Evaluation of Economic Impacts of Michigan VII Program (Vehicle Infrastructure Integration)

Prepared for
The Michigan Department of Transportation

by

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Executive Summary

The technology to allow vehicles on the road to “communicate” with each other and with a central switchboard is here. An interactive, intelligent highway system, otherwise known as Vehicle Infrastructure Integration (VII), that ties these disparate technologies together has tremendous potential to improve traffic safety, decrease highway and road congestion, improve the flow of goods and people, and provide greater conveniences to vehicle operators. The state which pulls all of the available technologies, infrastructure and vehicles together into a fully functioning VII system first will be recognized as a leader in an emerging industry and will have the opportunity to export its knowledge and products to other states and countries.

Many new jobs can be expected in a state’s economy as a result of operating and maintaining a fully-deployed VII system--provided a viable business model can be developed. Regardless of how it is configured, a VII system along with its supporting industries will have many benefits, but it must be understood that such a system could cost a great deal of money to build (deploy), operate and maintain.

This report, by the Center for Automotive Research and Michigan State University is an attempt to provide a reasonable estimate of the economic and employment contribution to the State of Michigan’s economy from a fully-deployed VII system in the state. These estimates are based on a number of scenarios which incorporate the direct jobs, corresponding wages and other compensation that would be created from operating and maintaining a statewide VII system. Using a sophisticated economic estimating model, the contribution of indirect employment and the effects on tax revenues is also estimated. Further, the study provides insight into the industrial sectors of Michigan’s economy that could benefit from the VII system.

Through the analyses of a number of plausible scenarios examining a combination of unforeseen technological developments, three different levels or ranges of forecasts were revealed. The jobs that are forecasted are for the ongoing operation and maintenance of the VII system in the State of Michigan and do not include the jobs needed to initially deploy the system.

A. High impact forecast:	From 16,350 to 41,490 jobs generated
	$1.15 billion to $ 3.70 billion annual compensation
	$145 million to $448 million tax revenues

B. Medium impact forecast:	From 11,000 to 27,700 jobs generated
	$765 million to $ 2.5 billion annual compensation
	$100 million to $300 million tax revenues
C. Low impact forecast:	From 1,900 to 4,700 jobs generated
	$139 million to $ 402 million annual compensation
	$ 17 million to $ 50 million tax revenues

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Introduction

The technology to allow vehicles on the road to "communicate" with each other and with a central switchboard is here. An interactive, intelligent highway system, otherwise known as Vehicle Infrastructure Integration (VII), that ties disparate technologies together and communicates with drivers has tremendous potential to improve traffic safety, decrease highway and road congestion, improve the flow of goods and people, and provide greater conveniences to vehicle operators.

For individuals, a VII system could offer a better experience in navigating traffic – by identifying congestion or weather-related problems along a given route in plenty of time for the driver to take an alternate path. Services to the driver and vehicle passengers might also be available, such as obtaining directions, locating nearby businesses, accessing the internet, paying tolls and parking fees, and so on.

For businesses, the benefit of highest potential of a VII system is electronic information transfer, such as providing electronic support in clearing customs, meeting weight requirements of state highways, paying tolls, and in general providing electronic submission of required forms for the movement of freight. Assisted dispatch and monitoring of fleet vehicles, both freight vehicles and public transportation vehicles, are services that could both reduce the number of vehicles required (by streamlining operations) and provide better scheduling and timing of vehicle trips.

For government, resources could be saved in using a VII system to provide traffic flow information for heavily traveled routes, so that construction and maintenance of the roadway system can be optimized. Emergency services could also be optimized with better information on traffic accidents and incidents relayed by and through a VII system. Ideally, many incidents and accidents would be avoided, thereby easing the strain on emergency services.

For a state's economy such as Michigan's, many new jobs can be expected as a result of operating and maintaining a fully-deployed VII system--provided a viable business model can be developed. Regardless of how it is configured, a VII system along with its supporting industries will have many benefits, but it must be understood that such a system could cost a great deal of money to build (deploy), operate and maintain. The Center for Automotive Research (CAR), along with Michigan State University, has undertaken a study estimating one side of this equation: the employment impact of operating and maintaining a VII system to the state of Michigan.

Snapshot of One VII Initiative

To assist in gaining a perspective on the complexity of a VII system, the authors have included a look at one system described by the organization, *ITS America*, at their annual meeting in June 2007:

> *The VII Initiative is a cooperative effort between Federal and state departments of transportation and vehicle manufacturers, deploying a communications system that will be used primarily for improving the safety and efficiency of the nation's transportation system. VII is envisioned as a national communications infrastructure on all major roadways in the nation, with 250,000 hot spots and 15 million vehicles a year being equipped with VII technology-all meeting national standards of interoperability. VII will support vehicle-to-infrastructure and vehicle-to-vehicle communications for a variety of vehicle safety applications and transportation operations, as well as enable the deployment of a variety of applications that support private commercial interests, such a vehicle manufacturers. Onboard and roadside equipment, GPS, and wireless systems will all play a role in providing data to applications that will process it for different uses and then reverse the communications back to the users. Applications development is centered on improving safety and mobility, including, but not limited to: Electronic payments (for gas, toll, parking, etc.), traveler notification and information, signal timing optimization, ramp metering, roadway maintenance, weather information and monitoring. To significantly improve traffic safety by preventive actions, VII is many times dubbed as "Internet on Wheels".*
>
> *For businesses, to be a part of the VII-team, it will need to be a selling as well as an outreach job to demonstrate clearly that it is not a one way street of benefits flowing in one direction. According to ITS America, implementation of VII as it stands today is merely a goal. It is not inevitable, yet. Data management agencies, insurance industry, and private funding agencies have to be involved much more. The business models of private financing of the VII-infrastructure, if only due to the huge cost of*

deployment, have suddenly become more viable, having seen the success with traditional infrastructure, such as toll roads.

The government is heavily involved in making a decision on VII technology, due partly to:

> *42,000 fatalities every single year on the US roadways, where this is the leading cause of death for Americans from 4 to 33 years of age*
>
> *Traffic crashes cost the economy $230 billion per year, traffic injuries $60 billion per year, traffic congestion $63 billion per year and fuel wasted due to congestion is in the billions of gallons per year.*

At this time, eleven government agencies, including Homeland Security, Education, Justice, Transportation and FDA are sharing the responsibility of ensuring mobility services for all Americans by an ITS enhanced transportation system. US DOT is conducting standards activities, funding and monitoring the proof-of-concept testing and conducting policy research and undertaking outreach efforts to ensure public understanding of the benefits of the technology. Government resources could be saved in using a VII system to provide better traffic flow information, both in timing and routes, so that construction and maintenance of the roadway system can be optimized. Emergency services could also be optimized with better information on traffic accidents and incidents relayed by and through a VII system. Finally, ideally, many incidents and accidents would be avoided, thereby easing the strain on emergency services. Those are some of the reasons the government is partly involved in VII because transportation has risen to a number one political issue in every state across the country. In federal and state governments, the real business of transportation is now in their budget committees and ITS technology is at the forefront of this issue. [1]

Early on in this research, the authors attempted to define a VII system which would enable a simple path to economic analysis estimation, and came across many such examples of a VII system--all different from each other. This is but one of those examples.

[1] ITS America VII Highlights from the Annual Meeting June 2007

Study Scope

The focus of this study is to examine the potential economic and employment contributions of operating and maintaining a Vehicle Infrastructure Integration (VII) system in the State of Michigan. The economic and employment impacts of a VII system depend heavily on the form that such a new system will take and the necessary support industries to operate and maintain such a system. These employment impacts are a total of direct, indirect and expenditure-induced employment. Indirect employment refers to people who work at the goods and services suppliers who supply the industries that are represented in the VII system. Expenditure-induced employment is the employment resulting from consumer-goods related spending by the direct and indirect employees who earn an income as a result of working for industries represented in the VII system.

Early on in the research for this study, the authors were looking to define a VII system and found many examples of a VII system--all different from each other. Upon realizing that there was no singular definition of a “comprehensive VII system”, the study’s authors concluded that analyses of multiple scenarios was the ideal means of capturing the broadest definition of a VII system. As will be shown in this paper, this approach has revealed the clearest picture of the range of *potential* employment and economic impacts, while incorporating most of the components of a VII system.

For purposes of this study, the VII system is defined in a basic, technology-neutral sense: vehicle communicates with highway, highway communicates with vehicle, vehicle communicates with vehicle. The method of communication, for example, could be as simple as a sensor attached to the motor vehicle, and as complex as a screen-in-vehicle navigation system—however, this determination was not necessary to perform the analyses. By assessing the VII system investment and support requirements at the basic level, and without naming specific technologies, this study can stand as a proxy for a wide range of VII deployment scenarios. Additionally, without specifying technology uses or advances, there is no need for the study authors to look into the future and assess system capabilities or requirements in order to perform the analysis, nor are they required to estimate development and deployment costs of the system. As an example, who could have understood the functionality, sophistication, or level of adoption of the internet in 1985?

The study is divided into two sections.

Section I: includes a short overview of what such a program in Michigan might look like. For this overview, the authors relied on published studies of existing VII-related components and their costs. From this literature review, a statewide system was defined in order to estimate basic data for input into an economic impact estimating model.

Section II: provides an estimate from a number of scenarios of the economic and employment contribution to the State of Michigan's economy from the jobs, corresponding wages and other compensation that could be created from a fully functioning VII system in the state. The contribution of indirect employment and the effects on tax revenues is also estimated. These estimates were derived using the latest version of a state-of-the-art economic model. Further, the study provides insight into the industrial sectors of Michigan's economy that could benefit from the VII system.

Section I: Vehicle Infrastructure Integration (VII) Overview

At the heart of modeling a research and development program such as the VII program in Michigan is estimating the scope of the program and describing, what the VII system, once developed, will look like. This includes understanding the necessary infrastructure to support the VII system, as well as the near-term employment and wage inputs for the model. The technological capabilities already developed, available, and—in some cases—deployed and in use, allow for a nearly unlimited array of options in developing intelligent vehicles and an integrated infrastructure.

Defining the VII System

An assumption of this study is that VII as envisioned will be a mostly automated system using technology that has already been developed. When using technologies that have been developed to define the basic framework of a VII system, the bulk of the employment impact stems from operating and maintaining the VII system. It was assumed—for reasons already mentioned—that no new technology is needed to fully deploy the VII system and, therefore, very little upfront research and development investment is necessary. Once deployed, employment impacts (that is, jobs created) are based on operating and maintaining the system.

This study assumes that deployment of the full statewide VII system will occur by 2011. Deployment of the nationwide system requires a one-time, short-term expense ranging anywhere from $3 billion to $17 billion, which will temporarily create jobs in construction and product development. While these jobs are important, they are seen as transient and not of high importance when in deciding whether to institute a statewide VII system.

This study, instead, has focused on operation and maintenance impacts of the VII system five years after it goes fully online. By waiting until 2016 to estimate the economic and employment impacts, the VII system will be fully mature and the necessary ramp-up time to fully test and integrate the system will have passed.

A combination of methods was used to fully understand the framework for the potential VII system in Michigan. A literature review was first conducted, and industry experts from the public and the private sector were consulted. These efforts provided both a view of the current status of technical developments as well as some of the anticipated future developments. The data used to perform the economic modeling part of the research—direct employment and other data on the Michigan economy, system design, and the automotive industry—were collected by CAR from a wide variety of publicly available sources. Once the scope of the VII system, with related direct employment needs was assessed, a number of scenarios were created to account for the uncertainties associated with future technology advances--providing a sensitivity analysis on a range of employment and industry inputs.

This study analyzed dozens of scenarios encompassing a broad range of employment, technology and investment options. The results of modeling all the scenarios gave a reasonable estimate of the spectrum of economic impacts that might be realized within the State of Michigan from operating and maintaining a VII system.

An understanding of the basic framework of a VII system is necessary in order to conduct this economic impact study. For the purposes of this study, the authors chose to remain technology-neutral. In other words, no specific technology is assumed or specified, instead the system is defined in general terms. Therefore, in vehicles we assumed a "black box" (On Board Equipment or OBE)which can receive or transmit a variety of data from or to "roadside antennas" (Road Side Equipment or RSE). In addition, regional data processing facilities may also be part of the communication network within the state. Defining the system this way allows for a variety of scenario analyses to be performed on the system without being constrained by specific technology and business case requirements. These scenarios are discussed later in this paper.

Direct Full Time Equivalents (FTE) Estimates

Before an estimate of total job creation can be analyzed, a reasonable estimate of direct employment necessary to operate and maintain a VII system must be quantified. A literature review and consultations with government and industry experts gave a portrait of what types of uses might constitute a VII system. Table 1 below contains examples of applications (end uses) of the VII system. A basic VII system sends messages from the vehicle to roadside infrastructure, from the infrastructure to the vehicle, and from vehicle to vehicle.

From the literature review, actual applications (end use cases) were categorized into one of six components that constitute the basic framework for a VII system. These components are:

1. highway infrastructure,
2. public transportation,
3. government management of commerce (freight and trucks),
4. private sector management of commerce,
5. internet service providers, and
6. roadway communications management (regional data collection and analysis center).

For each of these components, capital investment, operations and maintenance spending (O&M) and job creation were estimated based on much of the data contained in the U.S. DOT Intelligent Transportation Systems Costs Database (http://www.itscosts.its.dot.gov/). The Costs Database includes very detailed costs for specific applications that have been tested in the U.S. within the past 15 years. More than 300 unit cost elements were classified into system cost estimates for the above 6 major components of the VII system. Many of the applications had estimates of FTE (full-time equivalent) labor requirements.

Based on the investment and job data from the Federal Costs Database, as applied to a VII system in Michigan, the authors estimate that slightly more than 6,000 people are required as of the year 2016, to operate and maintain the VII system when the system is fully functioning.

To further understand how the approximately 6,000 FTE jobs were estimated, please refer to the tables in Appendix A, which show the cost components analyzed.

Table 1 **: End Use Case Examples**

Communication Path	End Use Case Examples
Vehicle to Infrastructure	Central Data Collection
Infrastructure to Vehicle	Commercial Vehicle Operations
Vehicle to Infrastructure	Commercial Vehicle Operations
Infrastructure to Vehicle	Internet Based Data Transfers
Vehicle to Infrastructure	Internet Based Data Transfers
Infrastructure to Vehicle	Road condition alerts
Vehicle to Infrastructure	Road condition alerts
Vehicle to Vehicle	Road condition alerts
Infrastructure to Vehicle	Roadside services and conveniences
Infrastructure to Vehicle	Traffic warnings and alerts
Vehicle to Infrastructure	Traffic warnings and alerts
Vehicle to Vehicle	Traffic warnings and alerts
Infrastructure to Vehicle	Transit Vehicle Operations
Vehicle to Infrastructure	Transit Vehicle Operations
Vehicle to Infrastructure	Vehicle-based Violations and Warnings

In order to estimate the number of jobs created and their potential economic impact in terms of compensation and tax revenues, the model needs an input of the projection of the number of direct jobs necessary to operate, maintain, and improve the VII system. These direct jobs must be classified by occupation, compensation level, and specific industry before they are entered into the model. For instance, perhaps 50 software development technicians earning $50,000 annually are necessary to bring a statewide VII system on line, and 25 are needed to maintain the system. For the purposes of this study—which looked at the longer-term, permanent economic impacts of a VII system in the state—we looked at the 25 software development technicians and their compensation needed to operate and maintain the system. These jobs, and their compensation, are input into the model which then estimates the number of supporting jobs created in a range of industries associated with software development and operation—such as computer development and manufacturing.

Section II: Estimates of the Economic Contribution of the Vehicle Infrastructure Integration Program to the State of Michigan

The purpose of this section is to provide a comprehensive analysis of the estimated economic contribution associated with the activities involved in developing and operating a VII system in the state of Michigan. The potential developments within this emerging industry have been analyzed in this report; the data used represents the most up-to-date information available.

Model Inputs

The first input component of this economic contribution study is the number of jobs that will be created to deploy and maintain the VII system. As discussed earlier in this paper, it was determined that roughly 6,000 FTEs would be required by 2016 to operate and maintain the VII system in Michigan. While this estimate is based on the investment and job data from the Federal Costs Database, the actual number of FTEs necessary to operate and maintain the system could vary significantly.

To allow for unforeseen technological developments, sensitivity analyses were performed on the original estimated labor inputs. These labor input sensitivities were developed by increasing the estimated jobs required by 50 percent (9,000 jobs), decreasing by 50 percent (3,000 jobs), and using a floor estimate of 1,000 jobs. The scenarios at any of these levels of employment (1,000, 3,000, 6,000 and 9,000) are for relatively low levels of employment when compared to total state employment. As a consequence, the model results are fairly linear. This means that as the direct employment is changed by percentage increases or decreases, so too does the total employment increase or decrease by the same percentage, up to the direct FTE ceiling of 9,000 jobs.

The second input component of this economic contribution study is the categorization of employment that will be created to deploy and maintain the VII system. Based on the literature review and the discussions with industry leaders, a list of industries that contribute to the development and operation of a VII system was compiled. Ten major types of jobs, plus two construction categories, were determined to be the industries in which employment in a VII system would be highly concentrated.

The major job categories are:

1. Telecommunications providers
2. Internet service providers
3. Call centers
4. Administrative and support services
5. Management of companies
6. Repair and maintenance services
7. Truck transportation and related services and activities
8. Transit transportation and related services and activities
9. Parts manufacturing for motor vehicles
10. Computer and electronic product manufacturing

The construction categories are:

1. Road and infrastructure construction
2. Line construction

The third input component of this economic contribution study is the timeframe to fully deploy and to maintain the VII system. For purposes of this study, it is assumed that the VII system will be fully deployed by 2011. Operations and maintenance followed for the next five years, therefore the full economic and employment impact of the VII system, including full deployment, operations and maintenance is estimated for the year 2016.

SCENARIO DEVELOPMENT

As previously discussed, in developing this impact analysis for VII system development in Michigan, the authors performed a number of sensitivity analyses on the quantity of jobs needed to deploy, operate and maintain the VII system. The next step was to perform sensitivity analyses on the mix of job categories needed to deploy, operate and maintain the VII system. This was necessary due to uncertain technological developments and market demand in the study's timeframe, which could impact the development and functionality of the VII system. These sensitivity analyses are categorized by the predominant industry involved in the operation and maintenance of the VII system. For instance, in the first of these analyses, internet service providers, the VII system is heavily dependent on infrastructure and operations based on automated communications provided by the ISP industry. Other analyses which follow are predominantly dependent on other industries, and are labeled as such. Within each of these analyses that emphasize a particular industry, scenarios were run with different levels of industry dominance, (heavy and medium). The results described below are for the analysis with "heavy" industry dominance. Complete results for the other levels of industry dominance are provided in Tables 3, 4 and 5 in the Results Section. For each of these levels of industry dominance, a number of model runs were performed altering the total quantity of jobs as described above (this refers to the employment levels of 1,000, 3,000, 6,000, 9,000 jobs). For each of these industry analyses, up to thirteen model runs were performed. The result of each of these industry analyses, based on the initial estimate of 6,000 jobs necessary to operate and maintain the VII system, are described below. (For the estimates based on 1,000 direct jobs, 3,000 direct jobs or 9,000 direct jobs, please see the tables B1 through B6 in Appendix B.)

The scenarios provided below are pictures that have been "painted" in order to explain the different levels and types of FTEs in each scenario. Due to the complexity of the system and the uncertainty of future technologies—both in the vehicle and on the road—the authors found early on that attempting to construct an exact picture of a VII system and then model it was close to impossible. Instead, the authors started with the calculations of 6,000 total direct jobs and the occupational mix necessary to operate and maintain a general VII system—as discussed earlier—and moved backwards. For each of the scenarios below, the starting point was the original job levels and occupations, which were then varied to produce a range of impact results. From these results, the authors constructed pictures to help the reader understand how a VII system may look in each scenario. Performing the analyses this way enabled the authors to take into account the many "what-if you changed this" questions that they encountered in the months of research for this study. When testing sensitivities based on the various job occupations and the quantity of jobs that might be required to operate and maintain a VII system in Michigan, nearly an infinite number of scenarios can be imagined. These scenarios contained in this study are the most plausible combination of job occupations and employment numbers that, together, should help to estimate the complete picture of a VII system. In fact, the authors are quite confident that the true make-up of a VII system for the State of Michigan is contained within the high and low parameters of these scenarios.

Scenarios

In every scenario which was modeled, the authors assumed that 6,000 jobs were necessary to deploy the VII system by 2011. For the reasons discussed earlier, these short-term, transient construction and product development jobs are not contained in the total job creation estimates of this study. (Other results from the sensitivity analyses can be found in tables B1 through B6 in Appendix B.)

Table 2: Scenario Job Mix

	Percentage of jobs									
Scenario	Managers	Internet Service Provider Employment	Call Center Employment	Trucking Industry Employment	Government Employment	Telecommunications Employment	Manufacturing Employment, Electronics Components	Manufacturing Employment, Auto Parts	Engineering and Research Science Employment	Employment of Maintenance Technicians
High ISP	10	60	10						10	10
Medium ISP	10	50	10	10	10				5	5
High Call Ctr	10	10	60						10	10
High Call Ctr with Telecomm	10		75			10				5
Medium Call Ctr with Maintenance	10		40						25	25
High R&D	10	10	10						60	10
Medium R&D	10	5	10	10	10				50	5
High Mfg (electronics)	10	10	10				60			10
High Mfg (auto parts)	10	10	10					60		10
High Trucking	10	10	10	60						10
High Govt	10	10	10		60					10
High Telecomm	10	10	10			60				10
Equal Mix	10	10	10	10	10	10	10	10	10	10

Internet Service Provider (ISP) analyses. This scenario suggests that once basic infrastructure is in place, that is some form of black box in vehicles (OBE) and attached to existing poles along roadways (RSE), most of the work would be in providing and servicing the communication flows between vehicles and the infrastructure as well as a backhaul network to a server. .With this scenario, it was envisioned that most of the work created by this fledgling industry would be information technology (IT) or ISP employment. Including the 6,000 direct jobs, it is estimated that a total of 14,290 jobs are created to operate and maintain the VII system with ISP employment (using the run with the greatest concentration of ISP employment).

Total compensation for all of the 14,290 jobs is forecast in 2016 to be $1.16 billion. Taxes on this compensation amount $143.0 million, with another $111.6 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $904.4 million in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

Call Center analyses. In the Call Center scenario, the development of the industry could greatly mimic the present example of the OnStar service as operated by GM Corporation. The majority of OnStar employees work in call center type jobs. In the scenario with high call center employment, sixty percent of new employment was assigned to jobs created by work in call centers. The remaining employment was equally divided between managerial jobs, maintenance workers, internet service providers, and information technology jobs. Three different runs of this scenario were performed in which the mix of call center jobs versus ISP and IT jobs was changed slightly from run to run. Including the 6,000 direct jobs, it is estimated that a total of 11,378 jobs are created to operate and maintain the VII system with call center employment (using the run with an equal mix of call center and IT jobs).

Total compensation for all of the 11,378 jobs is forecast in 2016 to be $830.5 million. Taxes on this compensation amount $104.9 million, with another $44.8 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $680.8 million in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

Research and Development analyses. This vision of the industry suggests that most of the work that may be created by this new industry will be in the ongoing research & development (R&D) of new technology. The potential uses for VII are limited only by the imagination. While many technologies are already available, they may be too cumbersome or expensive to produce for a mass market, therefore employment would be primarily in improving and developing technologies. Two different runs of this scenario were performed in which the mix of science-based R&D employment versus engineering-based R&D employment was changed. Including the 6,000 direct jobs, it is estimated that a total of 13,153 jobs are created to operate and maintain the VII system with primarily research and development employment (using the run with the highest R&D employment).

Total compensation for all of the 13,153 jobs is forecast in 2016 to be $1.134 billion. Taxes on this compensation amount $141.6 million, with another $81.2 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $911.2 million in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

High employment in manufacturing analyses. Many of the interviewees employed by automakers felt that this new industry would not create a significant number of new jobs in Michigan in the manufacturing of either electronic equipment or automotive parts. However, there is an expectation that consumer demand for more functions and services may create new opportunities for automakers. In this example, the VII System would develop and expand based on consumer demand for products and services. A large variety of applications, products and offerings would be created by both commercial ventures and the public sector to satisfy consumer demand. This scenario examines the impact from creating the majority of new jobs in manufacturing. Also, regarding employment impacts from industry, manufacturing employment tends to have the greatest ripple effect throughout the economy. This is because manufacturing industries require parts and raw materials inputs, which create more jobs than other industries which primarily create service jobs. This scenario was also run two times. The mix of jobs in auto parts manufacturing versus electronics manufacturing was varied in these two runs. Including the 6,000 direct jobs, and using the run with primarily electronics manufacturing employment, it is estimated that a total of 27,680 jobs are created to operate and maintain the VII system with manufacturing employment.

Total compensation for the 27,680 jobs is forecast in 2016 to be $2.464 billion. Taxes on this compensation amount $298.4 million, with another $300.4 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $1.865 billion in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

Trucking analyses. Much of the high economic value that could be created through using a VII system is the possibility of more efficient management of commercial fleets, as well as converting most freight management paperwork and regulation compliance to electronic form. In this example, most of the jobs created were assumed to be in freight transportation. Including the 6,000 direct jobs, it is estimated that a total of 12,606 are created to operate and maintain the VII system with employment centered in the trucking industry.

Total compensation for all of the 12,606 jobs is forecast in 2016 to be $1.014 billion. Taxes on this compensation amount $126.3 million, with another $72.4 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $815.2 million in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

Government analyses. Another scenario suggests that most of the ultimate uses for a VII system will be for traffic management and infrastructure planning. In this scenario, the jobs created were assumed to be government jobs in data collection and analysis to support better roadway management. This type of scenario suggests that the installations in vehicles would be some form of government mandated, uniform "black box", that primarily communicates with devices installed on existing roadway infrastructure (telephone poles, etc.). The devices in vehicles would be low-cost items, and would provide a variety of different kinds of data to the infrastructure system. Including the 6,000 direct jobs, it is estimated that a total of 10,935 jobs are created to operate and maintain the VII system with government employment.

Total compensation for all of the 10,935 jobs is forecast in 2016 to be $765.9 million. Taxes on this compensation amount $96.9 million, with another $39.7 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $629.2 million in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

Telecommunications analyses. This scenario assumes that the benefits of a VII System are reasonably equally spread across all sectors of the economy, but that the System is predominantly supplied and serviced by telecommunications companies, such as wireless cell phone or internet service providers. Within this system, the emphasis is on the private sector operating an open system that is primarily based on telecommunication networks. Including the 6,000 direct jobs, it is estimated that a total of 17,527 jobs are created to operate and maintain the VII system with employment based in the telecommunications industry.

Total compensation for all of the 17,527 jobs is forecast in 2016 to be $1.529 billion. Taxes on this compensation amount $185.9 million, with another $180.7 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $1.163 billion in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

Equal Distribution analysis. A scenario was tested in which the jobs created were in equal numbers across the ten job categories. Including the 6,000 direct jobs, it is estimated that a total of 16,900 jobs are created to operate and maintain the VII system with employment generally spread across all the relevant industries.

Total compensation for all of the 16,900 jobs is forecast in 2016 to be $1.441 billion. Taxes on this compensation amount $176.8 million, with another $137.2 million contributed to social insurance. When netting for social insurance contributions, and personal income taxes, the private disposable personal income generated from the activities related to the VII system in Michigan is $1.127 billion in 2016. (A table of these jobs, compensation and taxes is shown in the Results section.)

RESULTS

The tables in this part of the report show the estimates of the employment and economic contributions associated with the full deployment, operation and maintenance of a VII system in Michigan. These estimates are derived from the 6,000 direct jobs associated with ten predominant industries that could be involved in the operation of a VII system. (For estimates derived from the 1,000 direct jobs, 3,000 direct jobs or 9,000 direct jobs, turn to Appendix B.) In addition to estimating the direct employment, this report with the aid of the economic model software also estimates indirect and expenditure-induced employment as a result of the VII system in Michigan. Indirect employment refers to people who work at the goods and services suppliers who supply the industries that are represented in the VII system. Expenditure-induced employment is the employment resulting from consumer-goods related spending by the direct and indirect employees who earn an income as a result of working for industries represented in the VII system.

Table 3 below shows estimated total jobs created as a result of thirteen separate analyses. In addition, Table 4 shows the compensation and taxes generated by the jobs in these analyses.

Total jobs created range from a high of 27,680 in a scenario in which electronics manufacturing is predominant to a low of 10,935 jobs in a scenario where the jobs created are primarily in the public sector, analyzing the traffic data. Because the number of direct jobs that we estimate for operating and maintaining a VII system in Michigan are small in comparison to the entire labor force of the state, the results were approximately linear for the scenarios where the number of direct jobs were changed. In other words, when the 6,000 direct jobs input into the model were reduced by 50 percent to 3,000 jobs, the total estimated jobs created also were reduced by 50 percent. This held true for increases in the direct jobs input. For further details, see the tables in Appendix B.

Table 3: Estimated Total Employment, 2016

Scenario	Jobs
High ISP	14,290
Medium ISP	13,650
High Call Ctr	11,208
High Call Ctr with Telecomm	11,378
Medium Call Ctr with Maintenance	11,309
High R&D	13,153
Medium R&D	12,626
High Mfg (electronics)	27,680
High Mfg (auto parts)	21,048
High Trucking	12,606
High Govt	10,935
High Telecomm	17,527
Equal Mix	16,900

Table 4: Total Employment, Compensation and Taxes, 2016

		Millions of Current Year, Nominal $			
Model Run Description	Employment	Compensation	Taxes	Contributions to Gov Social Insurance, other Transfers	Net Disposable Income
High ISP	14,290	1,158.9	143.0	111.6	904.4
Medium ISP	13,650	1,081.6	133.8	98.2	849.7
High Call Ctr	11,208	818.5	103.5	44.3	670.7
High Call Ctr with Telecomm	11,378	830.5	104.9	44.8	680.8
Medium Call Ctr with Maintenance	11,309	856.8	108.5	43.2	705.1
High R&D	13,153	1,134.0	141.6	81.2	911.2
Medium R&D	12,626	1,026.3	132.6	37.9	855.9
High Mfg (electronics)	27,680	2,464.1	298.4	300.4	1,865.3
High Mfg (auto parts)	21,048	2,021.3	244.6	206.4	1,570.3
High Trucking	12,606	1,013.9	126.3	72.4	815.2
High Govt	10,935	765.9	96.9	39.7	629.2
High Telecomm	17,527	1,529.4	185.9	180.7	1,162.9
Equal Mix	16,900	1,441.0	176.8	137.2	1,127.0

Table 5 shows the distribution of employment for each of the scenarios in the direct, indirect and expenditure-induced categories. In addition, capital investment-related employment and export-related employment are listed. Capital investment-related employment is derived from employment created to service the capital investment needs of the VII system. Export-related employment is employment created by demand for knowledge, good or services by other VII systems outside of the state of Michigan.

Taking the estimated total employment and dividing it by the direct employment in each of the scenarios, the authors estimate the jobs multiplier associated with each scenario. The estimated multiplier range is from a high of 4.6 down to 1.8. The employment multiplier can be thought of in two ways. For example, in the high job creation scenario, (1) there are 4.6 jobs in the Michigan economy for every direct job associated with operating and maintaining the VII system, or (2) there are 3.6 additional jobs in the Michigan economy for every direct job associated with operating and maintaining the VII system.

Table 5: Distribution of Total Employment, 2016

Scenario	Direct Industry Employment	Indirect Employment	Expenditure-induced Employment	Capital Investment-related Employment	Export-related Employment	TOTAL	Employment Multiplier
High ISP	6,000	4,077	3,176	723	314	14,290	2.4
Medium ISP	6,000	3,677	2,964	683	326	13,650	2.3
High Call Ctr	6,000	2,004	2,290	496	418	11,208	1.9
High Call Ctr with Telecomm	6,000	1,960	2,324	667	427	11,378	1.9
Medium Call Ctr with Maintenance	6,000	1,889	2,430	538	452	11,309	1.9
High R&D	6,000	2,751	3,262	676	465	13,153	2.2
Medium R&D	6,000	2,486	3,040	640	460	12,626	2.1
High Mfg (electronics)	6,000	12,720	6,726	1,897	337	27,680	4.6
High Mfg (auto parts)	6,000	7,442	5,741	1,366	500	21,048	3.5
High Trucking	6,000	2,704	2,863	610	429	12,606	2.1
High Govt	6,000	1,902	2,109	545	379	10,935	1.8
High Telecomm	6,000	4,906	4,227	2,014	380	17,527	2.9
Equal Mix	6,000	5,314	4,005	1,173	408	16,900	2.8

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Section III: Conclusions

Based on the investment and job data from the Federal Costs Database, as applied to a VII system in Michigan, the authors estimate that slightly more than 6,000 people are required as of the year 2016, to operate and maintain the VII system when the system is fully functioning. (Other analyses based on 1,000 direct jobs, 3,000 direct jobs or 9,000 direct jobs were performed and are included in the appendices. However, the authors feel the 6,000 direct jobs are the most plausible and realistic scenario.)

This study has shown that a fully deployed VII system in the State of Michigan will generate employment ranging from nearly 11,000 jobs up to 27,700 jobs, based on the mid-range estimate of 6,000 direct jobs. The compensation that will be earned for these jobs ranges from $765 million to $2.5 billion annually, and tax revenues generated range from $100 million to $300 million. These jobs are for the ongoing operation and maintenance of the VII system and do not include the jobs needed to initially deploy the system.

The employment estimates are based on current understanding of available technologies, and make no predictions of future technology innovation and market demand. Additionally, the results are realistic assumptions of economic and employment needs associated with fully deploying a VII system for the state of Michigan. However the VII system is envisioned by various audiences—and by whatever range of direct employment is necessary—the authors are confident the results presented in this paper suggest a reliable range in which the true employment and economic impacts surely lie.

This Michigan-based system assumes that Michigan is the first state in the immediate region to deploy VII. The results would change to some degree if a system is deployed in other states simultaneously, as some of the jobs to operate and maintain such a system could be shared across state lines.

Recommendations

This study has been focused on a narrow examination of the benefits of a VII system, namely the employment and associated economic impacts of operating and maintaining a fully functioning VII system in the State of Michigan. Of course, there are many other benefits such a system would provide beyond the impacts on job creation and retention, but these were outside the scope of this project. Additionally, there are many potential costs that were not included in this study.

1. It is recommended that a much broader view of these benefits and costs be examined -before a go or no-go decision is made to commit to implementing a statewide VII system.

   The safety and convenience (congestion avoidance and navigation assistance) benefits have the potential to be very significant. There also may be costs other than the funds that must be invested to further develop a VII system. Issues of privacy and ownership of collected data will have to be addressed to the satisfaction of all parties – government, consumer and manufacturer, who will be a part of the operation of the system.

2. A determination of sources of funding should be addressed prior to a full-scale commitment to the VII system.

   Questions remain as to who will provide the funding for system development – government or private concerns. Government funding for technology development and deployment may very well be justified with a VII system because of the great contribution to the public good. But at the same time, expected benefits to the government will have to be carefully outlined to protect individual rights. Likewise, many businesses could benefit from a VII system by having very specific geographic, demographic and consumer movement data from which they could see a profit. It could likely be that the private sector will absorb all of the costs of the VII system in exchange for the right to attempt to gain profit from the system. A current example of this is the proliferation of cell phones throughout society at little costs to governments, while providing many societal benefits, such as precise locational abilities and safety associated with carrying a phone.

3. A realistic attempt must be made to estimate consumer acceptance of a fully implemented VII system before large amounts of funding are allocated to deploy such a system.

Ownership and use of the vast amounts of potential data that can be collected by a VII system raise issues of rights to private and identified data (who drove where), and uses of the data, particularly by law enforcement agencies and commercial marketing concerns.

4. Unintended consequences are always a hidden factor of many major policy decisions and a realistic attempt must be made to account for these in future broad analyses of VII economic contributions and impacts. For instance,

   Manufacturers may have more features to offer on their vehicles, and more services, but auto repair shops may suffer with improved vehicle usage, performance and diagnostics.

   The joy of driving may increase dramatically as consumers are able to avoid congestion or drive to new localities without fear of becoming lost or stranded.

   The safety features alone may be an incredibly high motivator for VII system development via consumer pull, government push, and manufacturer ability to differentiate products and services.

5. Due to the limitations of the scope of this study, deployment was not considered. If this is deemed important for short-term job creation, the authors suggest looking at this more closely.
6. The results of this study are based on outcomes in the year 2016, given today's information on technology and potential job creation resulting from that technology. If more than a couple of years have passed from publication of this study, and no decision has been made to move ahead on fully deploying a VII system in Michigan, it would be advisable to revisit this study for a more up-to-date estimation of potential economic impacts.

The safety and convenience issues in the last two bullets alone may create an unprecedented need for additional highway infrastructure. In the last thirty years, vehicle miles traveled have more than doubled, while road capacity has increased by only 50 percent.[2] More vehicles, more variety in vehicle size, and relatively smaller road area make driving today significantly more challenging than when the baby boomers were taking their driving exams. Improvements in the driving and safety experience are sure to have notable impacts on the existing infrastructure.

Were the other factors mentioned above resolved with satisfaction, it would seem to make sense for the State of Michigan to proceed with deploying, operating and maintaining a VII system, with the caveat that the State does so soon. The jobs impact to the state could be minimized if Michigan were to wait and other surrounding states implemented their own systems, as some of the job creation could be economized across multiple states with the majority of the employment being located in the state that implements its system first. Additionally, the State of Michigan is synonymous with the automobile industry, and has been for the past century. As the ITS industry matures, it only makes sense that transportation-related—especially highway/motor vehicle—systems be developed first in Michigan, to take advantage of the sheer magnitude of motor vehicle-related engineering firms and people located in the State.

[2] Parry, Ian, Walls, Margaret and Harrington, Winston. "Automobile Externalities and Policies." *Journal of Economic Literature*, Vol. XLV, no. 2 (June 2007): 379.

Appendix A: Methods and Model

The basic approach in these analyses has been to use a specially constructed regional economic impact model, input VII industry-specific data, and generate estimates of the economic contribution associated with the sector on the state economy.

The Macroeconomic Model

For the estimation of employment and compensation associated with the VII program and various industrial sectors in Michigan, we use an economic model supplied and constructed specifically for this study by Regional Economic Models, Inc. (REMI) of Amherst, Massachusetts. We then make adjustments to the model to reflect the general characteristics of the VII program and associated industries. The REMI model, which has been fully documented and peer-reviewed, was designed for the type of analyses employed in this current study and has been used by CAR and other organizations for over two decades for these types of analyses.

The model used for this study is a model comprised of Michigan's economy. The multi-regional property of the model allows the user to "shock" a regional economy by causing a change in the level of employment or output for a given sector. When this activity is performed the model calculates the indirect and induced impact of the change within the region of impact as well as the total amount of inter-state trade affected.

The data input into this model included employment (at the end of 2006) for each affected industry in the state. Before the data was input, it was coded according to the North American Industry Classification System (NAICS).

The general methodology in the analyses is to run baseline simulations for the state's economy, then add jobs in the various VII involved industries and run another set of simulations. The difference between the simulations represents the impact the VII program has on Michigan's economy.

The Center for Automotive Research (www.cargroup.org), a nonprofit organization, is focused on a wide variety of important trends and changes related to the automobile industry and society at the international, federal, state and local levels. CAR conducts industry research, develops new methodologies, forecasts industry trends, advises on public policy, and sponsors multi-stakeholder communication forums.

Development of Estimated Employment Inputs

One step in determining the inputs for the REMI model was to estimate the number of direct employees that a VII system in Michigan will require. A list of 200 example end use cases of VII applications was gathered. From this list, all of the end use cases with similar attributes were combined into one broad use case. For example, the end use cases of a) beacon for child left in vehicle, b) drowsy driver advisory and c) speed limit assistant were combined a broad end use case for in-vehicle driver assistance.

From these broad a grouping of major potential components was created, which helped the authors better articulate what a VII system would look like in the state. These major components are:

highway infrastructure

public transportation

government management of commerce, freight and trucks

private sector management of commerce

internet service providers and call center operations

roadway communications management, regional data collection and analysis

Due to the fact that many of the installations are theoretical in nature, many of the major components listed above were based on various proxies, e.g., the number of large hospitals in Michigan was used as a proxy for the number of potential regional transportation centers for roadway communications management and for public transportation management.

The next step was to assign costs to the broader end use case categories. The U.S. DOT Intelligent Transportation Systems Costs Database (http://www.itscosts.its.dot.gov/) was consulted. The Costs Database includes very detailed costs and employment estimates for specific applications that have been tested in the U.S. within the past 15 years. More than 300 unit cost elements were classified into system cost estimates for broadly defined end use cases for Michigan. All dollars in the Costs Database were adjusted to 2005 dollars.

Table A 1: Labor Estimates **for** Operating a VII System in Michigan

OPERATIONS & MAINTENANCE							
Deployment	Unit of Measure	# Units	Installations	# Full Installation	O&M Cost Per	Total O&M Cost	Employment
Highway infrastructure - federal highways	Miles	1,800	1 per 15 miles	120	50,000	6,000,000	40
Highway infrastructure - state highways	Miles	7,500	1 per 25 miles	300	50,000	15,000,000	100
Public transportation	# Hospitals in Mich	150	Use Hospitals	150	700,000	105,000,000	2,100
Government management of commerce - weigh stations	# in Mich	14	14	14	600,000	8,400,000	112
Private sector management of commerce	Fleet Est based on # trucks		1,000	1,000	375,000	375,000,000	1,500
Internet service providers/Call centers	Based on OnStar and general call center data		10	10	1,500,000	70,000,000	1,400
Roadway communications management	# Hospitals in Mich	150	Use Hospitals	150	378,000	56,700,000	750

Once these numbers were developed, scenarios were next created that altered the percentage of occupations or types of jobs within the VII system.

Table A 2: Occupation Types Assigned by Scenario

Scenario	Constr	Electronics Production	MV Production	Trucking Industry Occupations	Government / Transit Occupations	Telecomm Occupations	Internet Service Providers	Engineering, professional and technical occupations	Management Occupations	Office or Call Center Occupations	Repair and maintenance occupations
High ISP							60	10	10	10	10
Medium ISP				10	10		50	5	10	10	5
High Call Center							10	10	10	60	10
High Call Center with Telecomm						10		5	10	75	
Medium Call Center with Maintenance								25	10	40	25
High R&D							10	60	10	10	10
Medium R&D				10	10		5	50	10	10	5
High Mfg (electronics)		70		10				10	10		
High Mfg (auto parts)			70	10				10	10		
High Trucking				60			10	10	10	10	
High Government					60		10	10	10	10	
High Telecomm						60	10	10	10	10	
Equal Mix		10	10	10	10	10	10	10	10	10	10
Occupation/Industry Scenario	100										
Occupation/Industry Scenario		100									
Occupation/Industry Scenario			100								
Occupation/Industry Scenario				100							
Occupation/Industry Scenario					100						
Occupation/Industry Scenario						100					
Occupation/Industry Scenario							100				
Occupation/Industry Scenario								100			
Occupation/Industry Scenario									100		
Occupation/Industry Scenario										100	
Occupation/Industry Scenario											100
Deployment	70		5		10			5	10		

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Appendix B: Tables

Table B 1: Total Employment, Compensation and Taxes, 2016. 9,000 Direct Employees

				Millions of Current Year, Nominal $	
Model Run Description	Employment	Compensation	Taxes	Contributions to Gov Social Insurance, other Transfers	Net Disposable Income
High ISP	21,378	1,743.7	214.1	183.0	1,346.6
Medium ISP	20,416	1,627.6	200.4	162.8	1,264.4
High Call Ctr	16,754	1,232.5	154.9	81.9	995.7
High Call Ctr with Telecomm	17,010	1,250.5	157.0	82.7	1,010.8
Medium Call Ctr with Maintenance	16,905	1,290.0	162.4	80.6	1,047.0
High R&D	19,676	1,706.1	212.1	137.3	1,356.7
Medium R&D	18,883	1,594.1	198.5	122.9	1,272.7
High Mfg (electronics)	41,490	3,704.4	447.7	466.7	2,790.0
High Mfg (auto parts)	31,518	3,037.2	366.7	325.0	2,345.5
High Trucking	18,848	1,525.8	189.0	124.3	1,212.5
High Govt	16,349	1,154.0	145.1	75.2	933.7
High Telecomm	26,236	2,295.1	280.3	247.8	1,767.0
Equal Mix	25,290	2,166.0	265.0	220.9	1,680.1

Table B 2: Distribution of Total Employment, 2016. 9,000 Direct Employees

Scenario	Direct Industry Employment	Indirect Employment	Expenditure-induced Employment	Capital Investment-related Employment	Export-related Employment	TOTAL	Employment Multiplier
High ISP	9,000	6,117	4,719	1,125	417	21,378	2.4
Medium ISP	9,000	5,515	4,401	1,065	435	20,416	2.3
High Call Ctr	9,000	2,999	3,401	785	569	16,754	1.9
High Call Ctr with Telecomm	9,000	2,933	3,452	1,040	585	17,010	1.9
Medium Call Ctr with Maintenance	9,000	2,825	3,611	848	621	16,905	1.9
High R&D	9,000	4,120	4,860	1,055	641	19,676	2.2
Medium R&D	9,000	3,723	4,528	1,003	629	18,883	2.1
High Mfg (electronics)	9,000	19,093	10,062	2,888	447	41,490	4.6
High Mfg (auto parts)	9,000	11,156	8,580	2,090	692	31,518	3.5
High Trucking	9,000	4,049	4,260	955	584	18,848	2.1
High Govt	9,000	2,848	3,130	859	512	16,349	1.8
High Telecomm	9,000	7,354	6,305	3,063	514	26,236	2.9
Equal Mix	9,000	7,965	5,976	1,800	549	25,290	2.8

Table B 3: Total Employment, Compensation and Taxes, 2016. 3,000 Direct Employees

Model Run Description	Employment	Compensation	Taxes	Contributions to Gov Social Insurance, other Transfers	Net Disposable Income
		Millions of Current Year, Nominal $			
High ISP	7,202	575.0	71.8	40.7	462.5
Medium ISP	6,879	535.8	67.2	33.6	435.0
High Call Ctr	5,660	404.4	52.1	6.7	345.6
High Call Ctr with Telecomm	5,745	410.4	52.8	7.0	350.6
Medium Call Ctr with Maintenance	5,710	423.4	54.5	6.2	362.7
High R&D	6,635	562.2	71.1	25.1	466.0
Medium R&D	6,371	524.8	66.5	20.0	438.3
High Mfg (electronics)	13,886	1,226.0	149.4	134.6	942.0
High Mfg (auto parts)	10,583	1,005.7	122.6	87.6	795.5
High Trucking	6,358	502.1	63.5	20.7	417.9
High Govt	5,521	378.0	48.8	4.3	324.9
High Telecomm	8,821	758.4	93.9	61.9	602.6
Equal Mix	8,505	715.4	88.7	53.0	573.7

Table B 4: Distribution of Total Employment, 2016. 3,000 Direct Employees

Scenario	Direct Industry Employment	Indirect Employment	Expenditure-induced Employment	Capital Investment-related Employment	Export-related Employment	TOTAL	Employment Multiplier
High ISP	3,000	2,043	1,623	321	215	7,202	2.4
Medium ISP	3,000	1,844	1,515	300	220	6,879	2.3
High Call Ctr	3,000	1,009	1,177	207	267	5,660	1.9
High Call Ctr with Telecomm	3,000	987	1,194	292	272	5,745	1.9
Medium Call Ctr with Maintenance	3,000	941	1,247	235	287	5,710	1.9
High R&D	3,000	1,383	1,664	297	291	6,635	2.2
Medium R&D	3,000	1,251	1,553	279	288	6,371	2.1
High Mfg (electronics)	3,000	6,360	3,393	906	227	13,886	4.6
High Mfg (auto parts)	3,000	3,729	2,903	642	309	10,583	3.5
High Trucking	3,000	1,359	1,465	264	270	6,358	2.1
High Govt	3,000	957	1,086	231	247	5,521	1.8
High Telecomm	3,000	2,460	2,147	966	248	8,821	2.9
Equal Mix	3,000	2,664	2,035	545	261	8,505	2.8

Table B 5: Total Employment, Compensation and Taxes, 2016. 1,000 Direct Employees

		Millions of Current Year, Nominal $			
Model Run Description	Employment	Compensation	Taxes	Contributions to Gov Social Insurance, other Transfers	Net Disposable Income
High ISP	2,475	192.1	24.3	0.1	167.7
Medium ISP	2,370	181.7	22.9	0.0	158.8
High Call Ctr	1,964	146.9	17.8	0.0	129.1
High Call Ctr with Telecomm	1,992	148.7	18.0	0.1	130.6
Medium Call Ctr with Maintenance	1,980	153.4	18.6	0.0	134.8
High R&D	2,289	193.2	24.1	0.0	169.1
Medium R&D	2,201	182.5	22.6	0.0	159.9
High Mfg (electronics)	4,701	401.9	50.0	24.4	327.5
High Mfg (auto parts)	3,605	328.8	41.3	8.6	278.9
High Trucking	2,196	174.7	21.6	0.0	153.1
High Govt	1,916	138.8	16.7	0.0	122.1
High Telecomm	3,017	246.3	31.7	0.0	214.6
Equal Mix	2,911	232.0	27.0	5.0	200.0

Table B 6: Distribution of Total Employment, 2016. 1,000 Direct Employees

Scenario	Direct Industry Employment	Indirect Employment	Expenditure-induced Employment	Capital Investment-related Employment	Export-related Employment	TOTAL	Employment Multiplier
High ISP	1,000	690	585	52	148	2,475	2.5
Medium ISP	1,000	624	550	46	150	2,370	2.4
High Call Ctr	1,000	347	436	15	166	1,964	2.0
High Call Ctr with Telecomm	1,000	339	443	43	167	1,992	2.0
Medium Call Ctr with Maintenance	1,000	328	460	22	170	1,980	2.0
High R&D	1,000	471	601	45	172	2,289	2.3
Medium R&D	1,000	427	563	39	172	2,201	2.2
High Mfg (electronics)	1,000	2,129	1,174	247	151	4,701	4.7
High Mfg (auto parts)	1,000	1,253	1,012	160	180	3,605	3.6
High Trucking	1,000	464	533	34	165	2,196	2.2
High Govt	1,000	329	406	22	159	1,916	1.9
High Telecomm	1,000	830	760	267	160	3,017	3.0
Equal Mix	1,000	898	721	127	165	2,911	2.9

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