

Working Paper

Arizona State Freight Plan

(ADOT MPD 085-14)

Phase 3 Working Paper General Manufacturing Sector Profile and Transportation Performance Needs

Prepared for:

Arizona Department of Transportation

Prepared by:

CPCS

In association with:

HDR Engineering, Inc.

American Transportation Research Institute, Inc.

Elliott D. Pollack & Company

Dr. Chris Caplice (MIT)

Plan*ET Communities PLLC (Leslie Dornfeld, FAICP)

Gill V. Hicks and Associates, Inc.

Working Paper

This working paper is one of 10 focusing on key Arizona economic sectors. Its purpose is to document the economic profile, outlook and transportation performance needs of Arizona's general manufacturing sector. This working paper will later inform system improvement needs to increase Arizona's economic competitiveness and growth. This working paper is provided for comment and discussion and should not be interpreted as final.

Acknowledgements

The CPCS team would like to thank the Arizona Department of Transportation (ADOT) for its guidance and input in developing this working paper. The team also recognizes the considerable contribution of general manufacturing sector stakeholders consulted in the development of this working paper.

Opinions

Unless otherwise indicated, the opinions herein are those of the author and do not necessarily reflect the views of ADOT or the State of Arizona.

Contact

Questions and comments on this working paper can be directed to:

Veiko Parming
Analyst
T: 647-479-9802
vparming@cpcstrans.com

Donald Ludlow
Project Manager
T: +1.202.772.3368
dludlow@cpcstrans.com

Cover Photo Credit : iStockPhoto.com

Table of Contents

Executive Summary.....	i
Acronyms and Abbreviations.....	iii
1 Introduction	1
1.1 Introduction: Why an Arizona State Freight Plan?.....	2
1.2 Project Objectives	2
1.3 Purpose of this Working Paper	2
1.4 Methodology	3
1.5 Limitations.....	3
2 General Manufacturing Sector Profile	4
2.1 Overview of General Manufacturing Sector	5
2.2 Economic Profile and Importance to Arizona’s Economy.....	5
2.2.1 GDP and Commodity Flows	5
2.2.2 Commodity Flows	6
2.2.3 International Trade	7
2.2.4 Employment and Wages	9
2.3 Locations and Traffic Profile.....	9
2.3.1 Activity Clusters.....	10
2.3.2 Major Origins and Destinations	13
2.3.3 Modal Breakdown.....	13
3 Supply Chain Structure and Transportation Performance Parameters	15
3.1 Supply Chain Structure	16
3.2 Transportation Performance Parameters	19
3.3 Barriers to Transportation Performance.....	20
3.4 Trends and Implications	21
4 Sector Priorities for Transportation System Performance Improvement	23
4.1 Priority Improvements Needs	24
Appendix A: List of Stakeholders Consulted	25

Executive Summary

Economic and Traffic Profile

Arizona's general manufacturing sector is very diverse. In terms of tonnage, the sector is dominated by non-metallic mineral products manufacturing, which is locally oriented and produces low-value, high-density products such as cement, stone, and concrete. On the other end of the spectrum in terms of value added, chemical manufacturing (which includes pharmaceuticals) and fabricated metal products manufacturing combine to produce nearly 50 percent of total value. These are more nationally oriented in terms of demand potential and correspond to Arizona industrial clusters – bioscience in the former case, and supplying the aerospace and defense industry in the latter.

	Measure	General Manufacturing Sector	Arizona (Statewide)
Economy	GDP (2012, \$ million)	\$7,625	\$271,503
	GDP Annualized Growth (1997-2012)	3.01%	4.9%
Jobs	Employment (2013)	53,576	2,619,055
	Compensation per Employee (2013)	\$64,574	\$57,393
Transportation	Total Commodity Flows (2012, Mt)	28.0	138.2
	Top Origin (2012, Mt)	California (1.6 Mt)	California (9.5 Mt)
	Top Domestic Destination (2012, Mt)	California (1.2 Mt)	Mexico (5.6 Mt)
	Intrastate Flows (2012, Mt)	20.6	101.8
	% Truck (2012)	90.4%	87.2%
Source: CPCS Analysis of data from Bureau of Economic Analysis and 2012 Commodity Flow Survey			

The general manufacturing sector in Arizona contributed \$38.5 billion to the state's gross domestic product (GDP) in 2012, or 2.8 percent of the state's total output. Since 1997, GDP in the general manufacturing sector has grown at an annualized rate of 3 percent per annum, growing slower than the statewide average of 4.9 percent.

In 2012, \$16.1 billion of general manufacturing goods that originated in other states were moved to Arizona, \$8.4 billion of goods originated in Arizona were destined for other states, and \$4.5 billion in goods were moved within the state of Arizona. The major trading partners nationally were California and Texas, and internationally Mexico and Asia.

The biggest concentrations of employment are located in Phoenix – mostly in the southern part of the metropolitan area, as well as Casa Grande and Tucson.

Overall, truck is the major mode for general manufacturing commodities. Around 20 percent of inbound and outbound freight is by rail (in terms of tonnage). Air and multiple modes account for over 20 percent (combined) of outbound freight by value. Almost all intrastate shipments are moved by trucks.

Figure ES-1-1: Subsectors by Tonnage

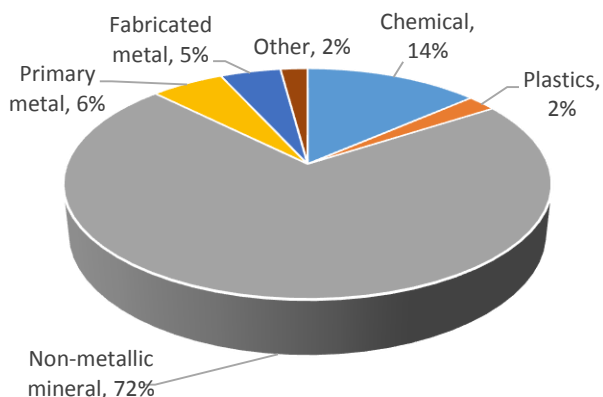
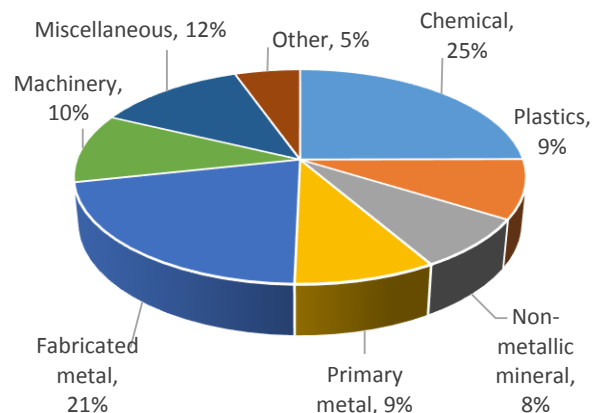


Figure ES-1-2: Subsectors by Value of Shipments



Source: Commodity Flow Survey 2012, for shipments originating in Arizona. Tonnages for NAICS 315, 332 and 333 not available, estimated from shipment values and national average value densities

Supply Chain Structure and Transportation Performance Needs

The supply chains of general manufacturers are highly diverse. At one end, cement and concrete supply chains are highly localized and dependent on trucking, while at the other end, higher-value product supply chains (like pharmaceuticals) are increasingly globalized and rely on truck and air. In between are a large array of companies with a national orientation manufacturing parts, components, and equipment. Others, especially in fabricated metal manufacturing, predominantly serve local customers, such as aerospace companies. The different supply chains lead to diverse transportation priorities, but on the whole general manufacturers in Arizona are somewhat more removed from transportation issues than companies in other sectors.

Supply and demand issues also vary by region. Nearly every manufacturing sector has been, and will continue to be, impacted by reductions in federal government spending. This complicates forecasting future supply and demand, and thus transportation needs. Federal government spending reductions disproportionately impact Southern Arizona economic regions, not only in general manufacturing but also high tech manufacturing and even research and development.

Notable Barriers and Related Priority Improvements to Enhance Competitiveness and Growth

Road construction could be better coordinated, especially in less dense areas, taking better account of oversize restrictions. Arizona's commercial vehicle weight restrictions are lower than neighboring states such as Nevada and Utah. Increasing allowable vehicle weights could lead to greater efficiencies and remove trucks from the road.

Improved international connections at Phoenix Sky Harbor International Airport (PHX) would help make Phoenix more competitive for companies with an international orientation.

The issues related to delay and uncertainty at West Coast ports in 2014-2015 negatively affected manufacturers that relied on those ports for sourcing or exports. There is a hope that in the future a Mexican port may serve as a viable alternative for Arizona manufacturers.

Acronyms and Abbreviations

ACA	ARIZONA COMMERCE AUTHORITY
ADOT	ARIZONA DEPARTMENT OF TRANSPORTATION
API	ACTIVE PHARMACEUTICAL INGREDIENT
CFS	COMMODITY FLOW SURVEY
CNC	COMPUTER NUMERICAL CONTROL
GDP	GROSS DOMESTIC PRODUCT
GPO	GROUP PURCHASING ORGANIZATION
JIT	JUST-IN-TIME
MPD	MULTIMODAL PLANNING DIVISION
Mt	MILLION TONS
PHX	PHOENIX SKY HARBOR INTERNATIONAL AIRPORT
SAR	SPECIAL ADMINISTRATIVE REGION
TUS	TUCSON INTERNATIONAL AIRPORT

1 Introduction

Key Messages

The Arizona Department of Transportation, Multimodal Planning Division, retained a team led by CPCS Transcom, Inc. to assist in the development of Arizona's State Freight Plan.

The aim of this working paper is to establish the freight transportation performance needs, outlooks, and economic contribution of Arizona's general manufacturing sector (defined here as NAICS Codes 313-315, 325-327, 331-333, 337, 339). This will later inform the analysis of broader transportation system based needs and priorities.

This working paper was developed in large part through stakeholder consultations and analysis of general manufacturing sector data.

1.1 Introduction: Why an Arizona State Freight Plan?

Arizona's economic potential is supported by the state's transportation infrastructure, which connects sources of production to markets.

When transportation infrastructure and related services are efficiently designed and competitively positioned, businesses benefit from lower transportation costs, faster and better transportation services, and increased reliability, which in turn contribute to their own competitiveness and growth, and that of the broader region.

Jurisdictions with access to competitive transportation infrastructure and services are at a competitive advantage in attracting investment, creating jobs and realizing economic growth. Arizona's State Freight Plan can help enable this outcome.

To this end, the ADOT's Multimodal Planning Division (MPD), is developing Arizona's State Freight Plan which will provide strategic guidance to enhance Arizona's economic competitiveness and facilitate economic growth.

1.2 Project Objectives

The State Freight Plan will define immediate and long-range investment priorities and policies that will generate the greatest return for Arizona's economy, while also advancing other key transportation system goals, including national goals outlined in MAP-21. It will identify freight transportation facilities in Arizona that are critical to the State's economic growth and give appropriate priority to investments in such facilities.

The State Freight Plan will ultimately provide Arizona with a guide for assessing and making sound investment and policy decisions that will yield outcomes consistent with the state's visions, goals, and objectives, and notably, promote regional competitiveness and economic growth.

1.3 Purpose of this Working Paper

Since it is economic activity – particularly from goods movement sectors - that drives demand for freight transportation infrastructure and services, optimization of the state's freight transportation system, and related strategies, goals and investments, must start by addressing the transportation performance needs of the sectors moving freight. Yet the transportation performance needs of freight can differ by sector and commodity group, locations, and even company.

For this reason, the team identified 10 key freight sectors in Arizona for specific focus: wholesalers and retailers, food and beverage, high-tech manufacturing, general manufacturing, transportation equipment manufacturing, transportation and logistics, mining (except oil and gas), energy (oil and gas), agriculture, and forestry.

The purpose of this working paper is to provide a focused assessment of the transportation performance needs, outlooks and economic contribution of the general manufacturing sector (defined here as NAICS Codes 313-315, 325-327, 331-333, 337, 339).

Specifically, it addresses the following key questions:

- At a high level, what is the profile and economic contribution of general manufacturing to Arizona's economy?
- How do the supply chains of Arizona's general manufacturing sector utilize the transportation system and what are the major origins, destinations, intermediate points, and final products of these chains?
- How are general manufacturing supply chains structured and managed, and what are the primary drivers of transportation decisions and related performance needs?
- What are the key trends in the general manufacturing, how are these influencing freight flows, and what are the implications, opportunities and challenges for the competitiveness of Arizona's freight system going forward?

1.4 Methodology

This working paper is informed by a combination of literature review, data collection and analysis, and consultation with general manufacturing stakeholders. Documents reviewed are footnoted throughout the working paper, as appropriate. A list of individuals consulted is provided in Appendix A (unless the stakeholder has specifically requested non attribution).

1.5 Limitations

This working paper is in many cases informed by data and input provided by third parties. CPCS has verified this information to the extent possible through analysis and cross-checking with other sources but cannot guarantee the accuracy of data received from third parties.

2

General Manufacturing Sector Profile

Key Messages

The general manufacturing sector is very diverse. It includes non-metallic mineral products, chemical products, fabricated metal products, machinery, and other industries.

The general manufacturing sector in Arizona contributed \$38.5 billion to the state's GDP in 2012, or 2.8% of the state's total output. In 2012, \$16.1 billion of goods originated in other states and were destined to Arizona, \$8.4 billion originated in Arizona and were destined for other states, and \$4.5 billion in goods traveled within the state of Arizona.

The major trading partners nationally were California and Texas, and internationally Mexico and Asia.

2.1 Overview of General Manufacturing Sector

Arizona's general manufacturing sector is very diverse. From a freight tonnage perspective the sector is dominated by non-metallic mineral products manufacturing, which is locally oriented and produces low value-density products such as cement, stone, and concrete. Non-metallic mineral products represent 19.2 Mt of 26.8 Mt (72%) of an Arizona-origin freight tons.

From a value perspective, chemical manufacturing (which includes pharmaceuticals) and fabricated metal products manufacturing combine to produce nearly 50 percent of total value (\$5.1 b. and \$4.4 b., respectively, of a total \$20.4 billion). These are more nationally oriented and correspond to Arizona industrial clusters – bioscience in the former case, and supplying the aerospace and defense industry in the latter.

Figure 2-1: Subsectors by Tonnage

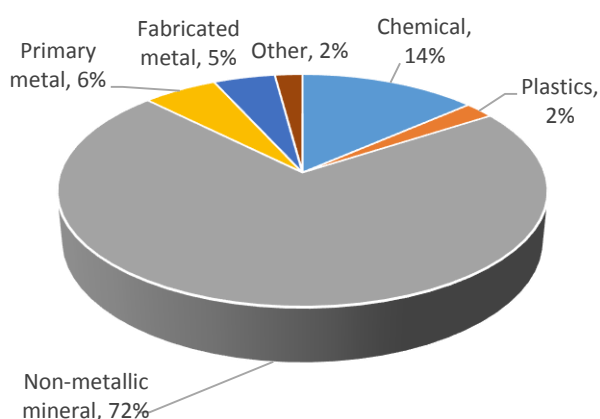
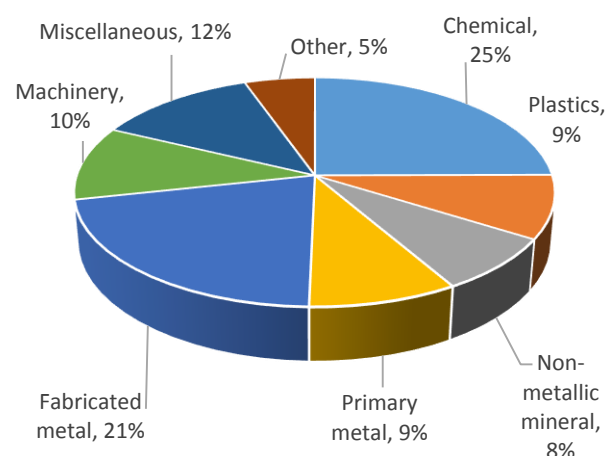


Figure 2-2: Subsectors by Value of Shipments



Source: Commodity Flow Survey 2012, for shipments originating in Arizona. Tonnages for NAICS 315, 332 and 333 not available, estimated from shipment values and national average value densities

For the purpose of this paper, general manufacturing excludes high-tech (electronic products, semiconductors), transportation (including aerospace), food and beverage, forestry and paper products, and petroleum and coal products, each of which is the subject of a separate working paper.

2.2 Economic Profile and Importance to Arizona's Economy

2.2.1 GDP and Commodity Flows

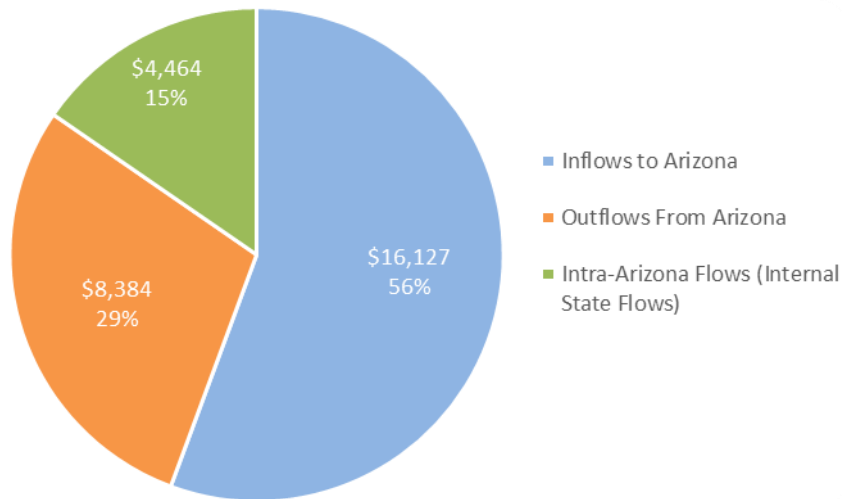
The general manufacturing sector in Arizona contributed \$38.5 billion to the state's GDP in 2012, or 2.8 percent of the state's total output. Since 1997, GDP in the general manufacturing sector has grown at an annualized rate of 3 percent per annum, growing slower than the statewide average of 4.9 percent.¹

¹ Bureau of Economic Analysis Regional Economic Accounts, GDP by State. GDP in current dollars.

2.2.2 Commodity Flows

Overall, \$29 billion of goods from the general manufacturing sector traveled into, out of, or within the state of Arizona in the year 2012. Of this, \$16.1 billion of goods originated in other states and were destined to Arizona, \$8.4 billion originated in Arizona and were destined for other states, and \$4.5 billion in goods traveled within the state of Arizona.

Figure 2-3: Value of Flows Into, out of, and Within Arizona in 2012 (\$millions)

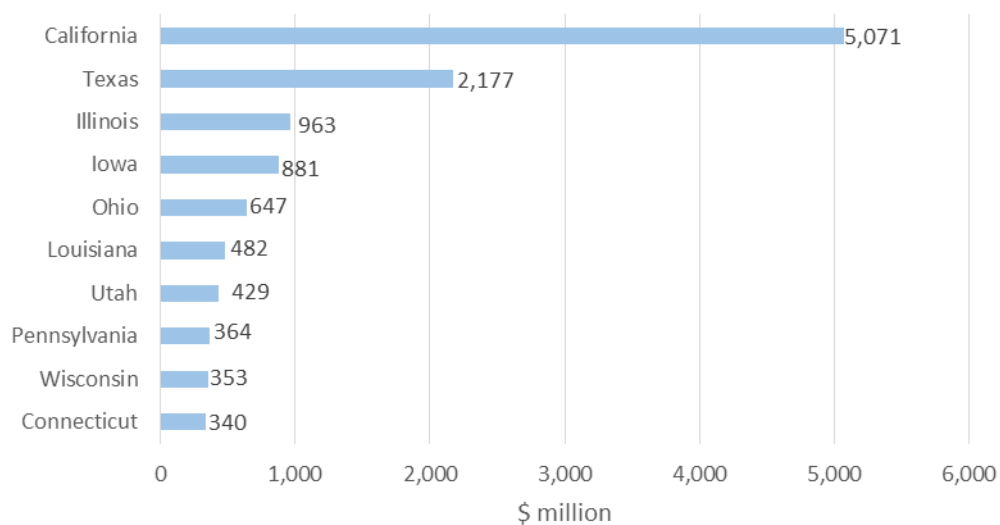


Source: CPCS analysis of Commodity Flow Survey, 2012.

Origins of Domestic Inflows to Arizona

The figure below summarizes the origins of general manufacturing products that were shipped to Arizona from other states. California was the largest origin of general manufacturing goods destined for Arizona with \$5.1 billion in products, followed by Texas and Illinois at \$2.2 billion and \$963 million respectively.

Figure 2-4: Value of Top 10 General Manufacturing Sector Inflows to Arizona by State or Origin (2012)

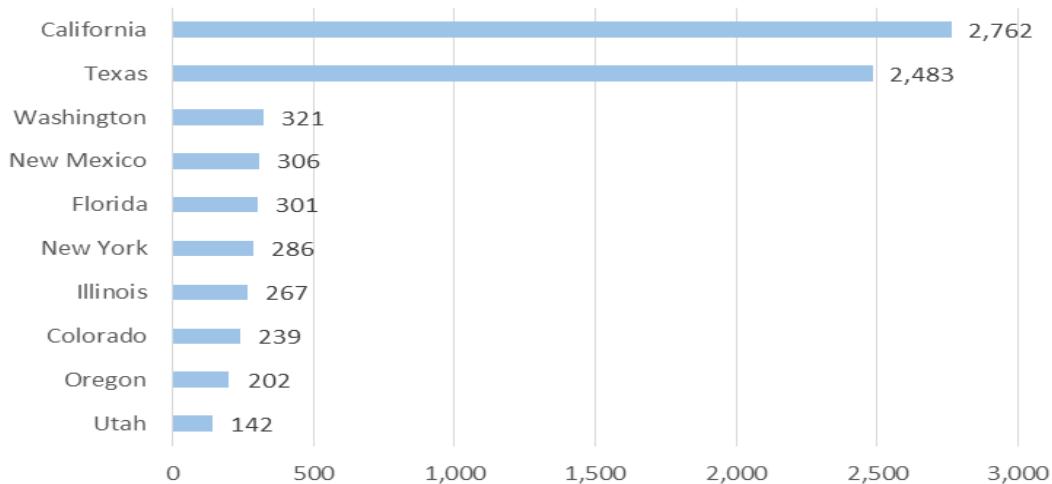


Source: CPCS analysis of Commodity Flow Survey, 2012.

Destinations of Domestic Outflows From Arizona to Other States

The figure below summarizes the destination of general manufacturing products originating in Arizona. California was the largest destination of Arizona manufacturing products, where \$2.8 billion worth of products originating in Arizona were destined, followed by Texas with \$2.5 billion in outflows from Arizona in the sector. Some of these flows may have been subsequently destined for international destinations (export via ports in California or border crossings in Texas).

Figure 2-5: Value of Top 10 General Manufacturing Sector Outflows from Arizona by State of Destination (2012)

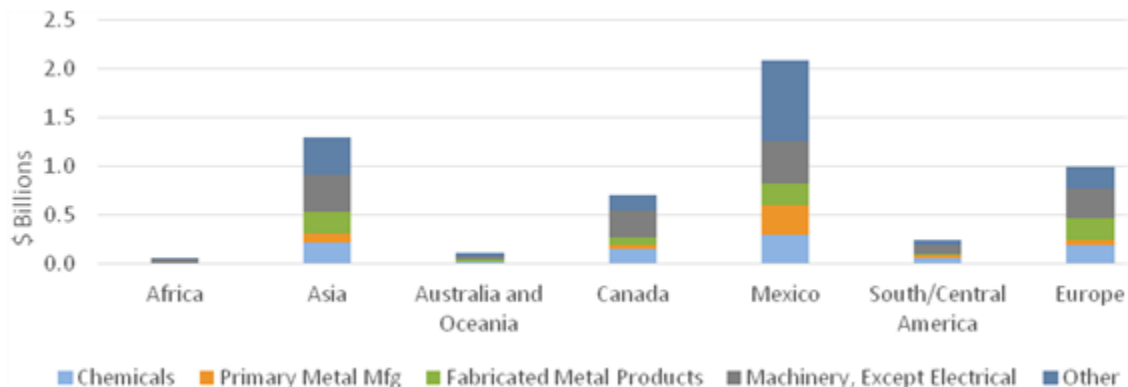


Source: CPCS analysis of Commodity Flow Survey, 2012

2.2.3 International Trade

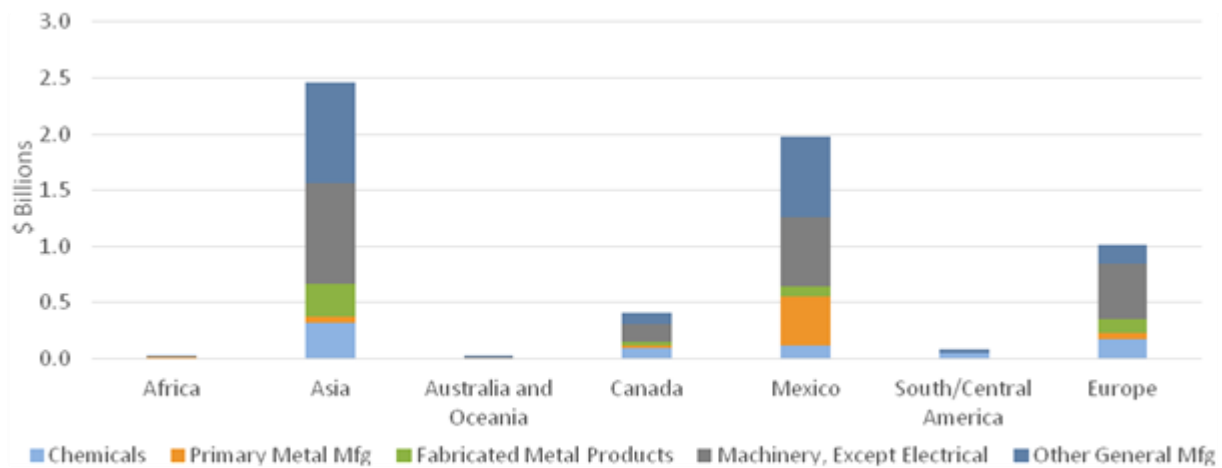
Exports from Arizona in the general manufacturing sector totalled \$5.5 billion in 2014 while imports were registered at \$6.2 billion. The largest destinations for exports of goods from the general manufacturing sector was Mexico, followed by Asia. On the import side, the largest origin was Asia.

Figure 2-6: Destinations of Arizonan International Exports in the General Manufacturing Sector (2014)



Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

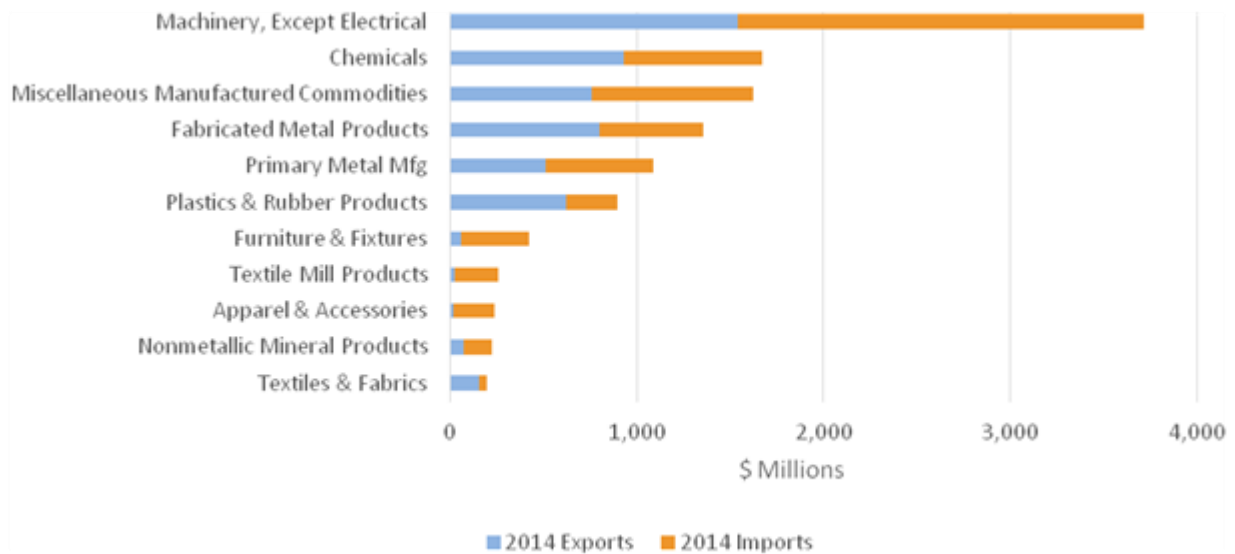
Figure 2-7: Origins of Arizonan International Imports in the General Manufacturing Sector (2014)



Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

General machinery is the largest generator of international trade in the sector to and from Arizona, generating \$2.2 billion in imports and \$1.5 billion in exports in 2014.

Figure 2-8: Top Traded Products in the General Manufacturing Sector (2014)

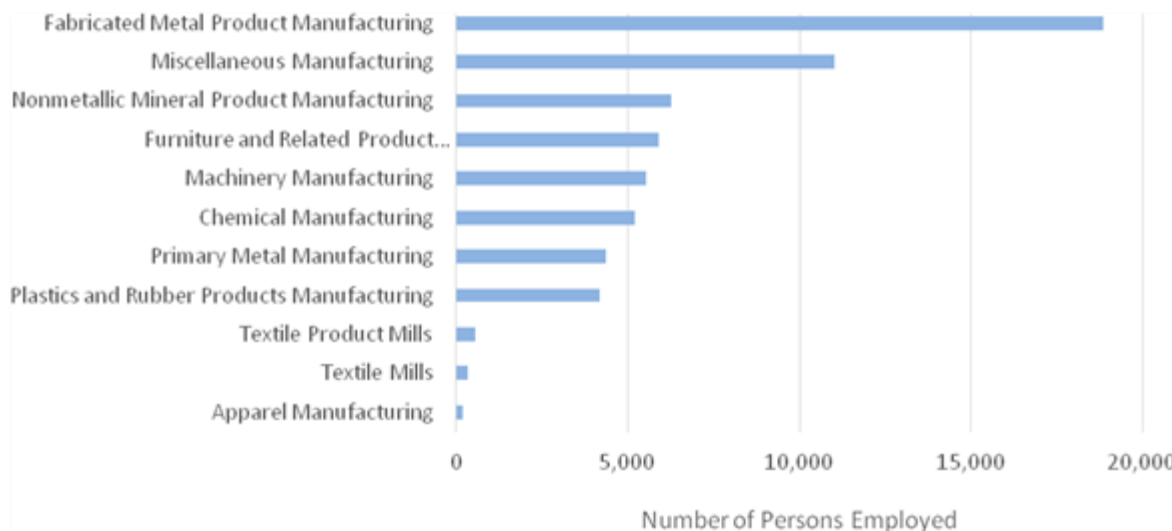


Source: CPCS analysis of United States Census Bureau Electronic Export Information. Accessed April 2015.

2.2.4 Employment and Wages

In 2013 the sector employed 53,576 people (excluding self-employment), representing 2 percent of total employment in the State.² The total wages and salaries paid to employees in 2013 was approximately \$3.5 billion dollars,³ making the average annual earnings per employee in 2013 approximately \$64,500 for the sector. (Notably, some of the industries have a small sample size).

Figure 2-9: Breakdown of Employment in the General Manufacturing Industry in Arizona



Source: CPCS Analysis of Quarterly Workforce Indicators dataset, United States Census Bureau

The largest industry generating employment in the general manufacturing sector is fabricated metal product manufacturing, which includes mostly products related to architectural and structural metals and machine shop products. The second largest industry is miscellaneous manufacturing, which is dominated by medical equipment and supplies production.

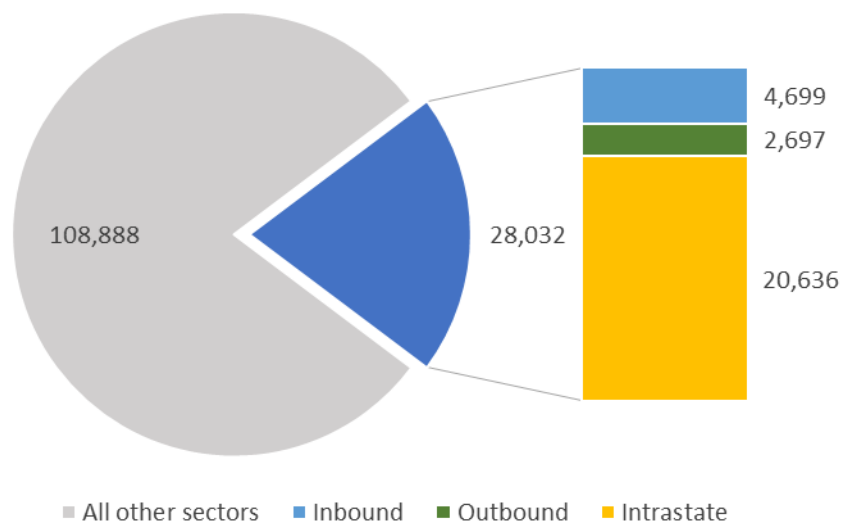
2.3 Locations and Traffic Profile

As illustrated in Figure 2-10, the general manufacturing sector (shaded dark blue) generates over 20 percent (28 Mt) of Arizona's total freight volumes. The majority of these flows (20 Mt or 74 percent) are transported within the state. Over 4.5 Mt are inbound freight from other states, some of which are likely coming from overseas, and over 2.5 Mt go out to other states, some of which are likely exported overseas.

² Bureau of Economic Analysis Regional Economic Accounts, Personal Income and Employment by State. SA27N Wages and Salaries by NAICS Industry

³ Bureau of Economic Analysis Regional Economic Accounts, Personal Income and Employment by State. SA6N Wages and Salaries by NAICS Industry

Figure 2-10: Arizona General Manufacturing Sector Volume ('000 Tons)



Source: CPCS analysis of Commodity Flow Survey, 2012.

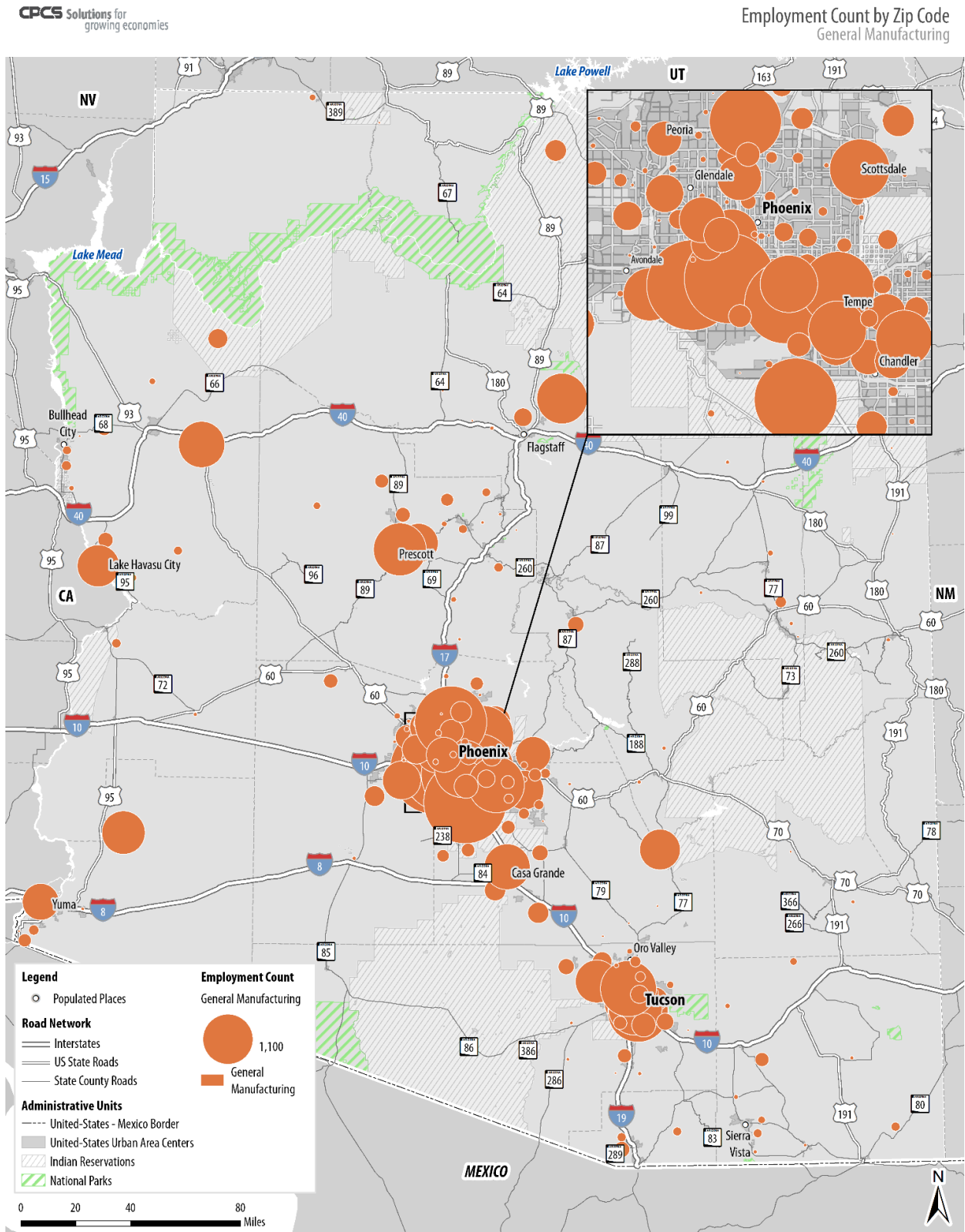
The numbers presented are obtained from the Commodity Flow Survey (CFS), 2012. CFS accounts for only domestic movements. These include domestic shipments as well as the domestic components of international supply chains.⁴ Not included are wholesale and retail shipments, as these are part of a separate working paper on the wholesale and retail sector.

2.3.1 Activity Clusters

The activity clusters of general manufacturing are illustrated in Figure 2-11. The biggest concentrations of employment are located in Phoenix (mostly in the southern part of the metropolitan area), as well as Casa Grande and Tucson.

⁴ In CFS, the sum of individual state volumes is slightly lower than the national volume which is due to data suppression and rounding in individual state-to-state movements. For consistency across all the graphics (maps and charts), this paper presents the total of state level volumes.

Figure 2-11: Arizona General Manufacturing Sector Employment Clusters



Source: CPCS analysis of County Business Pattern Data, 2013 by U.S. Census Bureau.

The commodity flow information was extracted from Global Insight's Transearch dataset for 2013. Only Arizona-generated (originated or destined) flows are shown in the map (e.g. the map excludes any through traffic). The major corridors used by this sector are I-10, I-17, and I-40 east of Flagstaff. The sector uses I-10 extensively because California and Texas are the biggest domestic trade partners of Arizona in terms of manufactured commodities.

Annual Outbound Tons Per Sq. Mile

5,001 - 10,000
10,001 - 25,000
25,001 - 50,000
50,001 - 100,000
100,001 - 200,000
Above 400,000

Annual Tonnage 2013

< 125,000
125,000 - 400,000
400,000 - 800,000
800,000 - 1,250,000
1,250,000 - 2,000,000
> 2,000,000

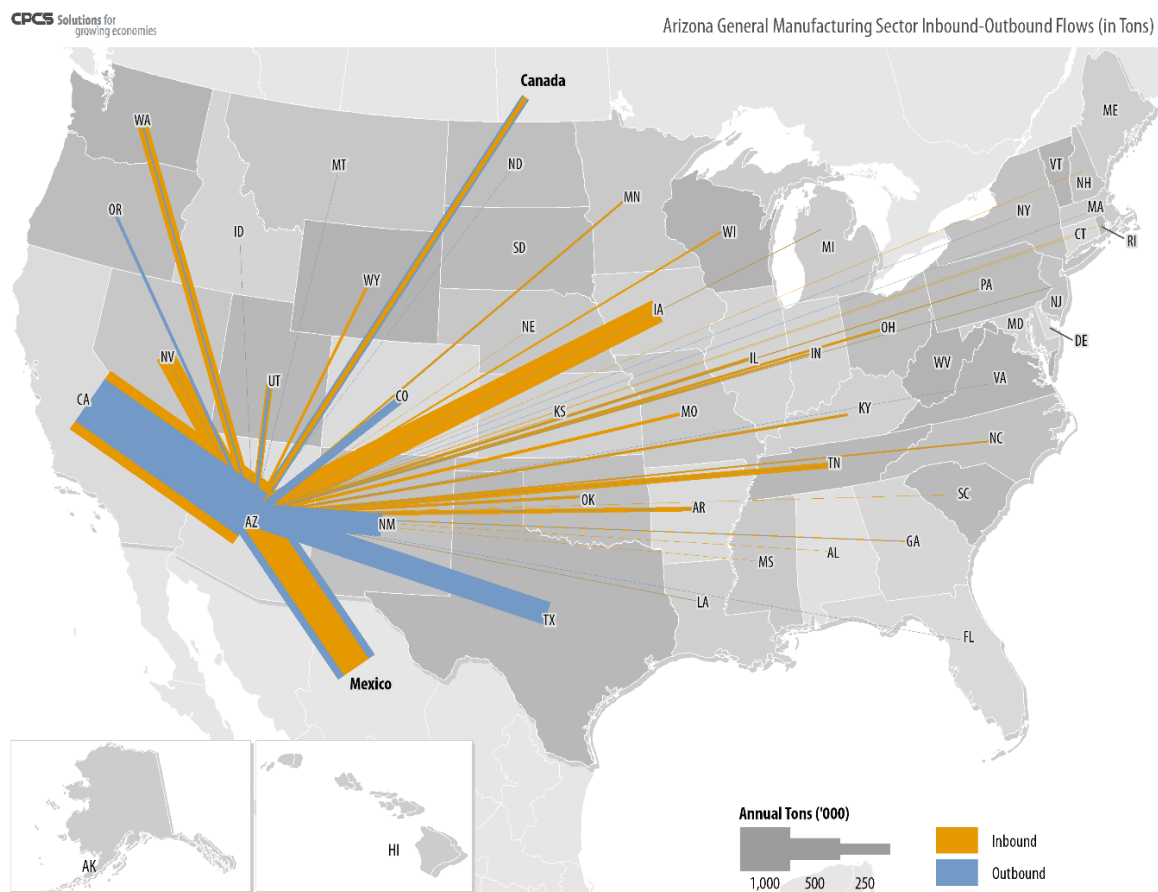
Annual Tonnage: Originating and Destined to Arizona
General Manufacturing

CPCS

2.3.2 Major Origins and Destinations

The origins and destinations of Arizona's freight flows are varied, with 5.5 Mt of inbound and 3.9 Mt of outbound traffic. Mexico is an important international trade partner, accounting for 12.5 percent of all inbound traffic, and 26 percent of all outbound traffic. In terms of domestic flows, California is the single most important domestic trade partner of Arizona's general manufacturing sector (for both inbound and outbound traffic) – Arizona receives more than a third (1.6 Mt) of its inbound domestic freight from California, and just less than half (1.1 Mt) of its domestic outbound tonnages go to California. Other inbound movements originate from across the country, notably from Iowa, Washington, and Nevada. Domestic outbound flows are generally limited to nearby states, like New Mexico, Texas and Colorado.

Figure 2-13: Arizona General Manufacturing Sector Inbound-Outbound Tonnages



Source: CPCS analysis of Commodity Flow Survey, 2012. The import/export figures were obtained from Freight Analysis Framework 3 estimates for 2012

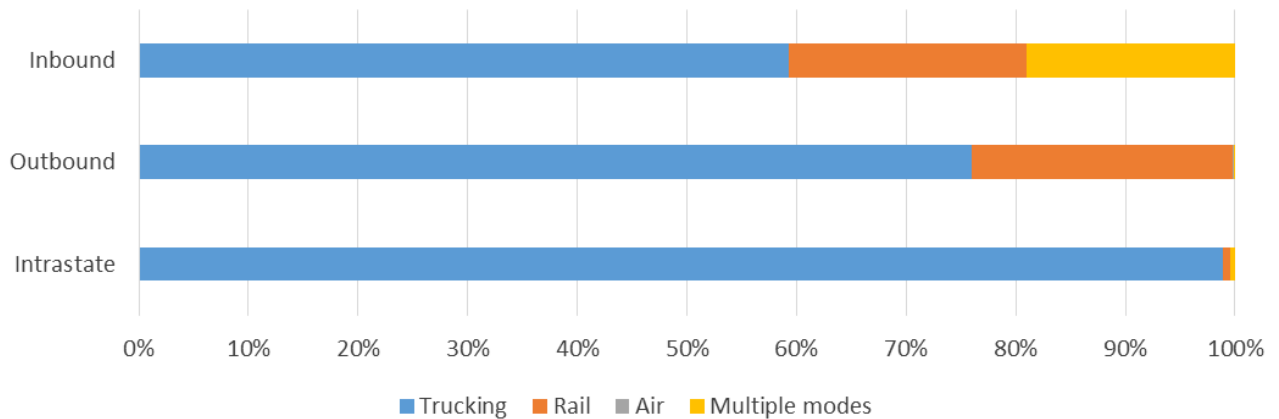
2.3.3 Modal Breakdown

Overall, trucking is the major mode for transportation of general manufacturing commodities, in terms of both volume (Figure 2-14) and value (Figure 2-15).⁵ In terms of tonnage, railways

⁵ Individual mode volumes may not sum to the aggregate "All Modes," which is due to data suppression and rounding at detailed mode level.

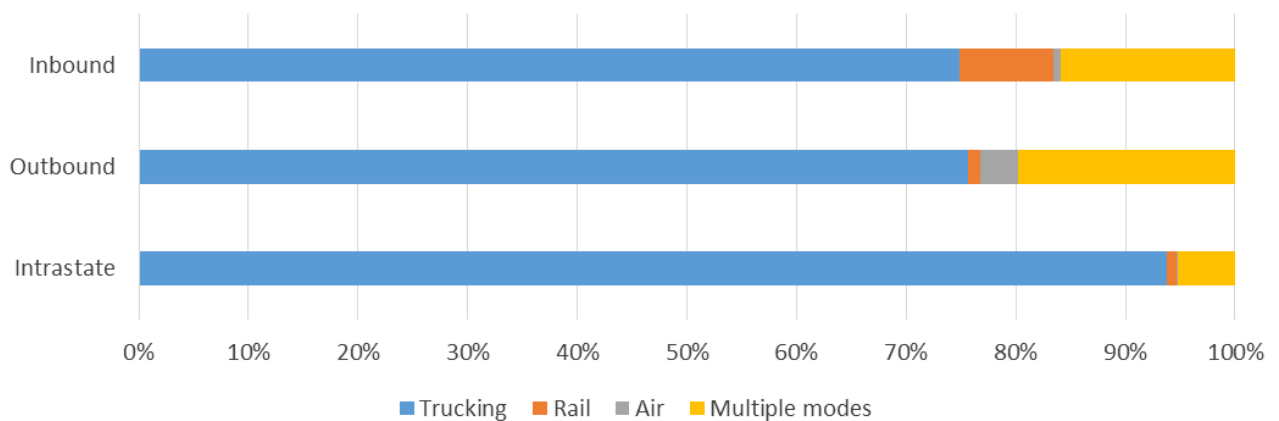
carry a significant proportion of inbound and outbound freight (more than 20 percent), though the dollar value of such shipments is under five percent. A notable portion of inbound tonnage is multimodal (truck and rail), but not on the outbound side. In terms of dollar value, more than three percent of the total share is shipped by air and around 20 percent use multiple modes, including small package and parcel. The dominance of trucking is even more pronounced for intrastate shipments, nearing 100 percent. As expected, railways are used to transport heavier but low-value commodities and air is used to ship lighter but more valuable commodities.

Figure 2-14: Arizona General Manufacturing Sector Volume (Tons) by Mode



Source: CPCS analysis of Commodity Flow Survey, 2012.

Figure 2-15: Arizona General Manufacturing Sector \$ Value by Mode



Source: CPCS analysis of Commodity Flow Survey, 2012.

3

Supply Chain Structure and Transportation Performance Parameters

Key Messages

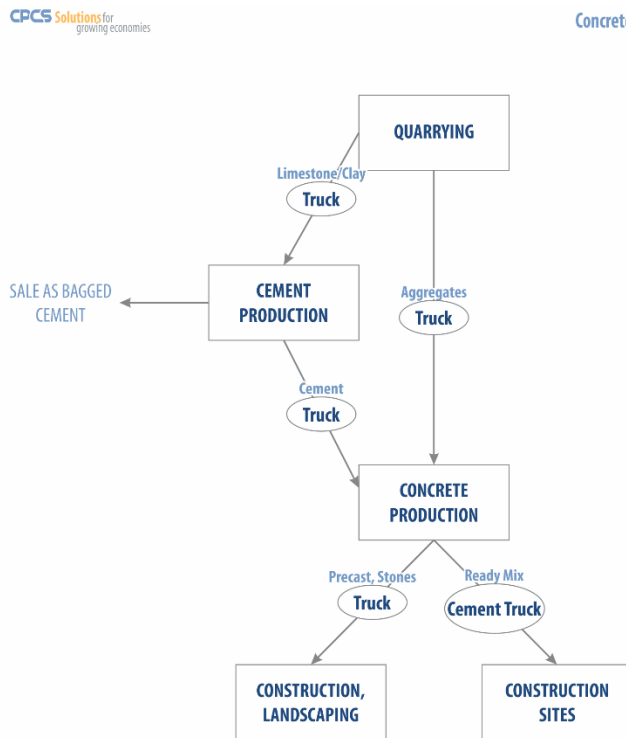
The supply chains of general manufacturers are highly diverse. At one end of the spectrum, cement and concrete supply chains are highly localized and dependent on trucking as a mode of transportation. At the other end, the supply chains of high-value products such as pharmaceuticals are increasingly globalized and rely on both trucking and air (and, as of fairly recently, ocean shipping).

The different supply chains also led to differences in transportation priorities. However, on the whole it seems general manufacturers in Arizona are somewhat more removed from transportation issues than companies in other sectors.

3.1 Supply Chain Structure

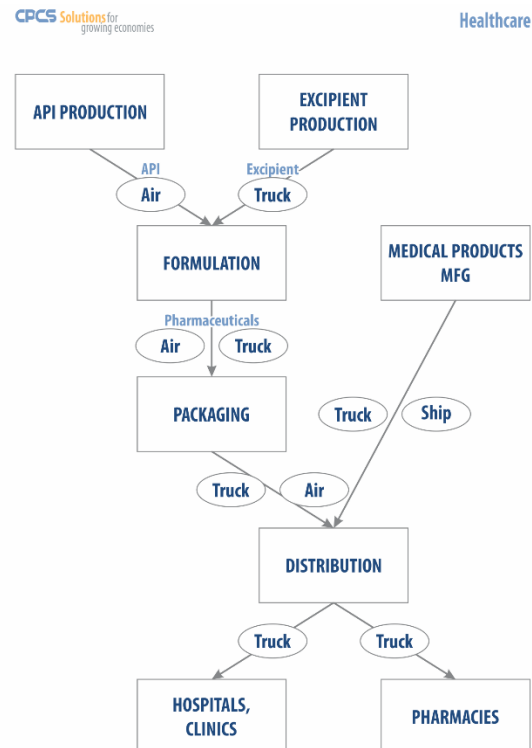
General manufacturing covers a diverse array of commodities with distinct supply chains, including fabricated metal products, pharmaceuticals, medical devices, machinery, plastics, and cement and concrete, among others. Figures Figure 3-1 and Figure 3-2 show supply chains representing industries at different ends of the value density spectrum: concrete and healthcare.

Figure 3-1: Cement & Concrete Supply Chain



Source: CPCS

Figure 3-2: Healthcare Supply Chain



Shipments of cement and concrete products in Arizona are low in value but relatively high in tonnage. In this supply chain, raw materials (limestone, clay) are heated into clinker and then grinded into cement. The vast majority of cement is sold bulk to concrete manufacturers, while some is bagged for retail sale.⁶ Concrete is made by combining aggregates, cement, water, and additives (and steel rebar in the case of precast). The majority of concrete (70 percent) is produced as ready-mix⁷ (delivered to a construction site by truck in unhardened form), while the rest is produced as a finished product (precast concrete, concrete landscaping products). Ready-mix concrete is a somewhat atypical example of a low-value product that is nonetheless

⁶ Agudelo, Isabel. "Supply Chain Management in the Cement Industry." MIT, 2009.

⁷ PCA, Cement Industry Overview, Economics of the U.S. Cement Industry, 2013.

very time-sensitive due to its perishability. The cement and concrete industries are local or regional rather than national or international.

Shipments of pharmaceuticals represent 16 percent of total shipments originating in Arizona across all sectors, according to the 2012 CFS. Although most of these are from distributors, there is also some manufacturing in the state. The healthcare industry also includes medical devices (these comprise most of the “miscellaneous manufacturing” category⁸ and cover everything from hospital consumables to diagnostic imaging equipment and prosthetic devices).

Pharmaceuticals are manufactured by combining active pharmaceutical ingredients (APIs) with inert ingredients called excipients. While end-use pharmaceuticals are traditionally developed and made in the U.S. and Western Europe, APIs are often sourced from China or India.⁹ Excipients, which give the drug its physical form, may be chemical ingredients produced primarily for other industries, such as food and beverages. Medical devices are often manufactured in Asia, especially high volume, labor-intensive items; others are manufactured domestically or near-shored, for example in Mexico. Because of the higher value density, more exacting temperature control requirements, and often greater time sensitivity, the pharmaceutical supply chain is more dependent on air and trucking, while the medical device supply chain relies on ocean shipping and trucking. Arizona’s bioscience industry is not a national hub like San Diego, Boston, or New Jersey, but is growing, with notable competencies such as biopharma.¹⁰

Another important part of the sector is fabricated metal products, which includes for example metal parts makers and computer numerical control (CNC) machining specialists. This industry has a low degree of concentration (e.g. few large companies, many small companies) and many companies appear to rely heavily on customers in the local aerospace industry. Despite the high employment (see Figure 2-9), the freight impact both by tonnage and volume is more modest. Interviews revealed that the customer generally arranges

PING

PING is a manufacturer of golf equipment located in Phoenix since 1961. The company produces golf clubs, accessories and apparel for sale by sporting retailers across the country, as well as for numerous professional

golfers on the PGA Tour, such as Bubba Watson. PING’s Phoenix manufacturing center serves customers nationwide. As golf equipment is neither high volume nor extremely time critical, PING’s challenge in getting product to customers has more to do with manufacturing turnaround than with the transportation system. Nonetheless, on-time performance is an important criterion for the company’s transportation providers.



Text Source: Ping website; Cook, Bob. “How a declining middle class is killing golf.” *Forbes*, May, 2014; consultations. Photo Source: Ping website.

⁸ Detailed flow data are not available but employment in 3391 Medical Supplies and Equipment is about 75% of 339 Miscellaneous Manufacturing for the state of Arizona, according to Census data

⁹ International Trade Administration, “Pharmaceutical Industry Profile.” 2010.

¹⁰ Flinn Foundation. “Arizona’s Bioscience Roadmap, 2014-2025.”

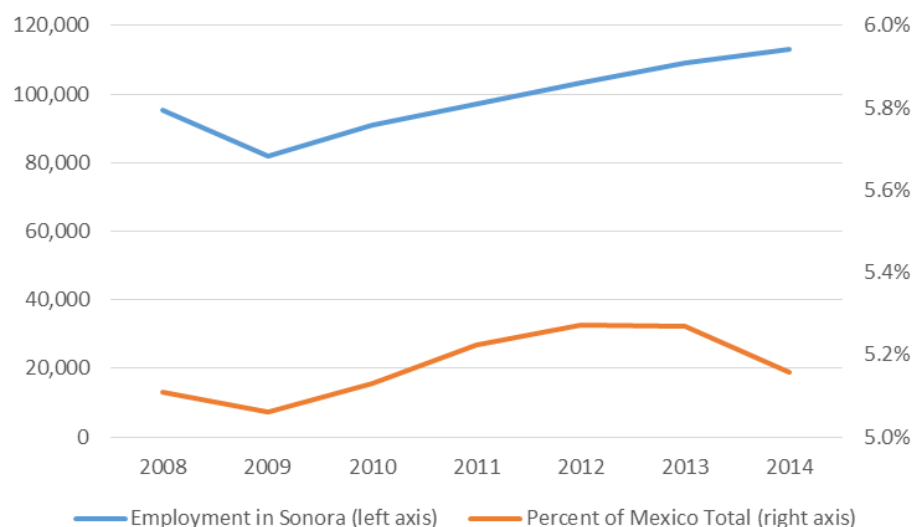
transportation of the assemblies or parts to and from their facilities, typically by FedEx or United Parcel Service (UPS).

The general manufacturing sector is too diverse to be fully covered in a few paragraphs. Among the general manufacturers in Arizona are companies making specialty equipment, parts, and components. One such company, the golf equipment manufacturer PING, is profiled in the text box on the previous page. Many companies tend to be nationally oriented, possibly with a few suppliers or customers overseas. However, others, especially in fabricated metal manufacturing, predominantly serve local customers, such as aerospace companies.

Supply and demand issues also vary by region. Nearly every manufacturing sector has been, and will continue to be, impacted by reductions in federal government spending. This complicates forecasting future supply and demand, and thus transportation needs. Federal government spending reductions disproportionately impact Southern Arizona economic regions, not only in general manufacturing but also high tech manufacturing and even research and development.

The maquiladora economy of Nogales, Sonora is also worth noting. Although outside Arizona, the maquiladoras have many cross-border linkages since much of their trade is with the U.S. and in many cases the owners are also U.S.-based. Since the 1960s, the sector has evolved over time, becoming more complex and focusing on just-in-time delivery rather than simply wage competitiveness. The maquiladora economy in Nogales, which employs 35,000, includes various general manufacturers, but much electronics and parts production/assembly is oriented towards the auto industry and, increasingly, the aerospace industry.¹¹

Figure 3-3: Employment in IMMEX (Maquiladora) Program, Sonora, 2008-2014



Source: Instituto Nacional de Estadística y Geografía (INEGI); also: Arizona Eller, Arizona-Mexico Economic Indicators: IMMEX Program Employment

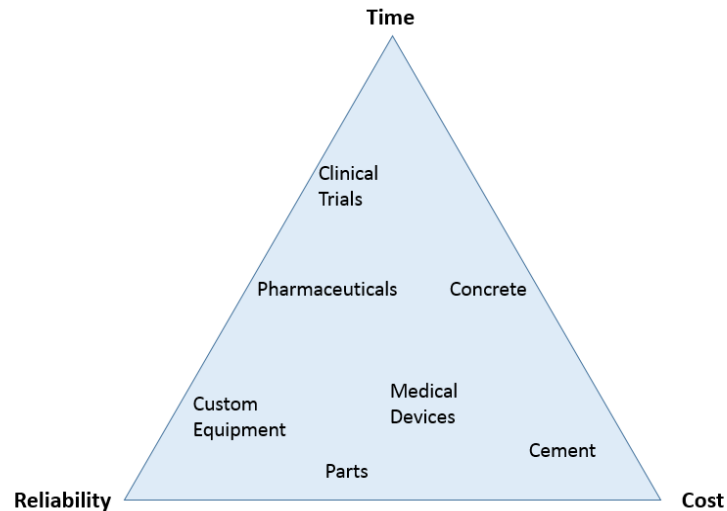
Note: As of 2007, IMMEX replaced maquiladoras as the series tracked by INEGI. IMMEX includes all maquiladoras but has a wider coverage.

¹¹ Pavlakovich-Kochi, Vera. "Maquiladora Related Economy of Nogales and Santa Cruz County." University of Arizona Eller. April, 2014.

3.2 Transportation Performance Parameters

The general manufacturing sector is very heterogeneous and different industries within the sector can have very different priorities, as demonstrated illustratively in Figure 3-4. In general, the most time-sensitive products are highly perishable or are rush orders needed for immediate use or application. Low-value and/or highly generic products are most sensitive to cost, while reliability is highly valued when stockpiling inventory is unfeasible or unattractive and when the customer pays a high penalty for late arrival.

Figure 3-4: Transportation Parameters for Illustrative General Manufacturing Products



Source: CPCS

The different priorities are also reflected in the modes of transportation used. Among higher-weight shipments, road is the dominant mode for products like concrete, although rail sometimes has applications (for example in transporting coal for fuel in cement plants).

Compared to other sectors, general manufacturing is not dominated by large firms. Other than concrete manufacturers, companies are unlikely to own their own fleets, instead often relying on small package and less than truckload carriers. Air may be used for time-sensitive products or small products being transported across the country or internationally. Ocean service, both full container and less-than-container, is also seen as a reliable, cost effective mode for international transport.

Hexcel

Founded in 1946, Hexcel Corporation is a leading advanced composites manufacturer serving Commercial Aerospace, Space and Defense, Wind Energy, and Industrial customers. The Casa Grande plant is one of eight in the U.S., complemented by nine in Europe and one in Asia.

The Casa Grande plant was established in 1965. Today it specializes in honeycomb structures and parts, notably for aerospace applications. Given modern just-in-time inventory strategies, reliability is an important transportation criterion for such suppliers. Late or missed deliveries can result in costly delays in customers' manufacturing operations as well as cumbersome inventory backlog for the supplier.

Text and Photo Source: Hexcel website



3.3 Barriers to Transportation Performance

Taken as a whole, general manufacturing companies appear to be somewhat more removed from transportation issues than companies in other sectors. There may be several reasons for this. For one thing, few companies consulted operate a private truck fleet, distribution center, or logistics division (but instead, hire these services). Many companies consulted do not view transportation as a core competency, but rather as wholly secondary to their central function, which is manufacturing product. There are two sides to this. On the one hand, many manufacturers as well as their customers, appear to be satisfied to outsource transportation and logistics to 3PLs or LTL/small package carriers such as UPS and FedEx, and are pleased with the service they receive. On the other hand, companies producing construction materials serve local markets and for them it is a question of adapting to transportation challenges rather than relocating their operations to another state.

Concrete Manufacturers

Non-metallic mineral products, which include cement, concrete, ceramics, and stone, account for 10% of Arizona's freight flows by tonnage. If the gravel and crushed stone that constitute the inputs for these products are added, the combined tonnage represents over 50% of statewide flows.

Concrete production consists of ready-mix concrete, delivered to jobsites in cement trucks; and concrete products such as precast concrete (structures, pipes, vaults, etc.) and landscaping products (pavers, stones). Both ready-mix and precast require specialized vehicles to transport. Because of the low value density combined with raw material abundance and process standardization, concrete production is highly localized. Companies operate in-state or, at most, through the Southwest.

Transporting oversized precast concrete loads to remote locations can be a challenge. Given overwidth restrictions on many access roads, road closures can have an outsized impact if not carefully coordinated. One precast manufacturer cited a case in which road closures combined with access restrictions resulted in a circuitous detour that added 150 miles to a delivery in northern Arizona.

Text Source: consultations

Data Source: Commodity Flow Survey, 2012

Photo Source: Olson Precast website



Multiple high-value product manufacturers cited air service was cited as a barrier. Concerns were raised about the low number of international direct flights as well as about the inadequacy of cargo service. Space on passenger flights can be tight, especially when transporting oversized freight. However, there was also some skepticism expressed about whether there was simply enough industry in Arizona to support expanded cargo service.

Manufacturers also mentioned truck reliability and availability as issues. According to one manufacturer, trucks not appearing when tendered is a significant issue impacting their business. Concern was also raised about the difficulty in obtaining trucks during the end of the fruit and vegetable growing season in California, in late summer.

Some though not all Arizona manufacturers revealed that issues related to delay and unreliability at West Coast ports in 2014-2015 negatively impacted operations. One manufacturer expressed hope that a seaport in Mexico such as Guaymas could at some point prove a viable alternative to the West Coast ports for Arizona importers or exporters.

Overall, manufacturers did not express significant concern with the physical quality of roads.

In terms of regulation, manufacturers are interested in liberalizing weight laws to the levels permitted by Utah and Nevada and identified this as a potential source of increased efficiencies. However, it was observed that any change in truck size and weight would have to be considered against possible deleterious impacts on road quality. At present, ADOT is operating at the maximum weight limits on Interstates and U.S. highways allowed by FHWA (these maximums are not uniform across all states due to grandfather clauses).¹²

3.4 Trends and Implications

A top priority for cement manufacturers is reducing energy needs and reliance on fossil fuels. Cement plants increasingly utilize alternative fuels derived from paper and packaging, sawdust, tires, and solvents.¹³ Because of the high transportation costs relative to product value and the widespread availability of raw materials, this industry will likely continue to be highly local.

Globalization in pharmaceutical and medical device manufacturing has been held back by factors such as global regulatory variability, but these supply chains are increasingly lengthening and consolidating. Medical device logistics is changing from one-size fits all models that result in significant sub-optimality (e.g. high inventories for some products and shortages for others, unnecessary use of expensive air transportation for less critical products).¹⁴ Pharmaceutical companies are increasingly identifying global centers of manufacturing excellence; one or two locations may be sufficient to manufacture a certain drug or dosage form for worldwide distribution.¹⁵ Important issues in transportation are loss prevention, identification of counterfeits, and temperature control. A very recent trend has been a modal shift from air to sea transportation, as ocean reefers are proving capable of handling some of the highest-value and most time-sensitive products, requiring a stable temperature range of 2° to 8°C (35° to 45° F). Even with increased thermal protection measures, ocean freight is up to 70 percent cheaper than air freight.¹⁶ Another trend is towards the use of living cells and tissues rather than chemicals as APIs.¹⁷ For both pharmaceuticals and medical devices, an increasing focus on home healthcare is expected to drive growth over the next ten years.¹⁸ This method of delivery may be more conducive to small package delivery.

Arizona's bioscience industry is composed of manufacturing plants, start-ups, hospitals, labs, and many other actors. Arizona's Bioscience Roadmap¹⁹ identifies five specific transformative

¹² FHWA, Western Uniformity Scenario Analysis: Executive Summary.

¹³ PCA, Economics of the U.S. Cement Industry.

¹⁴ McKinsey & Company, "Building New Strengths in the Healthcare Supply Chain." January, 2013.

¹⁵ Connell, Bill. "Pharma Manufacturing on the Move." Pharmamanufacturing.com. May, 2012.

¹⁶ Hollman, Michael. "Pharma producers ramp up ocean freight." IHS Maritime 360. January, 2015.

¹⁷ Douglas, Merrill. "Navigating Pharma Logistics." Inbound Logistics, August, 2012.

¹⁸ Reuters, "The Global Pharmaceutical Logistics Market Will Experience an Increase in Demand for Products Through 2019: Technavio." April, 2015.

¹⁹ Flinn Foundation. "Arizona's Bioscience Roadmap, 2014-2025."

steps that would help Arizona emerge as a national force, including greater availability of risk capital, developing premier research infrastructure, and developing ties to neighboring states and Mexico. Many other general manufacturers, such as suppliers to the aerospace industry, will be similarly tied to the overall economic performance of their respective hubs.

Many specialized general manufacturers, such as CNC manufacturers for the aerospace industry, face competition from similar manufacturing operations in Sonora and other states in northern Mexico. Prospects for growth are uncertain but likely linked to factors that affect the relative attractiveness of manufacturing in Mexico compared to the U.S.

Characteristics of Arizona perceived by businesses in this sector to be advantageous include available workforce, dry air (which is conducive to certain manufacturing processes), low risk of natural disasters and severe weather, and central location within the southwest United States.²⁰

²⁰ Business Insider, “Here’s how an Arizona aerospace manufacturing plant became a global success.” June, 2015. See also: Gersema, Emily. “Dunn-Edwards Paints moves plant to Phoenix, adds jobs.” AZCentral.com. June, 2011.

4

Sector Priorities for Transportation System Performance Improvement

Key Messages

Road construction could be better coordinated, especially in less dense areas, taking better account of oversize restrictions.

Arizona's weight restrictions are lower than neighboring states such as Nevada and Utah. Increasing allowable vehicle weights could lead to greater efficiencies and remove trucks from the road.

The West Coast port issues of the past year negatively affected manufacturers that relied on those ports for sourcing or exports. There is a hope that in the future a Mexican port may serve as a viable alternative for Arizona manufacturers.

High-value product manufacturers would like to see more direct flights from Sky Harbor to international destinations and more dedicated cargo flights.

4.1 Priority Improvements Needs

Stakeholders identified a number of priority improvement needs in the sector.

Road construction could be better coordinated, especially in less dense areas. Alternative routes must be evaluated from the perspective of any road restrictions, such as over-wide restrictions. Lack of coordination can lead to significant circuitry, inefficiency, and cost.

Arizona's truck weight restrictions are lower than neighboring states such as Nevada and Utah. Increasing allowable vehicle weights would lead to greater efficiencies and remove trucks from the road. At present, there is variability by state in the maximum commercial vehicle weights prescribed by FHWA, due to grandfather clauses.²¹

The 2014-2015 West Coast port issues related to delay and uncertainty have made some manufacturers uncomfortable about their reliance on these gateways. Reorienting to the East Coast is not necessarily seen as an ideal solution. One manufacturer expressed hope that a sea port in Mexico could at some point prove a viable alternative for Arizona exporters.

Truck reliability and availability was also mentioned as an issue. This is an industry-wide concern due to factors such as the general driver shortage.

Overall, manufacturers did not express significant concern with the physical quality of roads.

Improved international connections at Phoenix Sky Harbor International Airport (PHX) would help make Phoenix more competitive for companies with an international orientation. Connections to cities like Frankfurt, Germany; Hong Kong, China S.A.R., and Shanghai, China were mentioned.

Also relating to air transportation, increased dedicated cargo flights out of the Phoenix area would help with shipping reliability, especially for shipping oversize items that are presently poorly accommodated by passenger airlines. The challenge is that as the industry consolidates to regional hubs, the trend for airports the size of PHX has been downward.

²¹ FHWA, Western Uniformity Scenario Analysis: Executive Summary.

Appendix A: List of Stakeholders Consulted

Name	Title	Organization
Angie Everett	Certified Purchasing Manager	BearCat Manufacturing
David Ackley	Director of Operations	ChemResearch
Kymberly Raham	Materials Manager	Hexcel
Moe Spell	Contracts Administrator	Olson Precast
Joe Bocian	Director, Logistics & Transportation	Parker
Kathy McGovern	Logistics Manager	PING
John Foley	Shipping Manager	Polymicro (Molex)
Dale Diulus	Vice President, Logistics	Salt River Materials Group