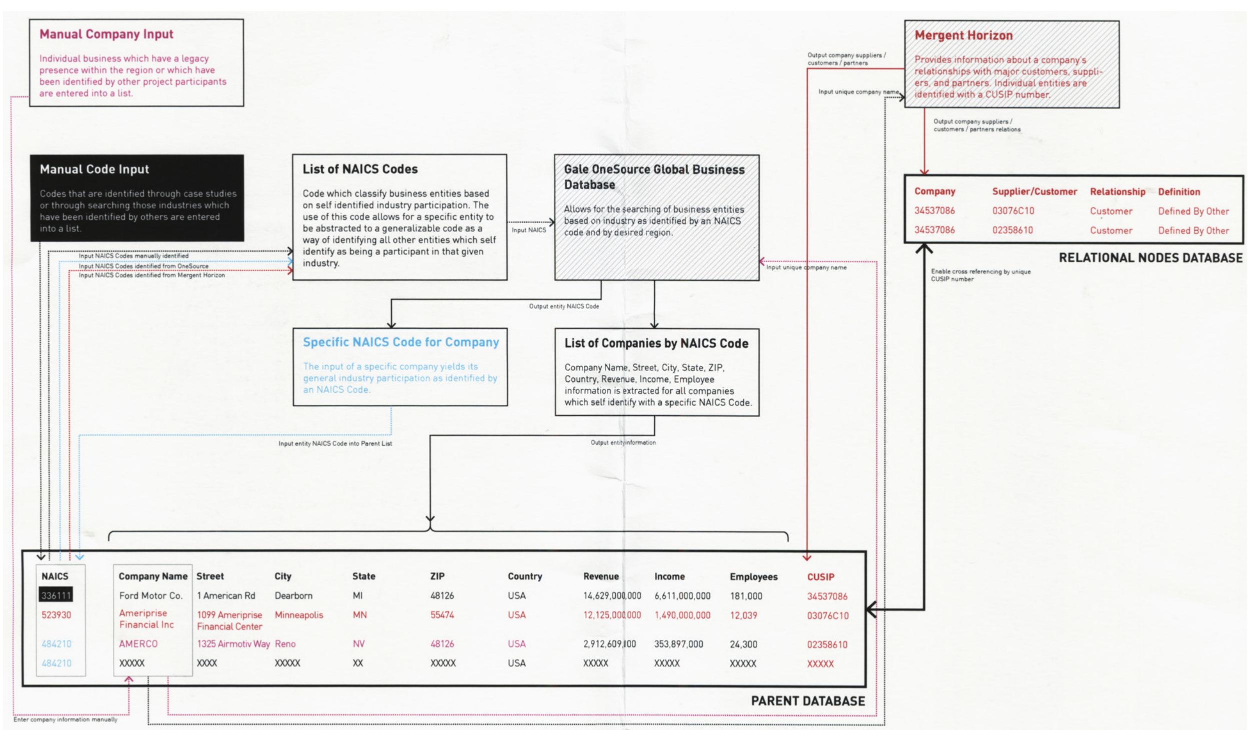

Figure 29: Data Acquisition and Data Assemblage Workflow and Process Diagram.

developed within the case studies relied on case-by-case research using publicly available financial and annual reports. This method produced useful insights but was seen to be time and labor-intensive. We initially hoped to use OneSource to build a more easily reproducible and robust relational dataset, since we were already using that database to build the industry lists described in the previous section. Although the OneSource database was useful for gathering information about individual companies, it does not report inter-firm transactions; nor does it provide information about individuals within those companies. Moreover, OneSource does not openly assign unique, widely recognized identifier codes to the companies, making it difficult to create links within OneSource-generated lists and between lists generated from other sources. To overcome this barrier we utilized FactSet's financial research and investment analytics tools, which provide financial information on public and some privately-held companies. FactSet allows for many of the same queries as OneSource, with the added benefit of applying multiple unique identifier codes to companies and individuals, allowing for relational cross-referencing between entities. For this project we used Committee on Uniform Securities Identity Procedures (CUSIP) identifiers, and where not available, FactSet assigned FactSet ID numbers. Switching to FactSet enabled us to create tables of customer, supplier, and traded partner relationships as well as relations between boards of directors through companies and for these relationships to be described visually.

The initial set of identifiers produced from the NAICS queries is then fed back into FactSet as an input to generate a list of customers, identified by their CUSIP or FactSet ID numbers, for each input entity. This process (see Figure 29) is repeated for suppliers and partners, as well as board members. From this data six datasets are created to describe the traded and untraded relationships between entities as well as a hybrid dataset that contains both traded and untraded relationships; each describes both the "nodes", unique entities containing no duplicates as well as the "edges," or lines that describe the connections between the unique nodes. These node and edge files are the basis for describing the relationships and can be visualized as graph diagrams utilizing different platforms, such as Gephi, a network visualization software, and different layouts to communicate different data stories as discussed in section 3.2.3 *Relational Mapping*.

4.1.2.3 Research Institutions

Using techniques similar to those of the industry mapping, we produced datasets and maps of major research institutions in Southeast Michigan, including research universities, Federal and state research facilities, private and non-profit research and development centers, and research entities operated as public-private partnerships. We have included not only institutions located within SEMCOG counties, but also significant national institutions elsewhere in Michigan, Northern Ohio, and Southwestern Ontario which form partnerships and have or which might have large spillover effects in the SEMCOG region. In total, we have mapped twelve research universities in the greater region, seven of which are located in SEMCOG counties. As with the industry maps, individual research institutions were geocoded by address to create geospatial point maps. General information for universities and colleges including name, location, population, and type of institution is available from the

U.S. Department of Education's National Center for Education Statistics (NCES) College Navigator. Additional classification standards for size, degree type, research activity, and ownership are available through The Carnegie Classification of Institutions of Higher Education database. The Higher Education Research and Development (HERD) Survey, published by the National Science Foundation (NSF) National Center for Science and Engineering Statistics (NCSES) provides detailed reports of research expenditures and funding sources at American universities, including:

- Total R&D Expenditures by source of funds: Includes total expenditures ranked by institution, and amount of funds obtained from Federal, state and local, institution, business, nonprofit, and other sources.
- Total R&D Expenditures by field: Includes total R&D expenditures in the environmental sciences, life sciences, math and computer sciences, physical sciences, psychology, social sciences, unclassified sciences, engineering, and all non-science and engineering fields.
- Federally financed expenditures: Includes total Federally-funded R&D expenditures subdivided by funding agency, including the departments of Defense (DOD), Energy (DOE), Health and Human Services (DHHS), and Agriculture (USDA), as well as NASA, NSF, and all other federal agencies.

Figure 30: SEM: Research Institutions: public and private research institutions. Point data scaled relative to primary geospatial location indicating total research expenditures per annum.

- R&D Personnel: Includes the total number of R&D personnel at both public and private institutions, subdivided into principal investigators, other personnel, and postdoc researchers.

The Council of Ontario Universities' CUDO survey provided total R&D expenditures and amount of funds awarded to Ontario universities from the Social Sciences and Humanities Research Council of Canada (SSHRC), the Natural

Science and Engineering Research Council on Canada (NSERC), and the Canadian Institutes of Health Research (CIHR). In our maps, research universities are scaled both according to their research budgets and number of research personnel.

We have also identified 118 non-university research facilities in the SEMCOG region, though this list may require future expansion and may not currently be exhaustive based on the limits of standardized reporting. NCSES provides data on research funding and expenditures for all *Federally Funded Research and Development Centers* (FFRDC) including the national laboratories and national defense research facilities, although none exist in Michigan. Southeast Michigan does contain other Federal facilities administered by the Environmental Protection Agency (EPA), DOE, DOD, and U.S. Army, as well as a number of state facilities, primarily associated with the Michigan Department of Transportation (MDOT); information on non-FFRDC facilities, including both Federal and state-administered facilities is often limited. To find these facilities, we conducted systematic searches of all Federal and state agency and department websites for offices, laboratories, testing centers, and other locations in Michigan. Similarly, information on corporate, non-profit, public-private, and other independent research facilities is scattered and varies in detail. Certain industries maintain their own databases which may include industry-specific R&D facilities. For example, AutomotiveOEM™ publishes a national listing of automotive manufacturers and suppliers with information drawn from the Automotive Who's Who industry database; the listings include a section for automotive manufacturing facilities engaged in "New Technologies," which primarily include private R&D centers and testing facilities (AutomotiveOEM, n.d.). A review of university and government websites was helpful in revealing a number of joint research ventures, typically partnerships between state agencies and universities, and occasionally including private industry and nonprofit organizations. While there exists comprehensive, publicly available information related to university research in the region, we have been unable to obtain similarly complete data on government and independent research facilities; as a result, non-university research institutions are represented as unscaled, geospatial points that do not necessarily register in scaled geospatial mapping. At this time and within the geospatialized dataset, we have only represented regional research institutions based on geospatial point locations, and have not run further spatial statistics analyses. All data available has been assembled into our parent meta-dataset for the region.

4.1.2.4 Physical Infrastructural Assets

To account for the existing physical and infrastructural assets present geospatial data was assembled to describe existing regional infrastructure and mobility networks. These infrastructures are significant in so far as they help to enable the development of clusters, through enabling the geographic colocation of firms, structuring and enabling their hard benefits as well as soft benefits as discussed in section 2.1.1 *Geographic Concentrations of Firms*. Assembling GIS datasets from Federal, state, and county-level governmental sources, as well as from regional planning and transit authorities, and nonprofit organizations focusing on mobility and open data, we produced a series of five thematic maps:

- Road-based mobility systems including all expressways and roadways sorted by class; gas stations, alternative fueling stations, and electric charging stations; urban and intercity bus routes, terminals, and stops; carshare and park-and-ride points; autonomous vehicle and smart vehicle infrastructure; intermodal passenger and freight hubs; and international border crossings. Data was obtained from U.S. Census Bureau's TIGER shapefiles, regional transit authorities, city and non-profit-run open data portals, and private companies. (see Figure 31)

- Rail-based mobility systems including all active, secondary, and inactive freight and passenger lines; Amtrak passenger stations, scaled by ridership; rail intermodal hubs; and international rail crossings. Data was obtained from U.S. Census Bureau's TIGER shapefiles. (see Figure 32)
- Air and water infrastructure including major and minor airports, landing strips, and heliports; major Great Lakes ports and U.S. Army Corps of Engineers-administered docks and terminals; passenger ferry and ship terminals; air and lake-shipping intermodal hubs; and Great Lakes shipping lanes. Data was obtained from Federal Aviation Administration (FAA) and the US Army Corps of Engineers Navigation Data Center.
- Nonmotorized mobility infrastructure including on and off-street bike routes; bike share stations; and municipalities and counties with Complete Streets or other nonmotorized plans in place. Data was obtained from SEMCOG, county, and city data portals.
- Passenger-only mass- and public transportation, recombining multimodal passenger mobility infrastructures from the previous four maps, and excluding limited-access car-only networks.
- Power infrastructure including power plants by energy type and scaled by generation capacity, including smart-grid linked private solar arrays; regional electricity power transmission grid; gas, oil,

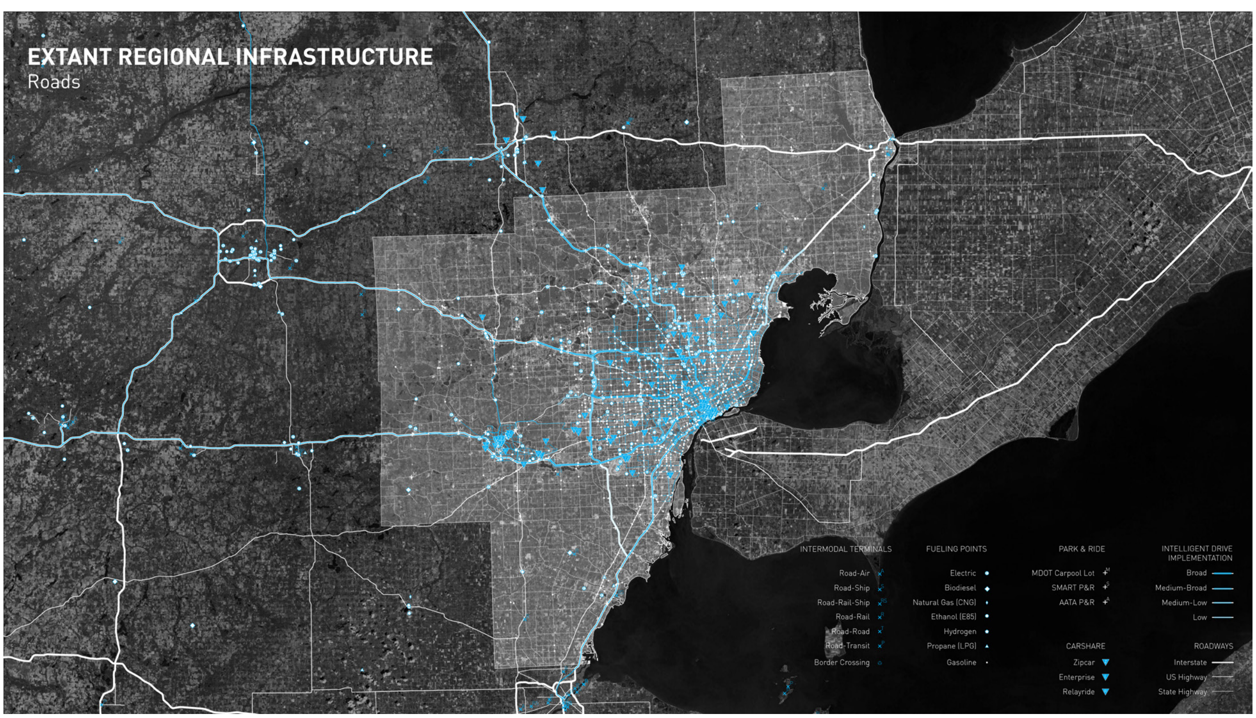

Figure 31: Extant Physical Infrastructure: SEM Road Systems. This map deplicts the existing road based infrastructure within the region and includes notation locating *existing* New Mobility spatial assets tied to the road network(s).

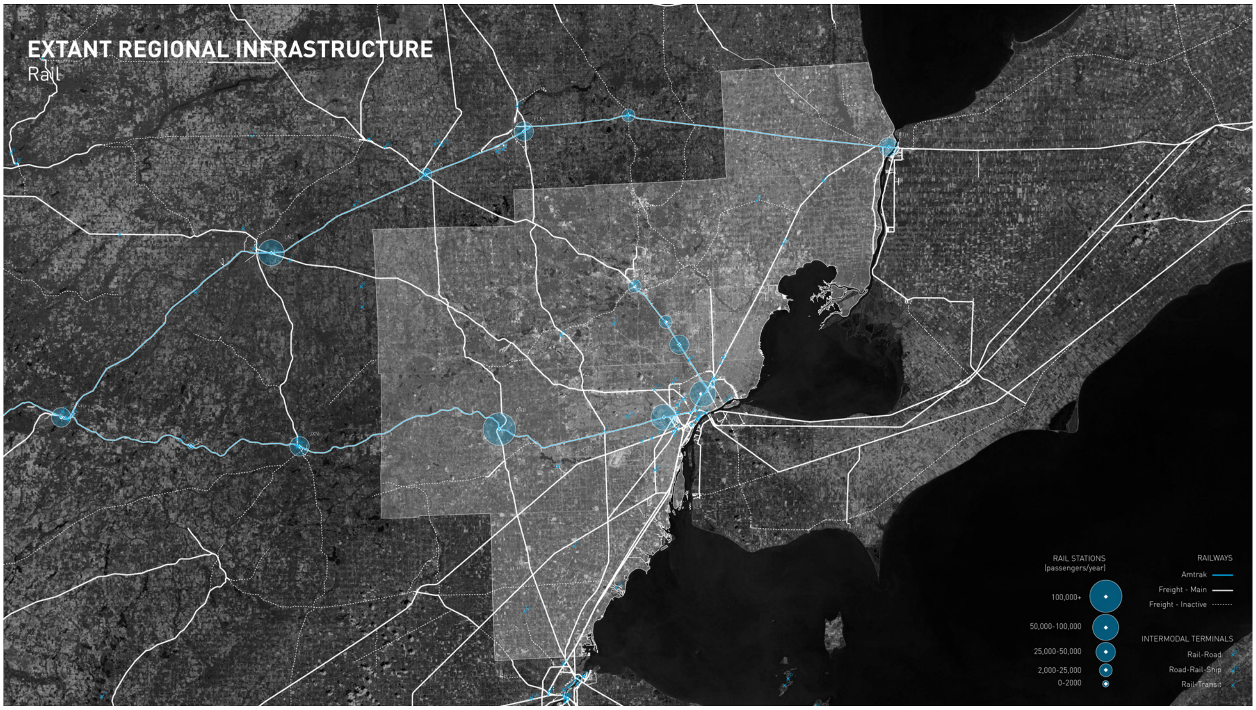

Figure 32: Extant Physical Infrastructure: SEM Rail Systems. This map depicts the existing road based infrastructure within the region and includes notation locating *existing* New Mobility spatial assets tied to the rail network(s).

and petrochemical transmission pipelines. DOE Alternative Fuels Data Center, U.S. Energy Information Administration, and the National Renewable Energy Laboratory.

These infrastructural assets were mapped separately from the other regional assets. Possible future analyses could include study of the mobility-sheds and mobility-deserts created by overlaid transportation systems; investigations of population, wealth, knowledge, business and industrial productivity in proximity to particular infrastructural paths and nodes and their relation to industry concentrations; and network connectivity and complexity analysis.

4.1.2.5 Institutions for Collaboration and Other Catalytic Organizations

In addition to mapping existing industries, institutions, and infrastructures, we also searched for and mapped instances of publicly supported projects and initiatives (through a combination of federal, state, and municipal funds) which could generate or enhance those aforementioned regional assets in the near future and which could catalyze a New Mobility industry cluster. The dataset of possible cluster initiatives that might formalize or institutionalize includes all organizations, foundations, grant-making and philanthropic organizations, and funding sources that could potentially generate new economic activity or stimulate existing activities related to industry development, institutional growth, and infrastructural capacity-building. It also includes organizations that support innovation within firms, provide mentorship, help with business planning and regional planning, advise on technological advances, provide marketing services, or create opportunities for networking. Other catalysts include, start-up incubators, business improvement districts, non-profit interest groups, NGOs, education centers, industry associations, and others institutions for collaboration and organizations which help to pull the cluster together and promote collaboration amongst their participants. Data collection centered on foundations that might fund a range of initiatives, and might be sources of future funding for cluster activities and initiatives as well as other catalytic actors. These entities are relevant as a means to spatialize the presence of catalyzing agents, but may also operate as key locations that are constitutive of 'special meeting places' that support untraded relations.

Many agents were identified through Sustainable Mobility & Accessibility Research and Transformation's (SMART) extensive expert network in the space of New Mobility; this served as the basis for further research into the other partner organizations. SMART has also developed an open global databank of New Mobility enterprises called the Mobi Platform (www.mobi-platform.com). Though these resources are currently still in development, it does contain self-reported information by New Mobility enterprises in the region. As such, SMART operates in part as an existing IFC within Southeast Michigan, an agent of catalytic value similar in potential operation as those identified and discussed through the case study analysis, but lacking the formal mandate to sponsor cluster activity. The U.S. Small Business Administration Cluster Initiative identifies fifty-six federal funded cluster initiatives nationwide, including three in Southeast Michigan: the Southeast Michigan Advanced Energy Storage System Initiative, CEEDS MI, and the Advanced Contract Manufacturing of Southeast Michigan Cluster (U.S. Small Business Administration, n.d.). US Cluster Mapping also proved to be a valuable source for identifying organizations already involved in cluster activities. Regional economic development organizations, such as the MEDC, provide valuable resources for identifying entrepreneurial programs and spaces that facilitate connects and networking opportunities between participants. After a preliminary list of IFCs and other catalysts was assembled using the above resources, affiliated partner organizations and additional regional actors were located using branching web searches. The names of the organizations, addresses, contact information, and primary area of activity were added to the dataset and geocoded in ArcMap.

4.1.2.6 Catalytic and Near-Future Projects

In review of cluster literature and through insights derived from the case studies, a separate task was undertaken with the intent of capturing the presence of potential and future catalytic projects. While local initiatives are understood to often be significant factors in mobilizing areas of cluster activity, it is difficult to account for projects and opportunities that are not yet known. As a proxy for this domain of cluster catalysis, we undertook a mapping of all proposed and near future projects that have been publicly disclosed in Southeast Michigan related to New Mobility. These projects may be executed by the Federal or state government, regional planning authorities or transit agencies, universities, non-profit organizations, or private companies; many projects may develop with support from the catalysts described above. The database of proposed and near-future cluster-catalyzing projects primarily includes transportation infrastructure projects, and also includes mobility services,

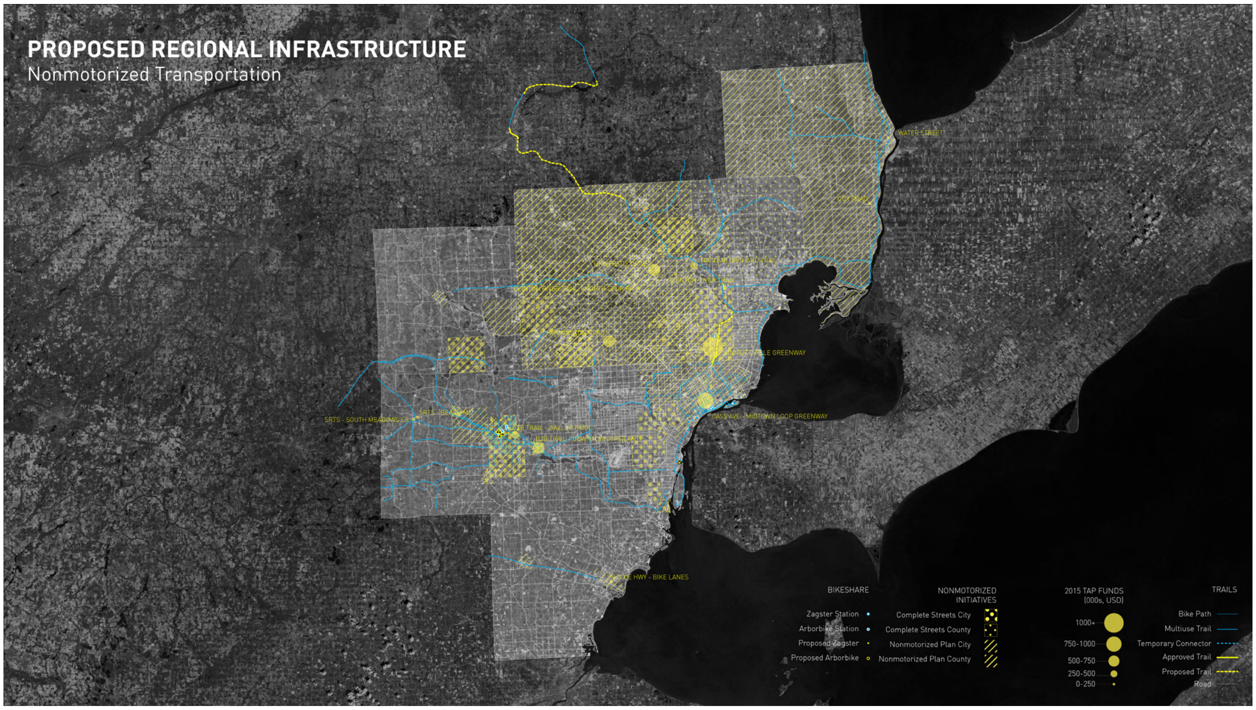

Figure 33: Catalytic Future Projects: Proposed Non-Motorized Projects within the SEM Region. Specific vectors associated with new project proposals, zones defining new non-motorized policy proposals, New Mobility solution proposals including bike-share nodes and related TAP funding location commitments spatialized relative to existing networks.

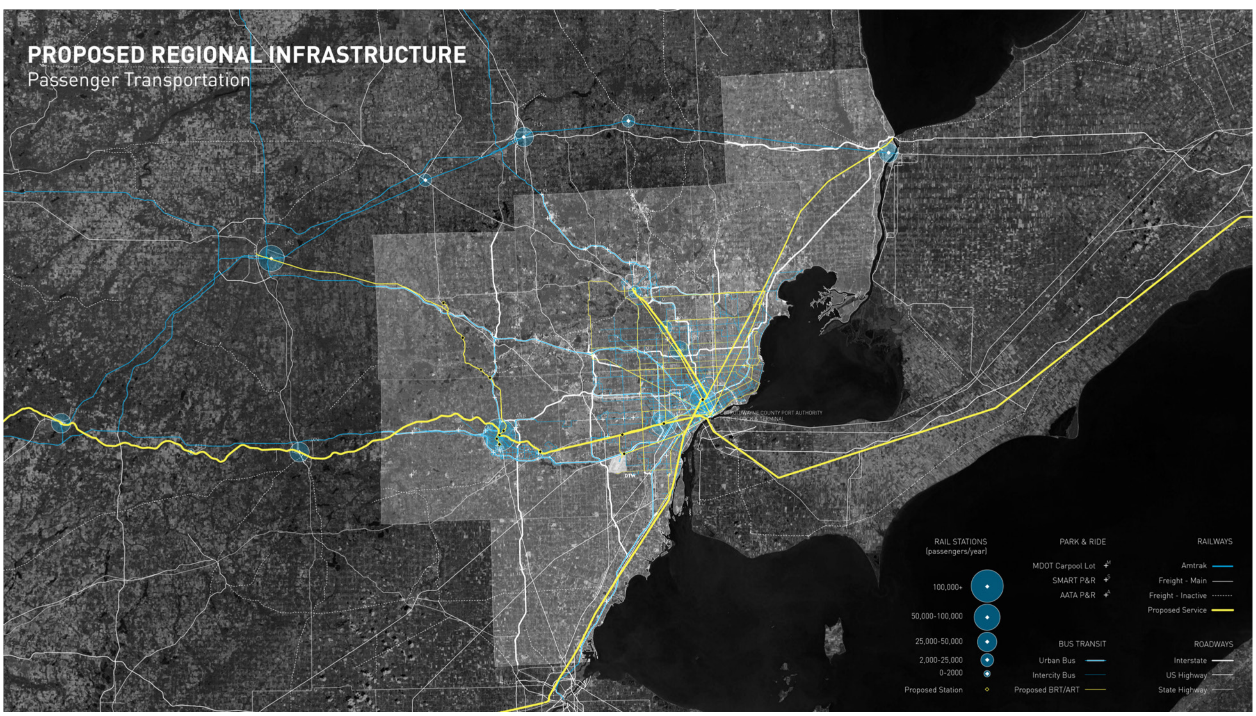

Figure 34: Catalytic Future Projects: Proposed Passenger Projects within the SEM Region. Specific vectors associated with new project proposals, new and existing intermodal hub sites, existing passenger demand loads, and corollary systems are depicted.

pedestrian and cyclist initiatives, energy infrastructure, and logistics facilities. Transportation projects include the construction of new bus and rail public transit systems, construction or improvement of regional and interstate rail systems, the deployment of intelligent transportation systems along roadways, port and airport expansions, and the construction of new international border crossings; we have excluded road construction and widening projects and scheduled maintenance. Future mobility services include expansion of urban bus networks, regional integration of local transportation networks, improvement of rural and suburban transit and ride-sharing services, and development of integrated fare payment systems. Pedestrian and cyclist initiatives include the introduction of new public bike-share services, improvement of community bike facilities, improving integration of bike transportation and motorized transit, pedestrian safety programs, and the expansion and improvement of regional pedestrian and cycling trail infrastructure (see Figure 33). Future energy projects include the development of renewable energy power plants and programs promoting the installation of smart-grid integrated solar arrays on private buildings. Future logistics projects include a number of intermodal freight terminals and expansions at Great Lakes shipping ports and other international ports of entry. Included in all of the above are any development incentive zones and other areas that receive special political or economic considerations that may encourage new mobility projects.

Public information is readily available for all projects that have received or anticipate state and federal funding. The Southeast Michigan Council of Governments (SEMCOG), Southeast Michigan's regional planning partnership, provides a comprehensive three-year list of future transportation-related projects receiving Federal funding through the Michigan Transportation Improvement Program (TIP), and a one-year list of future projects approved for Federal Transportation Alternatives Program (TAP) funds. SEMCOG's 2040 Regional Transportation Plan for Southeast Michigan contains many other regional transportation projects which have not yet received Federal funding, are currently under study, or which are still in the early-ideas stage. Older and occasionally obsolete long-range regional plans also exist; we have included the projects proposed in these plans, even if they are no longer under active review. All public transit service providers as well as most counties and some cities also produce publicly-available short- and long-range plans for transportation, transit, land use, and economic development; although these tend to have a great deal of overlap with the larger region-wide plans, they often describe local projects and non-Federal or internally-funded initiatives in greater detail. Finally, many of the institutions, non-profits, and other cluster-catalyzing agents discussed in section 4.1.2.5 provide a great deal of information on proposed private or community-led initiatives, speculative and recommended projects, and hybrid projects not otherwise listed in regional, county, and municipal plans. Other proposed projects and initiatives, including university-led, private, and non-profit projects, as well as public projects which have not yet been approved for funding were collected through extensive web-searches and entered individually into a still-growing database. Proposed projects are mapped as new layers superimposed on our existing infrastructure map series. Appendix A2.8 contains a list of proposed and near-future New Mobility projects.

4.2 Data Collection Limitations, Gaps, and Next Steps

Through our data collection methods we have been able collect much of the spatial and relational data that has been identified in the general methodology and positioning of this project. The sources listed above have all proved valuable for assembling the range of actors that might be implicated in future industry clusters in the Southeast Michigan region, as well as being broad enough that they could serve other regional investigations. However our data collection methods have not been without their limitations and in this section, we review the challenges that were faced regarding the collection of data for this project, how these were addressed and possible next steps to address them. Generally the challenges around data collection can be categorized as those relating to scope, granularity, availability, and connectivity.

4.2.1 Scope

A primary challenge of this research effort is in approaching the fundamental question of how to accurately define the New Mobility economy or industry. Inherently, in the nature of New Mobility, it is a panoply of complimentary capacities that are likely to deliver solutions through cooperation rather than a single emerging industry type and further, entities likely to participate in and catalyze aspects of the cluster may not be self-aware of New Mobility opportunity space. The case studies revealed that rather than representing a specific industry sector cleanly delimited by an existing NAICS categorization, New Mobility assembles a diverse range or participants that cut across multiple NAICS categories, sometimes in surprising ways. The conceptualization of this is positioned in section 2.1.2 *Cluster Specialization*, but in terms of data collection, this opened up a significant and fundamental question: how do we identify all the industries that could be implicated in the provision of New Mobility products and services? What is the list of NAICS numbers that could be assembled around the field of New Mobility?

Additionally, New Mobility represents a new paradigm in conceiving of our relationship to transportation and mobility in relation to our everyday lives and current transportation related activities, services and options. In this respect New Mobility has the potential to touch all areas of economic and industry activity – from manufacturing of autonomous vehicles, to developing denser cities, to creating more efficient freight movements, to teleconferencing and so on. In this respect a case might be made that the initial list of 513 industries is too restrictive or does not capture all of the relevant categories. Through feedback from experts engaged in the area of New Mobility we have made efforts to ensure that this initial probe represents the current state of forward thinking on the implications of New Mobility on industry activity. As New Mobility evolves this initial list may become obsolete, but in its initial form it represents an attempt to identify a field of actors, at a specific moment in time, which may be mobilized around more sustainable transportation futures. In subsequent projects this static list will need to be revisited, interrogated and further refined, especially with respect to the speed at which disruptive technologies or systems enter the space. The speed of uptake and market penetration in both the sharing economy and wireless aggregator toolspace that paralleled the development of this project are potent examples of such disruption.

The use of NAICS numbers presented another challenge in this project. Given the broad net that they cast over companies, and the reliance on companies to self-report which NAICS numbers best represented their industry activity, a wholly accurate picture of the companies that are participating in a given industry might not be available. This is a limitation of this classification system generally. Specific companies might do an activity related to New Mobility 30% of the time, but identify themselves as part of the industry that makes up 70% of their activities may not be identified and captured in our data collection methods. Additionally, companies might misidentify their activities as being part of one industry while actually participating in another industry. Without going through each company and verifying they activity these outliers will appear in the visualizations. Because of the nature of the NAICS system and the number of firms within the datasets, at this time in this project, the challenge of entity validation is difficult to overcome. However, because this project is primarily concerned with the visualization of assets towards possible future clusters and representing industry activity and assets in a broad way, these challenges do not hinder the outcomes of this project. Once actors are assembled around a specific field of activity, and decision- and policy-makers have agreed upon a direction or directions for a cluster, a more thorough analysis of specific assets would be required.

4.2.2 Granularity

The data we have aggregated has been at the entity level. For example, we are able to identify that two companies exist in proximity to one another, that there exists a traded relationship, and that they share a common director on their boards. However, as previously stated, publicly available data does not exist at the intra-firm level. We have been unable to track employee movements, exchanges of insider knowledge, and other delicate relationships between companies which we know are important for innovation and cluster formation. In the case study of Saguenay, the Sotrem-Rio Tinto Alcan deal the acquisition of a former plant largely depended on the personal connections, employment history, and insider expertise of one individual. Similarly, though we can speculate on the importance of a large research university located in proximity to a large corporation, we have not been able to collect data on the number of university alumni who currently work at that company, specialized talent pipelines that exist, corporate influences on academic research activities, patent-sharing and other priority knowledge-sharing agreements, and so on. Additionally, data on social networks and the informal exchanges of knowledge so important for innovation, in places such as churches, social and athletic clubs, volunteer organizations, school organizations, alumni and professional associations, bars, and neighborhood block parties where people from different departments, organizations, and industries may interact, trade information, and create connections in unpredictable ways, has not been collected in this project but constitutes a data-space that may be critical to predictive analysis associated with cluster development. Given the type of publicly available or subscription-based data available to us, we have not been able to capture the full breadth of traded and untraded relationships between regional actors, nor the hidden capital, logistical, social, or otherwise intangible benefits which accrue in a cluster scenario. This challenge could be overcome through the use of surveys and data mining techniques, and could be explored in subsequent phases of work related to this project.

4.2.3 Availability

Limited availability of information has presented a number of challenges during this research project. First, our reliance on publicly available information has limited the types of insights we are able to produce, while precluding other lines of inquiry. For example, Federal regulations require that publicly-traded companies, public universities, non-profit organizations, and other tax-exempt entities publish regular reports of certain financial information. This information is generally easy to locate and can produce valuable insights—however, it does not address any of the issues raised in the previous section regarding intra-firm organizations or networks, nor is it readily or uniformly available for private companies and institutions. One instance where this becomes particularly apparent is in the relational mapping. Through the methods outlined in section 3.2.3, NAICS Industries and Unique Companies Dataset *w*e are able to reveal connections between two entities, however the data made available through FactSet does not quantify those relationships – all relationships are expressed equally while we know that not all traded or untraded relationships have the same strength or significance in the network. In many cases, the public disclosure of this type of information is not and is not subject to rules regulating its quality or veracity. In future phases of this project more detailed financial and relational data might be pursued for all entities, however, because it is not easily available through established databases, the absence of this data from our datasets has not negatively affected our visualization process; therefore, in this phase of the project we have chosen to forego its collection, assembly, and inclusion.

4.2.4 Dataset Connectivity

A fourth challenge faced during data collection is the limited connectivity between our datasets. Over the course of our research, we have created many separate datasets, each cataloging its own type or family of regional asset and each drawing from its own set of data sources. These datasets function well as stand-alone collections of information—the question is how we can get the individual datasets to "talk" across one another or have the ability to be cross-referenced. Since we lack a universal key or identification system for elements across all our datasets and also lack common metrics for comparison between different asset types, it is difficult to join or cross-reference all of our datasets. For example, industry relational data downloaded from the FactSet database uses the widely-accepted CUSIP number, or proprietary FactSet ID to identify individual entities; however company information downloaded from the OneSource database does not include an entities' CUSIP number, making it difficult to link our OneSource-derived industry dataset with our relational industry dataset. Additionally not all entities are able to be defined by unique identifiers such as CUSIP or FactSet ID. In the case of research institutions, American and Canadian universities report their research activity using different metrics, and to different degrees of detail; meanwhile, non-university research institutions do not report this information at all. Without standard data fields and consistent availability and granularity of data within those fields, we are limited in the types of analyses we can perform. These challenges ultimately lead to questions of how we can create effective geospatial visualizations which synthesize multiple, diverse datasets. Overlaying our geospatialized data is one simple but often useful strategy; however, future work will benefit from continued exploration of new methods of structuring, combining, and visualizing the complex body of information that has been assembled through this research project.

5.0 Stakeholder Input and Process Development

Stakeholder engagement during the development of this project was an iterative process and included soliciting stakeholder feedback as a way to assess our methods, provide input on the efficacy of a range of visualization techniques, and provide comment on the data which we assembled. Capitalizing on SMART's extensive networks within the region and beyond, we held meetings during different stages of the project with diverse group of actors representing sectors such as business, government, academics, NGOs and entrepreneurs. The purpose of these meetings was to gain feedback on how we were on developing visualization tools to identify, categorize, represent, and spatialize a region's physical and non-physical assets towards identifying nascent, emergent or possible New Mobility Cluster opportunities.

In the initial session *(SMART Steering Meeting, June 2013)* we looked for feedback on data collection and mapping techniques that we had explored through our historical precedents and through some preliminary case study work on the Great Lakes Megaregion. We were looking to assess the merits of the various mapping techniques as a means of assessing refinements, gaps, and opportunities in the New Mobility cluster. The discussions also helped determine and identify the industries and sectors that should be part of the New Mobility cluster in the Southeast Michigan region and could be a key player in providing new mobility solutions in the future. These involved thinking beyond the legacy industries and identify components that might be nascent in the region.

We incorporated feedback from the earlier session to develop the three case studies along with create additional visualizations for the Southeast Michigan region. The later stakeholder engagement session *(SMART Roundtable of New Mobility Industry, July 2014)* we not only looked for feedback on the visualization techniques that were employed to identify the relationships within the cluster case studies but to also determine how these products could be understood / utilized by expects with multiple disciplinary expertise in their work. We also wanted to identify additional ways in which we could assemble information within new database structures that could be useful for comparison with other sources, while recognizing gaps in information collection inherent to this research focus.

During the course of development, work in progress was also presented to the Michigan Economic Development Corporation to share our findings with them on the potential for New Mobility cluster in the region. The meeting aimed to identify collaboration and support opportunities to further develop the findings of the research to support MEDC's needs.

More recently the project was exhibited at a one-day conference cohosted by SMART and UMTRI

Automotive Futures called “New Mobility Trends: The Business Models That Are Growing a Trillion Dollar Industry Cluster”. The event took place on February 18, 2015 at the Michigan League in Ann Arbor, MI. The audience of over 120 attendees included representatives from automotive and IT, startup companies, as well as state and national government leaders who together discussed how new business models can enable new transportation priorities, and how new transportation priorities can serve local and regional industries and economies. A comprehensive list of the stakeholder group engaged through this project is contained in Appendix 1.

6.0 Mapping Possible Clusters: A Scenario Approach

In the previous sections we have discussed the ways in which our project methodology has been deployed to identify and visualize the isolated factors and actors which are implicated in clusters and cluster development, from firms, to IFCs, to workforce availability, to existing and near future infrastructures. However, we know that clusters are much more than the presence or not of specific components and that clusters are much more complex ecosystems, that while not all similar, require the presence of more or less similar components and actors in a complex interaction around a specialized field. In this section we explicitly describe how scenario thinking is utilized towards the visualization of potential industry clusters. The biggest challenge when developing the scenario is determining what forces will begin to set the parameters for its development. While we have documented and cataloged numerous actors, we are aware that not all actors will participate in a specific cluster to the same extent; a map of all regional actors that could participate in any given cluster might not be the most helpful tool, nor reveal anything about potential economic development options. Given that the cluster will not be a "cluster of all things", it is necessary to identify what the potential cluster specialization could be and then determine which actors might be implicated, which are present, where connections exist, and where, importantly, where there are gaps in the field of actors or connections. The primarily concern of this project is with determining where New Mobility industry clusters might exist, and, as such, this informs the basis for scenario development. Catalytic and near future New Mobility projects within the region act as the origin of our scenarios, pointing to a model of demand through which to stimulate economic cooperation and innovation, a possible specialized field which relies on multiple industries, as well as regional developments which support the underlying economic foundations, developing human and social capital in return. In this way, near future New Mobility projects are viewed not just as a way to catalyze clustering, but as well as a way to sustain future activity.

Selecting from a list of existing proposed New Mobility projects within the region, (see Appendix 2.8), we have developed three scenarios of cluster development around three specific projects for which to test cartographic visualizations. These scenarios are meant to be illustrative of the potential of visualization to regional economic decision-makers and policy writers of the multiple possible cluster directions that the region could take, and is not intended to point to a specific correct solution. Rather, if we accept the role of the catalytic project, these mappings show the available "resources" within the region that could be assembled towards a specific specialization as part of a broader economic development agenda. Given a specific choice, for example, the desire to create and invest in an advanced battery cluster, the combinatory mapping strategies developed in this project help to reveal where opportunities might exist and where gaps are, to apprehend the density and intensity of potential actors from industry, and as a toolkit to help inform policies or initiatives for further research and implementation. The catalytic projects that we have used to test our combinatory visualization techniques are 1) the development of regional arterial bus rapid transit, 2) the development of the Aerotropolis global logistics hub

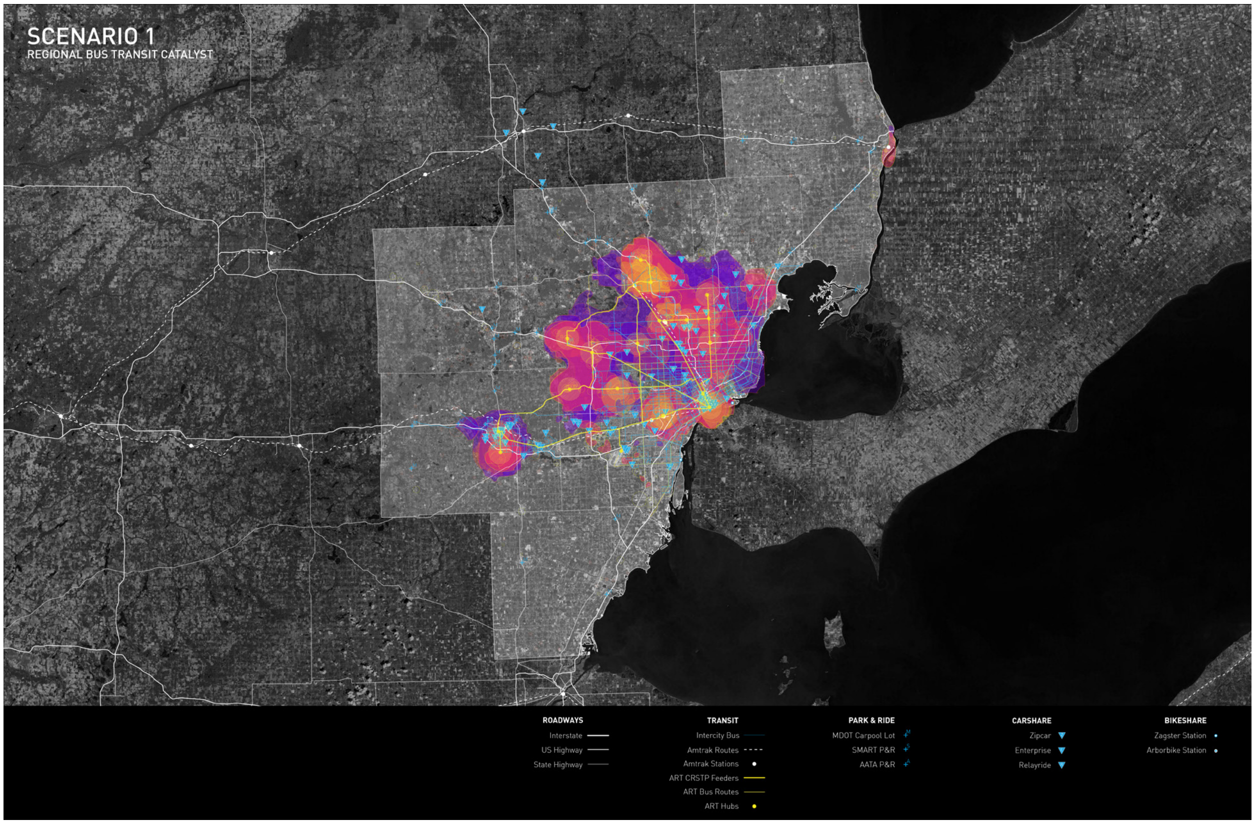

Figure 35: SCENARIO 1: SEM: Public Transit and Mobility as a Service Catalyst. Industry Actors and Supporting Actor concentrations (see Figure 36), combined with existing and proposed infrastructures and spatial interventions associated with ART network development and collatoral mobility assets as a field of potential engagement. (Note: each element is separable by layer and shown in aggregation here)

and 3) the development of intelligent transportation systems in Southeast Michigan.

6.1 Scenario 1: Public Transit and Mobility as a Service Catalyst

The Regional Transit Authority (RTA) of Southeast Michigan and SEMCOG have proposed the development of an arterial bus rapid transit (ART) network for the Detroit metropolitan area by 2040. This public transit development could be a catalyst for forming new ties between the region's automotive manufacturing sector, construction sector, high-tech and software development sector, and real estate development sector. This could engender various Mobility as a Service (MaaS) ventures. Where the specific innovation space is within the provision of ART systems is unknown, but within its operational paradigm there are at least three domains around which a cluster could form; 1) innovation and manufacturing of new rolling stock, 2) the development of new smarting sensing, telematics, and applications related to smart mobility and 3) development of new planning expertise and construction technologies.

The development and provision of new rolling stock technologies is the most obvious given Southeast Michigan's legacy of vehicle manufacturing. Leveraging the development of regional ART to form a cluster around the production of new ART systems would play directly into the region's traditional strengths. The development of new ART rolling stock could also leverage regional assets in clean drivetrain technologies and could strengthen the region's advanced batteries and alternative fuel sectors. This is the easiest potential cluster to imagine – a rapid transit cluster. However, ART systems, much like bicycle share systems as discussed in the example of BIXI, are increasing integrating technology and involve much more than the manufacturing of vehicles. As such, ART also has the potential to catalyze players from other emerging regional industries, especially in high-tech fields such as smart sensing systems and telematics, big data processing, and application development and user interaction design, which could operate as a standalone cluster or be integrated into a rapid transit manufacturing oriented cluster to deliver an entire systemic approach – this is the second cluster which could be catalyzed. Because ART buses primarily operate in busy, mixed traffic and rely heavily on smart systems to control traffic signals, there is a great need for highly-developed electronics, sensing devices, telematics, and smart systems software. Southeast Michigan's research universities and automotive R&D departments are already investing heavily in these areas, but deployment of this research for a regional-scale public system might reinforce, realign, and reorient academic-industry partnerships. Transit systems also drive demand for user-focused applications and services: mobile applications for bus tracking and route planning that make intermodal travel easier and more efficient to navigate, smart passes and other integrated payment systems that streamline and simplify payment, dynamic routing applications that shift bus routes in response to localized passenger demand, and other data-driven applications that reduce transit barriers and enrich passengers' riding experience. Many venture-capital funded startups, university spin-offs, and civic data nonprofits are already contributing to vibrant information and technology clusters in Detroit and Ann Arbor and the development of an ART system might act as a catalyst to further their development or evolve their composition. Finally, the development of ART routes also requires roadway and other infrastructure construction, station design and construction, and other construction-related work, which could be used as an impetus to develop a service and development based cluster. When ART routes incorporate fixed stations rather than simple shelters, there are many opportunities for multimodal integration, especially with last-mile systems such as bicycle sharing or ride sharing. These stations could also incorporate housing, civic services, local businesses and retailers—perhaps in conjunction with an integrated fare payment system—as well as designed public spaces, turning transit nodes into social and commercial hubs. The development of ART in Southeast Michigan would require all of these services and might present and opportunity to initiate a cluster around the planning, construction, and development of ART and adjacent opportunities, in the same way that expertise and specialized industries in the Netherlands are sought out worldwide for their expertise in water management and the design and construction of dike and tidal infrastructures.

Importantly, the development of ART not only has the potential to bring actors together around a common product towards the development of a regional specialization and industry cluster, but it develops a regional infrastructure which can contribute to the strengthening of the regional's economic foundations, through, for example, the improvement of quality of life and an increase in job accessibility, making the regional more attract to high quality personnel (HQP) outside of the region and potential contributing to retaining HQP in the future. ART also has the possibility of bringing people into contact with one another in informal way and connecting them to the places they want to get to, for example churches, sports arenas, cafés, etc., which is one of the soft benefits of clustering. Therefore, catalytic projects such as ART in Southeast Michigan not only is an industry specialization and specific

Industry actors (ART Systems Manufacturing):
326 Plastics and Rubber Products Mfg [316 companies]
331, 332 Metal Mfg [2,078 companies]
333 Machinery Mfg [1,267 companies]
334 Computer and Electronic Product Mfg [366 companies]
335 Electrical Equipment, Appliance, and Component Mfg [166 companies]
336 Transportation Equipment Mfg [520 companies]
423 Merchant Wholesalers (4231 Vehicle and Parts Wholesale) [597 companies]
485 Transit and Ground Passenger Transport (4851 Urban Transit Systems) [539 companies]
511210 Software Publishers [29 companies]
518 Data Processing, Hosting, and Related Services [372 companies]
531 Real Estate [6,706 companies]
811 Repair and Maintenance (8111 Automotive Repair) [4,311 companies]

Industry actors (Planning and Development):
236 Construction of Buildings [4,405 companies]
237 Heavy and Civil Engineering Construction [998 companies]
238 Specialty Trade Contractors [7,008 companies]
324 Petroleum and Coal Products Mfg (324121 Asphalt, 324191 Lubricants) [31 companies]
325 Chemical Mfg (3252 Plastics and Synthetics, 325510 Paint and Coating Mfg) [68 companies]
541 Professional, Scientific, Technical Services
(5413 Arch/Eng, 5414 Special Design Services, 5415 Computer Systems, 5416 Consulting Svcs) [7,029 companies]

Supporting actors:
221 Utilities (2211 Power Generation, 2212 Power Distribution) [229 companies]
923, 924, 925, 926 Government Administration [412 entities]
Federal and state- funding (DOT, FTA, FHWA, MDOT)
Regional/Municipal - organization (SEMCOG, RTA, Counties, Cities)
Transit authorities – operation (DDOT, SMART, AATA)
Industry - investment (legacy companies, transportation mfg sectors)
Venture capital – investment (supporting independent R&D, tech development)
Research institutions – R&D (providing planning analysis, technology development, etc)
Tech companies – developing support apps, devices
Local business – support (retail and office along routes)
Real estate – development (new TOD, land acquisition)
Universities – research

Figure 36: NAICS Actors and Supporting Actors implcated by the SEM Public Transit Catalyst Scenario and embodied in the mapping process.

demand to which firms can respond, but it could also produce larger benefits for the entire region and strengthen the

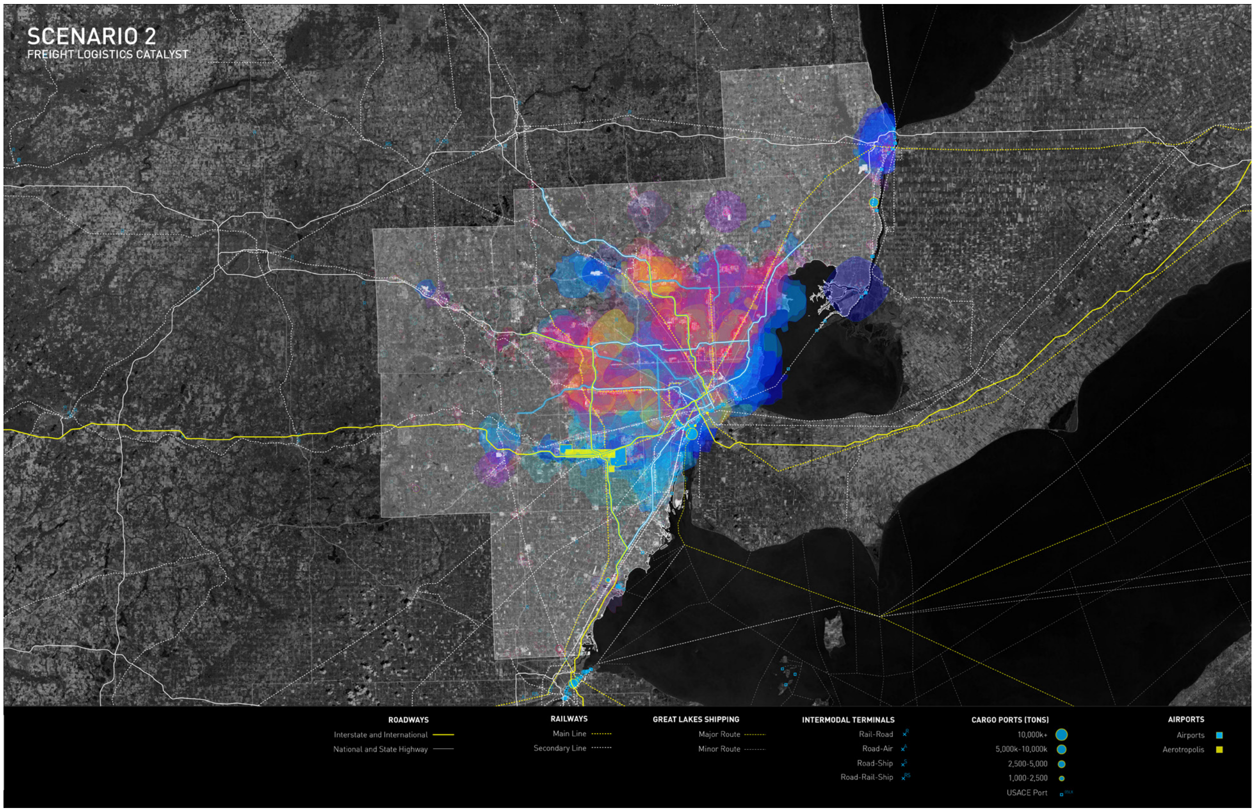

Figure 37: SCENARIO 2: SEM Freight Logistics Catalyst: Industry Actors and Supporting Actor concentrations (see Figure 38), combined with existing and proposed infrastructures and spatial interventions associated with advanced logistics initiatives and the Aerotropolis project as a field of potential engagement. (Note: each element is separable by layer and shown in aggregation here)

cluster initiative around ART – a positive feedback of industry growth, economic and regional development.

6.2 Scenario 2: Freight Logistics Catalyst

The Wayne County Economic Development Growth Engine (EDGE) has recently begun to develop the VantagePort Detroit Region Aerotropolis, a special business and trade zone centered at DTW and YIP airports. A well-developed global logistics hub at this location, as promoted by the Detroit Regional Chamber, would leverage Southeast Michigan's transportation infrastructure assets and has the potential to catalyze new partnerships between the manufacturing, transportation services, and information sectors, as well as state and local governments and regional planning authorities. The creation of a cluster centered on advanced logistics could draw together regional stakeholders in the primary sector, the secondary sector, wholesale, and retail, all who would stand to benefit from more efficient, higher volume flows of goods and materials in and out of the region, as well as developing services or products for other regions globally. The development of these systems locally, as well as globally, would require advanced logistics services such as smart fleet and container tracking, automated transfer management systems, and remote repositioning systems; automotive manufacturers like Ford are already engaged in collaborative R&D projects with universities and companies in the computer and software industries to develop these innovative systems. Southeast Michigan's universities could also play an important role in developing a logistics based cluster. The University of Michigan is a leader in technology, transportation and vehicle research, while Michigan State University boasts a top-ranked program in supply chain management and logistics—these and other institutions in the area could be leveraged towards producing innovation in freight mobility systems. A project such as Aerotropolis not only provides an opportunity to develop a cluster around innovative freight-mobility products and services, but also creates a centrally-located logistics hub for Southeast Michigan—located not only at a confluence of regional freight infrastructure, but also served by a major international air terminal and potentially by light, commuter, and high-speed rail lines—which could also serve as a potential forum for

Industry Actors:
236, 237, 238 Construction and Civil Engineering
3 All Manufacturing
48 All Transportation Services
49 Transportation & Warehousing
511210 Software Publishers
518 Data Processing, Hosting, and Related Services
522 International Trade Financing
541 Professional, Scientific, Technical Services (5413 Arch/Eng, 5414 Special Design Services
5415 Computer Systems, 5416 Consulting Svcs)
541614 Process, Physical Distribution and Logistics Consulting
926 Administration of Economic Programs
928 National Security and International Affairs

Supporting Actors:
531 Real Estate
International, Federal – political support (DOC, Canada DFAIT)
Federal, State – funding support (DOT, FHWA, FRA, MDOT)
State, Provincial – political, financial support (MEDC, MDOT, Ontario MOI)
Regional Authorities (FTA, Wayne County Airport Commission)
State, counties, and municipalities (business incentives, tax breaks, free trade zones)
Private transportation/logistics carriers (freight rail, air and trucking companies)
Regional industry and trading (all)
Real Estate – development
Universities – R&D

Figure 38: NAICS Actors and Supporting Actors implcated by the SEM Freight Logistics Catalyst Scenario and embodied in the mapping process.

networking, exchange, and collaboration between local and global industry and institutional partners strengthening

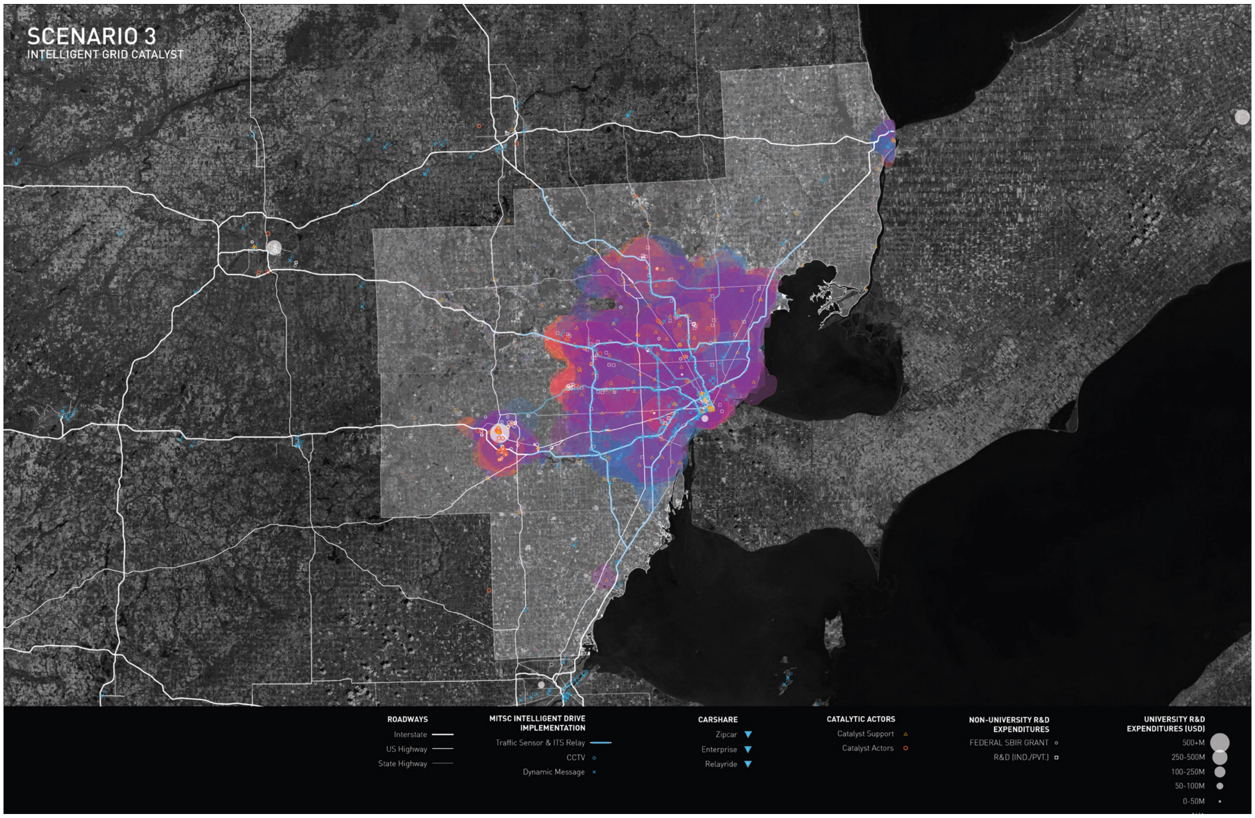

Figure 39: SCENARIO 3: SEM Intelligent Grid Catalyst: Industry Actors and Supporting Actor concentrations (see Figure 38), combined with existing and proposed infrastructures and spatial interventions associated with advanced logistics initiatives and the Aerotropolis project as a field of potential engagement. (Note: each element is separable by layer and shown in aggregation here)

the cluster as a whole.

6.3 Scenario 3: Intelligent Grid Catalyst

MDOT and SEMCOG are currently working toward the widespread implementation of intelligent transportation systems (ITS) technology across Southeast Michigan transportation networks. Designing and integrating ITS elements into transportation infrastructure, vehicles, consumer devices and services, and information platforms is an endeavor that would require close collaboration from a wide variety of stakeholders, including authorities at all levels in transportation, planning, and public safety and health; manufacturers of vehicles, computers, and other electronics; transit service providers, alternative mobility services, and commercial vehicle operators; information architects, programmers and computer scientists, and developers of applications and software; and many others. Many of MDOT's immediate goals for ITS implementation involve improving the safety and efficiency of highways, in areas including traffic flow, emergency response, work zone management, and data collection. Future applications include connected and autonomous vehicles, flexible routing systems and automatic payment for transit, and intelligent signal controls for emergency, commercial, and transit vehicles. In addition to updates to fixed infrastructure, new vehicles, devices, software, and data management systems must also be designed to incorporate ITS elements. Auto manufacturers, tech companies, and research universities are already investing heavily and collaborating on connected vehicles and autonomous vehicle development. Public transportation providers, bicycle share services, ride share services, and delivery services could also participate in ITS development and implementation in order to enable next-generation mobility systems. While the MDOT project specifically focuses on transportation information and automated vehicles, the types of sensor that are being proposed could be implicated in a much larger field of data collection. Recent initiatives at the University of Michigan including the Mobility Transformation Center (MTC) http://www.mtc.umich.edu/, have begun to aggregate a range of private and non-private industry partners around AV-related test facilities and the Data Science Initiative (DSI) http://midas.umich.edu/dsi/ has similarly been established to mobilize capacity, infrastructure and research related to bigdata science efforts that would align with such initiatives.

Looking at Chicago's Array of Things (AoT) project suggests what a slight expansion of MDOT's ITS project beyond transportation could look like. The AoT project envisions a citywide grid of environmental sensors producing real-time, open-source data on city environmental quality, vehicle traffic, and pedestrian traffic, which would be useful for groups involved in urban planning, public health and safety, environmental science, information and big data, as well as entrepreneurs. The AoT project is an ambitious collaboration between the University of Chicago, Argonne National Laboratory, and the City of Chicago, along with designers and researchers from other American universities and tech industry partners including Microsoft, Intel, Cisco, and Motorola. Finally, software and application developers will play a crucial role in making all of the information collected by ITS and AoT accessible and helpful to the general public. Conceptualizing MDOT's ITS project in this way, as a broader telematics project, reveals new opportunities of industry participation that might not otherwise be included, and points to the possibility of leveraging this ITS project towards the promotion of growth in the telematics space and the development of a telematics cluster in Southeast Michigan.

Industry Actors:
333314 Optical Instrument and Lens Manufacturing
334 Computer and Electronic Product Manufacturing
335 Electrical Equipment, Appliance, and Components Manufacturing
336 Transportation Equipment Manufacturing
484 Truck Transportation
485 Transit and Ground Passenger Transportation
488 Support Activities for Transportation
49 Delivery and Warehousing Services
511210 Software Publishers
517 Telecommunications
518 Data Processing, Hosting, and Related Services
5321 Vehicle Rental and Leasing Services
5415 Computer Systems Design and Related Services
541614 Process, Physical Distribution, and Logistics Consulting
5417 Research and Development
722330 Mobile Food Services
92 Public Administration

Supporting Actors:
Federal, State transportation agencies – funding and implementation (DOT, MDOT)
County and City governments – implementation, operation
Regional planning and transit – R&D, implementation, operation (SEMCOG, RTA, DDOT, SMART, AATA)
Universities – research
Private enterprise

Figure 40: NAICS Actors and Supporting Actors implcated by the SEM Intelligent Grid Catalyst Scenario and embodied in the mapping process.

7.0 Conclusions and Recommendations

This research project sought to develop visualization methods that could be supportive of the apprehension and development of economic development and industry clusters associated with the emergence of New Mobility solutions. In approaching this question, the team has examined literature regarding economic theory and the formation of cluster economies, and developed visualization tools that support the apprehension of related factors within regions. Several geospatial, time related and relational visualization techniques have been developed and reviewed with stakeholder participants to assess their relative efficacy. The project has also developed through these visualizations efforts at data aggregation across a wide range of sources to support the data-driven assembly of their content. While early efforts to develop these cartographies were undertaken through historical case study analysis of New Mobility-related clusters within the Great Lakes Region, specific representations have been developed through novel data aggregation to examine available data and information for Southeast Michigan. Scenario Planning techniques were utilized to test the limits to data sources, geospatial mapping techniques and assess the range of elements and ingredients assembled within individual cartographies. A central aim of the project was, through this research and speculative design-research based project, to develop an approach and model for a visualization toolkit that could be utilized by a range of disciplinary experts, industry representatives, policy experts and thought leaders that could support the development of a New Mobility economic cluster in Southeast Michigan.

Through the stakeholder consultation process, several issues were identified in light of both the case study research of historic cluster formations, and in the evaluation of and engagement with visualization produced that constitute a set of concluding points that we will present here – some of which point to mechanisms through which the efforts of this project might be refined through future development, others which point to challenges faced by projects such as this which attempt to visualize systems that are inherently in-formation, and others that point to challenges within the domains of data availability, accuracy and interactivity.

- As the phenomena of economic clustering is inherently related to issues of colocation, and related to several core factors that are explicitly geospatial including economic foundations, extant regional assets and emerging regional assets, geospatialization through cartographic visualization of a range of these issues can enable new apprehension of the regional context for economic development in this realm.

- Culturally there is a high degree of cartographic literacy across the capacity sets of many individuals, hence the most familiar types of mapping (geospatial) undertaken within this project were those most easily understood and interpreted across stakeholder participants. In order to be effective, broad legibility is important to facilitate discussion and decision-making across groups of multi-disciplinary composition.

- Existing traded relationships across firms within the economic sectors comprising a cluster constitute an important characteristic in describing the underlying economic conditions that indicate potential cluster strength. In defining these traded relationships significant challenges exist in assembling detailed, complete and interchangeable data to enable the production of meaningful visualizations of economic exchange and are limited to existing available data sources. Soliciting more robust reporting of relations between regional actors through entities such as IFCs or in partnership with firms associated with the emerging cluster could assist with overcoming this challenge.

- Multiple factors associated with the emergence of economic clusters are tied to untraded relationships between key actors within the opportunity space defining sector activity. Tools for visualization of the social networks that surround these contexts exist, however, a key challenge is to identify available datasets that would enable the building of such models. While increasingly, the phenomena of social media platforms and self-reporting of such relationships is becoming available, further work is required to assemble, parse, analyze and visually report these interactions in order to inform geospatial and traded dimensions of cluster mapping.

- The geospatial mapping practices developed through this project rely on data assemblage, geocoding through GIS based software platforms and post-processing in graphic design software packages in order to produce static maps (images) that represent the assembled data in a particular graphical format for a specific moment in time (data specific). New modes of mapping that sit on top of dynamic, open online large scale geospatial platforms (such as Google Earth), and that are driven by self-reported sourcing of the database content have the potential to disrupt the limitations of the static map, and address aspects of data availability – especially for emergent system participants. Such platforms constitute an import next-generation format for work of the kind undertaken in this project.

- In both economic cluster theory and case studies, the central role of Institutions for Collaboration (IFCs) in aggregating membership, producing awareness and facilitating cluster development are of great importance and often constitute a central catalyst in cluster formation and development over time. For regions aiming to foster specific clusters, and in the case of current interest in the New Mobility Economy within Southeast Michigan, the presence of such an entity or entities is important. An IFC focused on questions of the New Mobility economy could undertake key activities related to aggregating membership, promoting catalytic projects and connecting membership across sectors. This role is all the more important due to the wide range of often disconnected industry sectors that are implicated in many New Mobility projects regardless of scale.

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Appendix 1: Stakeholder Group

LAST NAME	FIRST NAME	COMPANY
Strother	Ansgar	A2B Bikeshare
Michaels	Larry	Argonne National Lab
Thompson	Maria	Arsenal Venture Partners
Bond	Vince	Automotive News
Snyder	Jesse	Automotive News
Zerilli	Ursula	Automotive News TV
Flanagan	Lauren	BELLE Capital USA
Doherty	Patrick	Case Western Reserve University
Nichols	Sue	Center for Systems Integration and Sustainability
Schondorf	Kristin	Chrysler
Clothier	Corey	Comet
Wang	Lei	Continental
Xue	Feng	Denso International America
Szczesny	Joseph	Detroit Bureau
Dorle	Chris	Detroit Future City
Earley	Matthew	Detroit Future City
Pfeiffer	Michael	Eaton
Dasgupta	Priya	Enterprise for a Sustainable World/Emergent Institute
Parikh	Jay	Escort Electronics
Lowell	Dana	Faurecia
Assmuth	Rolf	FCA
Shamoun	Christopher	FEV North America
Thomas	Chris	Fontinalis
Athavale	Shounak	Ford Motor Company
Berdish	David	Ford Motor Company
Coiffard	Gerard	Ford Motor Company
Coleman	Jon	Ford Motor Company
Dunn	Gregg	Ford Motor Company
Faber	Jeffrey	Ford Motor Company
Fu	Yan	Ford Motor Company
Jung	Jae Young	Ford Motor Company
Kotila	Peter	Ford Motor Company
Marsman	Eric	Ford Motor Company
Skehan	Amy	Ford Motor Company
Tolliver	Vaughan	Ford Motor Company
Walker	Jacqueline	Ford Motor Company
Wingfield	Eric	Ford Motor Company
Xie	Qianyan	Ford Motor Company
Yanakiev	Diana	Ford Motor Company
Naamani	Udi	Ford Motor Credit Company

LAST NAME	FIRST NAME	COMPANY
Bigelow	Lauren	GCN
Plazas	Alejandro	General Motors
Reaume	Daniel	General Motors
Stauffer	Louise	General Motors
Tiderington	Robert	General Motors
Xi	Josh (Xiaomin)	General Motors
Gupta	Rajiv	General Motors
LeFave	Yvonne	Go Green Trikes
Callewaert	John	Graham Sustainability Institute, University of Michigan
McAmmond	Matt	Hella
Miller	James	Hewlett Packard
Robb	John	Hyundai Motor Group
Chesbrough	Charles	IHS Automotive
Gott	Philip	IHS Automotive
Kapoor	Amit	Indian Institute for Competitiveness
Wilson	Steven	Institute for Research on Labor, Employment & the Economy
Bin-Nun	Amitai	KPMG LLP/Harvard University
Hsu	Jamie	Lawrence Tech University
Chao	Marcus	LEC
Claes	Kim	Magna International
Kang	Namwoo	Mechanical Engineering, University of Michigan
Abunasser	Nadia	MEDC
Shreffler	Eric	MEDC
Sorrell	Paula	MEDC
Zator	Roselyn	MEDC
Fiskars	Scot	MELCO
Keane	James	Meritor, Inc.
Norkin	Ody	Michigan Flyer
Grossman	Dave	Michigan Small Business Development Center
Gonsaly	David	MIT-ZLC
Monroe	Savita	Mobile Technology Association of Michigan
Krease	Kevin	Model D Media
Gearhard	Chris	National Renewable Energy Laboratory
Johnson	Tim	NextEnergy
Kuzon	Aniela	NextEnergy
Redfield	Jean	NextEnergy
Dsouza	Clive	OHIOE
Clark	Michael	Oracle
Titsworth	Rick	Oracle
Long	Paul	PLP
Borroni-Bird	Christopher	Qualcomm
Polk	Robert	RCP&A
Lienert	Paul	Reuters

LAST NAME	FIRST NAME	COMPANY
Padalkar	Aneesh	Ricardo Strategic Consulting
Shi	John	SAIC USA Inc.
Hannah	Jeffrey	SBD
Hazel	George	Scottish Smart Mobility
Severance	Dennis	Steven M Ross School of Business
Scott	Peter	Syracuse University
Crossley	Diana	Tauber Institute
Krisher	Tom	The Associated Press
Mochida	Kazuhiko	Toyota Motor Engineering
Laberteaux	Ken	Toyota Research Institute - NA
Hamza	Karim	TRI-NA
Hunscher	Helaine	U-M Center for Sustainable Systems
Hula	Aaron	U.S. Environmental Protection Agency
Tull de Salis	Rupert	UM CoC
Adriaens	Peter	UM Ross School of Business
Azgaldov	Pavel	UM Ross School of Business
Bartlett	Marvin	UM Ross School of Business
Fishelson	James	UM Taubman School of Architecture and Urban Planning
Kelbaugh	Doug	UM Taubman School of Architecture and Urban Planning
Thün	Geoff	UM Taubman School of Architecture and Urban Planning
Velikov	Kathy	UM Taubman School of Architecture and Urban Planning
Anand	Komal	UM-SMART
Chock	David	UM-SMART
Lu	George	UM-SMART
Mason	DJ	UM-SMART
Wu	Mengdi	UM-SMART
Zielinski	Sue	UM-SMART
Belzowski	Bruce	UMTRI
Fancher	Paul	UMTRI
Machiele	Michelle	UMTRI
Romine	Francine	UMTRI
Ueki	Ryuji	UMTRI
Weimerskirch	Andre	UMTRI
Maddox	John	UMTRI/TTI
Yang	Diange	Unversity of Michigan Dept. of Mechanical Engineering
Zellner (phone)	Moira	University of Illinois at Chicago
Assanis	Dimitris	University of Michigan
Bayrak	Alparslan Emrah	University of Michigan
Beimel	Ted	University of Michigan
Brisbin	Dwight	University of Michigan
Burton	Andrew	University of Michigan
Cai	Hua	University of Michigan
Chen	Shiyang	University of Michigan

LAST NAME	FIRST NAME	COMPANY
Currence	Greg	University of Michigan
De Kleine	Robert	University of Michigan
Ellis	Jay	University of Michigan
Hoard	John	University of Michigan
Li	Tianao	University of Michigan
Luo	Qui	University of Michigan
Molnar	Lawrence	University of Michigan
Patel	Umesh	University of Michigan
Qu	Zhi	University of Michigan
Raichur	Vineet	University of Michigan
Salmeen	Irv	University of Michigan
Senter	Richard	University of Michigan
Serratos	Gustavo	University of Michigan
Simon	Carl	University of Michigan
Vanzieleghem	Bruno	University of Michigan
Zhao	Ding	University of Michigan
Zhuang	Weichao	University of Michigan
Bacyinski	Eric	University of Michigan -Dearborn
Morton	Carrie	University of Michigan - MTC
Cristiano	John	University of Michigan -Dearborn
Mi	Chris	University of Michigan - Dearborn
Marx	Roberto	University of Sao Paulo
Duggan	Kerry	US Department of Energy
VanGessel	Ben	US EPA
Morris	Paul	Visteon
Batteau	Allen	Wayne State University
Martin	Liz	Zip Express
Robinson	Jessica	ZipCar

Appendix 2: Comprehensive List of Data Sources

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Appendix 3: Comprehensive List of NAICS Codes Identified and Utilized

[BLD] BUILDING

236///	**CONSTRUCTION OF BUILDINGS**
2361//	**RESIDENTIAL BUILDING CONSTRUCTION**
236210	Industrial Building Construction
236220	Commercial and Institutional Building Construction

237///	**HEAVY AND CIVIL ENGINEERING CONSTRUCTION**
237110	Water and Sewer Line and Related Structures Construction
237120	Oil and Gas Pipeline and Related Structures Construction
237130	Power and Communication Line and Related Structures Construction
237210	Land Subdivision
237310	Highway, Street, and Bridge Construction
237990	Other Heavy and Civil Engineering Construction

238///	**SPECIALTY TRADE CONTRACTORS**

321///	**WOOD PRODUCT MANUFACTURING**

3273//	**CEMENT AND CONCRETE PRODUCT MANUFACTURING**
327310	Cement Manufacturing
327320	Ready-Mix Concrete Manufacturing
327331	Concrete Block and Brick Manufacturing
327332	Concrete Pipe Manufacturing
327390	Other Concrete Product Manufacturing

3312//	**STEEL PRODUCT MANUFACTURING***

3323//	**ARCHITECTURAL AND STRUCTURAL METALS MANUFACTURING***

5413//	**ARCHITECTURAL, ENGINEERING, AND RELATED SERVICES**
541310	Architectural Services
541320	Landscape Architectural Services
541330	Engineering Services
541340	Drafting Services
541350	Building Inspection Services
541360	Geophyical Surveying and Mapping Services
541370	Surveying and Mapping (except Geophysical) Services
541380	Testing Laboratories

[BUS] BUSINESS SUPPORT

5416//	**MANAGEMENT, SCIENTIFIC, AND TECHNICAL CONSULTING**
541611	Administrative Management and General Management Consulting
541612	Human Resources Consulting Services
541613	Marketing Consulting Services
541614	Process, Physical Distribution, and Logistics Consulting Services
541618	Other Management Consulting Services
541620	Environmental Consulting Services
541690	Other Scientific and Technical Consulting Services

5417//	**RESEARCH AND DEVELOPMENT SERVICES**
541711	R & D in Biotechnology
541712	R & D in the Physical, Engineering, and Life Sciences
541713	R & D in the Social Sciences and Humanities

5418//	**ADVERTISING, PUBLIC RELATIONS, AND RELATED SERVICES**

541910	Marketing Research and Public Opinion Polling

551///	**MANAGEMENT OF COMPANIES AND ENTERPRISES**

561///	**ADMINISTRATIVE AND SUPPORT SERVICES**

[FIN] FINANCE

522///	**CREDIT INTERMEDIATION AND RELATED ACTIVITIES**
522110	Commercial Banking
522120	Saving Institutions
522130	Credit Unions
522190	Other Depository Credit Intermediation
522210	Credit Card Issuing
522220	Sales Financing
522291	Consumer Lending
522292	Real Estate Credit
522293	International Trade Financing
522298	All Other Nondepository Intermediation
522310	Mortgage and Nonmortgage Loan Brokers
522320	Financial Transactions Processing, Reserve, and Clearinghouse
522390	Other Activities Related to Credit Intermediation

5239//	**OTHER FINANCIAL INVESTMENT ACTIVITIES**
523910	Miscellaneous Intermediation
523991	Trust, Fiduciary, and Custody Activities
523999	Miscellaneous Financial Investment Activities

[ITS] INFORMATION & TECHNOLOGY

334///	**COMPUTER AND ELECTRONIC PRODUCT MANUFACTURING**
3341//	Computer and Peripheral Equipment Manufacturing
3342//	Communications Equipment Manufacturing
3343//	Audio and Video Equipment Manufacturing
3344//	Semiconductor and Other Electronic Equipment Manufacturing
3345//	Navigation, Measuring, Electromedical, and Control Instruments Mfg
3346//	Manufacturing and Reproducing Magnetic and Optical Media

335///	ELECTRICAL EQUIPMENT, APPLIANCE, AND COMPONENT MFG
3353//	Electrical Equipment Manufacturing
33591/	Battery Manufacturing
33592/	Communication and Energy Wire and Cable Manufacturing
33593/	Wiring Device Manufacturing
33599/	All Other Electrical Equipment and Component Manufacturing

511///	PUBLISHING INDUSTRIES (EXCEPT INTERNET)
511210	Software Publishers

515///	BROADCASTING (EXCEPT INTERNET)

517///	TELECOMMUNICATIONS

518///	DATA PROCESSING, HOSTING, AND RELATED SERVICES

519///	OTHER INFORMATION SERVICES

5415//	COMPUTER SYSTEMS DESIGN AND RELATED SERVICES
541511	Custom Computer Programming Services
541512	Computer Systems Design Services
541519	Other Computer Related Services

[MFG1] PRIMARY MANUFACTURE

313///	TEXTILE MILLS
3131//	Fiber, Yarn, and Thread Mills
3132//	Fabric Mills
3133//	Textile and Fabric Finishing and Fabric Coating Mills

314///	TEXTILE PRODUCT MILLS
3141//	Textile Furnishing Mills
3149//	Other Textile Product Mills

324///	PETROLEUM AND COAL PRODUCTS MANUFACTURING

325///	CHEMICAL MANUFACTURING
3251//	Basic Chemical Manufacturing
3252//	Resin, Synthetic Rubber, and Artificial Syntehtic Fibers and Filaments
3255//	Paint, Coating, and Adhesive Manufacturing
3259//	Other Chemical Product and Preparation Manufacturing

327///	NONMETALLIC MINERAL PRODUCT MANUFACTURING
3271//	Clay Product and Refractory Manufacturing
3272//	Glass and Glass Product Manufacturing
3273//	Cement and Concrete Product Manufacturing
3274//	Lime and Gypsum Product Manufacturing
3279//	Other Nonmetallic Minteral Product Manufacturing

331///	PRIMARY METAL MANUFACTURING
3311//	Iron and Steel Mills and Ferroalloy Manufacturing
3312//	Steel Product Manufacturing from Purchased Materials
3313//	Alumina and Aluminum Production and Processing
3314//	Nonferrous Metal (Except Aluminum) Production and Processing
3315//	Foundries

[MFG2] SECONDARY MANUFACTURE

332///	FABRICATED METAL PRODUCT MANUFACTURING
3321//	Forging and Stamping
3322//	Cutlery and Handtool Manufacturing
3323//	Architectural and Structural Metals Manufacturing
3324//	Boiler, Tank, and Shipping Container Manufacturing
332510	Hardware Manufacturing
3326//	Spring and Wire Product Manufacturing
3327//	Machine Shops; Turning Product; and Screw, Nut, and Bolt Mfg
3328//	Coating, Engraving, Heat Treating, and Allied Activities
3329//	Other Fabricated Metal Product Manufacturing

333///	MACHINERY MANUFACTURING
3331//	Agriculture, Construction, and Mining Machinery Manufacturing
3332//	Industrial Machinery Manufacturing
3333//	Commercial and Service Industry Machinery Manufacturing
3334//	Ventilation, Heating, Air-conditioning, and Commerical Refridgeration
3335//	Metalworking Machinery Manufacturing
3336//	Engine, Turbine, and Power Transmissions Equipment Manufacturing
3337//	Other General Purpose Machinery Manufacturing

334///	COMPUTER AND ELECTRONIC PRODUCT MANUFACTURING*

335///	ELECTRICAL EQUIPMENT, APPLIANCE, AND COMPONENTS MFG*

336///	TRANSPORTATION EQUIPMENT MANUFACTURING
3361//	Motor Vehicle Manufacturing
3362//	Motor Vehicle Body and Trailer Manufacturing
3363//	Motor Vehicle Parts Manufacturing
3364//	Aerospace Product and Parts Manufacturing
3365//	Railroad Rolling Stock Manufacturing
3366//	Ship and Boat Building
3369//	Other Transporation Equipment Manufacturing

[NRG] ENERGY

221///	UTILITIES
221111	Hydroelectricity Power Generation
221118	Other Electric Power Generation
221121	Electric Bulk Power Transmission and Control
221122	Electric Power Distribution
221210	Natural Gas Distribution

[REL] REAL ESTATE

531///	REAL ESTATE
531110	Lessors of Residential Buildings and Dwellings
531120	Lessors of Nonresidential Buildings (except Miniwarehouses)
531130	Lessors of Miniwarehouses and Self-Storage Units
531190	Lessors of Other Real Estate Property
531210	Offices of Real Estate Agents and Brokers
531311	Residential Property Managers
531312	Nonresidential Property Managers
531320	Offices of Real Estate Appraisers
531390	Other Activities Related to Real Estate

[TRN] TRANSPORTATION

481///	AIR TRANSPORATION
4811//	Scheduled Air Transportation
4812//	Nonscheduled Air Transportation

482///	RAIL TRANSPORTATION

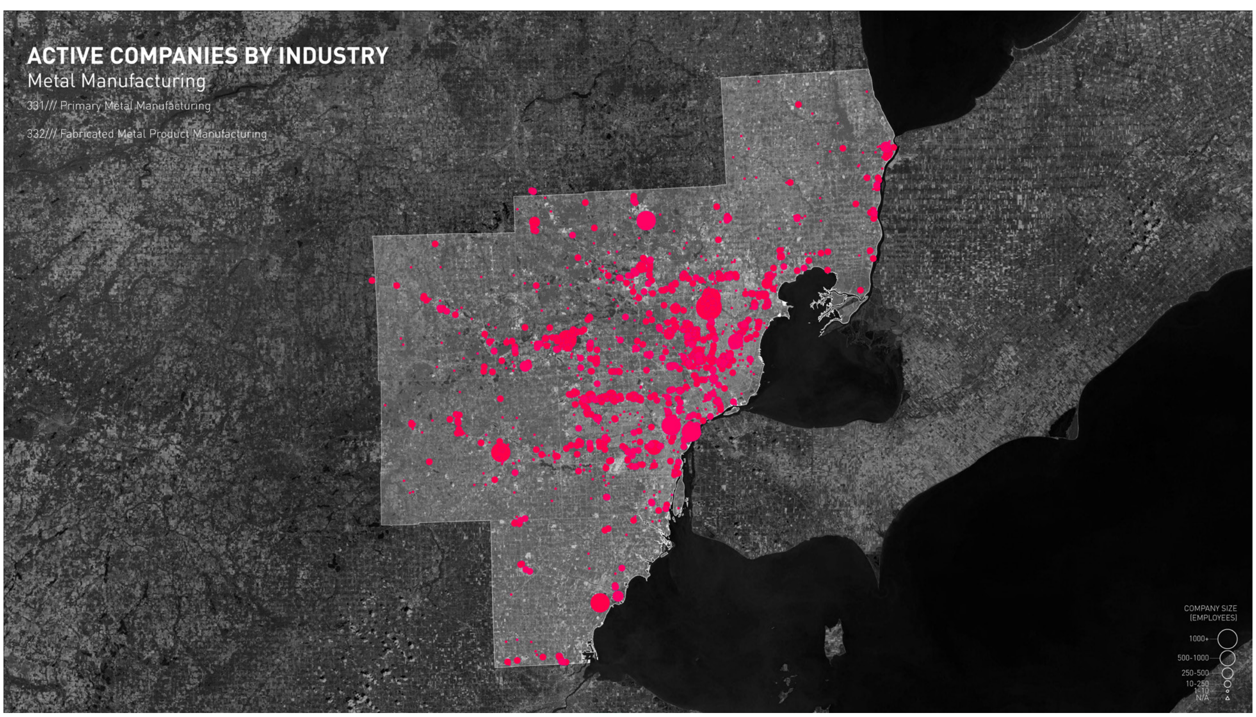
483///	WATER TRANSPORTATION
4831//	Deep Sea, Coastal, and Great Lakes Water Transportation
4832//	Inland Water Transportation

484///	TRUCK TRANSPORTATION
4841//	General Freight Trucking
4842//	Specialized Freight Trucking

485///	TRANSIT AND GROUND PASSENGER TRANSPORTATION
4851//	Urban Transit Systems
4852//	Interurban and Rural Bus Transportation
4853//	Taxi and Limousine Service
4854//	School and Employee Bus Transportation
4855//	Charter Bus Industry
4859//	Other Transit and Ground Passenger Transportation

488///	SUPPORT ACTIVITIES FOR TRANSPORTATION
4881//	Support Activities for Air Transportation
4882//	Support Activities for Rail Transportation
4883//	Support Activities for Water Transportation
4884//	Support Activities for Road Transportation
4885//	Freight Transportation Arrangement

532///	RENTAL AND LEASING SERVICES
5321//	Automotive Equipment Rental and Leasing
532411	Commercial Air, Rail, and Water Transportation Equipment Rental



Note: A video compilation of all XXX Industry Sectors compiled and mapped as part of this projectis available for public viewing at: https://vimeo.com/117215709