MISSOURI

State Freight & Rail Plan

ECONOMIC FUTURES AND NEEDS ASSESSMENT

2022

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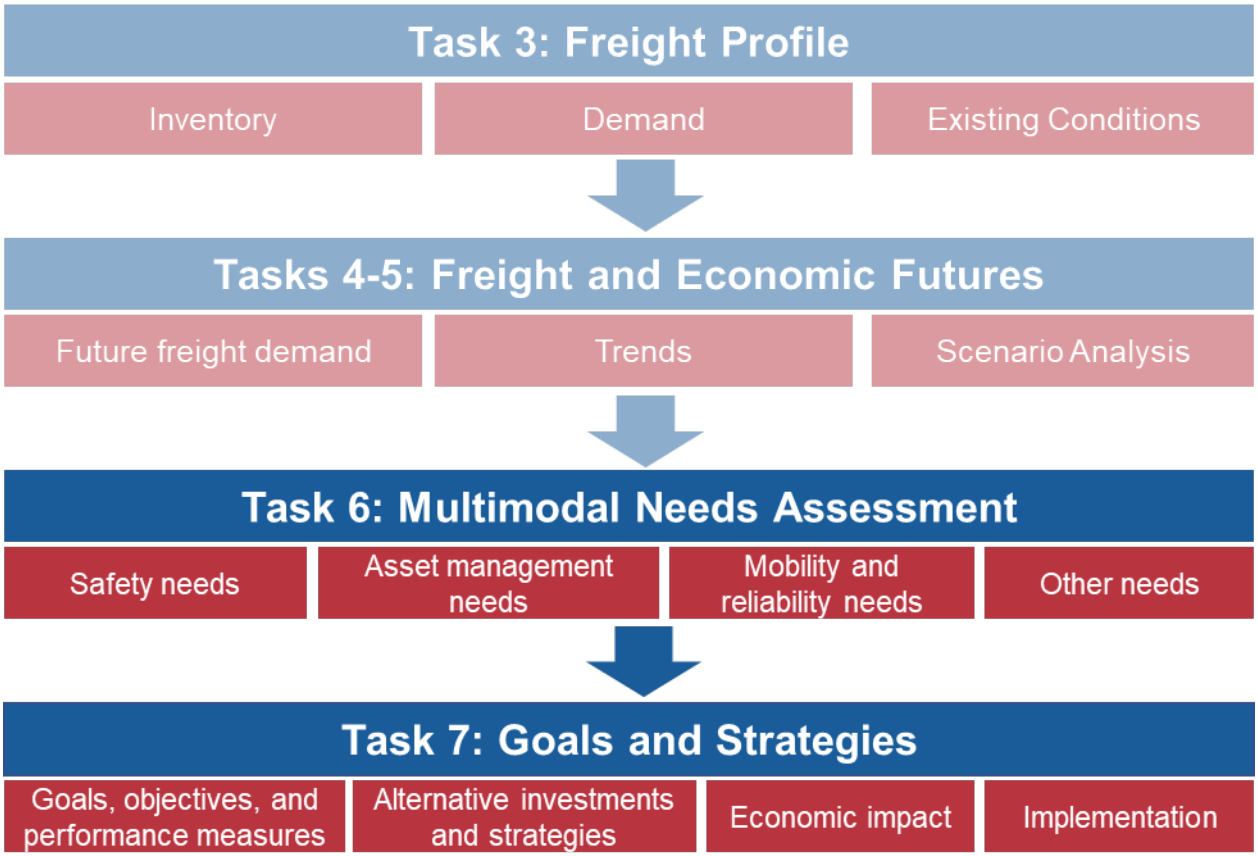
1.0 Introduction

The Missouri Department of Transportation is developing this State Freight and Rail Plan to provide MoDOT with a next-generation blueprint and plan for multimodal freight and passenger rail investment for the future. This plan is data-driven and supported by stakeholders to help Missouri maintain its competitive advantage and economic vitality aligned with freight movement within the state. Figure 1 shows the overall sequence of events for the development of this plan.

FIGURE 1 MISSOURI STATE FREIGHT AND RAIL PLAN TASK BREAKDOWN



The multimodal needs assessment task is a critical step in the SFRP process. It builds on the data analysis conducted as part of the Missouri Freight Profile and outreach to Missouri's most important public and private sector freight stakeholders to identify current and future needs and opportunities across highway, freight and passenger rail, air cargo, and ports and waterways. This assessment lays the groundwork for establishing the goals, strategies, recommendations and ultimately implementation of the 2022 SFRP.

The remainder of this report is organized as follows:

- **Section 2.0—Economic Profile & Industry Assessment** profiles statistics about Missouri industries and employment statewide and within each MoDOT District. This section also describes the supply chains for five

key industries in Missouri: agriculture, retail and e-commerce, transportation equipment manufacturing, food processing and chemicals.

- **Section 3.0—Freight Drivers, Trends & Disrupters** discusses factors that may contribute to changes for Missouri's key industries, as well as six macroeconomic trends and "disrupters" that could impact future freight flows throughout the state beyond the baseline forecast.
- **Section 4.0—Existing Freight Needs Assessment** presents the findings of the multimodal needs assessment for Missouri's highways, rail lines, airports and ports and waterways.
- **Section 5.0—Scenario Planning and Impacts on Future Freight Flows** presents the two modeled trends and "disrupters" scenarios identified as part of Section 3.0 on future freight demand in Missouri.
- **Section 6.0—Future Needs and Challenges** describes future needs and challenges with respect to evolving future freight demand in Missouri.
- **Section 7.0—Conclusion** discusses this report's key takeaways and findings.

2.0 Economic Profile & Industry Assessment

$6.9 BILLION

Total tax revenue collected from freight transportation economic activity.

Freight transportation supports every sector of the Missouri economy. Households depend upon the state's freight transportation network to receive supplies, goods and groceries. The state's businesses depend on the freight network and freight carriers such as trucking firms, railroads, marine and airports to deliver raw materials and supplies and to distribute finished goods. The economic activity resulting from freight transportation in 2019 created a total of 476,700 jobs valued at more than $25.5 billion in wages. The contribution to the Missouri economy in 2019 was more than $41 billion in gross state product, a measurement of a state's economic output. That translates into more than $6.9 billion in total tax revenue.

Transportation and industry sectors that support and are supported by freight movements are the foundation of the state's economy. To assess the economic and future needs for Missouri, this section focuses on those sectors statewide and by MoDOT district levels.

2.1 Statewide

Industries and Employment

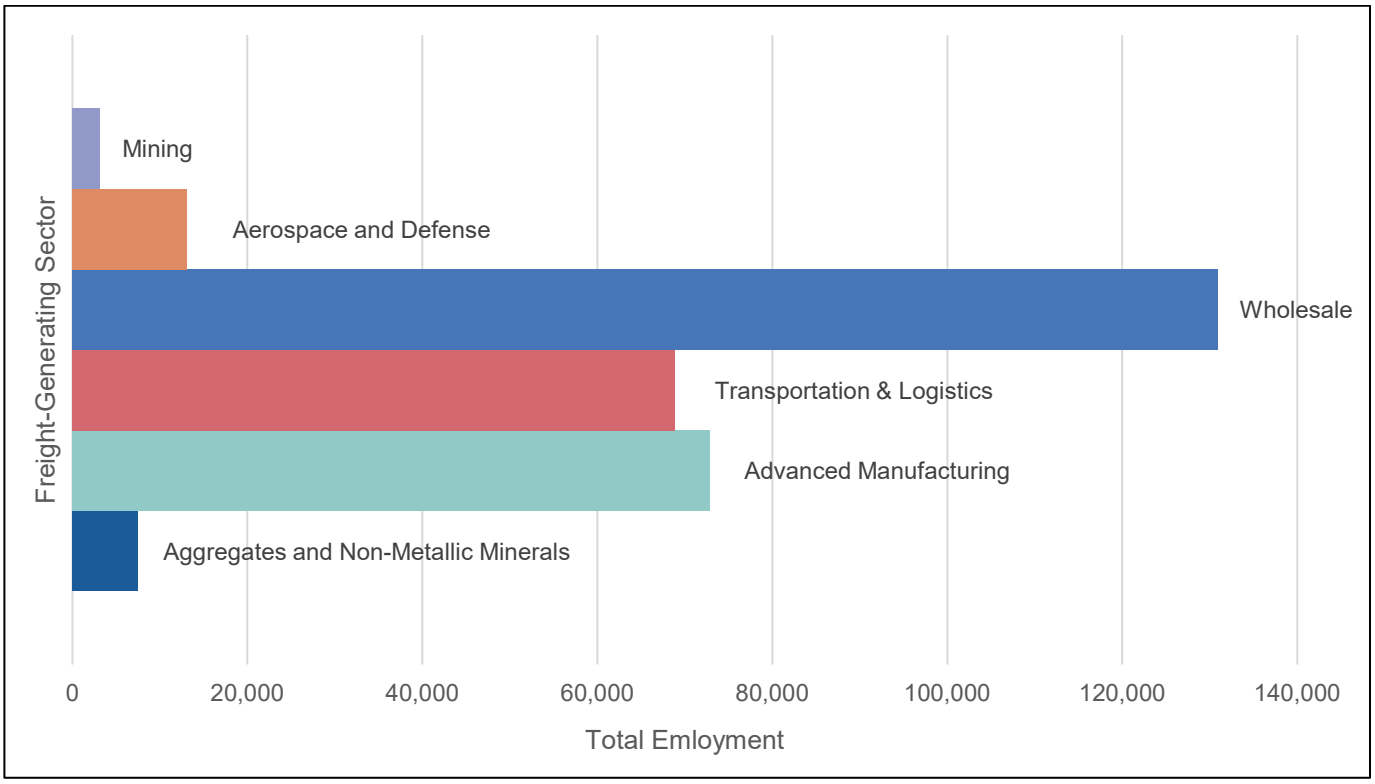
The largest freight-intensive industry sectors[1] in the state are measured by the number of establishments and employment. These currently include:

- Agriculture and Food & Goods Processing
- Automotive Suppliers
- Chemicals, Plastics and Rubbers
- Aggregates & Non-Metallic Minerals
- Advanced Manufacturing
- Transportation & Logistics
- Wholesale
- Military & Defense

[1] Sectors were identified by the Missouri Department of Economic Development's target industries, reports from the Missouri Department of Agriculture, as well as an economic shift-share and location quotient analysis for Missouri industry sectors using U.S. Bureau of Labor Statistics data.

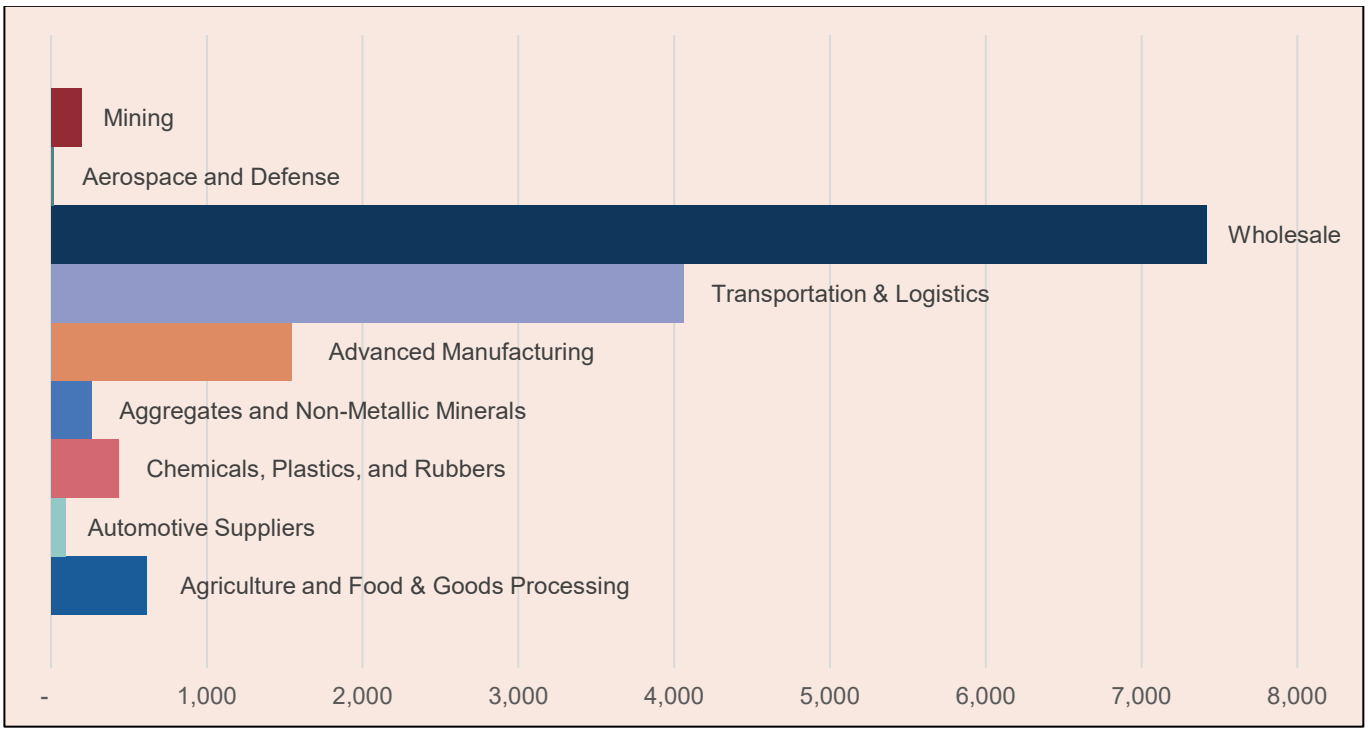
Figure 2 and Figure 3 show wholesale industry is the leader, with about 130,900 employees and 7,400 establishments, reflecting 35.5% of employees and more than half of establishments in freight-intensive industries across the state. This points to a heavy emphasis on business-to-business freight activity as well as supportive e-commerce business-to-consumer in distribution centers and warehouses statewide. The land-use intensive nature of the wholesale industry and the other leading industries—advanced manufacturing (72,900 jobs) and transportation and logistics (68,900 jobs)—make up a combined 74% of key freight industry employment and more than 90% of establishments.

FIGURE 2 TOTAL NUMBER OF EMPLOYEES IN MISSOURI'S KEY FREIGHT-GENERATING INDUSTRIES



Source: Metrics were calculated using U.S. Census ZIP Codes Business Patterns data, as well as commodity flow data from the TRANSEARCH highway network.

FIGURE 3 NUMBER OF ESTABLISHMENTS IN MISSOURI'S KEY FREIGHT-GENERATING INDUSTRIES



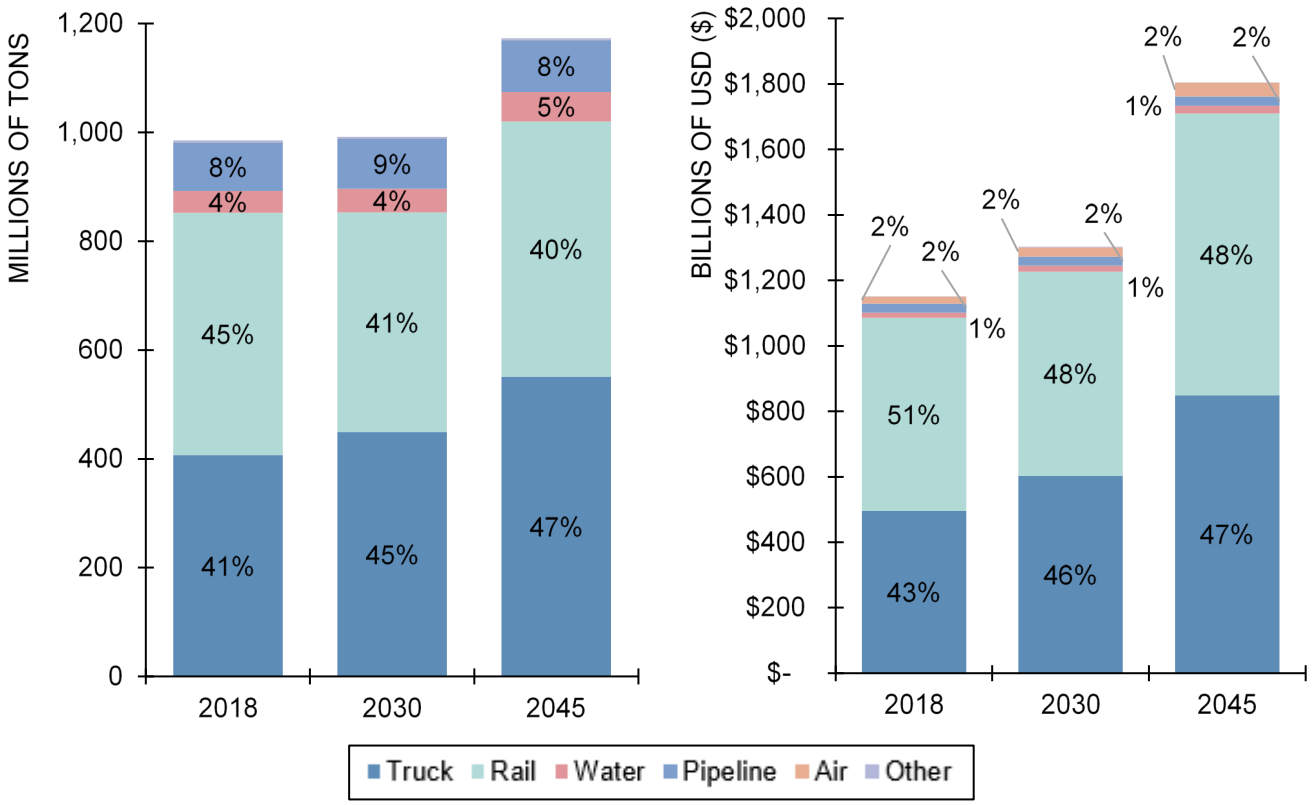
Source: Metrics were calculated using U.S. Census ZIP Codes Business Patterns data, as well as commodity flow data from the TRANSEARCH highway network.

Freight Demand: Commodities and Modes

Missouri is unique among U.S. states for the high volume and value of freight moving on the state's rail system. Rail carried 45% of the total weight and 51% of the total value of goods moving on the state's transportation system. Trucking accounts for the second highest modal share, accounting for 41% of goods moved by weight and 43% of goods moved by value. By weight, pipelines (9%) and waterways (4%) account for the bulk of the remainder of freight carried by the state's transportation system, with air and other modes only accounting for a tiny fraction.

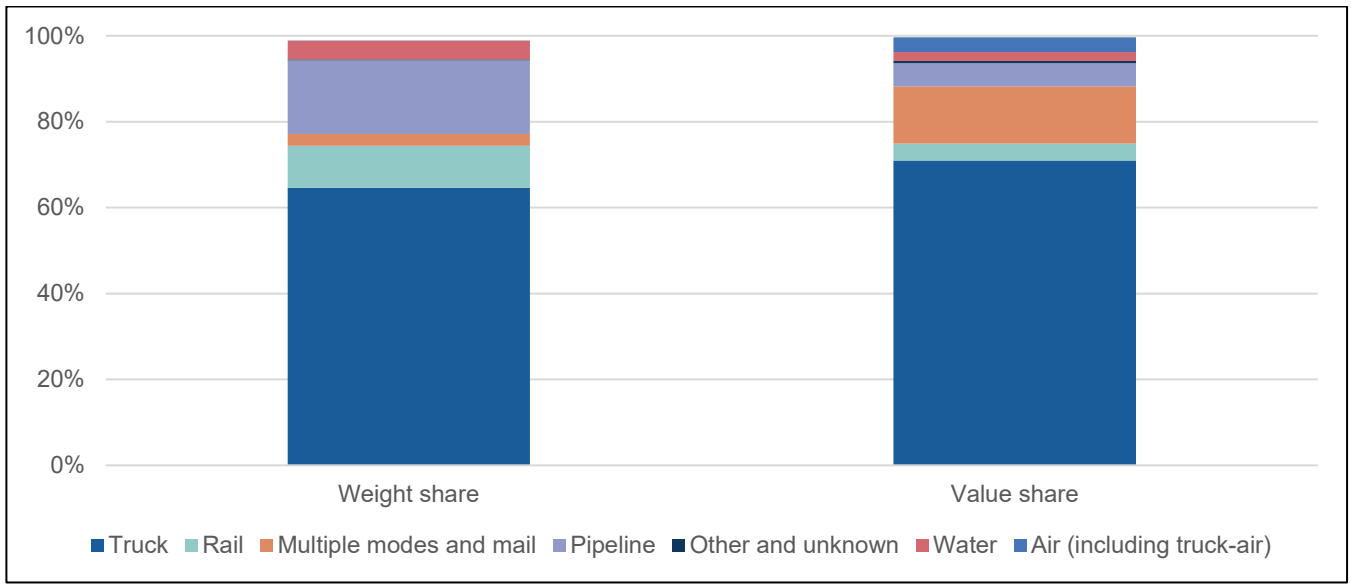
In contrast, rail carries about 10% of the of the total weight and 3.9% of the total value of goods nationally. Trucking has a much higher share at 65% of total weight and 71% of the value of goods. When measured by value, rail and truck transport account for more than 94% of the state's freight movements, with air, pipeline and water accounting for around two percent each. Figure 4 shows Missouri's freight by tonnage, value and mode. Figure 5 shows the national picture on freight mode share. One thing common between Missouri and the U.S. is that mode share diversifies by value. This accounts for the volume of goods traveling by air, which have high value but very little to no weight when compared to other modes. More detail on commodity flow is available in the Commodity Flow Profile as part of the 2022 SFRP.

FIGURE 4 MISSOURI FREIGHT BY MODE FOR TONNAGE AND VALUE, 2018



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 5 U.S. FREIGHT BY MODE, TONNAGE AND VALUE



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

The projections indicate Missouri's 2045 truck mode share will increase in both weight and value likely adding more trucks to the congested freight highway network. It will be crucial to enhance the interoperability of the modes to reduce congestion on surface transportation and promote an efficient freight system.

2.2 Key Industry Supply Chains

The term "supply chain" describes the sourcing, production and distribution of commodities and consumer products. A supply chain typically comprises many links, with each playing a role in taking a product from its inception to its final consumption or end-use. Supply chains outline the process of turning raw materials into finished products and getting them into the hands of final consumers, and as the name implies there are often many links required to source, produce and deliver products, especially in a global trade environment.

Agriculture

The U.S. is a world leader in agriculture productivity, and Missouri is one of the leading agriculture states. Missouri has 95,000 farms, second most in the nation, which cover two-thirds of the state's land acreage. In total, agriculture contributes $88 billion to the statewide economy.[2] Agriculture is also the single largest consumer of freight services in the U.S.; accounting for 24% of all freight tonnage and 27% of all freight ton-miles. Analysis using Missouri TRANSEARCH data to estimate similar state-level percentages suggests that agriculture and food manufacturing account for 27% of all freight tonnage in Missouri, and 17% of total freight by value.

Agriculture is truly a multimodal transportation user. However, highways are the vital first- and last-mile link to all other modes. Nationally, trucking accounts for 88% of agriculture freight movements by value, but only 56% of agricultural freight ton-miles, due to the key role railroads and barges play in moving grains over longer distances.[3]

Economic Contributions of Missouri's Agriculture Sector

Missouri farmers produce crops on 27.5 million acres or about two-thirds of the state's total area.[4] Missouri supports a diverse agriculture economy that ranks in the top ten for a variety of crops and value-added products. Missouri ranks second in hay production, fourth in rice production, sixth in soybean and cotton production and ninth in corn production. Among value-added products, Missouri ranks third in beef cattle production, fifth in goat production and sixth in turkey and hog production. Missouri also produces 291 million broiler chickens annually.

According to the U.S. Department of Agriculture, in 2020, Missouri exported $4.5 billion in plant and animal products to trading partners around the globe.[5] The top five markets for Missouri's agriculture exports are Canada, China, Japan, Mexico and South Korea. Nearly 72% of Missouri's exports go to Mexico, the state's top agriculture export partner, with China and Canada ranking second and third, respectively.[6] In 2020, Vietnam ranked as the 4th

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[2] *Missouri Ag Highlights,* Missouri Department of Agriculture. Accessed online: https://agriculture.mo.gov/topcommodities.php

[3] *The Importance of Highways to U.S. Agriculture,*

[4] Missouri Department of Agriculture and United States Department of Agriculture, National Agriculture Statistics Service

[5] United States Department of Agriculture, Economic Research Service

[6] Source: U.S. Census Bureau Foreign Trade Division, Accessed via Trade Stats Express, U.S. Department of Commerce

largest receiver of Missouri agriculture exports. But, as recently as 2018, Vietnam beat out Canada for the third spot as a top agriculture export partner.[7]

Transportation Facilities Supporting Missouri Agriculture

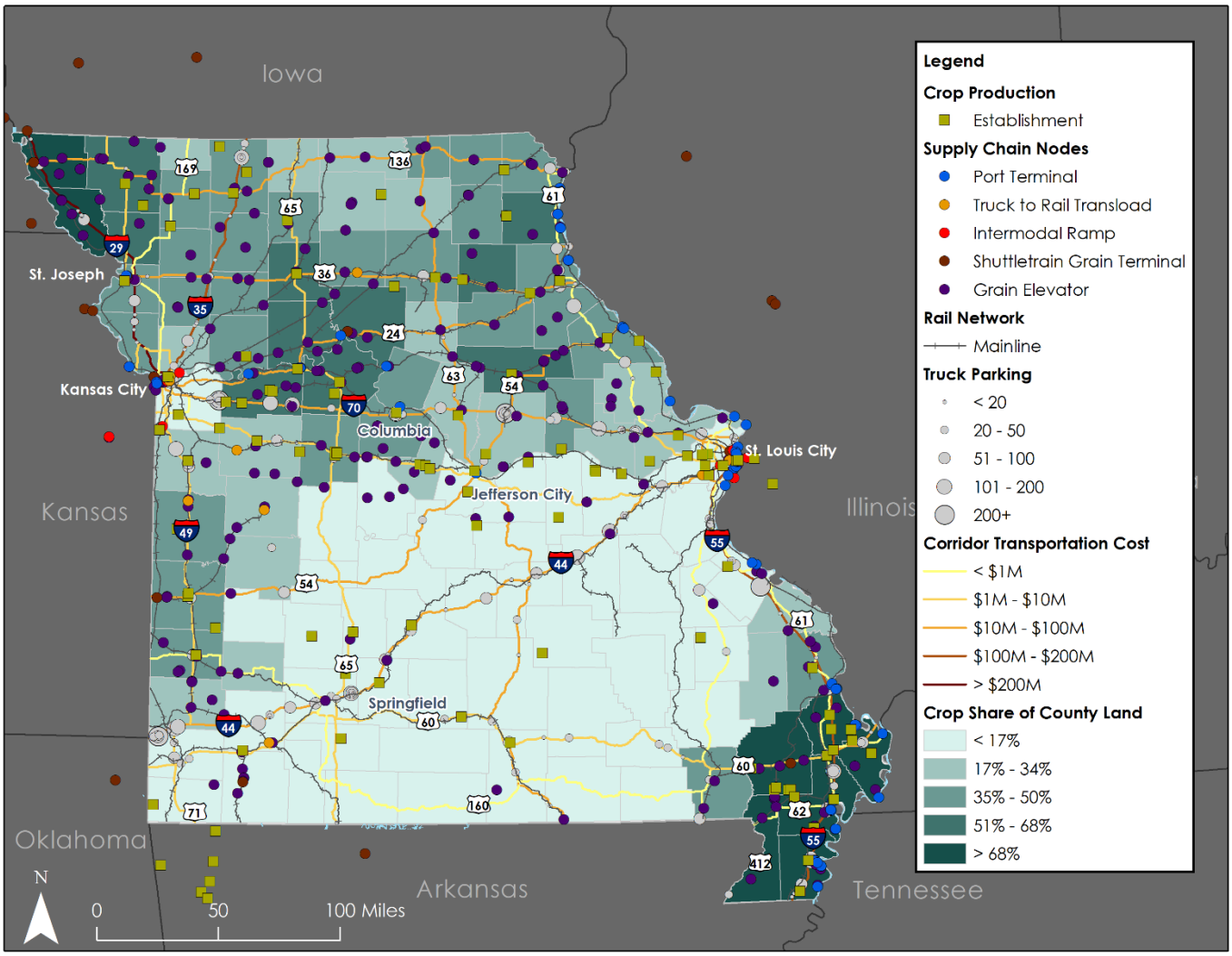
To support the examination of important supply chains to the Missouri economy, an inventory of key industry is crucial for the analysis. The map shown in Figure 6 displays facilities that play a variety of roles in agriculture supply chains. Agriculture establishments shown as yellow dots on the map were sourced from a business establishment data set from IHS Markit. These establishments are classified as *Agriculture Production—Crop;* businesses in this group include fertilizer facilities, seed plants, agriculture cooperatives, greenhouse nurseries, orchards and value-added farm establishments. As noted in a 2020 U.S. Department of Agriculture report, I-55, I-57, I-70, and I-29, as well as intermodal connections serve an important role in the movement of soybeans, grain, meat, vegetables, and milk.[8]

Grain elevators are shown as purple dots on the map in Figure 6. A grain dealer database maintained by the Missouri Department of Agriculture that lists nearly 300 grain warehouses/elevators across the state was used in populating the map. Grain elevators are commonly divided into three types: 1) Country elevators – located inland away from a river system typically served by truck and rail; 2) River elevators - located on any one of the inland waterway networks providing barge service, and 3) Export elevators - located at coastal gateways serving deep-water ports. The grain elevator inventory assembled for Missouri identified eleven-unit train grain elevators or "shuttle train" grain elevators on the railroad networks serving Missouri.

[7] U.S. Census Foreign Trade Division

[8] U.S. Department of Agriculture. (2020). The Importance of Highways to U.S. Agriculture. https://www.ams.usda.gov/sites/default/files/media/Main_Highway_Report.pdf

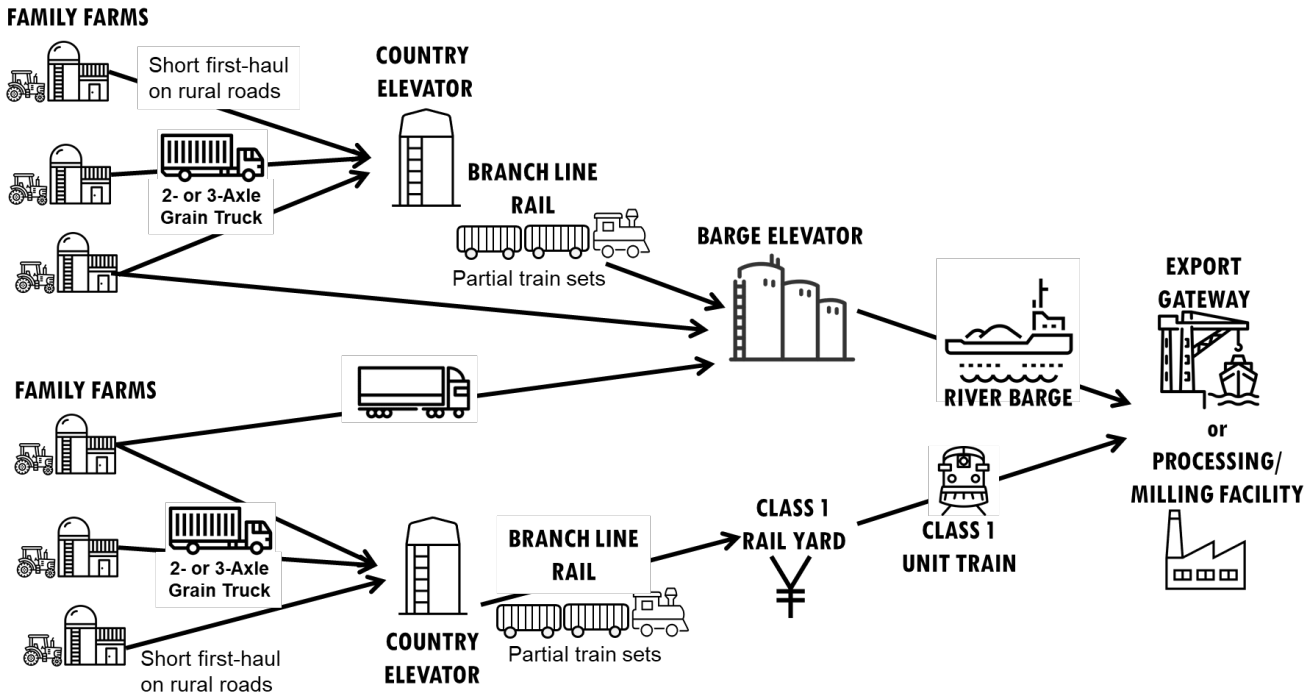
FIGURE 6 MISSOURI CROP PRODUCTION AND AGRICULTURE FACILITIES INVENTORY



Source: Quetica.

The Missouri Freight & Rail Profile—Volume 2 described the evolution of agriculture supply chains from the family-owned farms that prevailed throughout most of the twentieth century. While country elevators remain a staple of rural grain producing states to store and transload grain into trucks and rail cars, their significance in the modern grain supply chain is waning. Country elevators constructed prior to railroad deregulation in 1980 were designed to provide temporary storage capacity for grain harvested within a 10-to-15-mile radius of the elevator. Country elevators typically load partial train sets that are moved to a mainline rail yard where full train sets are assembled, (see Figure 7). A prominent feature of the traditional agriculture supply chain is the short “first-haul” from the field to a country elevator over rural roads. Most farmers hauling to a country elevator use two- or three-axle grain trucks or pull grain wagons to the elevator using a farm tractor.

FIGURE 7 TRADITIONAL AGRICULTURE SUPPLY CHAIN



During the mid-twentieth century many states, including Missouri, invested in "farm-to-market" road networks to support expanding agricultural productivity in the U.S. In 1952, Missouri undertook a major highway investment program designed to improve important agriculture routes which also transferred responsibility for highway and bridge maintenance from counties to the state:

> *"The Missouri 10-Year Highway Modernization and Expansion Program, better known as the Takeover Program, began in 1952. The department's goal was to incorporate and upgrade 12,000 miles of additional roads to the state's supplementary or farm-to-market highway system. The state relieved the counties of maintenance costs of these roads, providing welcome relief to rural Missouri.*
>
> *At the conclusion of this program, the department had met and even exceeded its goal of providing Missourians with a state-maintained road within at least 2 miles of more than 95 percent of all rural family units - a family unit being a farm home, school, church, cemetery or store."*[9]

In 1980, the Staggers Rail Act de-regulated the freight railroad industry. Free of economic oversight, Class 1 rail carriers embarked on a program of network rationalization resulting in the sale or abandonment of many branch lines serving country elevators. Class 1 railroads also focused on increasing the velocity of mainline rail corridors in the post deregulation era by offering the best rates on unit train movements of bulk commodities like coal, aggregates and grain. However, most grain elevators constructed prior to deregulation do not have the capacity to load a unit train of 110 cars in a timely fashion. A single unit train can carry approximately 400,000 bushels of grain.

[9] MoDOT website. Missouri Highways and Transportation Commission: Commission Background | Missouri Department of Transportation (modot.org)

To collect, store and transload enough grain to fill more than 100 rail cars requires a special type of elevator facility referred to as shuttle train elevators. To encourage grain elevator consolidation, Class 1 railroads offered incentives and design specifications to facility operators willing to make the investment in elevator upgrades. The typical shuttle train elevator can load a 110-car unit train in 15 hours or less. As previously noted, of Missouri's more than 300 grain elevators statewide, only eleven are shuttle train elevators. Trains loaded at these facilities typically run non-stop to deep-water ports in the Gulf Coast or Pacific Northwest.

In 2021, the United States Department of Agriculture (USDA) published a compendium of rail research, including references examining the impact of shuttle train services on railroad rates. Among the conclusions of the research:

- The combination of large terminal elevator facilities and shuttle service were found to reduce costs, increase speed, and increase rail capacity compared to traditional grain supply systems.[10]
- By three measures of efficiency (time, cost, and capacity), the shuttle train service enhances U.S. competitiveness on the global market.[11]
- Shippers using shuttle service saved an average of 24 percent per year in total transportation costs during the study period (2006-13).[12]

The trend towards higher volume, higher speed grain elevators can also be seen in barge transportation. For example, during outreach for this plan, the consultant team was alerted to a 15-mile stretch of the Mississippi River near St. Louis known as the Ag Coast of America. This portion of the Mississippi River hosts more than 15 river elevator facilities, including some of the largest barge elevators in the nation:

> *"Other facilities on the Ag Coast include the Cargill Grain Elevator, which is one of the busiest grain elevators in the nation; the Bunge-SCF River Grain Terminal in Fairmont City, which is designed for more than a million bushels of permanent storage and can handle high volumes of multiple commodities simultaneously; and four facilities in Cahokia, operated by Consolidated Grain and Barge Company, Louis Dreyfus and COFCO International Growmark, which are the four highest capacity facilities in the entire inland waterway. Facilities operated by ADM, Gavilon Fertilizer, SCF, and Italgrani Elevator Company, along with America's Central Port and the Municipal River Terminal in St. Louis, round out the 16 barge transfer facilities currently handling the tremendous volumes of agriculture and fertilizer products flowing through the Ag Coast."*[13]

In 2011, USDA examined the trend toward larger elevators in both rail and barge networks:

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[10] Hyland M.F., H.S. Mahmassani, and L.B. Mjahed. 2016. "Analytical Models of Rail Transportation Service in the Grain Supply Chain: Deconstructing the Operational and Economic Advantages of Shuttle Train Service," Transportation Research Part E 93:294-315.

[11] Ibid. Hyland.

[12] Ndembe, E., and J. Bitzan. 2018. "Grain freight elevator consolidation, transportation demand, and the growth of shuttle facilities," Research in Transportation Economics, Journal of the Transportation Research Forum 71:54-60.

[13] *Expanded Grain Handling Capacity in the Ag Coast of America Strengthens St. Louis Region.* 2021, July 20. CropLife. https://www.croplife.com/management/expanded-grain-handling-capacity-in-the-ag-coast-of-america-strengthens-st-louis-region/

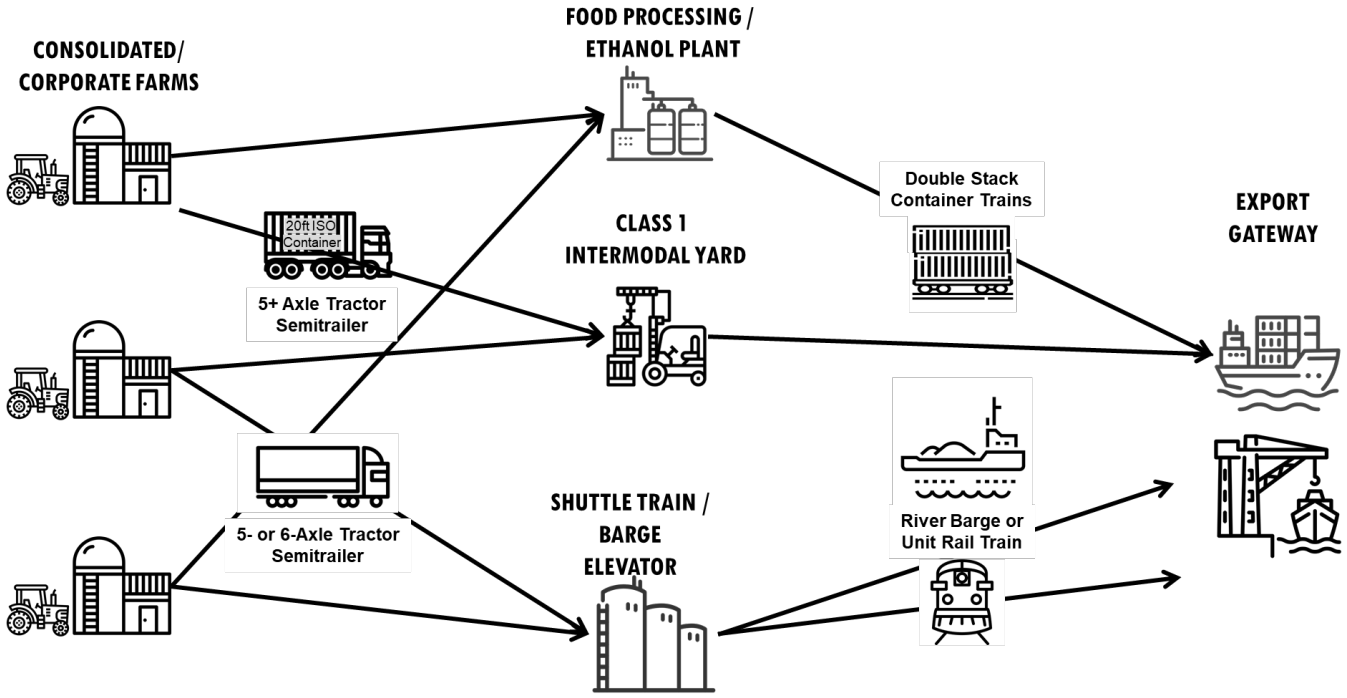
"Grain elevators are a critical component of the grain supply chain. Their size and location affect shipping logistics for grains and soybeans. In general, grain elevators store and move enough products to create economies of scale and merchandising opportunities in shipping bulk grain at the best price...Locational differences create comparative advantages among grain elevators… Large processing plants or elevators located by the Mississippi river have the advantage of using barge in addition to truck and rail…In conclusion, the size and location of elevators affect transportation costs. Larger elevators have a competitive advantage over smaller elevators because of economies of scale...However, smaller elevators have the important role of buying directly from the growers and supplying local processors by rail or truck."[14]

Over the past two decades, increasing demand for intermodal containers is another trend in agriculture supply chains placing addition strains on rural highways. To earn higher profits, many grain producers are placing greater emphasis on value-added food and energy products that frequently require intermodal containers for shipment. In Missouri, a value-added food initiative is a prominent priority of the Missouri Farm Bureau. With most intermodal rail yards located in or near major urban areas, agricultural products often travel hundreds of miles via truck from rural areas to access intermodal yards.

Figure 8 illustrates the greater complexity of modern agriculture supply chains. While bulk grain shipments continue to move by unit train and barge to deep-water coastal ports, increasingly grain is also being moved in large volumes to domestic value-added facilities, such as ethanol plants, animal/poultry feed lots and food processing facilities. In many cases, these valued-added processes are performed by farmer-owned cooperatives or limited liability corporations. An alternative market for creating greater on-farm value has been the emergence of Identity Preserved (IP) crops. Increasingly, both foreign and domestic consumers want more information about the food they eat. Many buyers want certified organic crops or crops grown from non-genetically modified seeds. Meeting these types of buyer preferences requires growers to maintain chain of custody over these products during shipment. The most prominent means of preserving crop identity is to load it into a sealed intermodal shipping container. In many cases, IP crop farmers market directly to foreign buyers to retain higher on-farm income. The map in Figure 2.5 shows the only intermodal rail facilities in Missouri are located in Kansas City or St. Louis.

[14] USDA Weekly Grain Transportation Report, September 8, 2011.

FIGURE 8 CONTEMPORARY VALUE-ADDED AGRICULTURE SUPPLY CHAIN



Source: Quetica.

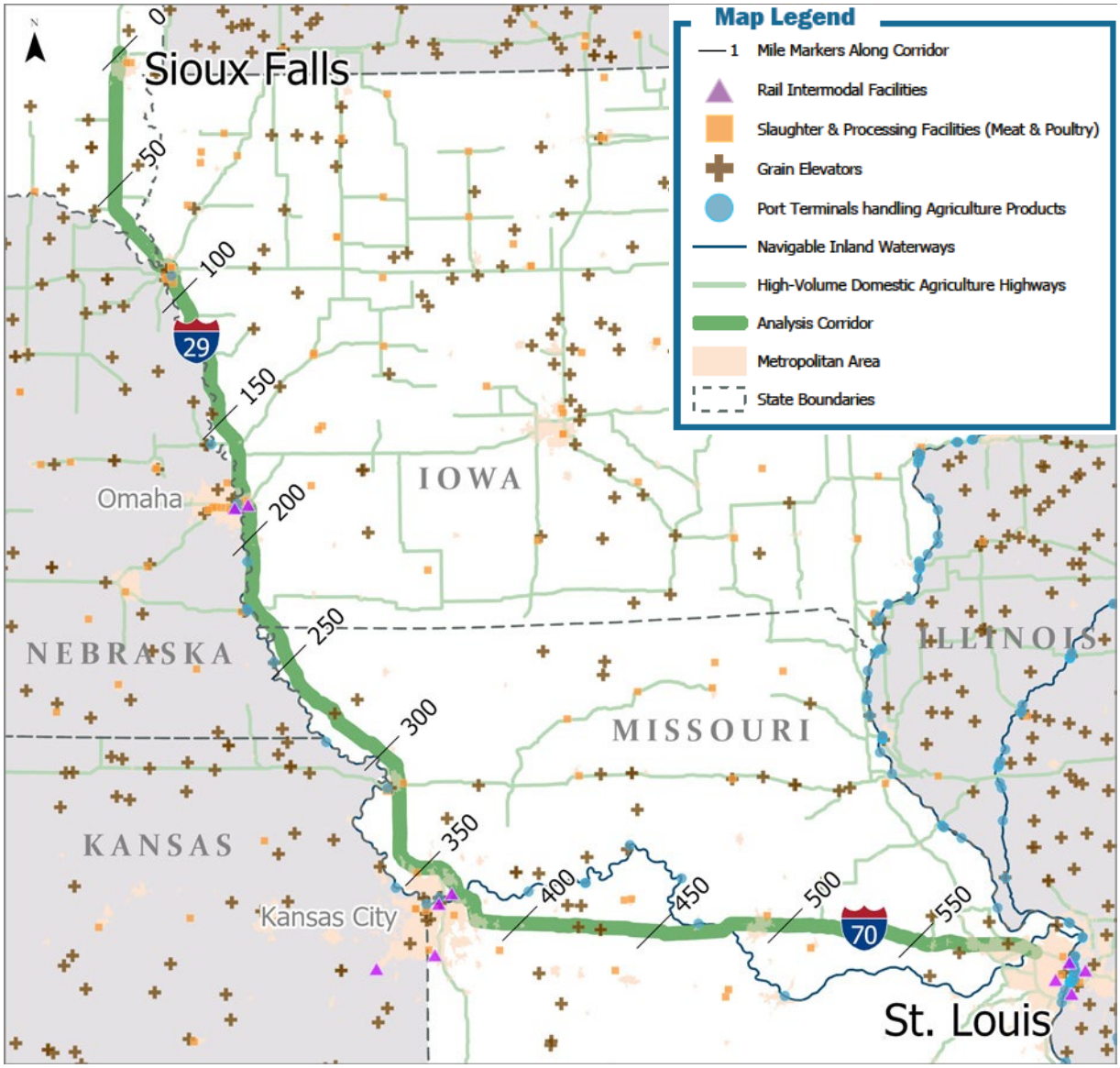
In many cases, the value-added trend is moving grain transport systems away from the fungible commodity handling of the past. Loading grain into containers on or near the point of production, then sealing the container until it arrives at the buyer's destination ensures the integrity of grain and food products during shipping. During interviews of freight facility operators for this plan, the operator of a container transload facility in Kansas City, MO noted that the facility was transloading IP grains from trucks to intermodal containers for farmers from Missouri, Kansas, Iowa and Nebraska, often resulting in first-haul truck trips extending hundreds of miles.

Analysis of private sector bill of lading data combined with TRANSEARCH freight flow data shows highway movements within crop production supply chains are most prevalent along several north-south interstate corridors through Missouri, including I-29, I-55 and I-35 (refer to Figure 25). Additionally, several U.S. highway corridors also show concentrations of transportation costs such as U.S. 36, U.S. 24, U.S. 136, U.S. 54 and U.S. 63. Many of these highways provide farmers in the state the crucial links to intermodal rail, grain elevator transload facilities and river elevators in the state.

A 2020 USDA report with analysis by the John A. Volpe National Transportation Systems Center also used TRANSEARCH data to identify and analyze High-Volume Domestic Agriculture Highways (HVDAH). The study found that as much as 80% of domestic agriculture tonnage moving on U.S. highways occurs on less than 20% of the highway network. Key HVDAH network elements in Missouri include I-29, I-55, I-57 and I-70.

The USDA report also identified 17 highway corridors, including a corridor from Sioux Falls, SD to St. Louis, MO that were examined in more depth. The nearly 600-mile corridor is shown in Figure 9.

FIGURE 9 SIOUX, SD TO ST. LOUIS, MO - HIGH VOLUME AGRICULTURE HIGHWAY CORRIDOR



Source: Volpe Center Analysis

The Volpe analysis estimates that the corridor carries nearly 5 billion ton-miles of agriculture products annually. More than one-half of the corridor length falls in Missouri, mostly on I-70. The primary commodity moving on I-70 between Kansas City and St. Louis is soybeans, bound for export down the Mississippi through Gulf Coast gateways. Meat, vegetables and milk also traverse I-70 in large volumes. The analysis also examined highway performance and noted that, while the overall reliability of the corridor is good, "*Travel times are particularly unpredictable in Kansas City near the I-29 and I-70 connection*."[15] The analysis found that pavement conditions on this mostly Interstate Highway corridor were good but identified eleven bridges on I-29 between Omaha and Kansas City were in poor condition.

[15] *Importance of Highways to U.S. Agriculture*, USDA. December 2020. Pg. 76.

A year before releasing its *Importance of Highways* Report, USDA released a companion research effort entitled *Importance of Inland Waterways to U.S. Agriculture.* The report noted that low transportations costs afforded to American farmers via inland waterways have been critical to the competitiveness of U.S. agriculture in world markets:

> "*Due to its efficiencies and lower costs, the inland waterways system saves between $7 billion and $9 billion annually over the cost of shipping by other modes… The U.S. economy depends on farmers using the inland waterways system to maintain a competitive position in the global export marketplace, with agricultural exports providing a significant positive contribution to the U.S. balance of trade.*"[16]

The *Importance of Inland Waterways* report examines the economic impact of inland barge transport on key agriculture states. The analysis estimates the direct and total (direct + indirect) economic contributions from the production of corn and soybeans and the volume of those commodities transported via inland waterways to Gulf Coast export elevators. Of the ten states examined, Missouri ranks third behind only Illinois and Iowa in terms of total employment and output associated with corn and soybean exports via inland waterways. Table 1 provides a summary of direct and total economic contributions from inland waterway corn and soybean exports for Missouri.

TABLE 2.1 ECONOMIC CONTRIBUTIONS FROM MISSOURI CORN AND SOYBEAN EXPORTS VIA INLAND WATERWAYS

Activity	Employment	Labor Income ($ Million)	GDP ($ Million)	Output ($ Million)
Corn Exports– Direct Economic Contribution	703	$3.2	$6.9	$95.0
Soybean Exports – Direct Economic Contribution	3,474	$76.1	$201.6	$922.0
Combined Direct Economic Contribution	**4,177**	**$79.3**	**$208.5**	**$1,017.0**
Corn Exports- Total Economic Contribution	1,267	$27.0	$50.9	$171.3
Soybean Exports – Total Economic Contribution	8,280	$278.7	$566.6	$1,564.9
Combined Total Economic Contribution	**9,547**	**$305.7**	**$617.5**	**$1736.2**

Source: IMPLAN, Agribusiness Intelligence

The Importance of Inland Waterways report also explored how the economic importance of inland waterways will increase with investments to upgrade and modernize lock and dam infrastructure as well as deepen the draft of lower Mississippi River by five feet. In 2019 Governor Parson wrote federal agencies to support the lower Mississippi dredging project:

> *"The Missouri River and Tributaries project has an estimated $735.7 billion annual economic impact and is responsible for approximately 2.4 million jobs, Parson said. The Soy Transportation Coalition calculated*

[16] *The Importance of Inland Waterways to U.S. Agriculture,* Agribusiness Consulting for USDA. August 2019. Pg. 1.

that completion of this project would result in $35 million in additional revenue for Missouri soybean farmers and $461 million across the U.S."[17]

Current Agriculture Supply Chain Issues / Challenges

Several of the issues discussed in the previous section are creating infrastructure challenges for agriculture transportation networks. One of the frequently overlooked impacts of elevator consolidation is the often much longer first- and last-haul between farm and elevator. Since high-capacity grain elevators tend to be strategically located on Class 1 rail lines or the river, farmers seeking lower rail or barge rates typically drive further over the highway network to access these facilities. In 2016, a study of harvesting equipment used by farmers in Iowa found: "*More and more grain is being hauled in trucks rather than wagons, sometimes for long distances… Eighty percent of the trucks reported were semi-trailer trucks… The semis had an average capacity of nearly 1,000 bushels compared to 547 bushels for the straight trucks."*[18]

A close examination of the map in Figure 2.5 shows most of Missouri's shuttle train elevators are located near Missouri's borders with neighboring states. The inventory identified only one shuttle train elevator centrally located in Missouri: The Ray Carrol Country Grain Growers elevator in Brunswick on the BNSF mainline. To compensate for the longer first-haul, most farmers have replaced 2- or 3-axle grain trucks with 5- or 6-axle tractor-semitrailer trucks. As a result of consolidation of grain elevators on the rail network, bigger, heavier trucks now travel longer distances on rural road networks. In 2015, Missouri's legal truck weight limits for grain and grain co-products were increased by 10% over normal weight limits on non-interstate highway facilities.

It should also be noted that, while the trend towards higher volume grain handling facilities has increased the average length of first-haul grain movements, a similar trend has occurred for last mile movements of fertilizers and pesticides. In 2016,U.S. farmers consumed just over 22 million tons of fertilizer.[19] Fertilizers used in the production of various crops are produced domestically, as well as imported. Just as railroad and barge networks are important to the export of grains, these same networks are used to move fertilizer products from coastal gateways to large storage facilities inland. However, virtually all fertilizer travels by truck over the "last mile" on its way to the farmer. While most fertilizer is handled in large quantities as a bulk commodity, it is increasingly being shipped using intermodal containers:

"*Somewhere in the world's busiest port of Shanghai, a container of fertilizer sits among tens of thousands of boxes, waiting for a ride to the U.S. It's been on the dock for months, trapped by typhoons and Covid outbreaks that have worsened major congestion in the global supply-chain network... The journey for our particular box of sandy-looking ammonium phosphate began in February. That's when, deep in the*

[17] Alisha Shurr, *Parson backs dredging of lower Mississippi River.* The Missouri Times. October 4, 2019.

[18] William Edwards, Alejandro Plastina. Grain Harvesting Equipment and Labor in Iowa. Iowa State University Extension and Outreach, June 2016. https://www.extension.iastate.edu/agdm/crops/html/a3-16.html

[19] Jeremy Martin *TFI Releases 2016 Commercial Fertilizer Report*. The Fertilizer Institute, July 15, 2021. https://www.tfi.org/newsroom/the-feed/2016-commercial-fertilizers-report.

agricultural heartland of the U.S. Midwest, a supplier for farmers in Illinois placed an order for eight container boxes filled with fertilizer from factories in central China."[20]

In 2020, TRIP, a private, nonprofit transportation research group, released a report ranking the condition of rural roads and bridges in all states:

"The report finds that Missouri's rural roads and bridges have significant deficiencies. Twenty-one percent of Missouri's rural roads are rated in poor condition – the 13th highest rate in the nation- and 28 percent are in mediocre condition. Nine percent of Missouri's rural bridges are rated in poor/structurally deficient condition, the 14th highest rate in the nation. Bridges rated poor/structurally deficient have significant deterioration to the major components of the bridge and are often posted for lower weight or closed to traffic, restricting or redirecting large vehicles, including agricultural equipment, commercial trucks, school buses and emergency services vehicles."[21]

In 2021, the Missouri Legislature passed the Missouri Transportation investment bill, allowing for the first increase to the state's gas tax since the 1990's. The bill which was supported by various farm groups will raise Missouri's gas tax of 19.5 cents per gallon and will continue to raise the tax by 2.5 cents per year until it hits 29.5 cents per gallon in 2025. Funds from the gas tax will pay for improvements to state roads and bridges. However, in December 2021, a bill was introduced to repeal the tax, with the outcome pending at this time.

The 2019 USDA report examining the economic importance of inland waterways also noted the need for infrastructure investments to maintain the waterway in a condition that keeps U.S. farmers competitive:

"Historically, barge traffic has grown, but lagging infrastructure maintenance and improvement needs have resulted in more frequent delays, with the percentage of vessels delayed increasing from 35 percent in 2010 to 49 percent in 2017. Delays can cost up to $739 per hour for an average tow, or more than $44 million per year."[22]

In December 2021, a coalition of farm groups, including the Missouri Soybean Merchandizing Council, proposed using $1 million in soybean checkoff funding to conduct pre-engineering and design work required to improve Lock and Dam 25, just north of St. Louis on the Mississippi River. The checkoff program started in 1991 as a provision in the 1990 Farm Bill. The program collects 0.05% of soybean sales each year to a fund managed by the United Soybean Board for education, promotion and research.

Another initiative being advocated by the Missouri Farm Bureau is the development of regional food systems, which enhance the food value chain at the regional or local level. The onset of the COVID-19 pandemic in 2020 highlighted weaknesses in the food supply chain's reliance on large scale food processers. Currently, the U.S.

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[20] Ann Koh, *One Stuck Box of Fertilizer Shows the Global Supply Chain Crisis,* Bloomberg. August 28, 2021. https://www.bloomberg.com/news/articles/2021-08-28/one-stuck-box-of-fertilizer-shows-the-global-supply-chain-crisis

[21] News Release: Missouri's Rural Roads & Bridges Have Significant Deficiencies & High Fatality Rates. TRIP website. Tuesday May 12, 2020. https://tripnet.org/reports/missouri-rural-roads-trip-news-release-2020/

[22] The Importance of Inland Waterways to U.S. Agriculture, Agribusiness Consulting for USDA. August 2019. Pg. 142.

protein packing market is highly centralized with only a handful of processors supplying most packaged meat products in the U.S. market.

When the “Big-4” meat packing processors; JBS, Tyson Foods, Cargill and Smithfield were forced to close large processing facilities due to COVID-19 outbreaks among workers, retail meat shortages followed. Yet, the small number of remaining independent and geographically separated meat processors remained open but did not have the capacity to handle the volume of livestock. The lack of protein packing processor capacity forced many farm and feed lot livestock producers to euthanize animals compounding the near-term supply recovery as the “Big-4” reopened plants. While meat shortages were mostly a short-term inconvenience in much of the United States, it had longer lasting dramatic negative effects on the global protein/food supply chain. The high cost of protein and supply in many parts of the world has yet to recover. Food shortages resulting from the pandemic however brought to light the value of localized food systems initiating changes to protein supply chains likely to playout over the next several years.

During interviews of freight facility operators for the Missouri Freight Plan, the operator of a container facility in Kansas City, Mo. discussed COVID impacts on the containerized grain movements. Prior to the pandemic, grain filled containers moving by rail from Kansas City to deep water west coast ports were most often bound for China. As the U.S. trade relationship with China soured, Vietnam became an attractive alternative market. The facility operator noted that many smaller developing countries like Vietnam do not have the infrastructure and equipment to efficiently handle ship load volumes of grain. Many niche market buyers prefer containers due to the ease of handling and distribution on the receiving end.

The long running trade imbalance between the U.S. and Asia has also contributed to a deficit of empty containers inland available to many value-added ag products. Most intermodal import/export trade is done using 20- or 40-foot ISO containers.[23] Most ISO shipping containers are owned by ocean container shipping lines. Because much of the import volume to the U.S. from Asia is low weight consumer goods, ISO containers usually “cube-out” before they “weigh-out” when loaded on a truck for over-the-road transport. To maximize the cubic capacity of over-the-road tractor semitrailers, the contents of inbound ISO containers are transloaded at or near the port to domestic containers. Domestic containers are typically 48- or 53-foot steel boxes that maximize the cubic capacity of over-the-road trucks. Shipping lines have historically placed higher value on getting empty ISO containers back to Asia quickly for reloading over repositioning empty containers within the US to be filled with agriculture exports. Since inbound container movements to the U.S. are primarily driven by population density, empty ISO containers usually end up in urban intermodal yards like Chicago or Kansas City. During stakeholder interviews conducted for the SFRP, Front Street in Kansas City was cited as one example of a congested urban facility in poor condition serving elevator facilities on the Missouri River near downtown KC.

[23] ISO stands for International Standards Organization, an international body that establishes the dimensions for shipping containers used in international commerce.

During the pandemic, the issue of container access has grown. In a January 2021 Transportation Research Board Annual Meeting session; *Pandemic Impacts on Agriculture Supply Chains,* Elena Asher Assistant Director-Export Logistics for Dairy Farmers of America based in Kansas City, indicated that access to containers had become an issue for their exports of powdered milk products.

REGULATORS TO PROBE CONTAINER SHORTAGE IMPACT ON U.S. EXPORTERS

"The Federal Maritime Commission will probe shipping lines that agricultural exporters say are holding back containers needed to reach foreign markets by holding back empty containers needed to export goods…

The Federal Maritime Commission said in a statement Friday that it would investigate actions by ocean carriers at the ports of Los Angeles, Long Beach and New York, as a crush of imports has triggered bottlenecks at the country's biggest export gateways and buffeted inbound and outbound supply chains.

U.S. exporters of soybeans, cotton, lumber and hay say they cannot find the boxes they need at distribution points in the middle of the country because shipping companies are rushing to unpack containers coming in from Asia and send them back empty, rather than loading them with American exports."[1]

—Costas Paris, Nov. 20, 2020

The Wall Street Journal

The topics of agriculture and transportation often direct our attention to rural highways supporting first-mile grain movement between the farm and a country elevator. However, the continuing evolution of modern agriculture and global supply chains are creating myriad demands on Missouri's transportation networks. Privately owned elements of the multimodal transportation networks serving agriculture have undergone dramatic network and facility changes that put different, if not greater demands, on publicly owned network elements. The desire to create more on-farm value in agriculture is also changing transportation service demands. The ongoing evolution of agriculture markets, continued growth in productivity and the enduring demands on highways as intermodal connectors will require re-investment and innovative approaches to keep Missouri agriculture competitive in the future.

Retail and E-commerce

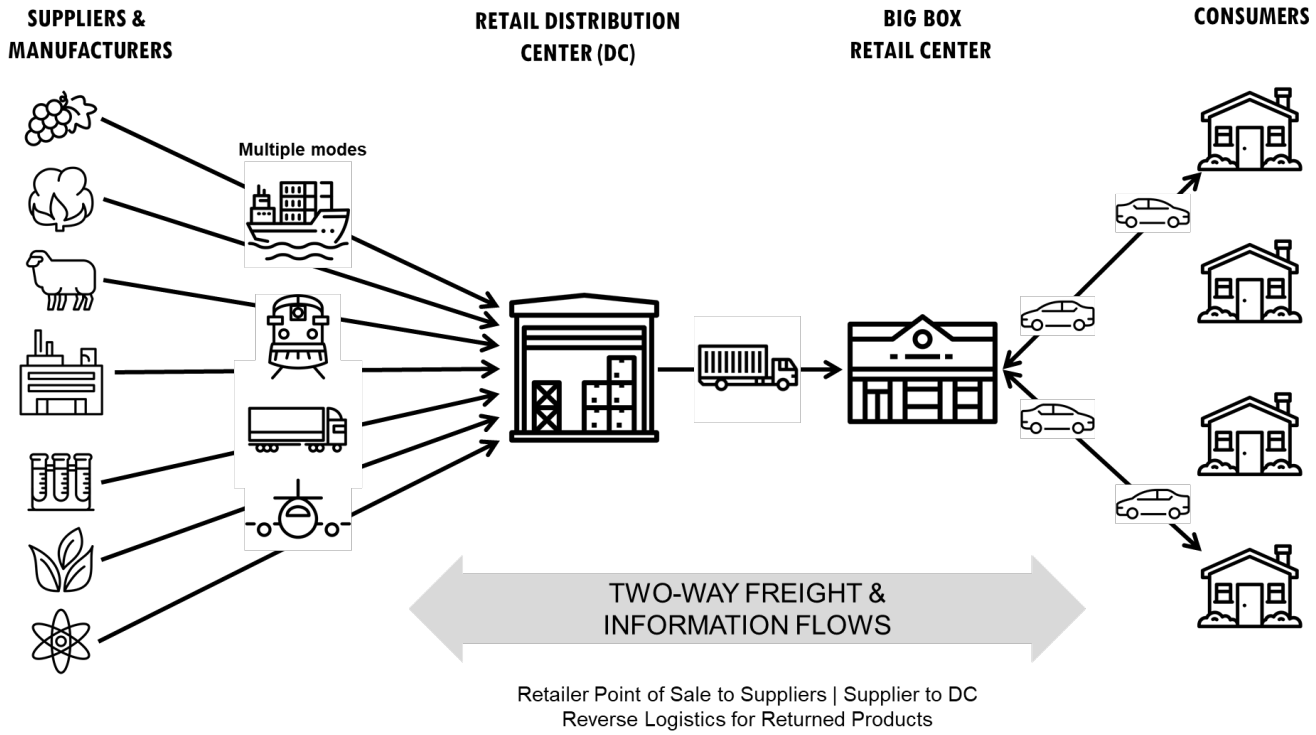
Another supply chain that has undergone tremendous change over the past several decades is retail commerce. For most of the 20th century, retail supply chains were characterized by *main street*" brick and mortar stores where individual businesses received and sold their goods to consumers buying at individual stores. These main street retail supply chains were characterized by producers/manufacturers and other product suppliers *pushing* product quantities into retail locations to stock inventory. The strategy around push supply chains was largely based on often slow and unreliable transportation networks. The logistics of push supply chains were driven by forecasts of predicted consumer demand. Products were produced and distributed in quantities sufficient to stock retail product inventories at levels forecast to meet consumer demand in the coming weeks or months. If forecasts were wrong, retailers could be left with high inventories of unsold goods placed on clearance or out-of-stock items resulting in missed sales opportunities and unhappy customers.

Starting in the late 1960's, retail giants like Walmart introduced *big box* stores. By assembling many products in a single location, retailers began to control inventory supply and transportation decisions using technology-based strategies to manage inventory and replenishment strategies. Point-of-sale customer data helped retailers monitor consumer buying practices. The data collected at the checkout counter was then sent through the supply chain to manufacturers or distributors for planning purposes. This reverse flow of customer sales data led to the evolution of

pull supply chain management and inventory replenishment, i.e., additional inventory is pulled from suppliers when customer sales data indicate in-store supplies are getting low.

Concurrent with the emergence of pull inventory management, the concept of *reverse logistics* also emerged as a means of handling unused, returned, or recycled products. The key attribute of pull supply chains is the two-way flow of information and freight. In this model, inventory levels are greatly reduced as the various links in the supply chain communicate with each other in real-time. This model places greater demands on distributors who handle a far broader variety of products from large, big box retailers. Pull supply chain management led to the development of regional distributions centers capable of handling a wide variety of products in large volumes. Large retail, manufacturing and transportation firms also began using customer data to optimize the location of distribution and transload facilities to minimize operating costs in supply chain networks. Figure 10 depicts a simplified big box pull supply chain network.

FIGURE 10 BIG BOX RETAIL SUPPLY CHAIN

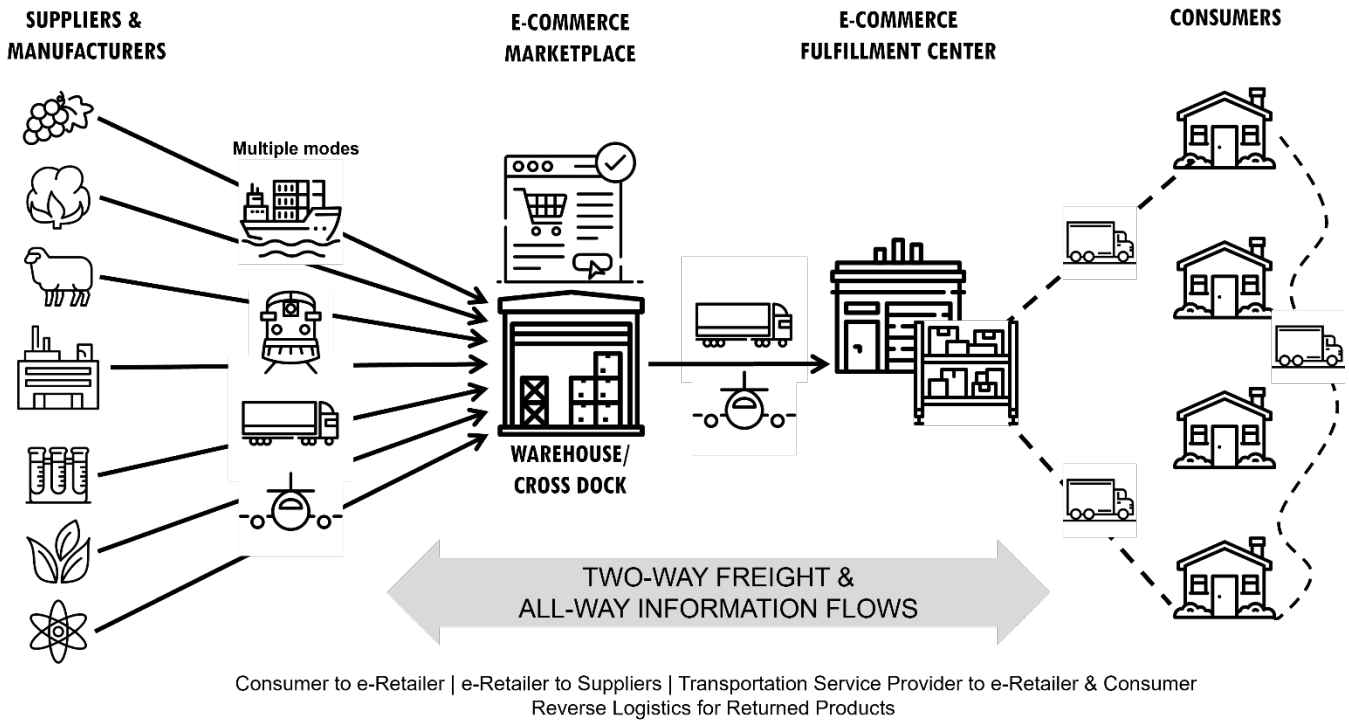


Source: Quetica.

E-commerce refers to any retail transaction conducted using the Internet. E-commerce slowly evolved in the retail market starting with the launch of Amazon in 1997. Originally a book selling marketplace, Amazon was for many their first introduction to e-commerce. In recent years, more consumers turned to the Internet to make retail purchases due to the convenience and cost effectiveness of online shopping. The COVID-19 pandemic in 2020 created an unprecedented and immediate leap in e-commerce demand as consumers largely avoided in-person shopping to adhere to social distancing and work-from-home protocols. The Census Bureau estimates that e-commerce now comprises 14.4% of total U.S. retail sales, an increase of 4.5%—or $271 billion dollars—over its retail share in 2018, resulting in a total industry value of $794 billion dollars.

E-commerce is changing metropolitan landscapes as traditional brick and mortar retail establishments close due to e-commerce competition. In the supply chain depiction shown in Figure 11, brick and mortar retail stores are replaced by an Internet-based marketplace and fulfillment centers located near consumers. The loss of brick-and-mortar retail establishments has been coined *The Amazon Effect*.

FIGURE 11 E-COMMERCE RETAIL SUPPLY CHAIN



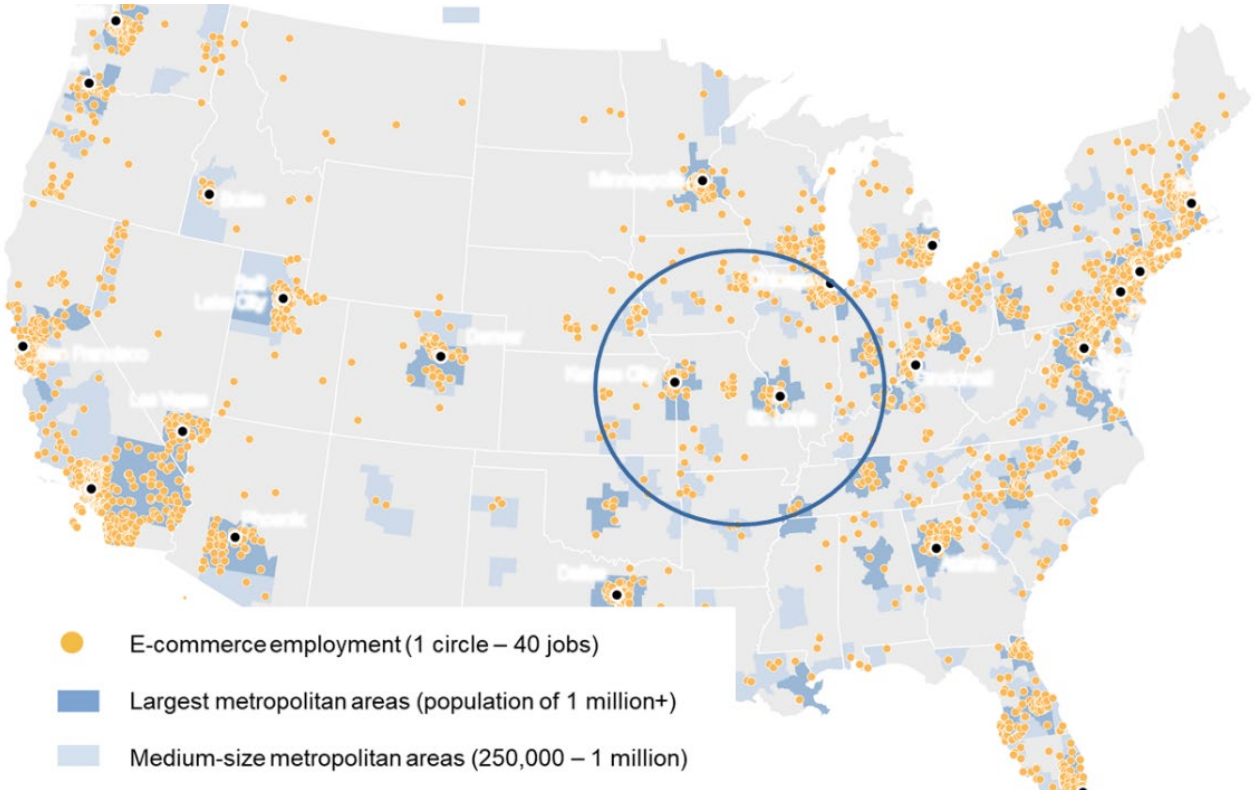
Source: Quetica.

Economic Contributions of E-commerce to the Missouri Economy

In 2017, the New York Times (NYT) examined the impacts of e-commerce on job growth in the U.S., and Figure 12 shows the results of that analysis. The data showed between 2002 and 2016 labor growth in the retail industry was relatively flat; department store employment declined 25%, warehousing jobs grew by 80%, but e-commerce grew by over 330%. Nonetheless, as a percent of all retail jobs in 2016, e-commerce jobs remained a small share of the total. The research presented by the NYT found that nearly three-quarters of e-commerce firms have four or fewer employees. Mapping e-commerce related employment showed that most of the job creation is occurring in large metropolitan areas; just 13% of electronic shopping employment lies in rural areas, while rural areas account for 23% of retail sales.[24]

[24] Robert Gebeloff and Karl Russel, *How the Growth of E-commerce is Shifting Retail Job.* The New York Times, July 6, 2017.

FIGURE 12 E-COMMERCE JOB GROWTH



Source: New York Times.

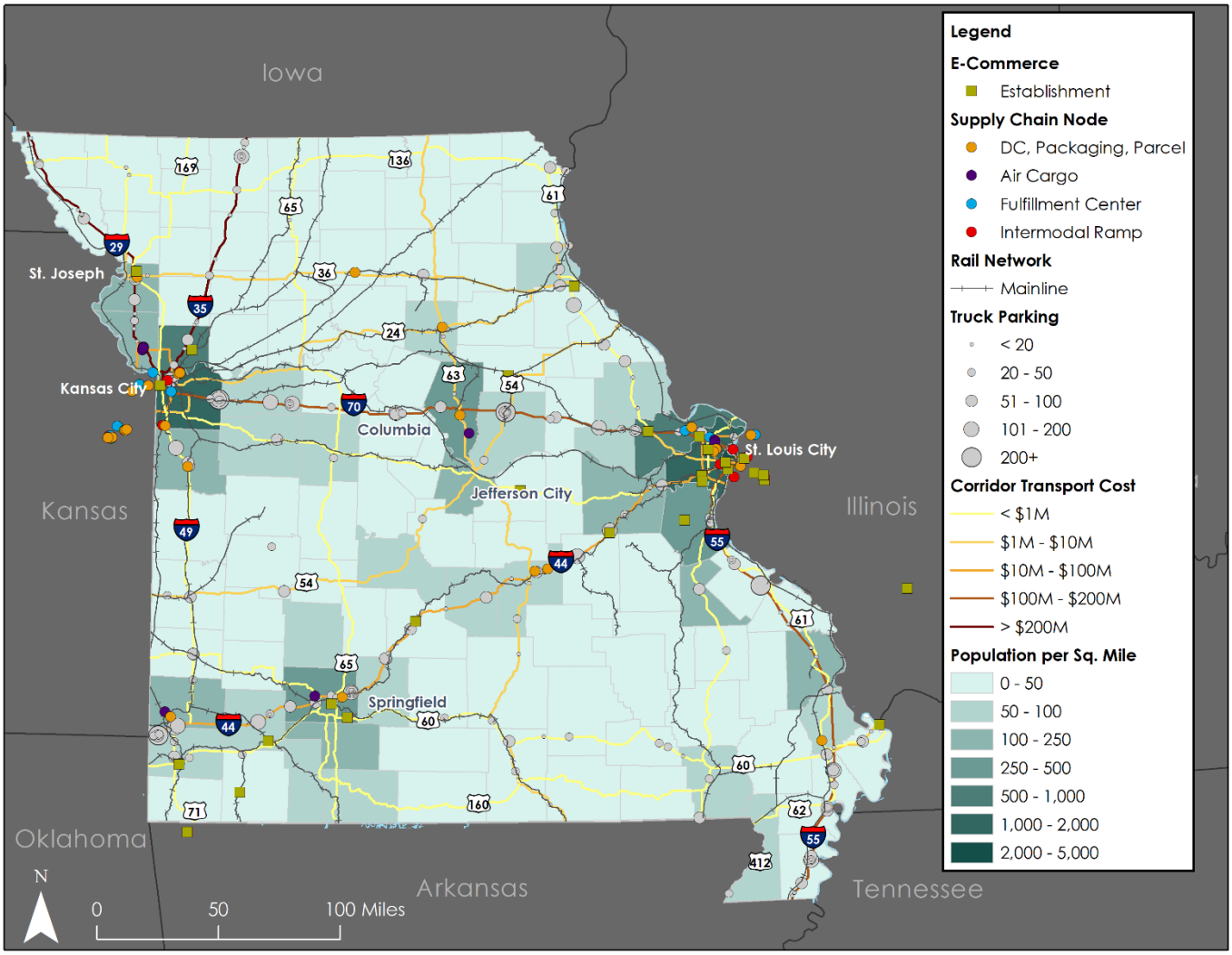
Transportation Facilities Supporting E-commerce in Missouri

The map in Figure 13 shows e-commerce facilities in and near Missouri. The establishments shown in the map are non-store retailers (NAICS 454). The largest concentration of e-commerce establishments is found in the St. Louis region which also has the highest concentration of population. A number of supply chain nodes are also located within the St. Louis region providing transportation and other supply chain services including St. Louis Lambert International Airport, intermodal ramps, fulfillment and distribution centers, packaging companies and parcel carriers. Other e-commerce activity can be seen in the Kansas City region along with Columbia and Jefferson City in the Central region and Joplin and Springfield in the Southwest region.

Analysis of private sector bill of lading data, combined with TRANSEARCH freight flow data and e-commerce's share of total shipments or revenue per subsector[25], shows highway movements within the industry's supply chains are most prevalent along several north-south interstate corridors through Missouri, including I-29, I-35 and I-55, as well as along the I-70 corridor running east and west. The map also identifies important transportation nodes within the supply chains including connections to the air cargo network, the intermodal rail network and parcel carriers.

[25] E-commerce Statistics (*E-Stats).* United States Census Bureau. https://www.census.gov/programs-surveys/e-stats/data/tables.html

FIGURE 13 MISSOURI E-COMMERCE



Source: Quetica.

Current Retail and E-commerce Supply Chain Issues and Challenges

Urban "mega-warehouse" developments are a future growth market fueled by e-commerce, giving rise to warehouse facilities of one million square feet or more. E-commerce supply chains require more than three times the distribution space required by traditional retail supply chains centered on brick-and-mortar distribution. (1.2 million square feet per million in sales). In 2019, Amazon opened an 855,000 square foot fulfillment center in St. Peters, Missouri a short distance from St. Louis. It was Amazon's first robotics fulfillment center.[26] The new facility employs an estimated 1,500 full-time employees.

Another trend associated with e-commerce is the mixing of retail spaces with distribution, and/or the use of former retail space for distribution. Increasingly, traditional brick and mortar retail stores are repurposed to warehouses,

[26] Steph Kukuljan, *Inside Missouri's first Amazon fulfillment center.* St, Louis Business Journal. June 26, 2019.

referred to as *dark stores* or *dark distribution centers.* These dark store facilities are closed to the public and are used for forward deployed inventory. Being close to consumers allows e-retailers to deliver goods in less time. Because new warehouse space is hard to find in urban centers, repurposing existing retail stores offers one solution. A similar trend is the development of *nano-fulfillment centers* or *micro-fulfillment centers*- new, smaller warehouses averaging about 10,000 sq. feet located close to or in major population centers. Historically, warehousing was viewed as a cost of inventory. Today the ability to deliver within hours is seen as a cost of marketing.

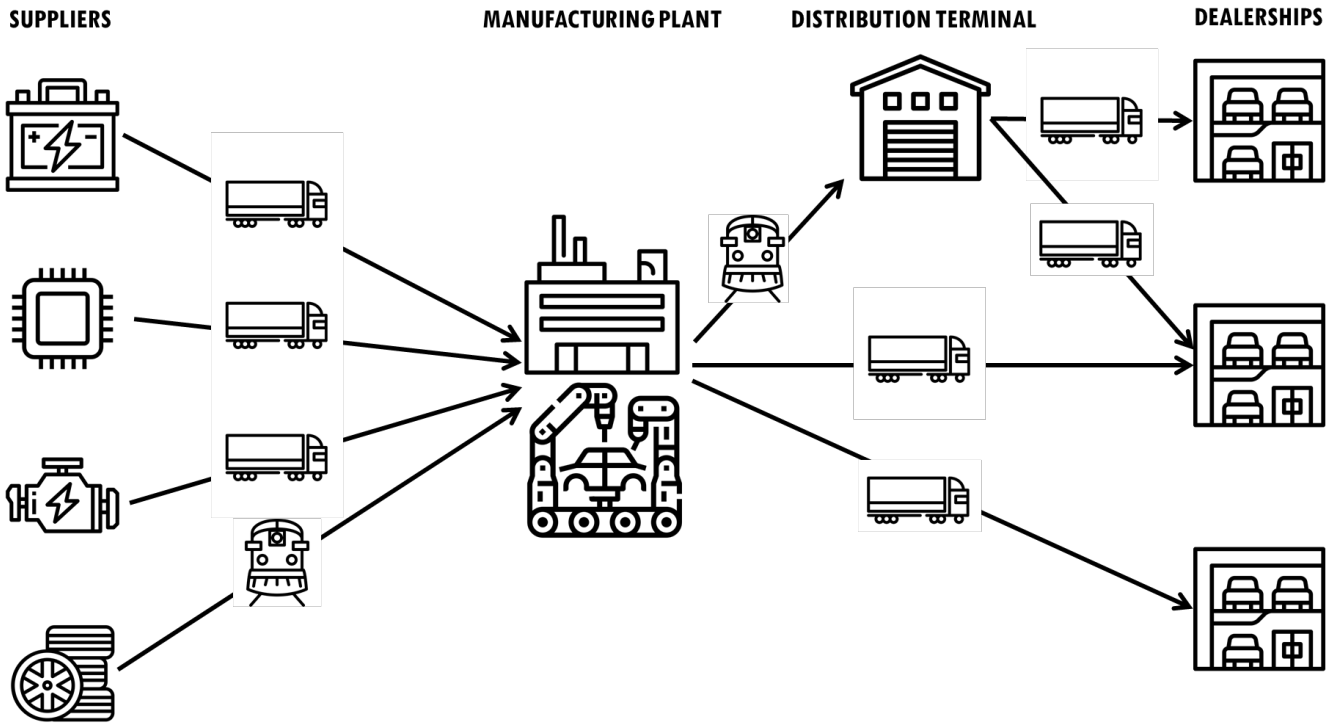
E-commerce is anticipated to grow as more consumers have familiarized themselves with the technology throughout the COVID-19 pandemic. E-commerce retailers will continue seeking ways to service customers under shorter delivery windows by moving distribution facilities closer to the end consumer. One way to shorten delivery windows is to build additional large distribution and fulfillment centers near metropolitan areas, as well as the repurposing and construction of new dark store and micro-fulfillment centers in the heart of population centers.

Transportation Equipment Manufacturing

The transportation equipment manufacturing subsector covers the production of vehicles across all modes of transport. It includes the production of finished products like motor vehicles, airplanes, locomotives and railcars, ships and boats, motorcycles and armored military vehicles as well as many of the parts and components that are combined to form the finished products.

The utilization of just-in-time manufacturing processes by the transportation equipment industry requires participants to tightly align production schedules with the deliveries of the needed inputs from suppliers (Figure 14). Suppliers also utilize the ocean and air networks to move inputs produced overseas to the U.S. and to make time-sensitive deliveries. The just-in-time process results in the ability of disruptions in the delivery of any one input to negatively impact the entire process. In addition, poor road conditions can result in wear and tear for trucks and trailers, while congestion can cause unexpected delays at the plant. Maintaining a state of good repair and appropriate levels of service across the multimodal network is needed for this process to be successful.

FIGURE 14 MOTOR VEHICLE SUPPLY CHAIN



Source: Quetica.

Economic Contributions of Missouri's Transportation Equipment Industry

Missouri's transportation equipment manufacturing industry consisted of more than 270 establishments in 2018, with employment topping 44,500. The industry is concentrated in two industry groups: the production of motor vehicles and its parts; and the production of aerospace products and its parts. According to the Missouri Partnership[27], the state's transportation equipment exports totaled more than $3.2 billion in 2019.

The motor vehicle industry group includes the businesses manufacturing motor vehicles, those manufacturing motor vehicle bodies and trailers and those manufacturing motor vehicle parts. Parts include engines and engine parts, electrical and electronic equipment, steering, suspension, brake systems, transmission and power trains, seats, trim, vehicle metal stamping and others.

The Missouri Partnership reported Missouri is home to roughly 25,180 employees across 235 automotive establishments: 15 producing motor vehicles, 81 producing motor vehicle bodies and trailers including motor homes and campers, and 139 producing various parts. Vehicle production accounted for the largest share of employees with 46% followed closely by motor vehicle parts at 43%. Major motor vehicle corporations with operations within Missouri include General Motors, the Ford Motor Company, Toyota, Johnson Controls, O'Reilly Auto Parts, Modine, TG Missouri, SRC Automotive and Faurecia.

[27] *Missouri: Center of Automotive Manufacturing Excellence.* Missouri Partnership. https://www.missouripartnership.com/industry-strengths/top-advanced-manufacturing-network-location/

Missouri's aerospace industry is comprised of roughly 100 manufacturing companies.[28] The Aerospace Product and Parts industry group consists of companies producing aircraft, aircraft engines/engine parts and other aircraft components. It also includes companies manufacturing guided missiles, space vehicles, propulsion units and parts.

Located in St. Louis, Boeing is Missouri's largest aerospace company with more than 16,000 employees. Boeing currently produces a number of aircraft for U.S. Air Force including the new F-15EX. Boeing recently announced a $70 million expansion in St. Charles to increase missile production.[29] Other major Missouri aerospace companies include GKN Aerospace producing parts and components in St. Louis, Seyer Industries producing advanced machined parts in St. Peters, PAS Technologies producing components in Kansas City, and NEMO Manufacturing producing electrical components for fighter jets in La Grange.

Transportation Facilities Supporting Missouri's Transportation Equipment Manufacturers

The map shown in Figure 15 displays facilities that play a variety of roles in transportation equipment manufacturing supply chains. The 166 business establishments shown as gold squares on the map were taken from IHS-Markit's *Freight Finder* business establishment data set, classified under the '336—Transportation Equipment Manufacturing' industry subsector. Roughly two-thirds of those establishments are producers of motor vehicles or parts and components for motor vehicles. The remaining establishments include producers of transportation equipment and parts for the aerospace rail and waterway markets and other types of transportation equipment. Industry activity is concentrated in the St. Louis and Kansas City regions. According to 2018 County Business Pattern data, roughly four out of every 10 industry

TOYOTA TO INVEST $13 BILLION OVER FIVE YEARS

In March 2019, Toyota announced its intention to invest $13 billion into its U.S. operations. Following an earlier 2017 investment pledge of $10 billion over five years. The March announcement highlighted an additional $3 billion investment over the same timeframe. $750 million will be spent across five states. The capital investment would support the creation of 586 new jobs.

Of the $750 million, $62 million was slotted for Toyota's Bodine Aluminum plant in Troy, Missouri to purchase new equipment resulting in the plant's 900 employees' ability to produce an additional 864,000-cylinder heads for its New Global Architecture. The plant's current production capabilities, roughly three million-cylinder heads per year, are used in every North American built Toyota and Lexus.

According to a Business Journal article discussing the announcement:

"These latest investments represent even more examples of our long-term commitment to build where we sell," Jim Lentz, chief executive officer for Toyota Motor North America, said in a statement. "By boosting our U.S. manufacturing footprint, we can better serve our customers and dealers and position our manufacturing plants for future success with more domestic capacity."

- Jacob Kim, ***Toyota to invest $62M in Troy Plant.*** *St. Louis Business Journal March 14, 2019*

[28] *Aerospace & Defense in Missouri.* Missouri Partnership. https://www.missouripartnership.com/wp-content/uploads/2016/08/Aerospace-and-Defense-in-Missouri-2.pdf

[29] *Boeing eyes $70M addition in St. Charles.* St. Louis Business Journal. July 17, 2019. https://www.bizjournals.com/stlouis/news/2019/07/17/boeing-eyes-70m-addition-in-st-charles.html

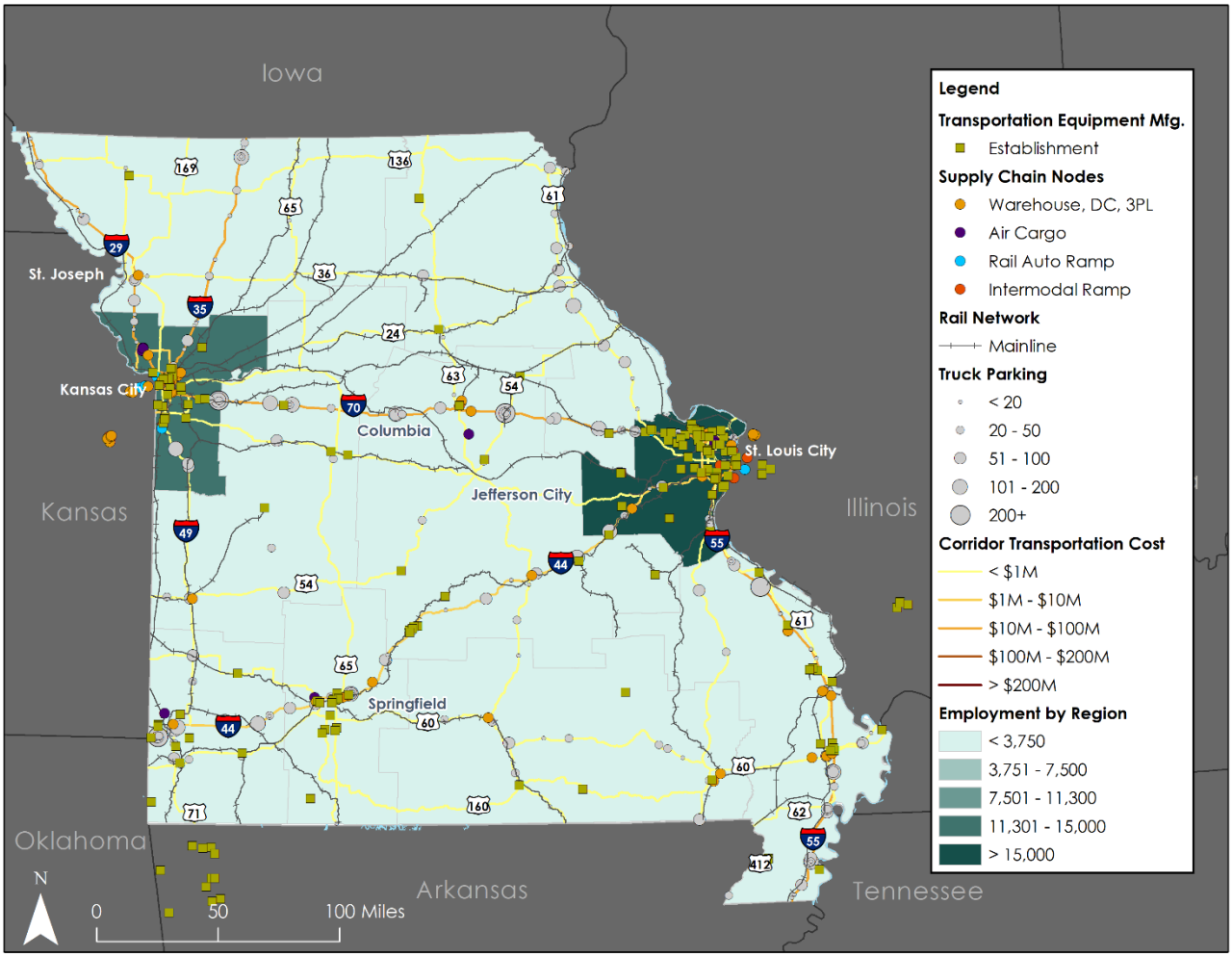
establishments were located within one of these two Missouri regions, while they accounted for almost 70% of the employment.

The map also identifies important transportation nodes within the supply chains including connections to the air and rail networks, warehousing and distribution locations, and third-party logistics providers. Manufacturers of motor vehicles use the rail network to deliver its inputs and rail auto ramps to load and unload large quantities of finished products to the rail network for distribution before reaching local automotive dealerships. Access to intermodal ramps allows industry participants to utilize standardized containers and efficiently move freight within the supply chain between the ocean, rail and highway networks both domestically as well as internationally through coastal ports and land-border crossings. Four Class 1 rail networks serve automotive shippers in Missouri: BNSF, KCS, NS and UP.

Analysis of private sector bill of lading data combined with TRANSEARCH freight flow data shows highway movements within the industry's supply chains are most prevalent along several north-south interstate corridors through Missouri including I-29, I-35 and I-55, as well as along the I-70 corridor running east and west.

Air cargo facilities provide overnight access to global markets and the Nation's 'hub-and-spoke' air cargo network to move parts and components between suppliers and buyers. While automotive manufacturers rely upon ocean networks to connect with overseas suppliers and markets, these modal connections are not located in Missouri. Warehouses, distribution centers and third-party logistics companies provide storage, distribution, logistics and fulfillment services to the industry for needed inputs into the final manufacturing process and parts to support after-market needs.

FIGURE 15 MISSOURI TRANSPORTATION EQUIPMENT MANUFACTURING



Source: Quetica.

Current Transportation Equipment Manufacturing Supply Chain Issues and Challenges

Several trends are presenting issues and challenges to the transportation equipment industry and its supply chains. Two will be discussed here: the impact of COVID-19 on the production of transportation equipment and the impacts on the industry from a transition into electric vehicles (EVs) and away from internal combustion engine (ICE) powered vehicles.

Production of U.S. motor vehicles was severely impacted in the spring of 2020 as motor vehicle factories were shut down in the early days of the pandemic to slow the spread of the virus. As the pandemic has continued, additional impacts have slowed U.S. production. The industry's global supply chains have not been able to keep up with demand for its products.

Electronic components, once limited to the starter, a radio and the electrical system to power windows and the like are now required for sophisticated technological systems. Connected and autonomous vehicle technologies are

examples of this of the progressing technology. With the introduction of image sensors, LiDAR and advance driver assistance systems on board, high-performance computers are needed.

The rise of EVs poses a particular risk for auto suppliers. Major systems that are essential to vehicles with internal combustion engines are absent from EVs. Makers of exhaust systems, fuel systems, and transmissions face the prospect of disruption as EVs become more mainstream.

- PwC

A global shortage of semiconductors has significantly impacted U.S. motor vehicle production. Factory shutdowns due to a lack of microcontroller units have impacted production for both GM and Ford and has caused analysts to predict a reduction in the global production of light-duty vehicles by 672,000 units.[30] According to *Supply Chain Dive*, important factors in the shortage include the competition the industry faces from high-volume semiconductor consumers such as producers of smartphones and computers and the extended lead-time needed to expand production of semiconductors.

Automotive supply chains are responding to growing demand for EVs. Changes in consumer preferences, advancements in technology and more stringent government emission regulations are increasing the demand for EVs. According to USA Facts, 727,000 electric-drive vehicles were sold in the U.S. in 2019. For comparison, U.S. consumers purchased 17 million light duty vehicles.[31] As production of EVs increase, it will increasingly push changes into the supply chains of not just the original equipment manufacturers, but also their suppliers. .

Research by PwC[32] shows that value added by suppliers to an ICE vehicle accounts for 50-55% of its total value whereas the value added by suppliers to an EV accounts for only 35-40%. This reduction is due to the fact EVs have fewer moving and wearing parts compared to ICE powered vehicles. According to UBS Global Research[33], the Chevy Bolt has a total of 35 moving parts and only three moving parts in the engine. By comparison, the Volkswagen Golf with an ICE has a total of 167 moving and wearable parts with 113 of those parts being in the engine. Certain suppliers will see demand for their products decrease as EV market share grows. For example, exhaust, fuel and transmission systems are not required by EVs. On the other hand, suppliers of several materials will see demand for their products increase. As part of its research, UBS estimated the increase in

General Motors extended factory shutdowns into March as a result of the semiconductor shortage. Ford said production in Q1 this year could fall by as much as 10% to 20% from the original plan. Overall, global automotive manufacturers could produce 672,000 fewer light vehicles in Q1, according to an estimate from IHS Markit.

- Supply Chain Dive

[30] *Why the automotive supply chain is in a semiconductor jam?* Matt Leonard, Supply Chain Dive. February 23, 2021. https://www.supplychaindive.com/news/semiconductors-tsmc-general-motors-ford-Infineon-mcu/595214/

[31] How many electric cars are on the Road in the United States? USA FACTS. October 2020. https://usafacts.org/articles/how-many-electric-cars-in-united-states/

[32] *Merge ahead: Electric vehicles and the impact on the automotive supply chain.* PwC. https://www.pwc.com/us/en/industries/industrial-products/library/electric-vehicles-supply-chain.html

[33] *Q-Series: UBS Evidence Lab Electric Car Teardown—Disruption Ahead?* UBS Global Research. May 2017 https://neo.ubs.com/shared/d1wkuDlEbYPjF/

demand for lithium to be 29x the current demand if EVs comprised 100% of passenger vehicles. Demand for other materials would grow as well including 19x for cobalt, 6.5x for rare earth metals such as neodymium and dysprosium, 5x for graphite and 1x for nickel. PWC reports the lithium-ion battery packs used to power EVs can account for up to 50% of its value.

Transportation equipment manufacturers' supply chains will become less complicated as the production of EVs increase, due to fewer components and systems in the EV manufacturing process versus ICE. However, the criticality of its suppliers will increase with a focus on lithium-based battery packs and other rare earth metals. As was seen with the COVID-19 pandemic, the decrease in supply of critical inputs can significantly impact the production of transportation equipment.

Food Processing

The food processing/manufacturing industry sector is comprised of a variety of subsector industry groups:[34]

- Animal Food Manufacturing
- Grain and Oilseed Milling
- Sugar and Confectionery Product Manufacturing
- Fruit and Vegetable Preserving and Specialty Food Manufacturing
- Dairy Product Manufacturing
- Animal Slaughtering and Processing
- Seafood Product Preparation and Packaging
- Bakeries and Tortilla Manufacturing
- Other Food Manufacturing

The Missouri Partnership, a public-private economic development organization refers to a combined agriculture and food processing industry sector in Missouri as the "*Agtech and Food Solutions*" industry.

Economic Contributions of Missouri's Food Processing Industry

In a 2016 report to the Governor, food, beverage and forest products manufacturing estimated that food and related products manufacturing contributed $15.5 billion to the Missouri economy.[35] According to the Missouri Partnership, the food production industry includes more than 400 companies and accounts for more than 15% of Missouri's manufacturing employees and includes $30 billion in pet food production.

[34] US Bureau of Labor Statistics, description of Food Manufacturing NAICS 311.

[35] Show-Me-State Food, Beverage & Forest Products Manufacturing Initiative: Report to the Governor.

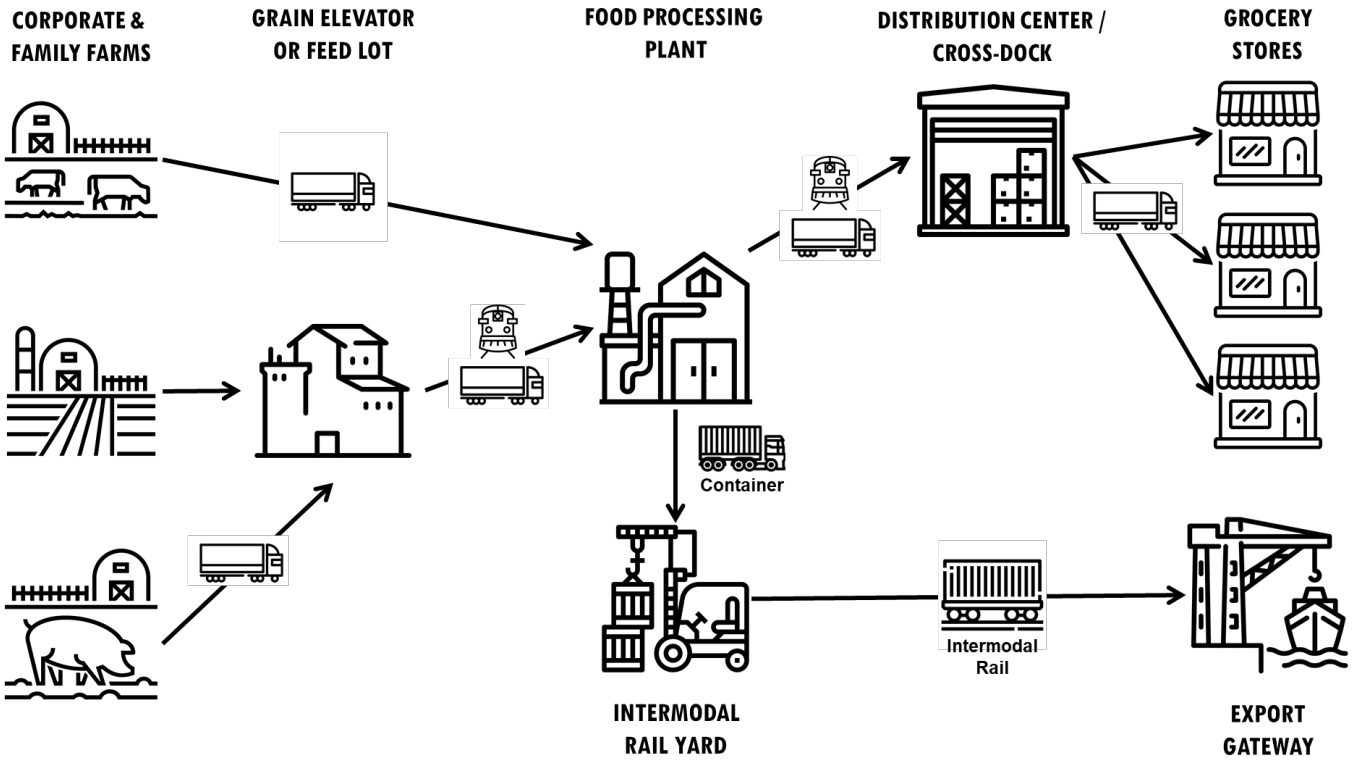
A generic flow diagram for the food processing supply chain is depicted in Figure 16. Due to the wide variety of food and beverage products, specific product supply chains will vary; however, for many food and beverage manufacturing processes, the supply chain begins with the raw commodity movements highlighted in the earlier discussion of agriculture supply chains.

For processed foods and beverage products, farmers transport harvested grains to a grain elevator or directly to a food or beverage production plant. For example, Anheuser-Busch works directly with over 1,000 farmers across the U.S. to ensure crops are grown to meet the company's specifications. Missouri is the fourth largest rice producer in the country and major supplier to Anheuser-Busch. Similar to IP crops, some specialty crops, like popcorn, are often packaged on or near the farm and then shipped to domestic or export markets via truck or intermodal container.

The meat processing industry begins with animal or livestock production. How animals are bred and raised differs between industry segments and the size of the operation. Much like the changes and consolidation in grain production, the livestock and poultry industries have undergone consolidation and specialization. For example, during most of the twentieth century, poultry farmers raised mature chickens from eggs. Chickens and eggs were typically part of the same process on farm production. While smaller on-farm or home flocks remain, much of the poultry industry has become specialized, with four major segments or types of production facilities: 1. Egg production, 2. Broiler production, 3. Turkey production, and 4. Pullet production. Today, it is common for breeder or pullet farms to specialize in hatching and raising young chickens (pullet is the term for a young chicken) that are then sent to a broiler farm operation. A broiler farm finishes raising young chickens specifically for the purpose of supplying meat. Broiler farms and livestock feedlots, where animals are finished or grown to their market weight, typically consume large volumes of grain and often take in grain by truck or rail.

To create greater on-farm or near farm valued-added production food processing establishments are increasingly owned by grain marketing firms, farm service companies or agricultural cooperatives. Processed foods for domestic consumption are transported by truck or rail to distribution center cross-docking facilities where mixed loads are prepared for grocery store distribution. Processed foods for export are loaded into dry or refrigerated containers and taken to the nearest intermodal yard to be shipped by rail to coastal deep-water ports.

FIGURE 16 FOOD SUPPLY CHAIN



Source: Quetica.

The trend for greater on-farm or near farm value-added production, is a focus of several Missouri farm industry associations. The Missouri Farm Bureau (MFB) highlights its Value-Added Initiative as one of its priority issues. On its website, MFB notes that more processing of raw goods in-state *"could keep billions more dollars in Missouri* [and] *this initiative could be the basis for Missouri's future agriculture growth."*

In partnership with MFB and other agriculture associations in the state, in 2019, the Missouri Agriculture Foundation commissioned a study to explore initiatives to further promote value-added agriculture and forest product production in the state:

> *"Missouri's economy is composed of a relatively significant food, beverage and forestry value-added processing industry, but substantial volumes of commodity crops and livestock are shipped out of the state without having undergone significant value-added processing. Revenue is being lost because large volumes of primary production leave the state without further in-state processing steps adding value to the product."*[36]

The movement towards more regional/local food systems is sometimes described as efforts to "shorten supply chains." As noted in the earlier discussion of Missouri's agriculture supply chains, issues resulting from the global COVID-19 pandemic created disruptions in the U.S. food supply chain including short term shortage of some food

[36] Show-Me-State Food, Beverage & Forest Products Manufacturing Initiative, Teconomy Partners for the Missouri Agriculture Foundation. February 2019.

items. The shorter supply chains have been realized through both large companies installing regional/local distribution centers and agriculture producers providing more direct distribution. Both of these resolutions have changed the supply chain and freight network needs in Missouri.

Another trend affecting food supply chains is e-commerce. According to FMI-The Food Industry Association, online grocery sales were up over 300% during the first several months of the global pandemic.[37] In its latest survey; *The Food Retailing Industry Speaks 2021,* during all of 2020: "*Ninety-five percent of grocery retailers offering e-commerce services saw online sales rise last year, with an average gain of 224%."*[38] With the COVID-19 pandemic convincing many consumers to stay at home, an already growing e-commerce marketplace surged. However, with the pandemic continuing to influence consumer behavior at the time of this report, the longer-term impacts on transportation remain murky. In the 2020 survey of grocers, it was reported that "*ship-to-home"* online sales through a traditional grocer or e-commerce marketplace with the delivery performed by a parcel carrier, were down 16%, while curbside pickup sales were up 75%. However, in the 2021 survey, 65% percent of grocery retailers said shortfall in trucking/ transportation capacity negatively impacted their business in 2020. So, it is unclear whether the trend toward curbside pick-up will carry over to a post-pandemic environment.

The supply chain diagram in shows several key developments in food supply chains that were accelerated by the COVID-19 pandemic. While recent surveys suggest that consumers are returning to in-store grocery shopping stores re-opened with protocols in place, online grocery shopping is likely to remain a significant share of the retail grocery market, as grocery sales are predicted to be one of the fastest growing segments of e-commerce.

The bottom portion of the food supply chain illustration (Figure 17) depicts the trend towards direct producer sales to grocers and consumers. Meat processing is one of the farm-to-table initiatives in the Midwest seeing strong support. In July 2020, the Missouri Department of Agriculture announced a $20 million grant program to support small meat and poultry processors:

> *"The governor says the grant program for smaller Missouri meat and poultry processors is for plants with less than 200 employees. Parson says it's aimed at increasing livestock and poultry processing capacity across the state."*[39]

The Missouri Legislature also extended the Meat Processing Facility Investment Tax Credit until December 31, 2027. During roughly the same time, U.S. Agriculture Secretary Tom Vilsack lead a series of listening sessions and hear similar concerns over the capacity of small beef and pork processing facilities (meat lockers) in the Midwest. In response USDA announced a grant program making $500 million available to expand local processing capacity.[40]

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[37] FMI-The Food Industry Association, Food Retailing Industry Speaks 2020. Online: Product: The Food Retailing Industry Speaks 2020: FMI

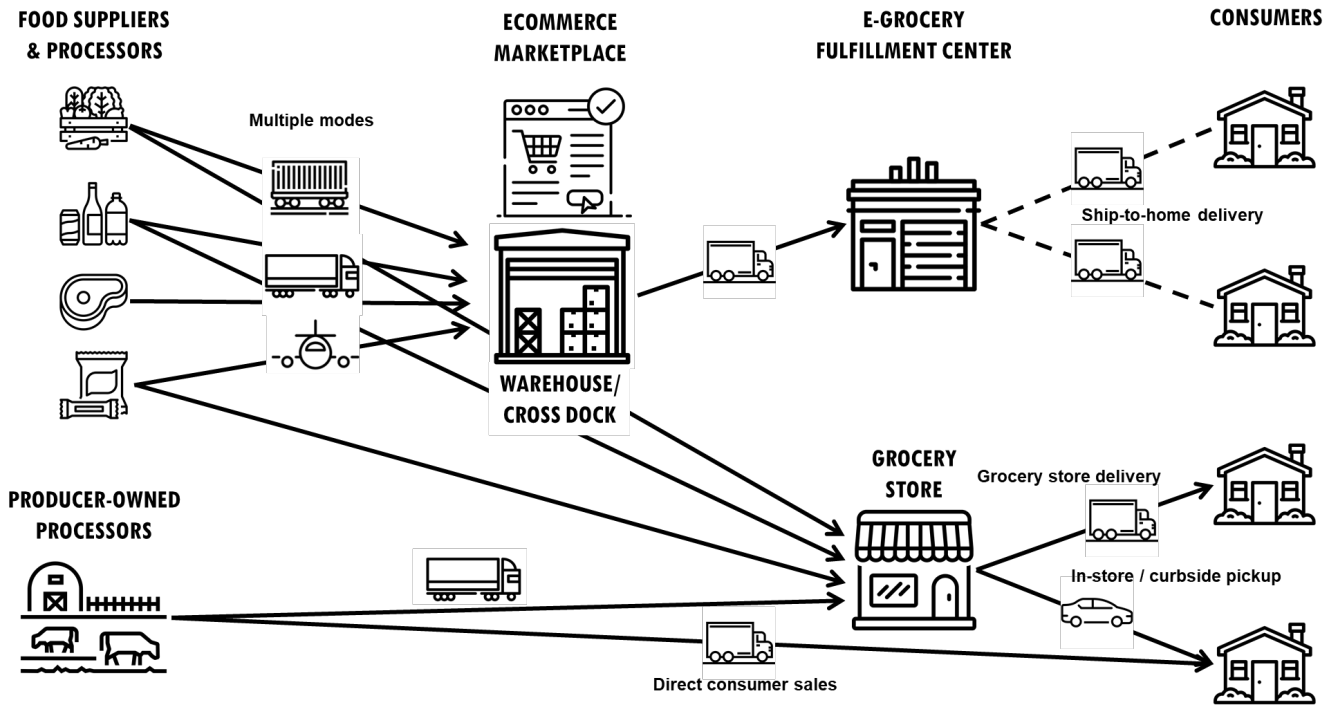
[38] Russell Redman, *FMI sizes up pandemic's financial impact on food retailers.* Supermarket News online, Sept. 16, 2021: https://www.supermarketnews.com/retail-financial/fmi-sizes-pandemic-s-financial-impact-food-retailers

[39] Brian Hauswirth, Missourinet. July 22,2020. Online: https://www.missourinet.com/2020/07/22/20-million-in-grant-funding-heading-to-missouris-smaller-meat-and-poultry-.

[40] USDA Press release No. 0154.21. July 9, 2021. https://www.usda.gov/media/press-releases/2021/07/09/usda-announces-500-million-expanded-meat-poultry-processing

In addition, the USDA Secretary committed more than $150 million to strengthen existing small and very small processing facilities to help them weather the pandemic and stay in the marketplace..

FIGURE 17 EMERGING FOOD SUPPLY CHAIN



Source: Quetica.

Transportation Facilities Supporting Missouri's Food Processing Industry

More than 100 companies in the processed food/agriculture sector that employ in excess of 100 workers are located in Missouri. Table 2 shows Missouri's top value-added food/beverage processors by employment, as reported by the Missouri Partnership. A quick review of the table demonstrates the great diversity in this sector.

TABLE 2.2 MISSOURI'S TOP FOOD SOLUTIONS COMPANIES BY EMPLOYMENT

Rank	Company, City	Products	# of Employees
1	Anheuser-Busch Co Inc., St. Louis	Beverages	3,300
2	Triumph Foods, St Joseph	Processed pork	2,900
3	Nestlé Purina Petcare Co., multiple locations	Pet Food	1,764
4	Tyson Foods Inc., Noel	Processed poultry	1,600
5	Tyson Foods Inc., Sedalia	Processed poultry	1,600
6	Simmons Foods Inc., South West City	Processed poultry	1,400
7	Kraft Heinz, Springfield	Dairy/Cheese Products	996
8	Smithfield (Farmland Foods Inc.), Milan	Processed pork	950
9	General Mills Inc., Hannibal	Soup products	920
10	Kraft Heinz, Kirksville	Processed meats	900

Source: Missouri Partnership

During April 2021, the Missouri Partnership announced two new food processing facilities that would soon be opening in the state:[41]

- Volpi Foods, a food manufacturing company, recently announced plans to open its newest production facility in Union, Missouri. The new 89,000 sq. ft. facility will be devoted entirely to slicing and packaging Volpi-produced meats, including prosciutto, salami and pancetta.

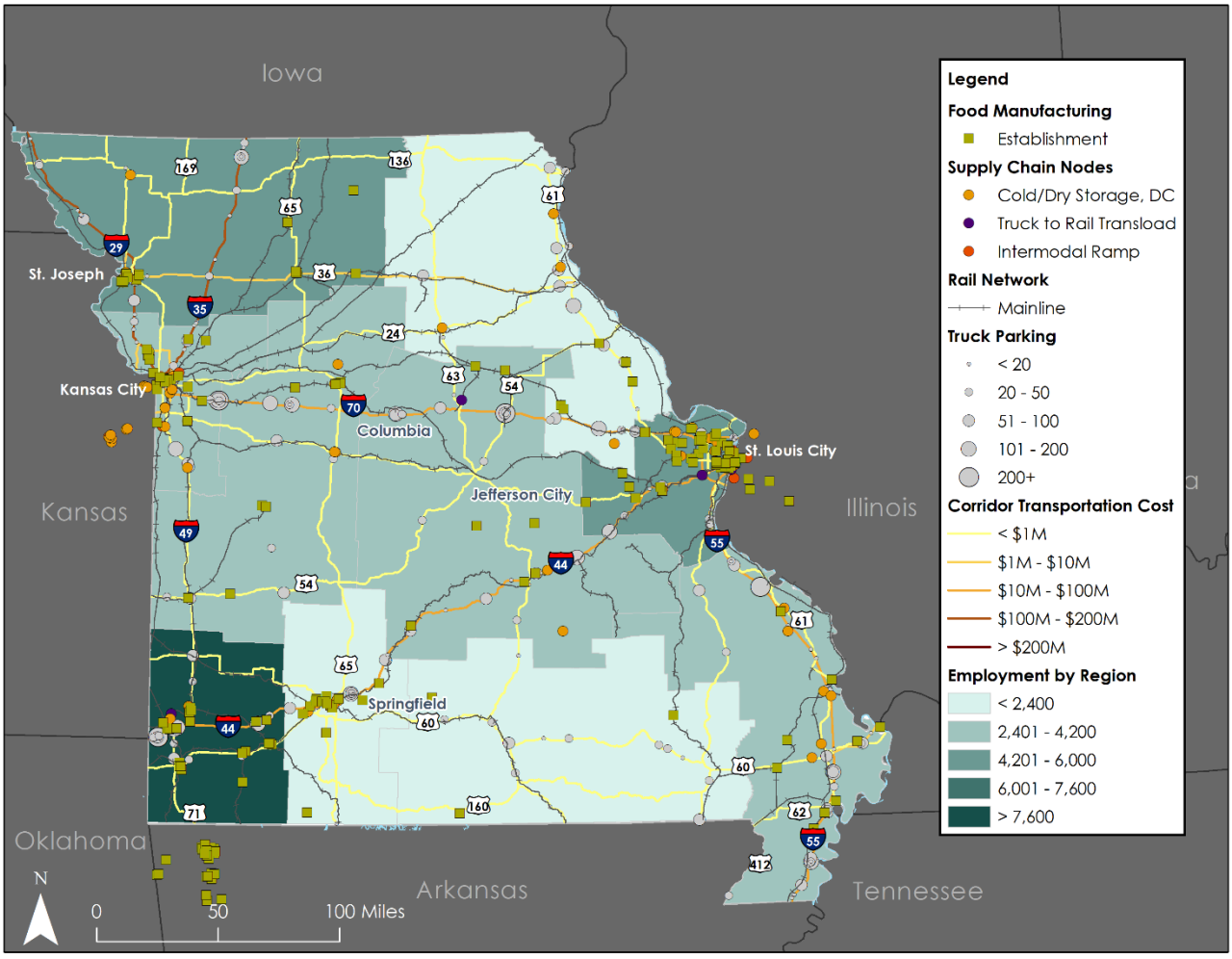
- Swift Prepared Foods, a leading global food company, announced in April of 2021 that Columbia, Missouri, had been selected for its new Italian meats and charcuterie production facility.

The map shown in Figure 18 facilities that play a variety of roles in Missouri's food supply chains. Gold squares represent food processing establishments, the number of which continue to grow in the state. Industry-related activity is located statewide. The St. Louis region is home to the largest number of establishments with 140 while the Southwest region shows the highest number of employees with close to 9,400.

Analysis of private sector bill of lading data combined with TRANSEARCH freight flow data shows highway movements within the industry's supply chains are most prevalent along the north-south interstate corridors of I-29 and I-35. Other interstate corridors showing significant transportation spend include I-55, I-70 and I-40. The map also identifies important transportation nodes within the supply chains including connections to cold and dry storage facilities and distribution centers which are used to stockpile, consolidate and deconsolidate products for food manufacturers. Intermodal ramps and truck-to-rail transload terminals are used in concert with highways to move manufactured food products and required inputs in bulk quantities.

[41] Missouri Partnership website, Monthly Archives: April 2021. https://www.missouripartnership.com/2021/04/

FIGURE 18 MISSOURI FOOD MANUFACTURING



Source: Quetica.

Current Food Processing Supply Chain Issues and Challenges

As discussed in the section addressing agriculture supply chains, since the latter half of the twentieth century, agriculture has seen extensive consolidation in both farms and transportation facilities that handle farm products. The trend in consolidation also extends to food processing where economies of scale have pushed specialization and automation, for the purpose of producing more outputs at the lowest cost. While American consumers have benefited from lower costs at store shelves, the COVID-19 pandemic also highlighted the fragility that accompanies industry consolidation. Infected workers at several large meat processing plants lead to closures that resulted in shortages and price hikes. One of the frequently repeated concerns as the pandemic has lingered is the need for greater diversity as a means of increasing food supply resiliency.

Even before the COVID-19 pandemic, the number of options for consumers to access food supplies in the U.S. was growing, the pandemic appears to have been a catalyst to accelerate this growth. Many consumers are now making selections based on how the food supplies are grown and harvested with non-GMO and organic foods growing in popularity. Traceability in food supply chains is trending along with shorter supply chains. Understanding

the inputs, production methods and handling properties for the food we consume is becoming increasingly important to health-conscious consumers. This reversal in the decades long consolidation trends is likely to favor more responsive forms of freight transportation, namely truck transport and to some extent intermodal container transport. Traditionally, agriculture and related food industries rely heavily on low-cost forms of transportation to move bulk products, primarily grain, to large domestic processing facilities and export gateways. However, if initiatives for more local value-added initiatives are successful, the need to move bulk food inputs long distances is likely to be diminished, though unlikely to be eliminated.

The implications for Missouri freight networks are likely to more emphasis on highway facilities serving local processors, and the need for better access among rural producers to more flexible transportation options, such as intermodal rail service. The current trends may also support re-examining how traditional transportation services like inland waterways are used:

> *"Key stakeholders behind the efforts to launch innovative container-on-vessel (COV) service to the Midwest on Friday announced that Hawtex Development Corporation is signing on as the lead developer for a new COV port facility in Jefferson County, Mo. to be developed in collaboration with Fred Weber/Riverview Commerce Park LLC and integrating a 300+ acre adjacent parcel owned by The Doe Run Company. The new port will be a critical link on the new, all-water, north-south trade lane connecting the Midwest and the St. Louis region to the lower Mississippi River and on to worldwide destinations."*[42]

The recent announcement of the Jefferson County development is just one piece of a plan to ultimately create an all-water container on vessel route between Kansas City, Jefferson City and St. Louis and on to the rest of the Lower Mississippi River and the world.

Trends in food processing and agriculture continue to evolve, and the services required to support the modern transportation needs of these industries is changing. However, the reliance of these industries on local highway and bridge networks is unlikely to waiver.

Chemicals

The chemicals industry is made up of businesses that take in raw materials and produce more than 70,000 chemical products used nationwide by agriculture, industry and households. The U.S. Department of Homeland Security's Cybersecurity and Infrastructure Security Agency reports that 96% of the goods produced in the U.S. are manufactured using products from the chemical sector[43]. According to the American Chemistry Council, the chemicals industry accounts for more than 25% of the nation's total economic output and 14% of the world's chemicals.[44]

Supply chains for the chemical industry can be thought of as four functional areas. These functional areas represent either nodes of a global supply chain network where production, logistics activities, or consumption occur,

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[42] *St. Louis Container on Barge Project Moves Forward*, Marine Link Online December 17, 2021. https://www.marinelink.com/news/st-louis-container-barge-project-moves-492961

[43] *Chemical Sector Profile.* U.S. Department of Homeland Security CISA. https://www.cisa.gov/sites/default/files/publications/Chemical-Sector-Profile_Final%20508.pdf

[44] American Chemistry Council- Our Industry. https://www.americanchemistry.com/Our_Industry/

or they represent edges which provide links between the nodes and facilitate the movement of materials and products. The four functional areas include:

- Manufacturing Plants: the sites where raw materials are received and processed into intermediate goods or final products.
- Transportation Systems: the road, rail, waterway and pipeline networks that move inputs from oil refineries, gas processors and other raw material sources to manufacturing plants and then distribute the intermediate goods and final products to warehouses or the end users. Also included are the nodes in the networks where modal handoffs occur.
- Warehousing: provides storage, consolidation and deconsolidation of large quantities of chemical products. Chemical warehousing is a highly regulated industry due to the potential for safety risks associated with exposure to hazardous materials and the potential for reactions resulting from chemical mixtures. Warehouse consolidation services involve co-loading multiple small shipments from different shippers into a single shipment or truckload going to a common destination. Deconsolidation involves a warehouse taking in full truckload, rail car, barge or container volumes of various products and mixing different products to produce custom shipments. For example it is common for some fertilizer warehousing companies to deconsolidate various chemicals to produce custom fertilizers based on a farmer's particular soil and crop needs.
- Consumers: the end users of the products including households, farms and institutions.

While the industry produces more than 70,000 products, it can be broken down into five subgroups based on product types:

- Basic Chemicals: include petrochemicals, industrial gases, synthetic dyes and pigments, ethyl alcohol and other organic and inorganic chemicals.
- Agricultural Chemicals: include pesticides, fertilizers and other chemicals for agricultural purposes.
- Consumer Chemicals: include household cleaners, detergents and bleaches; toiletry items like soap, shampoo, toothpaste and deodorant; and paints and polishes.
- Pharmaceuticals: include biological and medicinal products and diagnostic substances.
- Specialty Chemicals: include synthetic resins, rubbers and fibers; food additives such as synthetic sweeteners and preservatives; and others like printing ink, adhesives, explosives and photographic film and paper.

Due to the wide variety products and product values as well as the potential risks associated with chemical products transportation, the industry is highly regulated and consumes a broad array of transportation services. The logistics of chemical transportation needs to consider packaging, labeling, storage environment, and other risk management considerations. If not handled properly transporting some chemicals can pose risks to individuals, communities and the environment.

Economic Contributions of Missouri's Chemicals Industry

The American Chemical Council[45] reported Missouri's chemical industry totaled $10.39 billion, making it the fourth largest industry in the state. The council also highlighted other contributions the industry made to Missouri, including:

- $1.09 billion in wages with an average annual wage of $73,370
- $367 million in federal, state and local taxes
- $2.05 billion worth of goods shipped globally
- 16,325 additional jobs in the plastics and rubber product industries

County business pattern data from 2018 shows Missouri's chemicals industry included nearly 300 establishments and 19,000 employees. Major chemical corporations with operations in Missouri include Airgas, Amerisource Bergen, BASF, Dial Corp., Ecolab, GlaxoSmithKline, Ingredion, Monsanto, Pfizer, PPG Industries, Praxair, Procter & Gamble and Sika Corp. to name a few. These major corporations are predominantly located in the St. Louis and Kansas City metropolitan regions and include offices, manufacturing plants and distribution centers.

CATALENT PHARMA SOLUTIONS

In May 2018, Catalent Pharma Solutions completed the second phase of a $5.5 million expansion program at its Kansas City, MO facility. The two-year expansion program included an increase in the controlled-substance and controlled-temperature storage capabilities for its clinical supply business and expansion of the facility's cytotoxic and cold storage clinical drug packaging capabilities.

The Kansas City facility is focused on drug delivery solutions via the development of capsules, and soft gels, as well as packaging and distribution of drugs. The second phase specifically added a new sampling room, emergency generator, and a 3,600 square foot vault for substances on the Drug Enforcement Administration's (DEA) Schedule I and II.

According to the company's press release discussing the investment by General Manager of Clinical Supply Services Kevin Economos, the Kansas City facility's integrated solution combining analytics, oral solid manufacturing, and clinical supply services has benefitted Catalent's customers for 18 years:

"These latest expansions are critical enablers to our customers' continued growth, which reinforce our comprehensive global network and enhance Catalent's role as a market leader in the clinical supply industry."

- Catalent News, ***Catalent Completes $5.5 Million Expansion at Kansas City.*** *Catalent Pharma Solutions* website. May 17, 2018.

Transportation Facilities Supporting Missouri's Chemicals Industry

The map shown in Figure 19 displays facilities that play a variety of roles in the chemicals supply chain. Chemical establishments shown as gold squares on the map were taken from *Freight Finder,* a business establishment data set from IHS Markit. These establishments are classified as *Chemical Manufacturers* and include businesses producing pharmaceuticals, fertilizers, basic chemicals and other chemical products.

[45] American Chemistry Council- Chemistry in Missouri. https://docs.americanchemistry.com/chemistrymatters/state-data/Missouri.pdf

Industry activity is heavily concentrated in the St. Louis region. According to 2018 County Business Pattern data, roughly 130 of the state's chemical producing establishments and 10,400 employees are located there. These numbers equate to 44% of the establishments and 54% of the employment. Smaller clusters are found in the Kansas City and Northwest regions with roughly 2,430 and 2,250 employees, respectively.

Analysis of private sector bill of lading data combined with TRANSEARCH freight flow data shows highway movements within the industry's supply chains are most prevalent along several north-south interstate corridors through Missouri including I-29, I-35, I-55, as well as along the I-44 and I-70 corridors running east and west. The map also identifies important transportation nodes within the chemicals industry's supply chains including connections to the rail and inland waterway networks.

The U.S. Chemical Sector converts raw materials into more than 70,000 diverse products essential to modern life and distributes those products to more than 750,000 end users throughout the Nation. End users include critical infrastructure sectors, making the uninterrupted production and transportation of chemicals essential for national and economic security

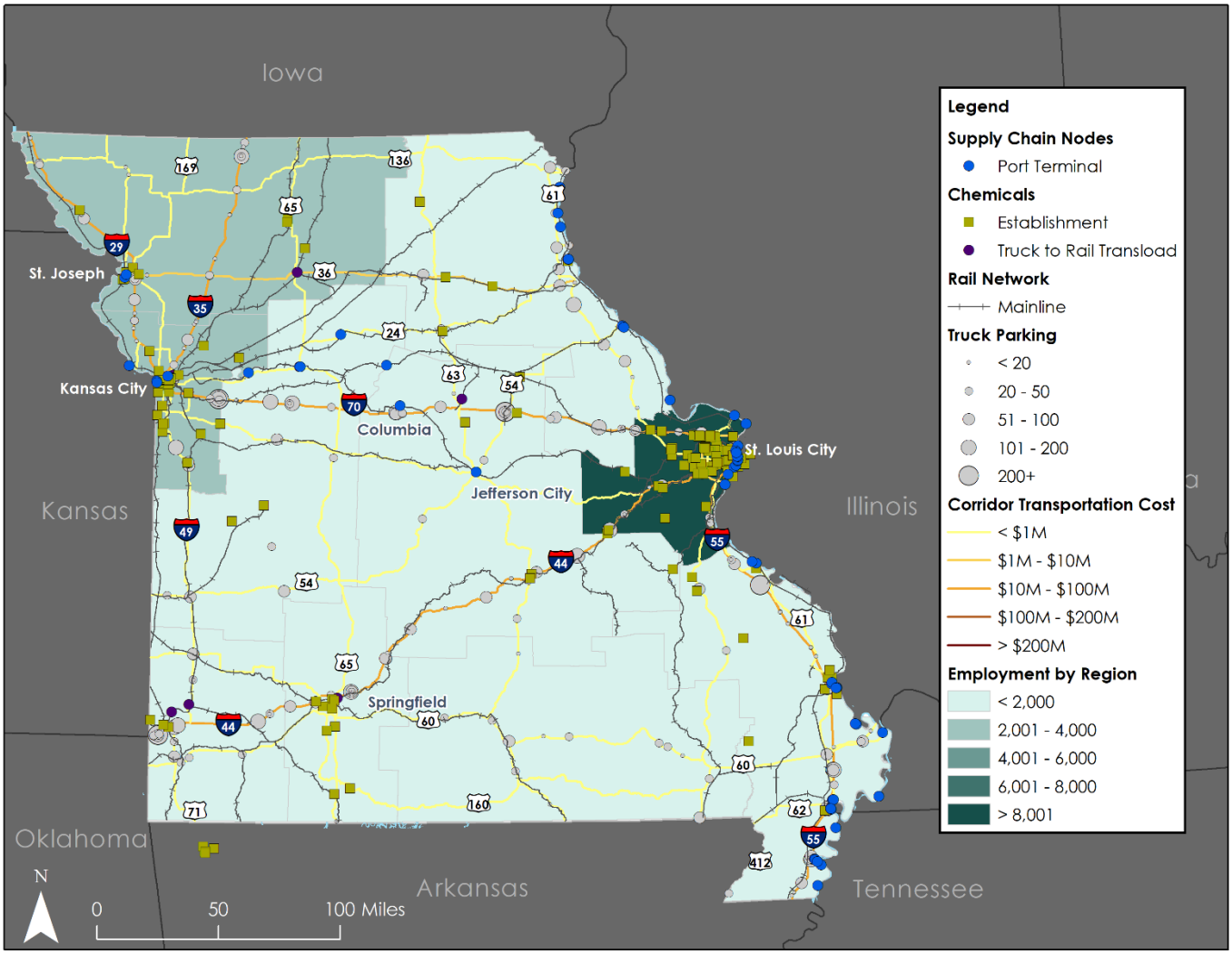
- CISA, Chemical Sector Profile

Port terminals along the inland waterway system allow companies moving fertilizers to gain economies of scale within their supply chains by receiving inputs and shipping their products via barges. A report for the National Waterways Foundation[46] found the liquid carrying capacity ratio between semi-tractor trailers and barges to be 144-to-1 based on 17,500 barrels. The same ratio for dry cargo was found to be 70-to-1, based on 1,750 short tons. These port terminals use commodity-specific handling equipment to transfer freight between the waterways and either the road and/or rail networks. Specific equipment includes boom and mast derricks, pneumatic pumps and hoses, conveyor systems, crawler cranes, clamshell buckets and pipeline-loading arms.

Truck-to-rail transload facilities provide chemical shippers in Missouri that are not located along an inland waterway or the nation's rail network access to economies of scale relative to trucking via rail transportation. The same National Waterways Foundation estimated the semi-tractor trailer to railcar ratio to be 46-to-1 for liquid bulk cargo and 16-to1 for dry bulk cargo. Transload facilities connect Missouri shippers to four Class I rail networks (BNSF, KCS, NS and UP) and multiple short lines including the Burlington Junction Railway, the Missouri & Northern Arkansas and Watco.

[46] *A Modal Comparison of Domestic Freight Transportation Effects on the General Public: 2001-2014.* Center for Ports and Waterways at the Texas A&M Transportation Institute. January 2017. http://nationalwaterwaysfoundation.org/documents/Final%20TTI%20Report%202001-2014%20Approved.pdf

FIGURE 19 MISSOURI'S CHEMICALS INDUSTRY



Current Chemicals Supply Chain Issues / Challenges

Due to its importance to the Nation's economy via its interdependencies with other critical sectors such as water, transportation systems, communications, energy, emergency services, food and agriculture, the U.S. Federal Government designated the chemical sector as a critical infrastructure sector in 2003. The 2015 Chemical Sector-Specific Plan[47] details the application of the National Infrastructure Protection Plan concepts to the chemical sector's unique operating conditions. According to the plan, it "sets the strategic direction for collaborative efforts to improve sector security and resilience," and "describes how the Chemical Sector manages risks and contributes to national critical infrastructure security and resilience."

[47] *Chemical Sector-Specific Plan: An Annex to the NIPP 2013.* U.S. Department of Homeland Security. 2015. https://www.cisa.gov/sites/default/files/publications/nipp-ssp-chemical-2015-508.pdf

Designated by Presidential Policy Directive 21 to be the Sector Risk Management Agency, the Department of Homeland Security leads public-private partnership efforts and works with the private sector to create tools and resources that help to improve security and resilience in the chemical sector.

The plan outlines several key operating characteristics related to supply chain risks that highlight the need for "vigilance from both the private and public sector." The fact that some chemicals, either alone or when combined with others, can cause significant bodily harm puts the industry at risk. Risks can originate from an unintentional release such as an accidental spill or an intentional release by malicious actors. Chemicals can be used to create weapons of mass destruction or improvised explosive devices or used for sabotage or contamination. Each of the many modes involved in transporting hazardous materials must do so safely throughout a worldwide supply chain in order to mitigate these risks.

> **With facilities, suppliers, and end users located around the globe, Chemical Sector operations are vulnerable to a variety of disruptions stemming from natural disasters, extreme weather, cyberattacks, biohazards, and pandemics. Local or regional disruptions to critical suppliers can cause cascading disruptions across geographic regions and in multiple industries.**
>
> - 2015 Chemical Sector-Specific Plan, Department of Homeland Security

Specific risks facing the chemicals industry include insider threats, cyber threats, natural disasters and extreme weather, deliberate attacks and terrorism, biohazards and pandemics. The *Harvard Business Review*[48] highlighted a string of supply chain disruptions beginning with the COVID-19 pandemic in 2020 (lockdowns causing inventory levels to fall, container shortages and port labor and trucking shortages), the shut-down of multiple petrochemical plants in Louisiana and Texas due to Hurricane Laura, severe winter weather in Texas, factory fires and the blocking of the Suez Canal that combined with surges in consumer demand to produce depleted inventories throughout the sector's supply chains. The disruptions and increases in consumer demand also led to price increases, higher rates of delinquent shipments and longer lead times for orders. Shortages of polyethylene, polypropylene and monoethylene prove especially consequential considering their inclusion in so many products ranging from food packaging to smartphones and more. Surveyed purchasing managers in April of 2021 anticipated the impacts from these disruptions to last for more than 12 months.

Review of chemical industry outlooks have identified several challenges facing the industry's supply chains moving forward.

- China and Deglobalization—while China is the world's largest market, growing trade tensions between China and the U.S. and the growing realization of risks associated with extended supply chains is causing deglobalization of the industry via the decoupling of China from the supply chain and accelerating companies' efforts to seek out lower cost locations. According to KPMG[49], "plant footprint and supply chain strategy are

[48] *The Latest Supply Chain Disruption: Plastics.* Harvard Business Review. March 26, 2021. https://hbr.org/2021/03/the-latest-supply-chain-disruption-plastics

[49] *Reaction: the new reality for the global chemical industry.* KPMG. https://home.kpmg/xx/en/home/insights/2020/07/new-realities-for-global-chemicals-industry.html

likely to become increasingly critical factors in business success over the coming years." Deloitte[50] found that 84% of chemical executives surveyed felt the industry could effectively navigate shifting trade policies by focusing on the management of supply chain risks and diversifying its suppliers through collaboration with regional partners to build the capabilities needed to shift target markets.

- Sustainability—consumer preferences valuing sustainability are causing the industry to focus on the development of decarbonization technologies and to diversify their product offerings away from those using hydrocarbons as a feedstock, or input into the manufacturing process of products. The Paint & Coatings Industry[51] notes that several U.S. chemical companies plan to "add mechanically recycled and renewable feedstock-based polymers to their product offerings and invest in advanced recycling to introduce potentially game-changing green technologies on a commercial scale."

- Growth opportunities—the Deloitte survey of chemical executives found that 64% indicated industry growth would come from advanced chemicals such as battery coatings for EVs, materials for construction applications, materials for microelectronics, recycling technologies and new solvent cleaning technologies. E-commerce is another growth opportunity as it is anticipated to grow its share of business-to-business chemical purchases in 2021.

The chemicals industry's importance to the state and other industries is clear, both financially and to the production of other products. It must keep a constant guard against a number of risks to the supply chain, in order to avoid disruption in the production of its own products, as well as those of other industries. Over the next few years, trends indicate the industry will deglobalize away from the Chinese market bringing production closer to the U.S. market and also focus its growth efforts on sustainability-based opportunities, such as recycled and renewable feedstocks and battery coatings for EVs.

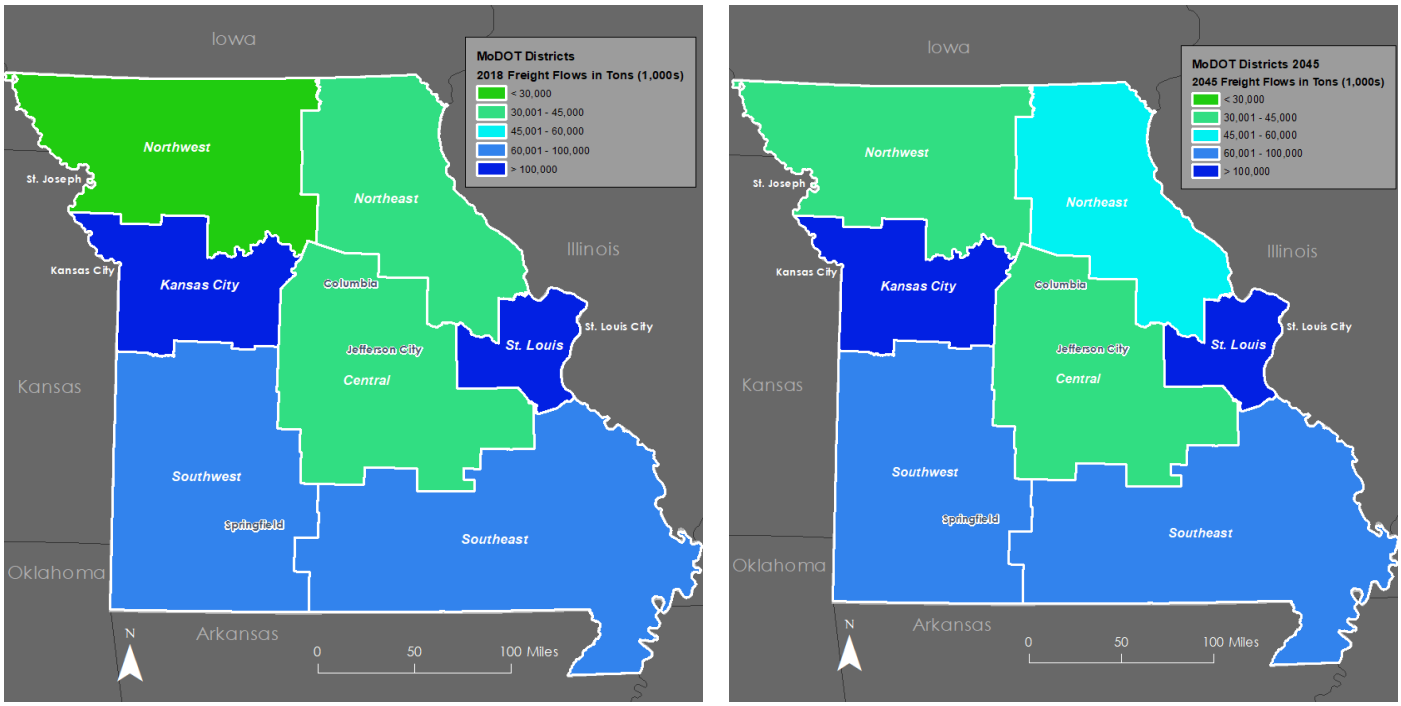
2.3 Freight Activity in the MoDOT Districts

This section evaluates how these trends impact, and are impacted, by regional differences and examines the freight activity originating and terminating in MoDOT's seven districts, as shown in Figure 20. The overall distribution of freight activity is not expected to change significantly, with the St. Louis and Kansas City regions continuing to dominate. Freight flows are projected to grow in each MoDOT district between 2018 and 2045, with the highest growth rates projected for the Central (32%) and Southeast (29%) districts, and the lowest growth projected for the Northeast district (5.6%).

[50] *2021 chemical industry outlook.* Deloitte. https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/chemical-industry-outlook.html

[51] *2021 Chemical Industry Outlook: Exploring Chemical Market Trends and the Continued Impact of COVID-19.* Paint & Coatings Industry. February 12, 2021. https://www.pcimag.com/articles/108411-chemical-industry-outlook

FIGURE 20 FREIGHT TONNAGE FLOWS | INBOUND, OUTBOUND, INTRA-DISTRICT, 2018 AND 2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

Each MoDOT District is uniquely positioned for goods movement depending on its proximity to other modes, neighboring states, and leading industries. Table 2.3, Table 2.4 and Figure 21 show employment in freight industry disaggregated by MoDOT District. Wholesale, advanced manufacturing, as well as transportation and logistics lead in the number of freight industry employment. Further analysis examines the share of industries and employment represented in each district, with a discussion of the mode share and commodities. These district profiles inform goals, objectives and strategies that leverage the strengths of regional difference in Missouri.

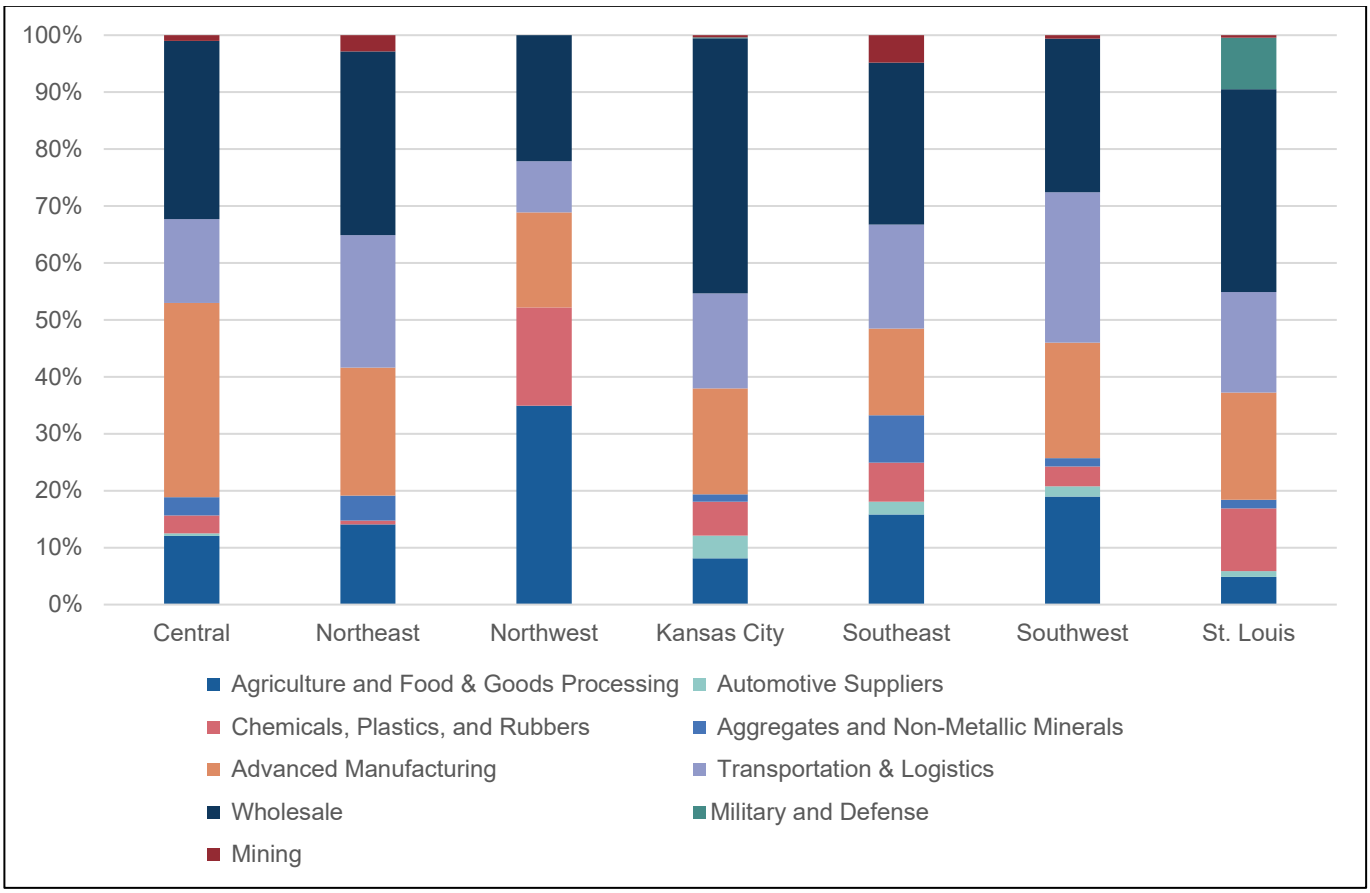
TABLE 2.3 EMPLOYMENT IN KEY FREIGHT INDUSTRIES BY MODOT DISTRICT

Districts	Agriculture, Food & Goods Processing	Automotive Suppliers	Chemicals, Plastics and Rubbers	Aggregates and Non-Metallic Minerals	Advanced Manufacturing	Transport & Logistics	Wholesale	Military and Defense	Mining
Central	2,643	98	681	702	7,469	3,213	6,848	—	220
Kansas City	7,082	3,493	5,187	1,132	16,214	14,518	39,054	160	328
Northeast	1,500	—	73	468	2,391	2,480	3,432	—	304
Northwest	5,620	—	2,774	—	2,690	1,441	3,565	—	—
Southeast	4,026	579	1,742	2,121	3,878	4,637	7,239	—	1,233
Southwest	12,632	1,176	2,346	939	13,536	17,558	17,948	—	402
St. Louis	6,877	1,427	15,636	2,158	26,729	25,020	50,560	12,881	582
Statewide[52]	—	—	—	—	—	7	2,244	—	46
Statewide Total	**40,380**	**6,773**	**28,439**	**7,520**	**72,907**	**68,874**	**130,890**	**13,041**	**3,115**

Source: U.S. Census County Business Patterns, 2018.

[52] U.S. Census Bureau reports employees and establishments that are assigned to the state but not a specific county.

FIGURE 21 PROPORTION OF EMPLOYMENT IN KEY FREIGHT INDUSTRIES BY MODOT DISTRICT



Source: U.S. Census County Business Patterns, 2018.

Every district has sizable employment in the wholesale industry which leads each district relative to its overall industry share, except for the Northwest, where agriculture dominates.

TABLE 2.4 NUMBER OF FREIGHT INDUSTRY ESTABLISHMENTS BY MODOT DISTRICT

Districts	Agriculture, Food & Goods Processing	Automotive Suppliers	Chemicals, Plastics and Rubbers	Aggregates and Non-Metallic Minerals	Advanced Manufacturing	Transport & Logistics	Wholesale	Military and Defense	Mining
Central	2,643	98	681	702	7,469	3,213	6,848	—	220
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Northeast	1,500	—	73	468	2,391	2,480	3,432	—	304
Northwest	5,620	—	2,774	—	2,690	1,441	3,565	—	—
Southeast	4,026	579	1,742	2,121	3,878	4,637	7,239	—	1,233
Southwest	12,632	1,176	2,346	939	13,536	17,558	17,948	—	402
St. Louis	6,877	1,427	15,636	2,158	26,729	25,020	50,560	12,881	582
Statewide[53]	—	—	—	—	—	7	2,244	—	46
Statewide Total	**40,380**	**6,773**	**28,439**	**7,520**	**72,907**	**68,874**	**130,890**	**13,041**	**3,115**

Source: U.S. Census County Business Patterns, 2018.

In terms of footprint, wholesale is clearly the leading industry across all districts, followed by transportation and logistics. This is consistent with the demands of space for storage and distribution in these two industries. Table 2.5 shows the share of key freight industry employment in each district. St. Louis and Kansas City have more than 60% of that employment type.

TABLE 2.5 NUMBER OF FREIGHT INDUSTRY JOBS BY DISTRICT, 2018

District	Total	Percentage
Central	21,654	5.9%
Kansas City	86,840	23.5%
Northeast	10,344	2.8%
Northwest	16,090	4.4%
Southeast	24,222	6.6%
Southwest	66,135	17.9%
St. Louis	141,288	38.3%
TOTAL	**368,824**	**100.0%**

Source: LODES Version 7.5 2018.

The following subsections provide further detail about each MoDOT District.

[53] U.S. Census Bureau reports employees and establishments that are assigned to the state but not a specific county.

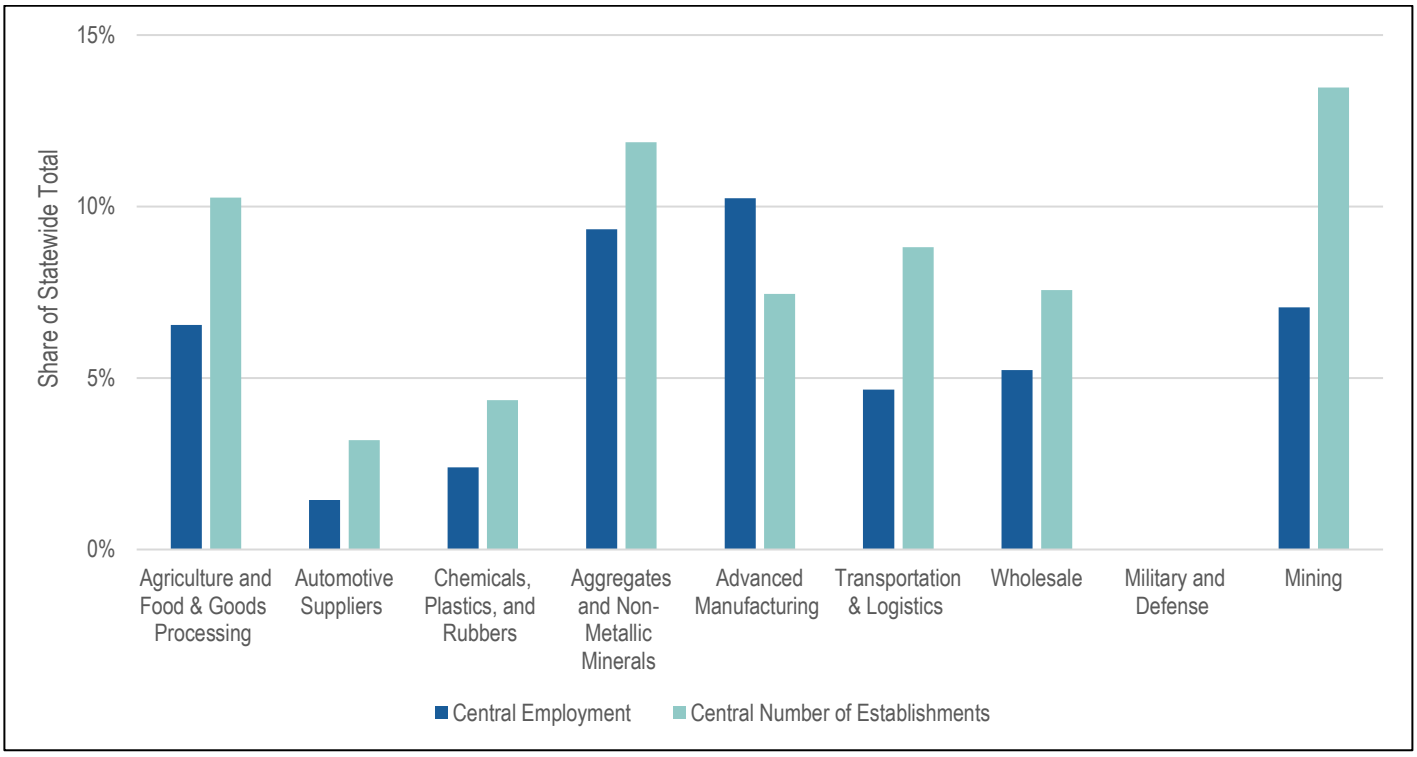
Central District

Central District has 18 counties covering more than 11,000 square miles. Columbia and Jefferson City are the largest cities in the district. Top area industries are financial, life sciences, agribusiness, warehousing/distribution and manufacturing. The district is home to Ft. Leonard Wood, and includes a portion of the Ozark Mountains, including the tourism and recreation areas of Lake of the Ozark, and smaller cities such as Boonville and Rolla. Regional airports are located in Columbia and Fort Leonard Wood (Waynesville). Major rail access is provided by Kansas City Southern, Norfolk Southern, Burlington Northern Santa Fe and Union Pacific. The region also has a Missouri River port facility in Boonville and is developing another one in Jefferson City.

Industry

The Central District employs 10% of the state's advanced manufacturing employment, followed by aggregates and non-metallic minerals (9%) and mining (7%). Although just 7% of the state's mining employment is in the Central District, it hosts nearly 14% of all mining establishments, as shown in Figure 22. There is no private military or defense industry in the district, however the army facility of Fort Wood and the Missouri National Guard are both located within the district. Automotive suppliers are the least represented in the Central District.

FIGURE 22 CENTRAL DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS[54]



Source: U.S. Census County Business Patterns, 2018.

[54] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

Industry projections for the Central District show growth within a 10-year horizon is consistent with the current leading industries and employment trends.

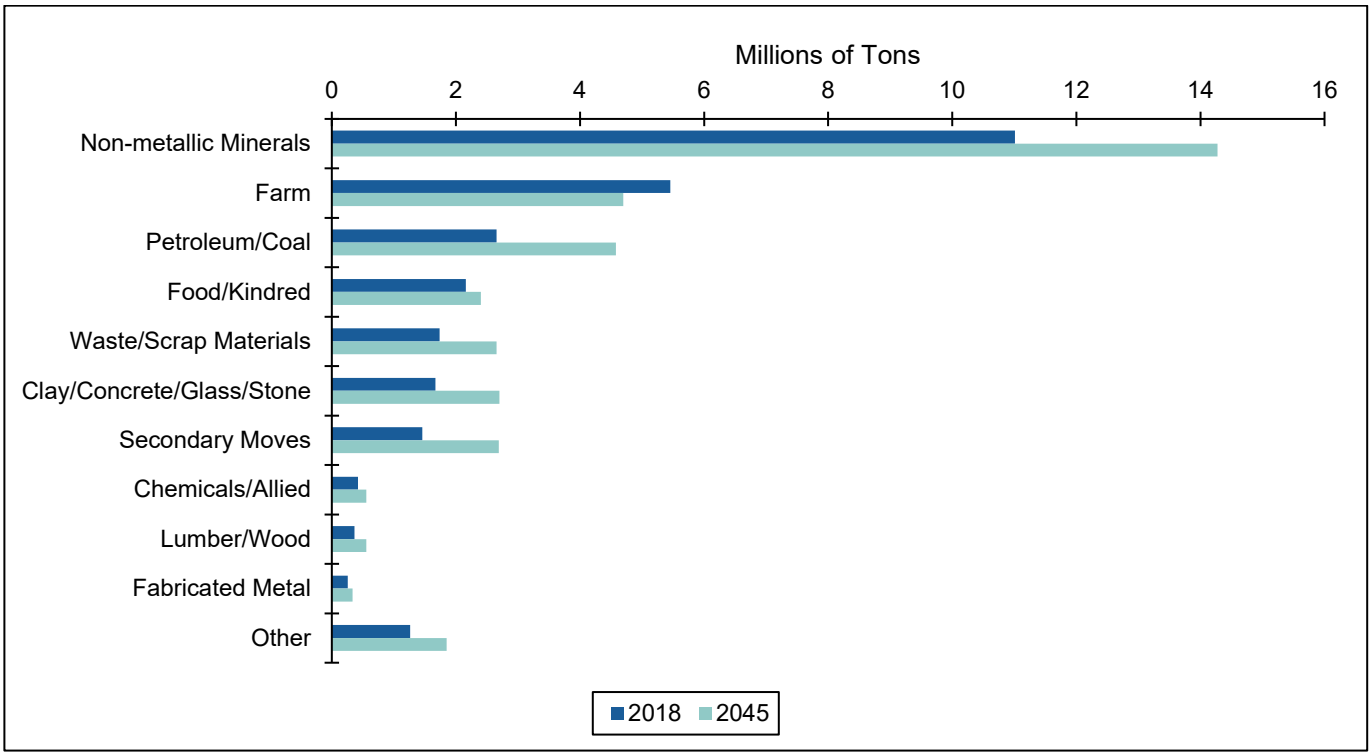
Freight Demand

Trucks carried the majority (97%) of goods, both in terms of weight and value in 2018, with remaining modes carrying minimal freight volumes. Overall, the Central District moved 28 million tons of goods worth $19 billion in 2018. Through 2045, these figures are expected to rise to 37 million tons of goods worth $27 billion.

By tonnage, nonmetallic minerals were the top commodity in 2018 (39%), followed by farm products (19%) and petroleum/coal (9%). Through 2045, increases in tonnage are expected for most commodities except for farm products, which is expected to drop in tonnage and share, from a 19% share to a 13% share, while non-metallic minerals are expected to increase to more than 14 million tons, or approximately 38% of all tonnage.

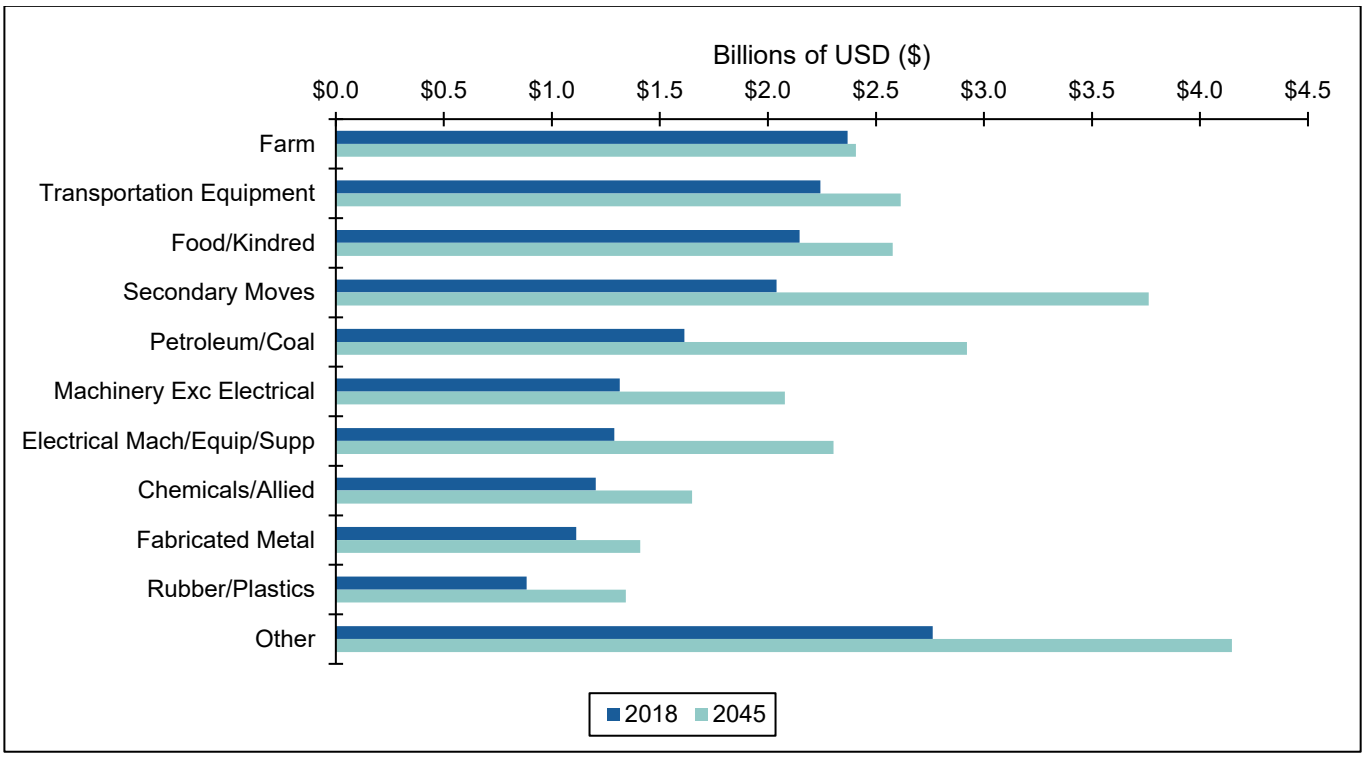
Based on value, there was somewhat less disparity among the top commodities. In 2018, farm products, transportation equipment, food/kindred products and secondary movements each accounted for more than $2 billion. Through 2045, secondary movements are expected to be the top commodity at almost $4 billion, or 14% of all value, followed by petroleum/coal (under $3 billion at 11%), and transportation equipment (more than $2.5 billion at 10%). Increases in value are expected for all commodities, although the amount for farm commodities appears to be notably smaller.

FIGURE 23 CENTRAL DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 24 CENTRAL DISTRICT TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

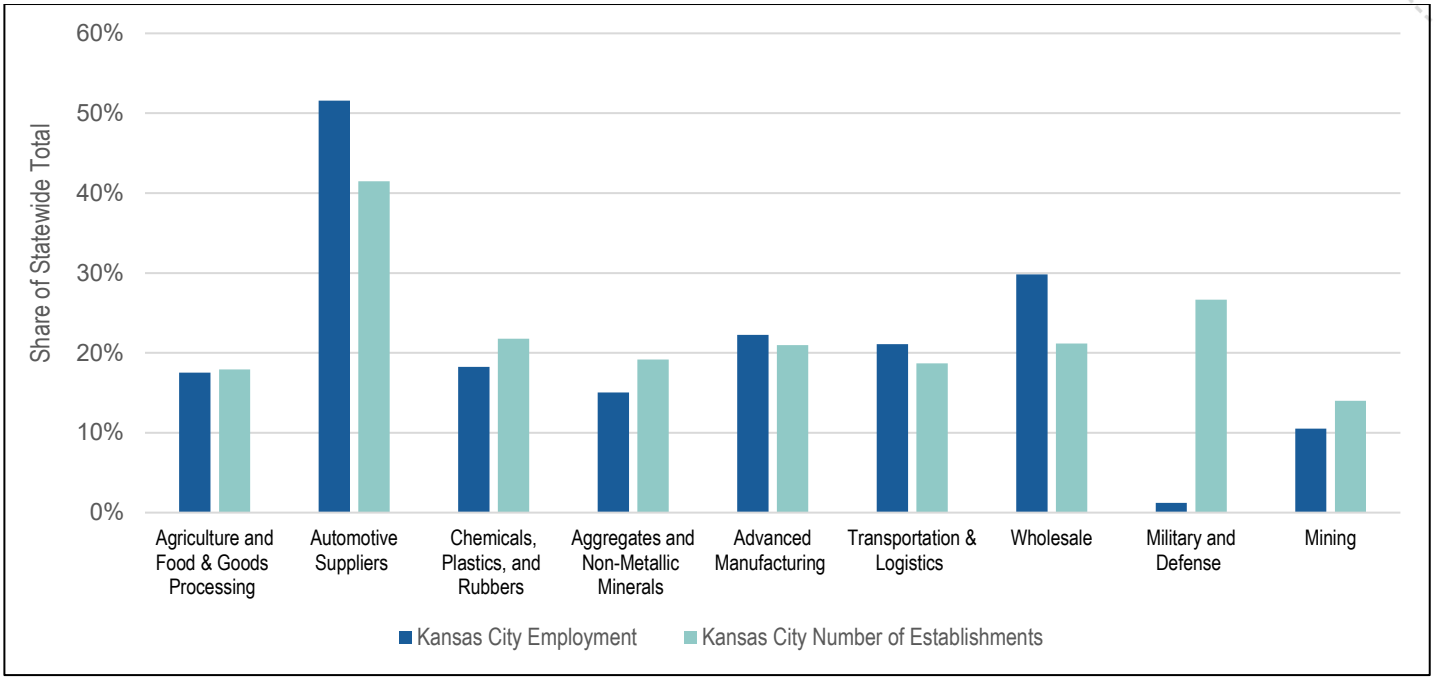
Kansas City District

The district includes Kansas City and surrounding suburbs and communities. Kansas City, Independence and Lee's Summit are the largest cities. Growing industries include advanced energy, biosciences, data centers, engineering, and manufacturing. Kansas City International Airport is the area's largest airport and one of three major commercial airports in the state. Kansas City is the second busiest and largest rail hub in the nation in terms of tonnage, following Chicago. Major rail access includes Burlington Northern Santa Fe, Central Midland, Canadian Pacific, Kansas City Southern, Kaw River, Missouri & Northern Arkansas, Norfolk Southern and Union Pacific.. The region's port is on the Missouri River in Kansas City.

Industry

Kansas City is the second largest freight hub in Missouri. Among the leading industries in the district are automotive suppliers, which represent over half of the state's total employment in the sector. Wholesale and advanced manufacturing are other leading industries in the district, which is also home to Whiteman Air Force Base as well as a military entrance processing station. Figure 25 shows the diversity of industries represented in the Kansas City District relative to the rest of the state. In terms of land use, all the key industries represent more than 10% of freight establishments in the state.

FIGURE 25 KANSAS CITY DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS[55]



Source: U.S. Census County Business Patterns, 2018.

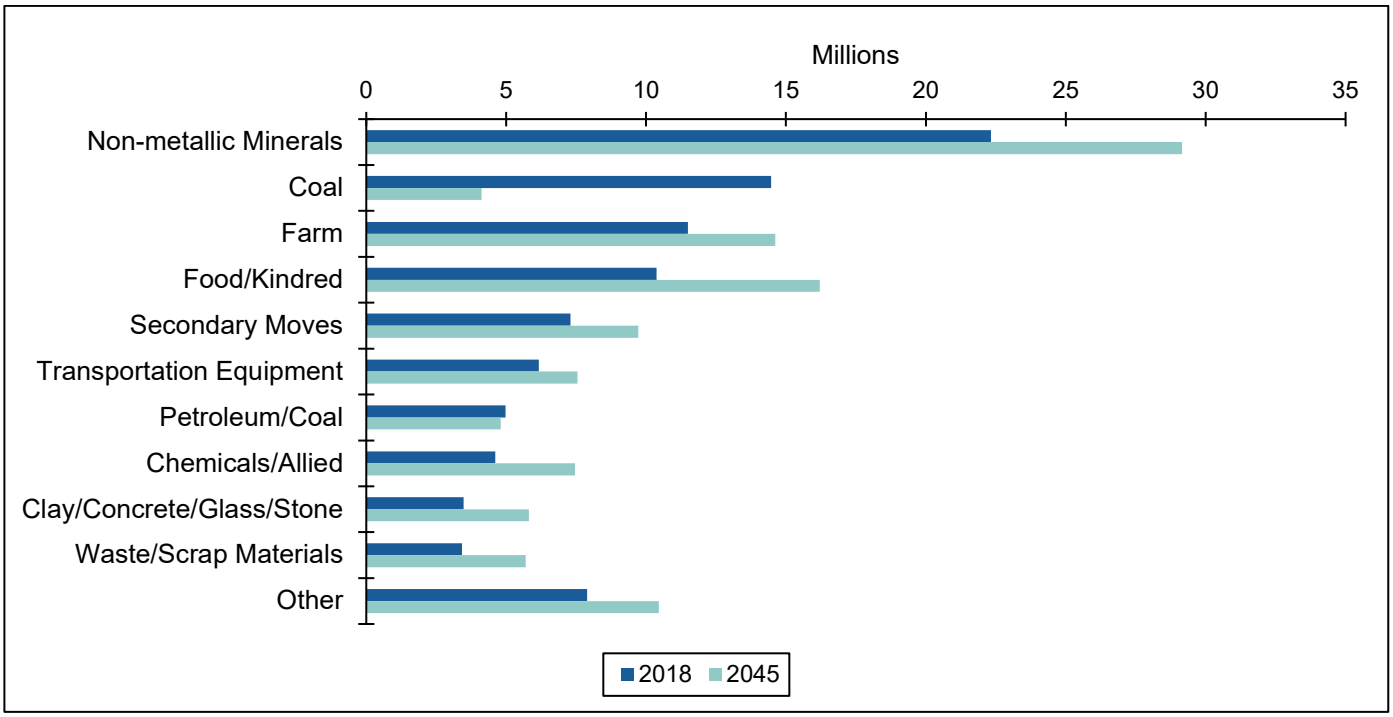
Freight Demand

The top commodities by tonnage and value are shown in Figure 26 and Figure 27 respectively. By tonnage, nonmetallic minerals, coal, farm products and food/kindred goods rounded out the top four with more than 58 million tons in 2018. By 2045, nonmetallic minerals are expected to remain the top commodity with an increase to 29 million. The biggest predicted drop is for coal, which is expected to decline from 14 million tons in 2018 to four million tons in 2045, including a decrease in the total share of commodities moved from 15% to just 4%. The biggest increase in market share is expected for food/kindred goods from 11% to 14%.

By value, transportation equipment had by far the largest share of all goods moved at 44% in 2018. This equated to almost $59 billion. This was followed by secondary moves (drayage and warehouse and distribution moves) and freight all kinds (general freight moved in containers) at 11% and 8% respectively. By 2045, transportation equipment shipments are expected to be valued at $72 billion, despite a decrease in market share to 38%. Increases in market share are however expected for most of the other top commodities, including chemicals/allied products and machinery.

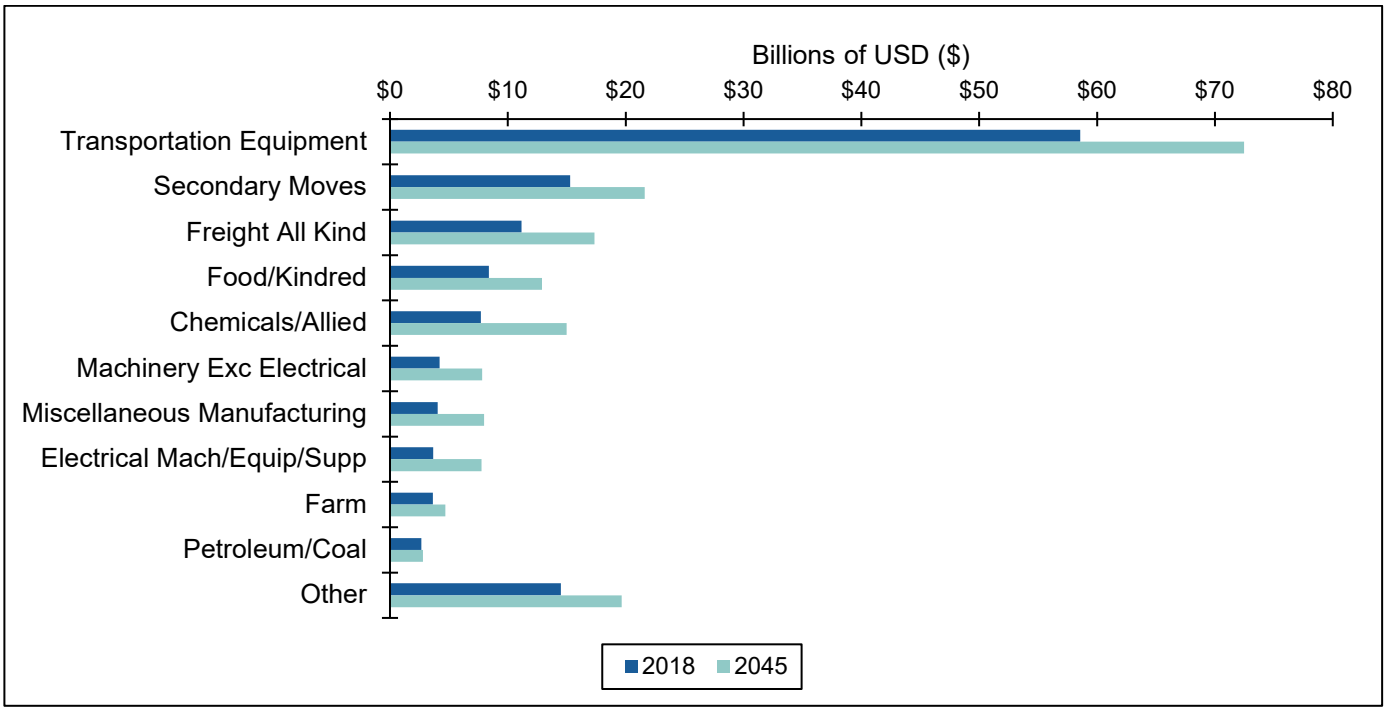
[55] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

FIGURE 26 KANSAS CITY DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS Transearch and STB Confidential Carload Waybill Sample.

FIGURE 27 KANSAS CITY DISTRICT TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS Transearch and STB Confidential Carload Waybill Sample.

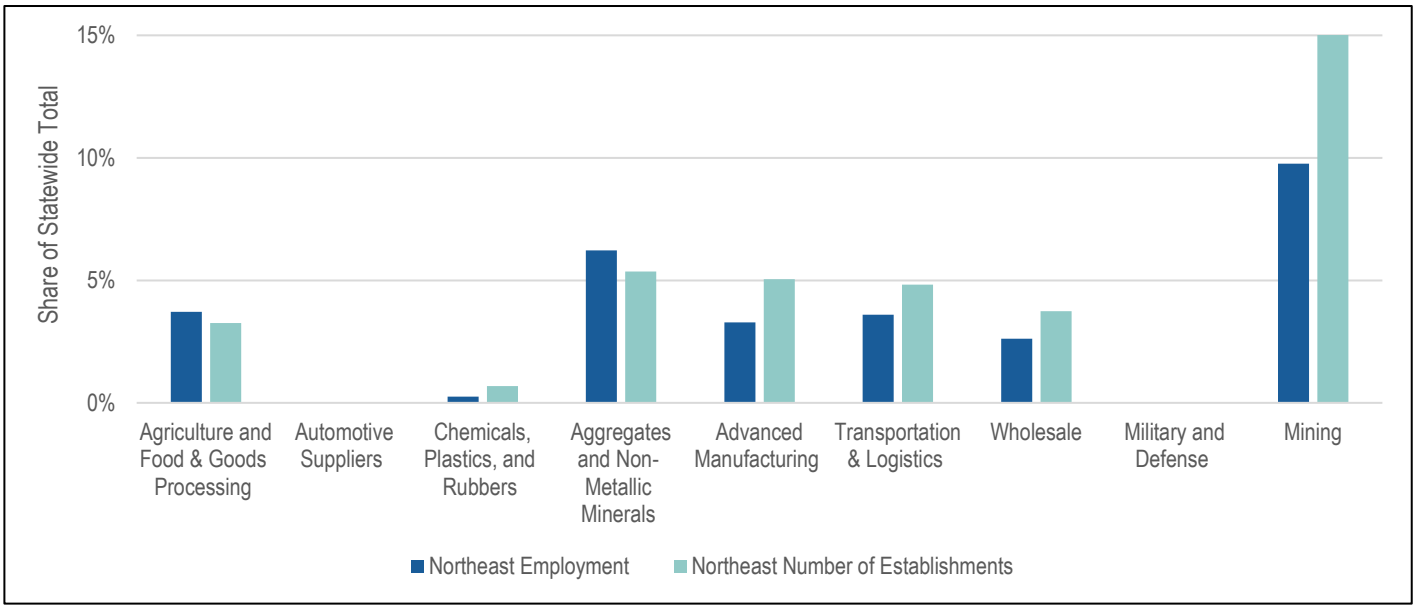
Northeast District

The Northeast District has 17 counties covering more than 10,000 square miles. Hannibal, Kirksville, Moberly, Mexico, Troy and Warrenton are the largest cities. Top industries include agribusiness, food processing, and manufacturing. Freight moves by multiple transportation modes in the Northeast District. Major area roads include I-70 and I-72 as well as US-24, US-36, US-54, US-61 and US-63. A regional airport is located in Kirksville. Major rail access is provided by Burlington Northern Santa Fe, Norfolk Southern, Kansas City Southern and Union Pacific. The region also has Mississippi River port facilities in Lewis County.

Industry

Mining is the leading industry in the Northeast District, as shown in Figure 28, representing nearly 10% of the total state employment for this industry. Other important industries include aggregates and non-metallic minerals, agriculture and food processing, and advanced manufacturing. The military and defense and automobile supplier industries are not present in the Northeast District.

FIGURE 28 NORTHEAST DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS[56]



Source: U.S. Census County Business Patterns, 2018.

Freight Demand

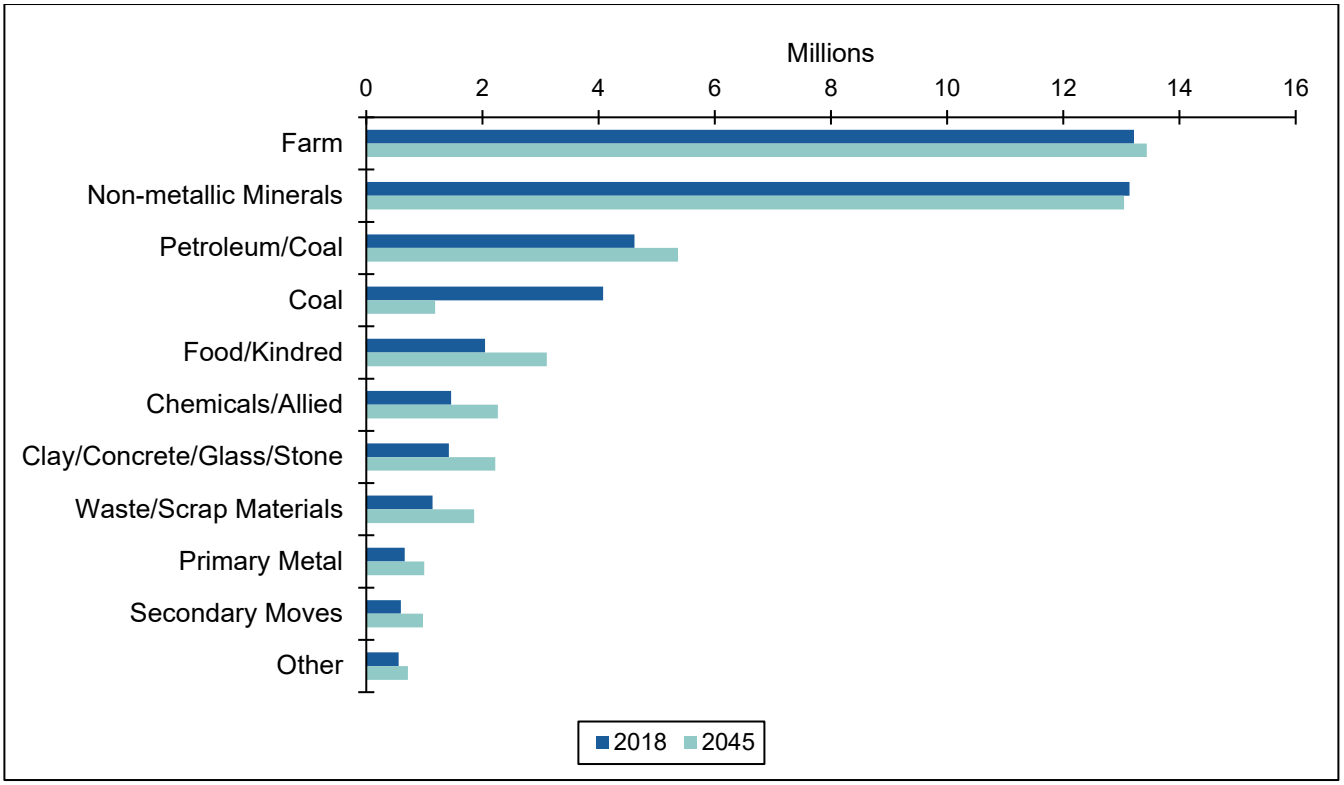
Farm commodities lead and are projected to climb through 2045 in the Northeast district. The top commodities by tonnage and value are shown in Figure 29 and Figure 30. By tonnage, farm products and nonmetallic minerals were the top shipments, each with approximately 13 million tons and a market share of 31%. None of the remaining commodities had more than five million tons transported. Through 2045, these trends are expected to remain

[56] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

constant, although notable increases in tonnage are expected for petroleum and food/kindred products. On the other hand, coal tonnage is expected to decline from four million tons to just over one million.

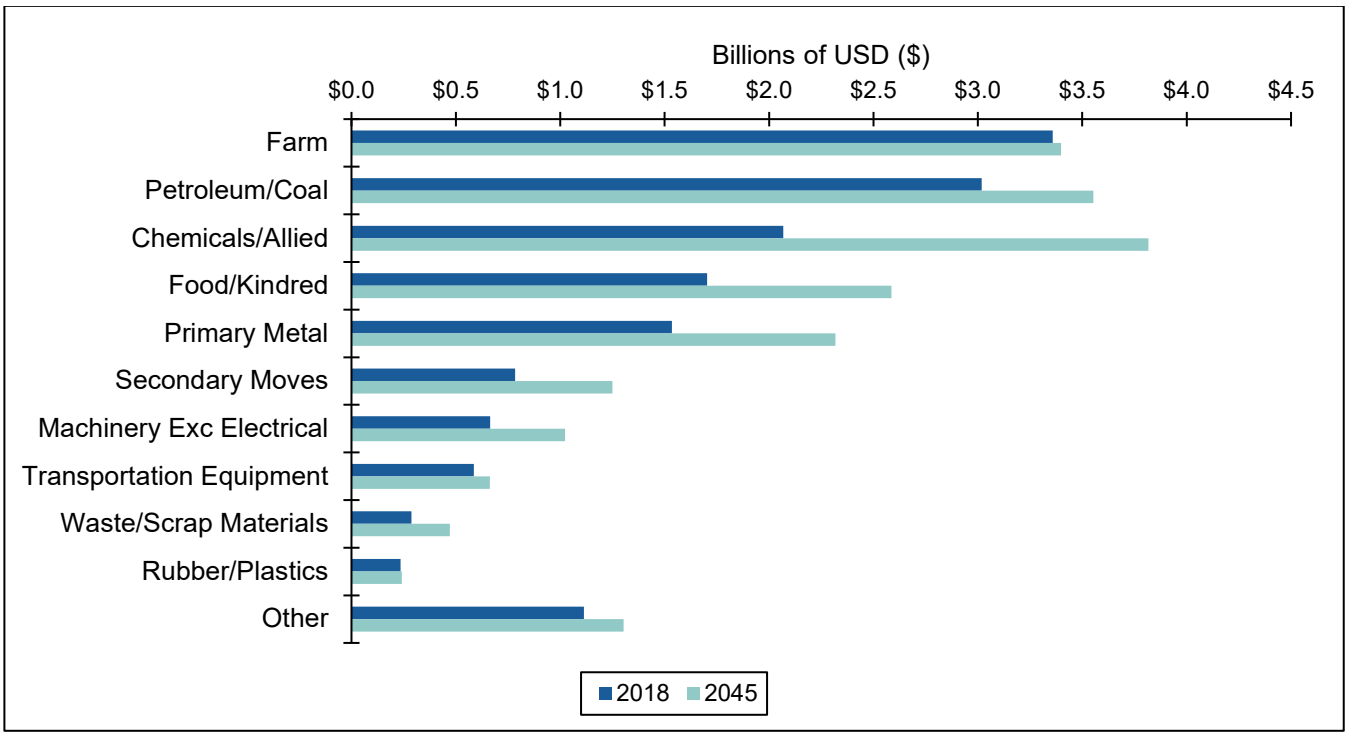
By value, farm products and petroleum products were the two highest sectors in 2018, each worth more than $3 billion, with a value share of at least 20% of transported goods. By 2045, chemicals/allied products are expected to be the top commodity by value, at $3.8 billion, followed by petroleum at $3.5 billion. Notable increases in value for food/kindred products and primary metals are expected as well.

FIGURE 29 NORTHEAST DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 30 NORTHEAST DISTRICT TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

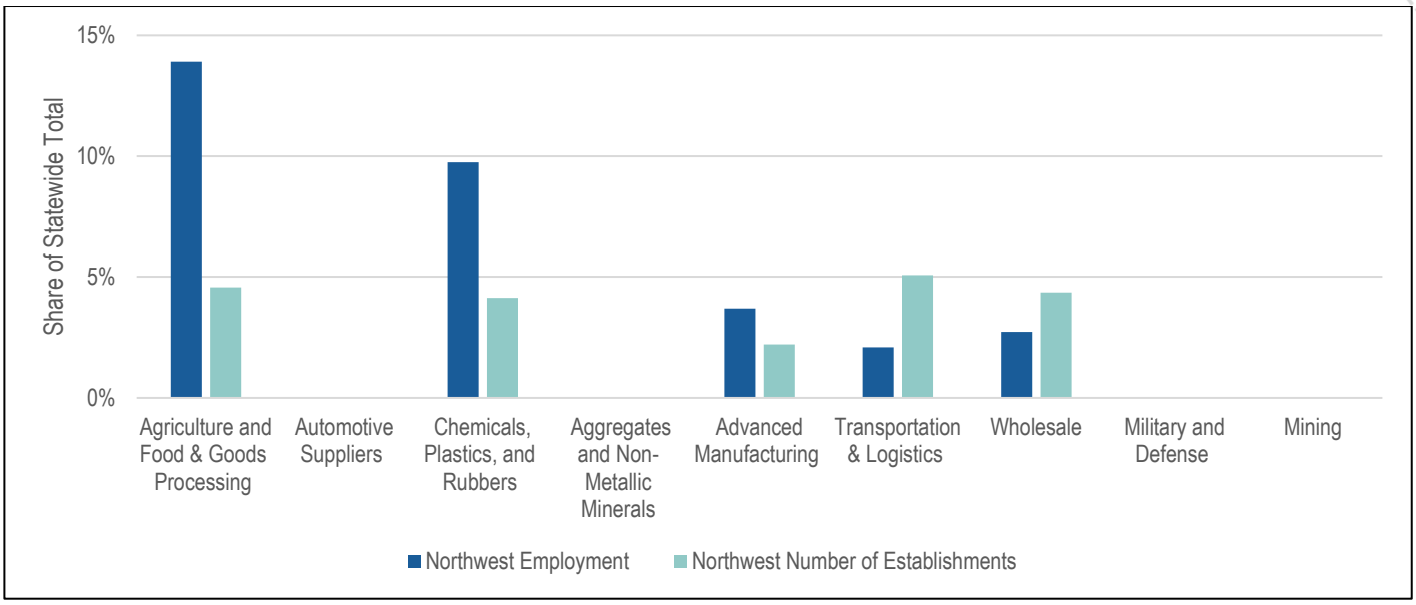
Northwest District

MoDOT's Northwest District has 20 counties covering more than 10,770 square miles. St. Joseph, Chillicothe and Maryville are the largest. Top industries in the region include agribusiness, animal health, and manufacturing. Freight moves by multiple transportation modes in the Northwest District. Major area roads include I-29, I-35 and I-229, as well as US-24, US-36, US-59, US-65, US-69, US-71, US- 136, US-159, US-169 and US-275. Regional airports are located in Cameron, Chillicothe, Maryville, St. Joseph and Trenton. Major rail access is provided by Burlington Northern Santa Fe, Canadian Pacific Railway, Missouri North Central, Norfolk Southern and Union Pacific. The region's Missouri River port facility is in St. Joseph.

Industry

The Northwest District employs 14% of the state's agriculture and food processing workers, while 10% of the state's chemicals sector employment is in the district, as shown in Figure 31. There is very little to no employment activity in the automotive supplier, aggregates and non-metallic minerals, as well as military and defense and mining.

FIGURE 31 NORTHWEST DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS, 2018[57]



Source: U.S. Census County Business Patterns, 2018.

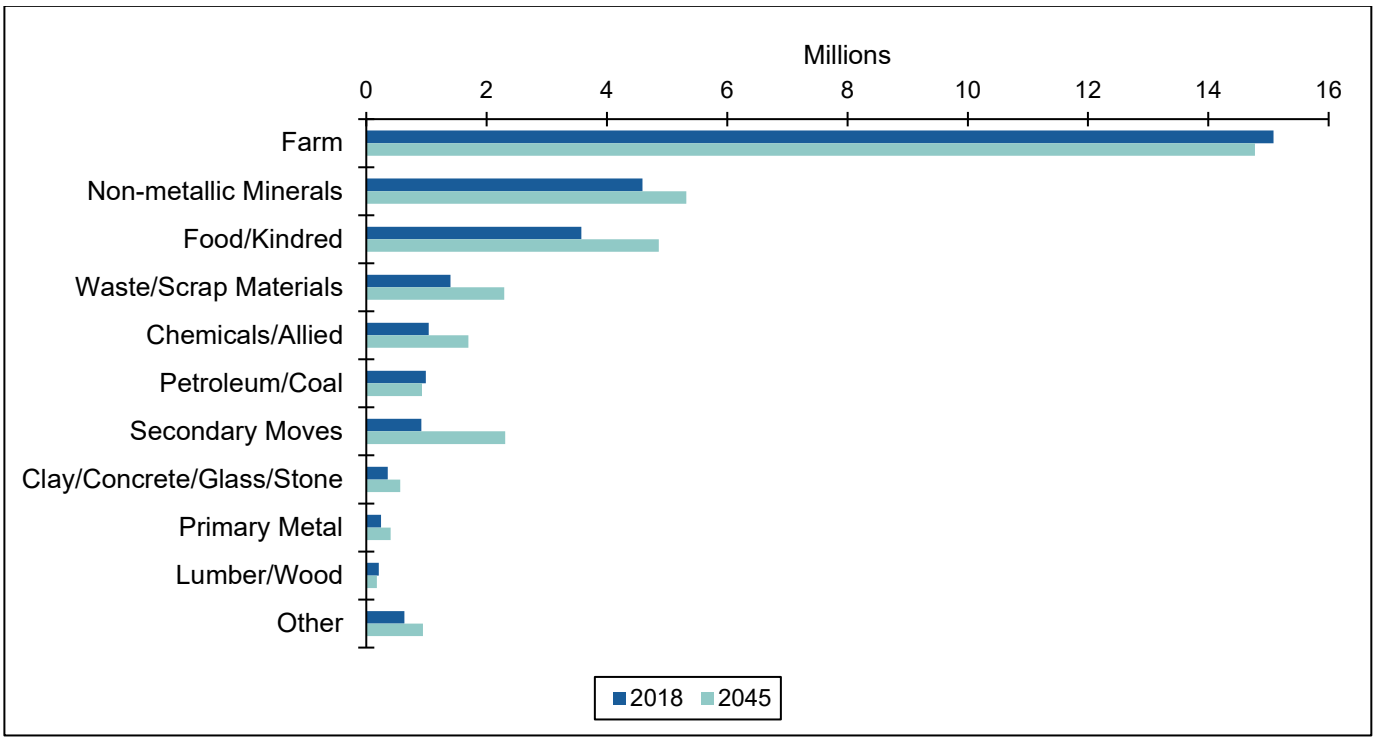
Freight Demand

Farm commodities lead and are projected to continue through 2045 in the Northwest District. The top commodities by tonnage and value are shown in Figure 32 and Figure 33. By tonnage, farm products totaled approximately 15 million tons in 2018, though they are expected to decline slightly by 2045. None of the remaining commodities had more than five million tons transported. Through 2045, these trends are expected to remain constant, although notable increases in tonnage are expected for nonmetallic minerals and food/kindred products.

By value, farm products and food/kindred products were the two highest commodities in 2018, each worth more than $4 billion. By 2045, food/kindred products are expected to be the top commodity by value, at $5 billion, followed by farm products at $4.7 billion. Notable increases in value for chemicals/allied products, secondary movements and machinery are expected as well.

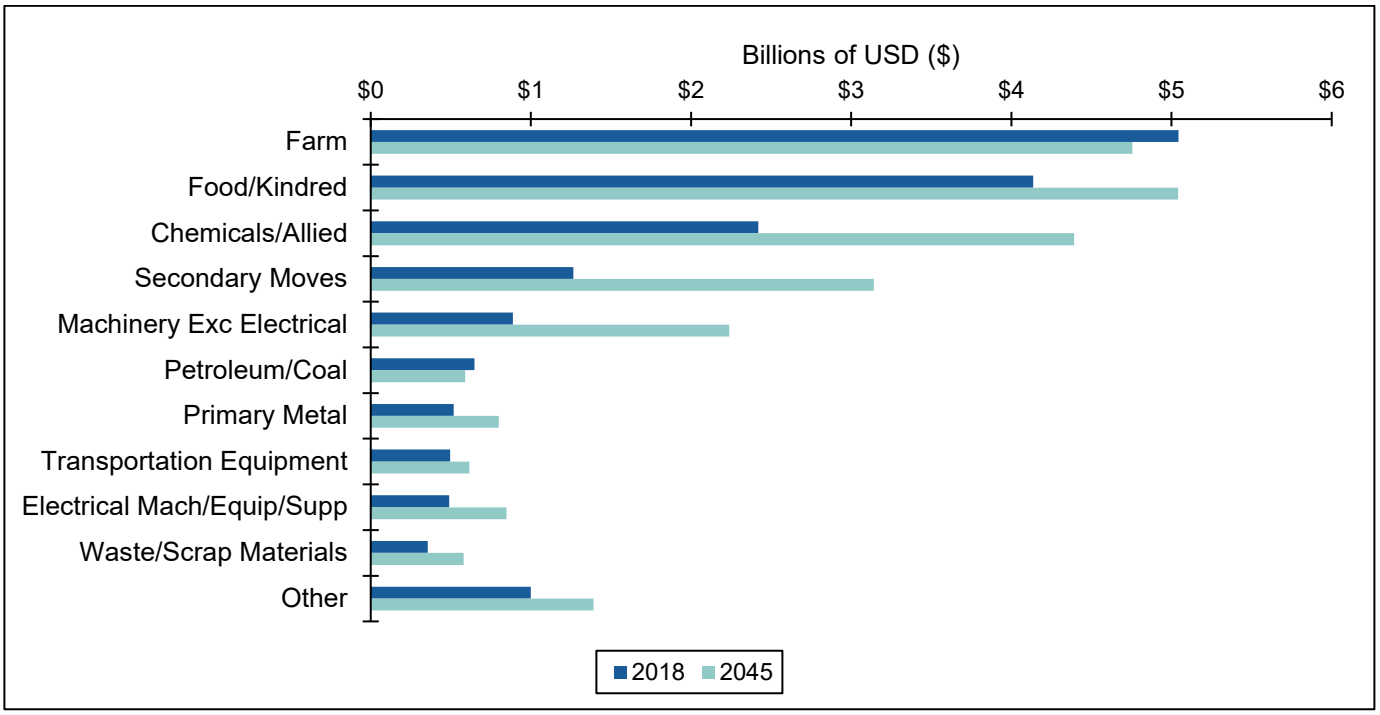
[57] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

FIGURE 32 NORTHWEST DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 33 NORTHWEST DISTRICT TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

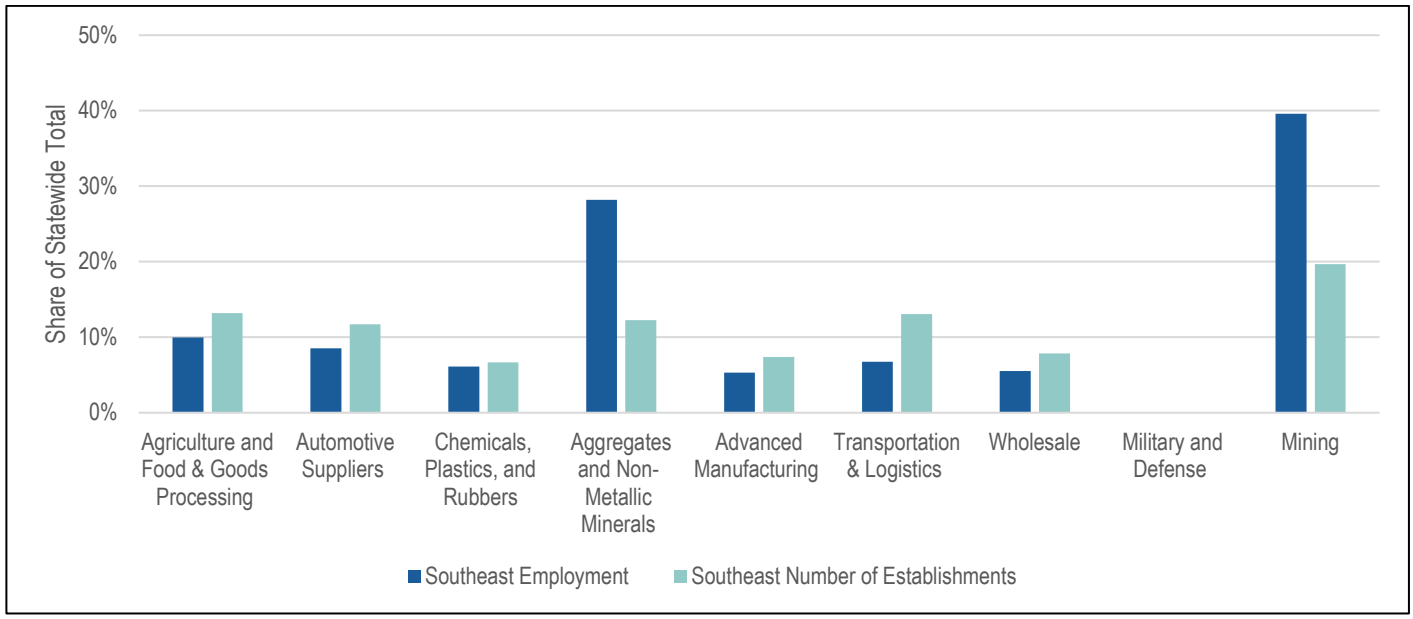
Southeast District

The Southeast District has 25 counties covering more than 16,000 square miles. Cape Girardeau, Poplar Bluff and Sikeston are the largest cities in the district. Top industries include agribusiness, manufacturing, life sciences and transportation/logistics. Freight moves by multiple transportation modes in the Southeast District. Major area roads include I-55, I-57 and I-155 as well as US-60, US-61, US-62, US-63, US-67 and US-412. Regional airports are located in Cape Girardeau, New Madrid and Sikeston. Major rail access is provided by Burlington Northern Santa Fe and Union Pacific. The region also has Mississippi River port facilities at SEMO Port in Scott City, Mississippi County, New Madrid County, Pemiscot County and Ste. Genevieve County.

Industry

The Southeast District is a hub for mining activity and is home to 40% of the state's mining jobs, as shown in Figure 34. Aggregates and non-metallic minerals are another important sector in the District, comprising 30% of the state's employment in the industry. There is some employment activity in the agriculture and food processing, automotive supplier and chemicals sectors.

FIGURE 34 SOUTHEAST DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS, 2018[58]



The Southeast District has one of the highest numbers of jobs in the agriculture industry, though manufacturing remains strong. As demonstrates, this district is projected to see growth in warehousing and distribution center building and associated businesses.

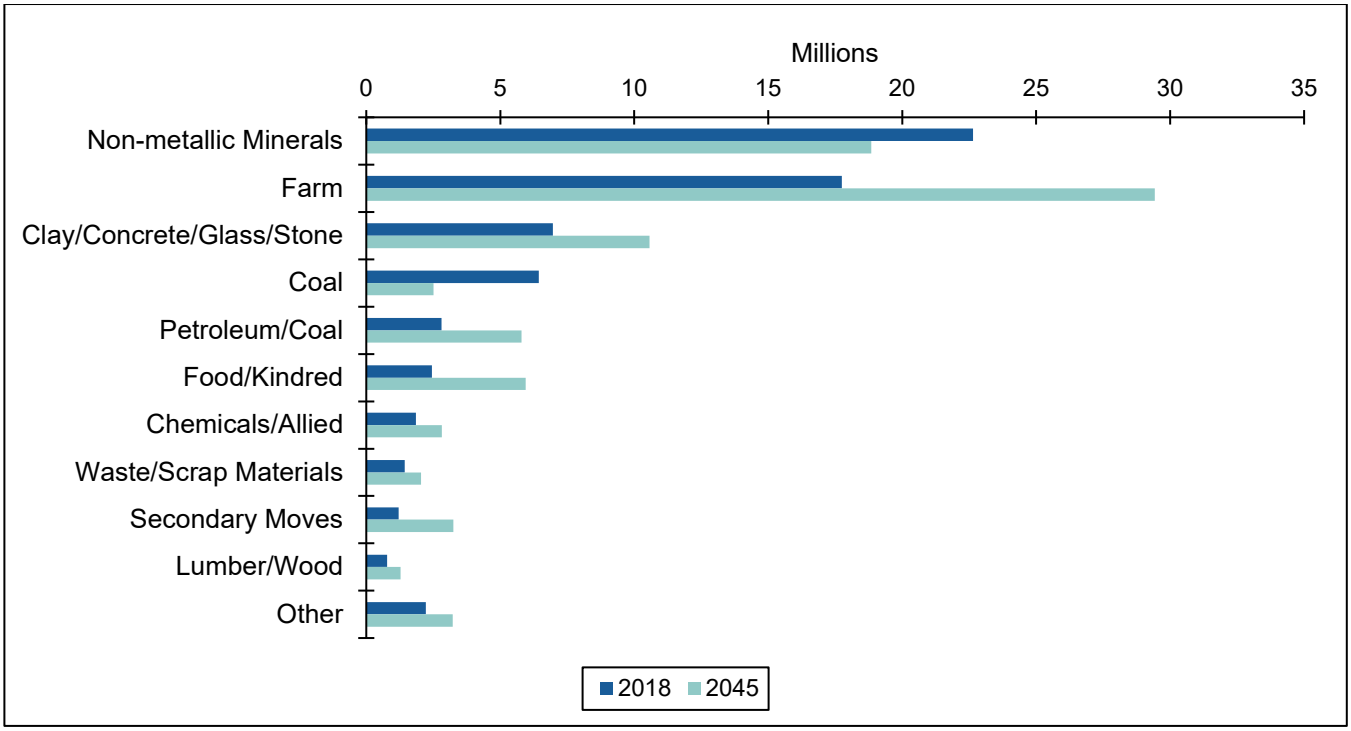
Freight Demand

Given the proximity to the Mississippi River, water (barge) is used to transport a sizable portion of goods, especially in terms of tonnage. In 2018, water comprised 35% of all tonnage, the most of any district, with an increase to 38%

[58] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

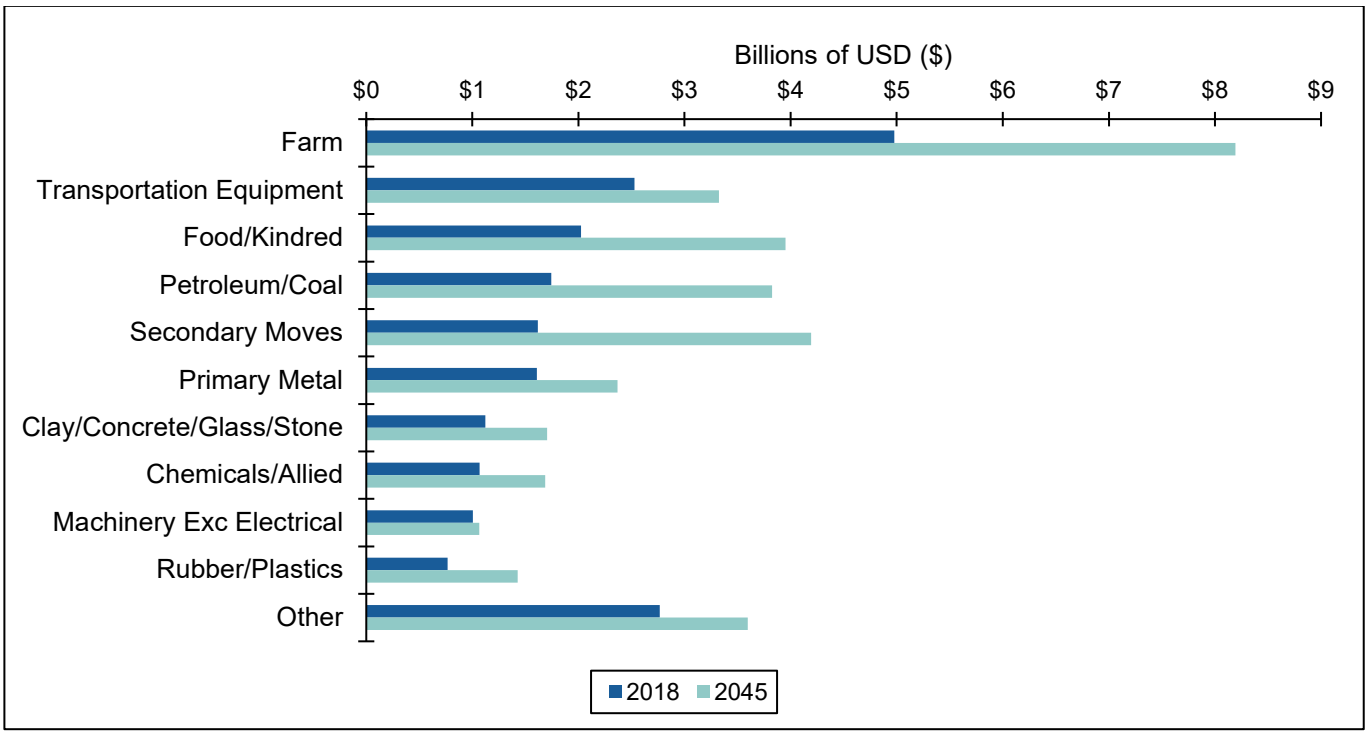
expected through 2045. This indicates that barge modes tend to carry heavy bulk goods, as opposed to high-value goods. Still, trucks comprised the largest proportion of tonnage moved at 48% in 2018, with an increase to 50% expected by 2045. These increases in modal share appear to come at the expense of rail tonnage which is expected to decrease from 17% to just 11% in 2045. In terms of value, truck comprised a much larger proportion of goods at 72% in 2018, compared to water (19%) and rail (8%). Despite a sizable increase in total value across all modes, these modal proportions are expected to remain largely in place through 2045.

FIGURE 35 SOUTHEAST DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 36 SOUTHEAST DISTRICT TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

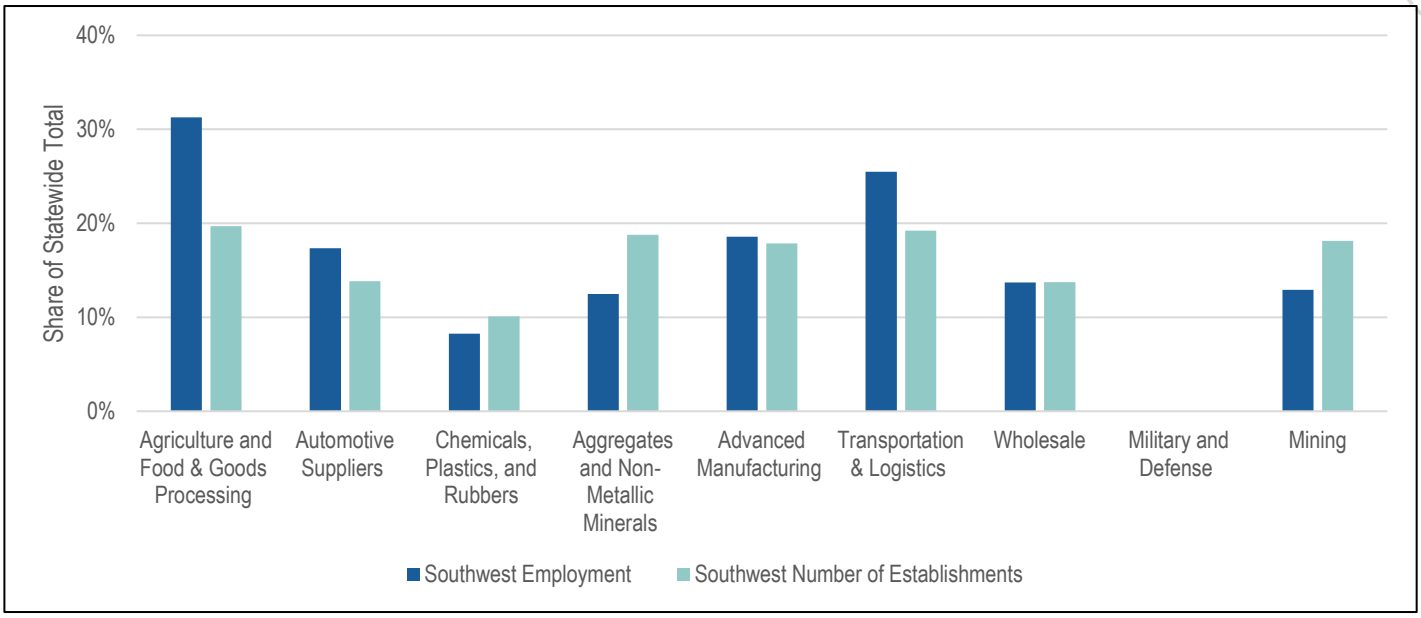
Southwest District

MoDOT's Southwest District has 21 counties covering more than 13,274 square miles. The region's immediate proximity to major freight operations in Northwest Arkansas presents a unique dynamic for the area. Springfield and Joplin are the largest cities in the district. Top area industries include transportation/logistics, information technology, manufacturing and warehousing/distribution. Freight moves by multiple transportation modes in the Southwest District. Major area roads include I-44 and I-49 as well as US-54, US-60, US-65, US-160 and US-166. Regional airports include Clinton Memorial Airport, Joplin Regional Airport and Springfield-Branson National Airport. Major rail access is provided by Arkansas & Missouri, Burlington Northern Santa Fe, Canadian Pacific Railway, Kansas City Southern and Missouri & Northern Arkansas.

Industry

The Southwest District has a strong and diverse freight industry presence, with a high share of agriculture and food and goods processing (30%) and transportation and logistics (25%) employment, as shown in Figure 37. It also has a relatively high share of automobile supplier and advanced manufacturing employment.

FIGURE 37 SOUTHWEST DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS, 2018[59]

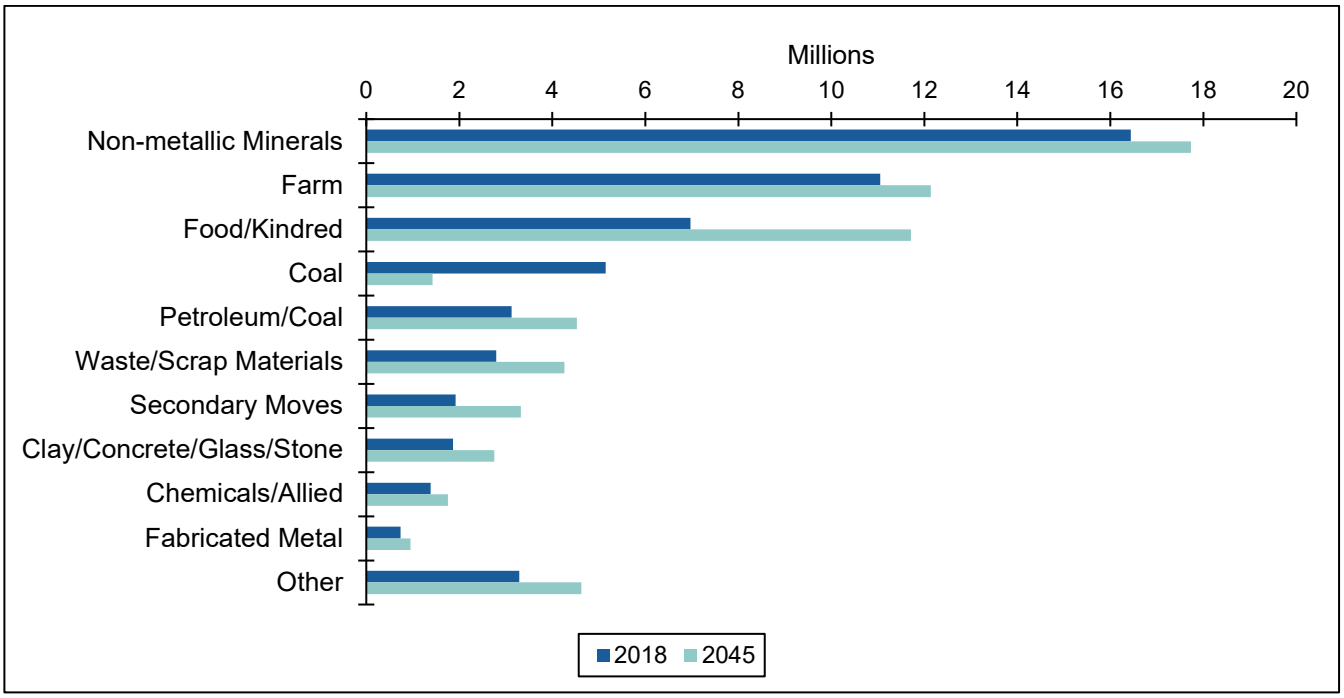


Freight Demand

Overall, the Southwest District moved 55 million tons of goods worth $38 billion in 2018. Through 2045, these figures are expected to rise to 65 million tons of goods worth $56 billion. Top commodities in terms of tonnage and value are shown in Figure 38 and Figure 39. In terms of tonnage, non-metallic minerals, farm products and food/kindred products are projected to remain top commodities through 2045.

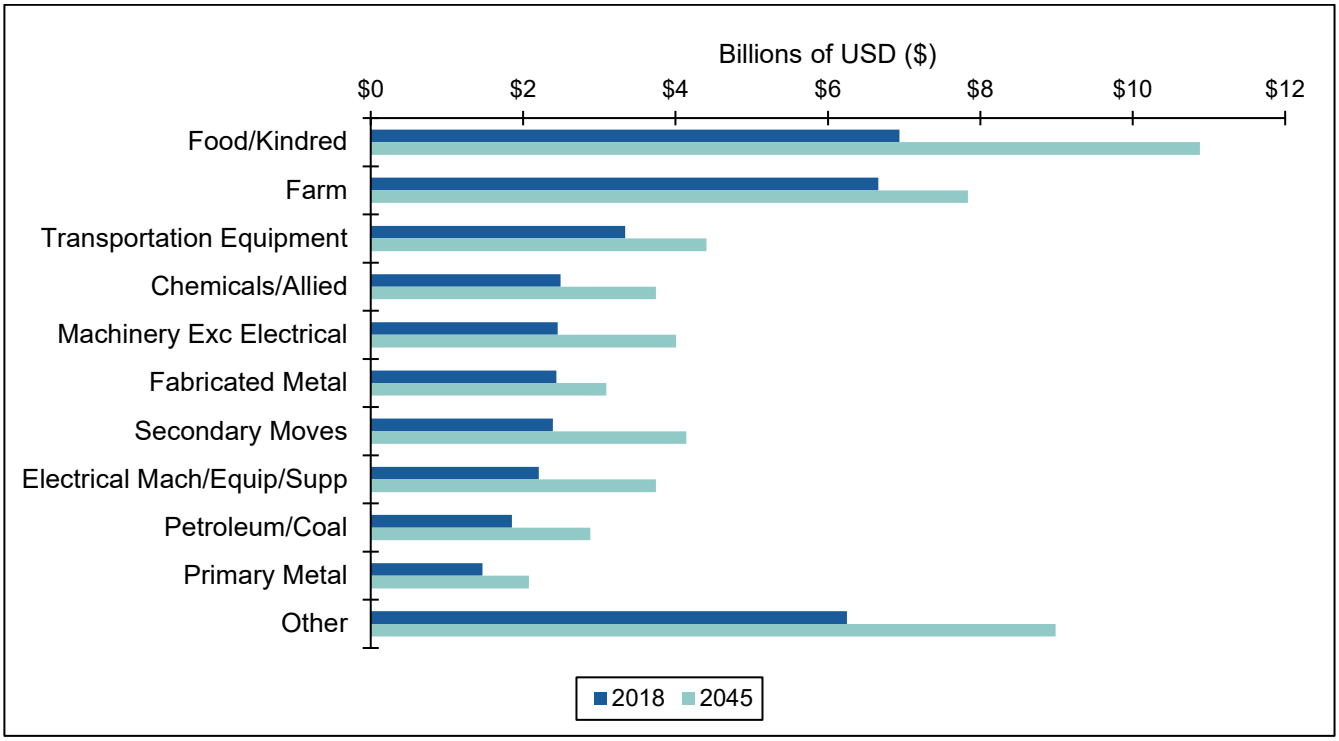
[59] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

FIGURE 38 SOUTHWEST DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 39 SOUTHWEST DISTRICT TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

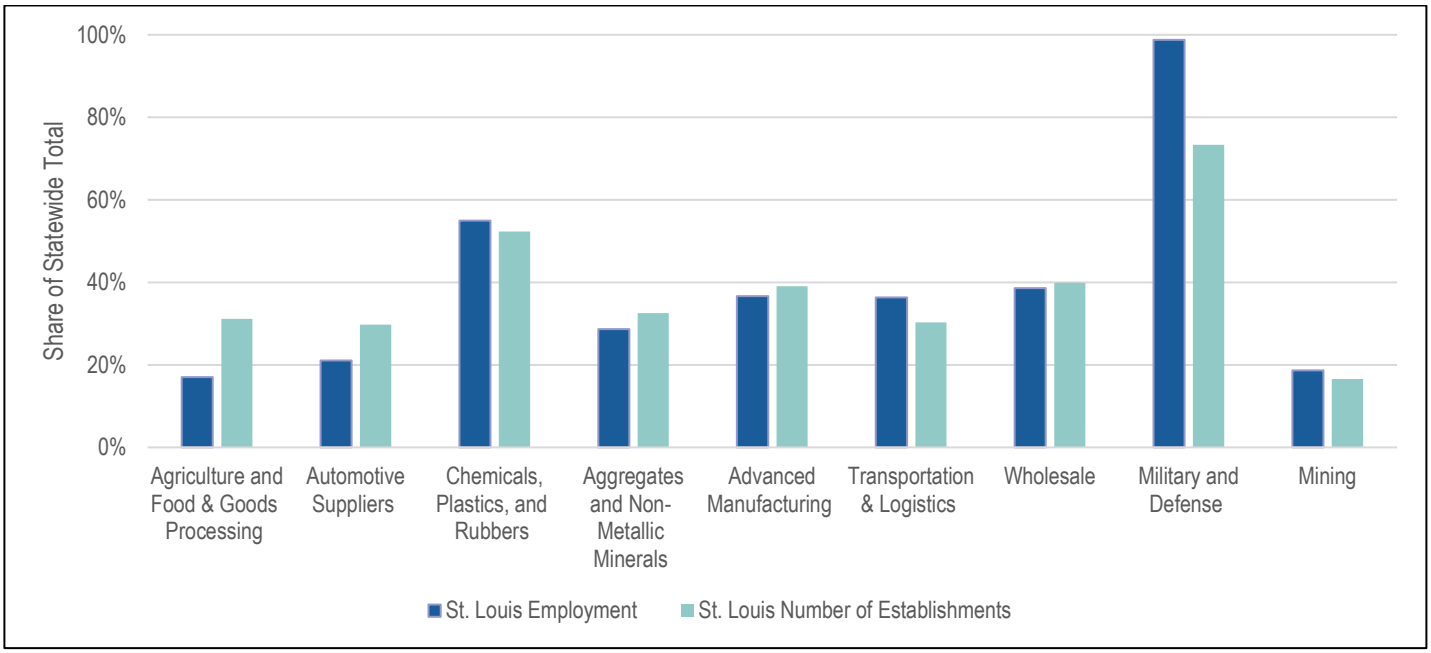
St. Louis District

MoDOT's St. Louis District has four counties and the City of St. Louis. St. Louis, O'Fallon, St. Charles and St. Peters are the largest cities in the district. Leading industries include plant and medical sciences, advanced manufacturing, information technology, financial services, transportation and distribution. Nine Fortune 500 firms are headquartered in the region. Freight moves by multiple transportation modes in the St. Louis District. Major area roads include I-44, I-55, I-64, I-70, I-170, I-255 and I-270 as well as US-40, US-50, US-61 and US-67. Lambert-St. Louis International Airport is the area's largest airport and one of only two major commercial airports in the state. Major rail access is provided by Burlington Northern Santa Fe, Canadian National Railway, CSX, Kansas City Southern, Norfolk Southern and Union Pacific. St. Louis is the third largest rail hub in the nation. The Port of St. Louis is the busiest inland port in the United States. In addition to St. Louis, there is an active port in Jefferson County.

Industry

The St. Louis District has very high employment and number of establishments in the state's military and defense industry sector, as shown in Figure 40, which is due to the strong presence of defense organizations such as the National Geospatial Intelligence Agency West, which provides intelligence support to U.S. forces. St. Louis also comprises a high share of the state's chemicals sector employment (55%) and establishments (52%).

FIGURE 40 ST. LOUIS DISTRICT SHARE OF EMPLOYMENT AND ESTABLISHMENTS, 2018[60]



Overall, St. Louis is the district with the most jobs. Manufacturing remains strong in St. Louis, with 65% of the freight-generating jobs coming from manufacturing. shows that while manufacturing may lead currently, projections show a growing focus in e-commerce industries, warehouse and storage, and truck transportation. Because of its

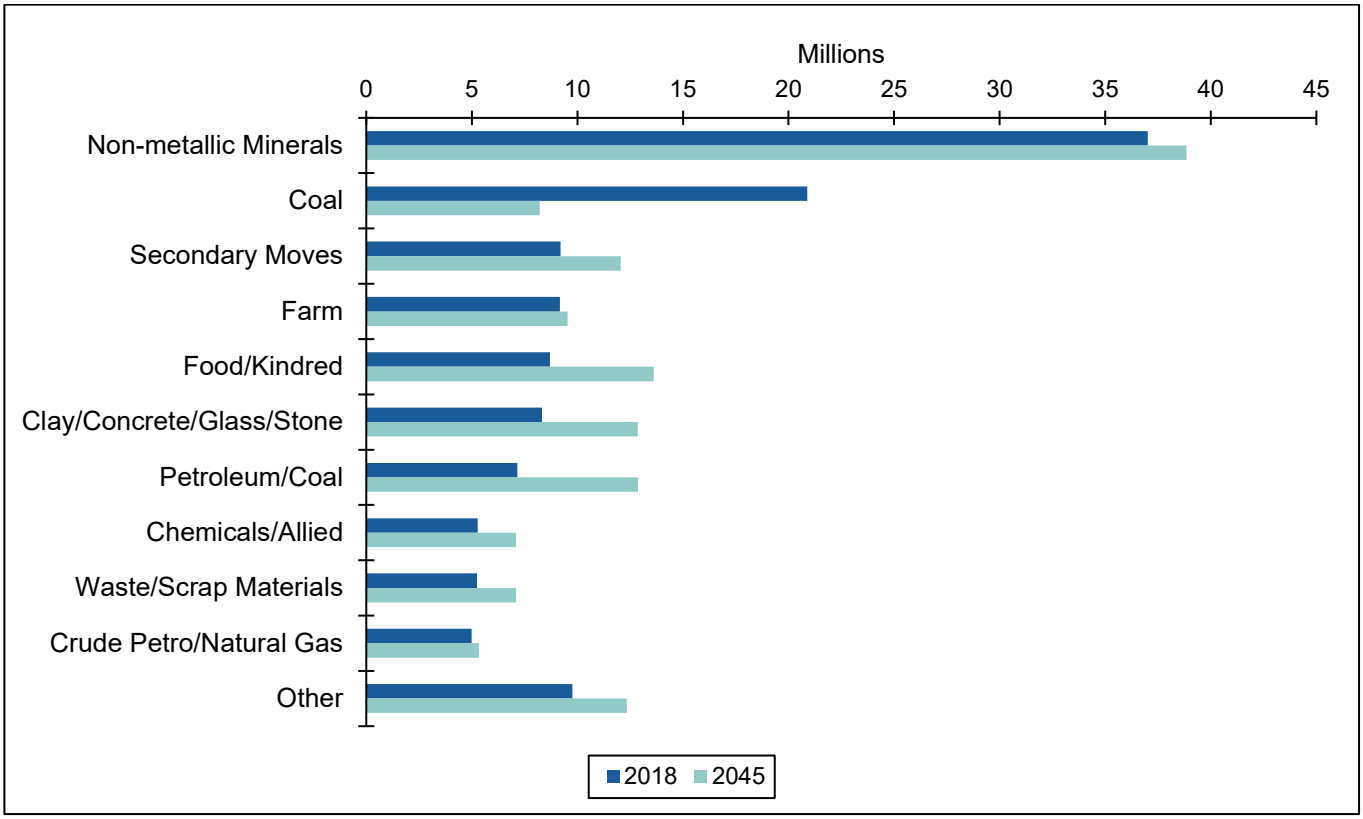
[60] U.S. Census Bureau County Business Patterns (2018) Data offers an approximate count of employment.

intermodal connections to air and waterways, merchant wholesaling and supportive activities for agriculture are also projected to grow.

Freight Demand

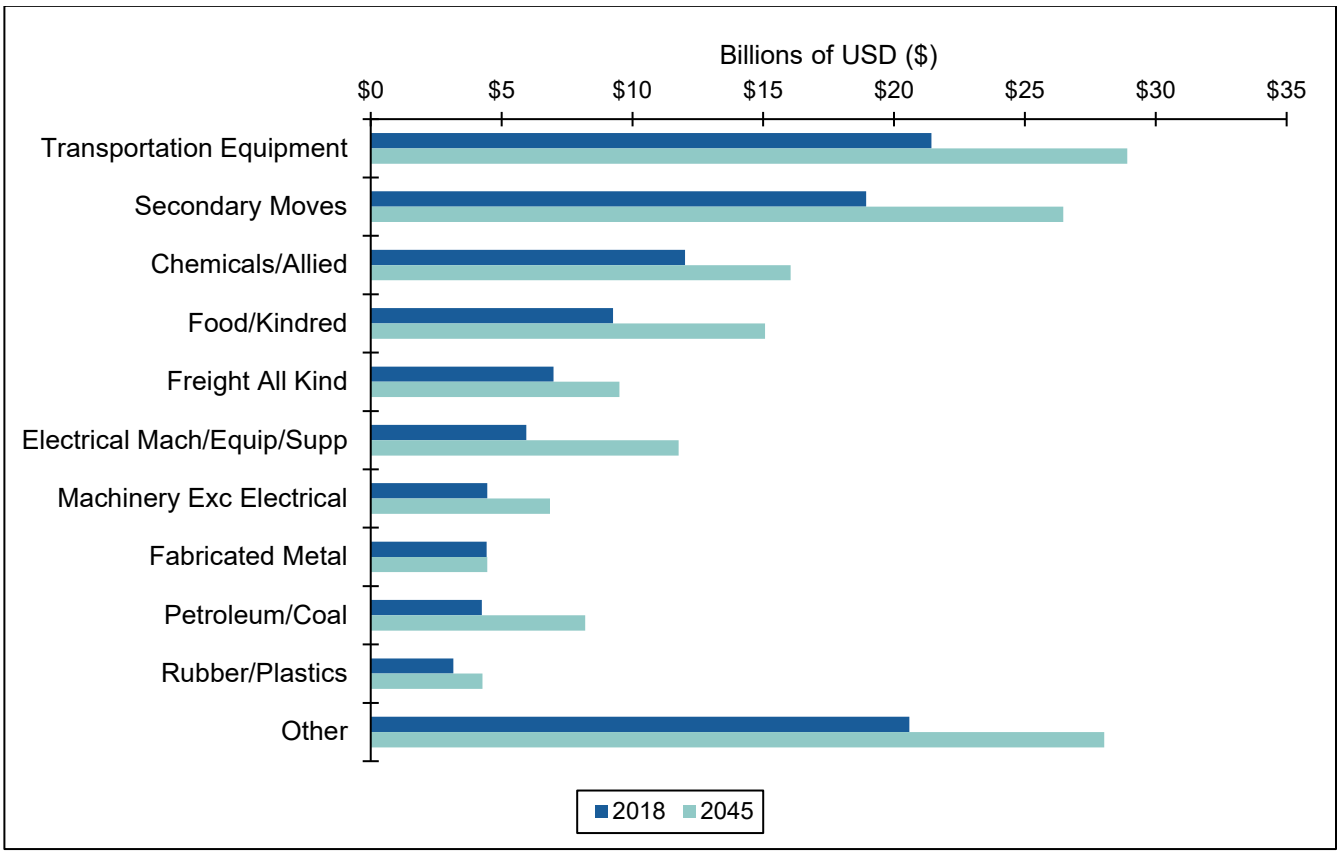
Overall, the St. Louis District moved 126 million tons of goods worth $111 billion in 2018. By 2045, these figures are expected to rise to 140 million tons of goods worth $160 billion. Top commodities in terms of tonnage and value are shown in Figure 41 and Figure 42. Nonmetallic minerals are the top commodity in terms of tonnage, with over 37 million tons in 2018, which is projected to increase to nearly 39 million tons by 2045. Coal was the second-highest commodity in terms of tonnage, but volumes are expected to decline significantly by 2045. Transportation equipment, secondary moves and chemical/allied products are the top commodities in terms of value.

FIGURE 41 ST. LOUIS DISTRICT TOP COMMODITIES BY TONNAGE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

FIGURE 42 ST. LOUIS TOP COMMODITIES BY VALUE, 2018-2045



Source: IHS TRANSEARCH and STB Confidential Carload Waybill Sample.

3.0 Freight Drivers, Trends & Disruptors

Freight investment decision-making in Missouri should not only support the needs of state's businesses and industries today, but also well into the future. The Commodity Flow Profile was developed as part of the 2022 SFRP. It details current and projected freight flows through 2050, forecasting future freight demand derived from socioeconomic, macroeconomic and societal trends and assumptions based on our current understanding of the future of freight. However, as we know from reacting to unexpected current events—such as the COVID-19 global pandemic and the war in Ukraine—there are infinite possibilities for the future that may be influenced by changes in technology, geopolitics and innovations, among many other influences.

There are several notable innovations in transportation, science, technology and data collection and management that are already impacting industries across the globe, and especially in Missouri. The strong presence of biotechnology, agriculture, advanced manufacturing and transportation and logistics sectors position Missouri to be at the forefront of these changes:

- **Biotechnology**: Missouri's health care and biotechnology sector is already robust, as the state is home to major health services companies such as Cerner, Centene and Express Scripts, in addition to world-renowned research hospitals and centers. Notably, Missouri's bioscience industry employs approximately 56,000 highly skilled individuals across more than 4,900 companies.[61] This strong and growing sector supports other key industries in the state, including pharmaceuticals, agriculture, manufacturing and transportation and logistics. This industry has specific freight and logistics needs to manufacture, handle and transport highly perishable and time-sensitive goods, and as the COVID-19 pandemic has demonstrated, there is a strong need for cold storage to address quality standards for vaccines and other life-saving medicines. In recent years, companies expanded their footprint in Missouri, such as Catalent Pharma Solutions, which recently developed a new 70,000 square foot expansion to increase its controlled-temperature storage capacity for its clinical supply business (where?).[62] Similar expansions for Missouri biotechnology companies may have similar requirements, adding new demands to the multimodal freight network for the transport of these critical goods.

- **Agriculture and "Agtech"**: As discussed in Section 2.2.1, Missouri is one of the leading agriculture states in the U.S., with 95,000 farms covering two-thirds of the state's acreage and contributing $88 billion to the statewide economy. The state is also a leader in agriculture technology, or agtech, covering both animal and plant sciences including innovations in crop science, biofuels and precision agriculture, animal health, such as pet food, vaccines and other domestic animal biological advancements. There are dozens of companies and organizations in this field located in Missouri, including Danforth Plant Science Center, Yield Lab, DuPont, BASF, Bayer Crop Science and Bunge. Several companies have moved their headquarters to Missouri in recent years, including Aker Technologies (previously based in Chicago) and Bunge (previously headquartered in New York), while several have expanded operations. For example, Boehringer Ingelheim is expanding its St. Joseph campus to manufacture vaccines for livestock, and Cosmos Corporation is expanding its headquarters

[61] https://www.missouripartnership.com/industry-strengths/health-innovation/

[62] https://www.missouripartnership.com/wp-content/uploads/2017/01/Health-Innovation-in-Missouri-9.pdf

in O'Fallon to increase manufacturing and distribution operations.[63] The bulk shipments related to growing and processing of agricultural goods combined with the storage and distribution of highly sensitive medicines and biofuels makes this sector especially dynamic and underscores the complexities of its transportation and logistics needs, which will only continue to evolve in the future.

- **Advanced Manufacturing**: New technologies continue to evolve the highly diverse advanced manufacturing sector across the Nation. In Missouri, the primary advanced manufacturing sectors include aerospace and motor vehicles and parts. Boeing's Defense, Space, and Security facility in Missouri produces F/A-18, EA-18, F-15 and T-7 Trainer fighter jets, along with the new unmanned MQ-25 refueling drone and other military equipment. In 2020 alone, Missouri produced nearly 600,000 vehicles at the Ford and GM plants, advanced military jets for the U.S. and allied militaries and more.[64] In addition, Missouri exports more than $7.3 billion in advanced manufacturing products, including small motors and engines, with examples such as Emerson and Kawasaki.[65] Growth in advanced manufacturing sectors will have a number of impacts across the state, including physical infrastructure needs, as well as impacts related to the lack of broadband availability limiting advanced manufacturing footprint in rural areas. Advanced manufacturing companies also require a highly trained workforce that can evolve to meet current and future needs. KC SmartPort is addressing this issue in the Kansas City area with workforce development programs (such as Prep KC) that begin at the high school level and bypass college for high-paying operator employment in distribution, manufacturing and other freight-related positions, with continuing education across the career spectrum. Sustained growth in this sector will require a strong labor force in addition robust physical transportation infrastructure to meet demand from domestic and international markets.

- **Energy Solutions**: In addition to the state's contribution to the agriculture and biofuels sector, businesses in Missouri are also leading the development and production of batteries for defense, space, automotive and consumer industries. Missouri is one of the top states in terms of battery production and leads the production of lead for batteries as well as the development of lithium batteries. These evolving technologies support many renewable energy markets and sectors, including solar generation, wind production and battery electric vehicle production. There are also a number of energy storage research centers with strong contributions to the field, including the Future Renewable Electric Energy Delivery and Management Systems Center at the Missouri University of Science and Technology, whose goal is to introduce distributed energy storage devices and distributed grid intelligence such as plug-in hybrid electric vehicles and other devices.[66] The research and production of new battery technologies is changing the supply chains required to produce essential consumer goods such as electric vehicles, in addition to the components and logistics behind powering the state's households, businesses and industries.

In addition to the industry trends driving changes in freight demand on the production side, population growth in Missouri will also impact consumer demand for goods. Between 2010 and 2020, the state's population grew from

[63] https://www.missouripartnership.com/wp-content/uploads/2018/01/Agtech-in-Missouri.pdf

[64] https://www.missouripartnership.com/industry-strengths/top-advanced-manufacturing-network-location/

[65] https://www.kawasakimaryville.com/

[66] https://www.missouripartnership.com/wp-content/uploads/2018/03/Energy-Solutions-in-Missouri.pdf

nearly 6 million people to over 6.1 million people, an increase of nearly 166,000 people or 3% total growth.[67] As discussed in MoDOT's Long Range Transportation Plan Update, Missouri is projected to continue to grow over the next 20 years, with a total population approaching 6.4 million people in 2040, as compared to 6.1 million in 2016. Missouri's net population increase will be primarily attributable to natural increase (births minus deaths), with slight gains in net migration. Other socioeconomic facts about Missouri inform domestic consumer and freight demand that impact the freight transportation network include:

- **Aging Population**: In Missouri, 17.3% of the population is over 65 years old, compared to the national average of 16.5%. Missouri's Office of Administration, Division of Budget and Planning, projects ten counties will have greater than 30% of their population over 65 by 2030.

- **Concentration of Population**: Since the 1900s, population in urban areas has increased from 36% to 70% and projections suggest the pattern will continue. As documented in the LRTP, information from the Missouri Census Data Center suggests people will continue to move toward urban areas, with higher population gains anticipated in the suburbs. Recent migration trends indicate that the next 30 years will bring large growth in the suburban counties surrounding Kansas City, St. Louis and Springfield, with significant declines continuing in the rural areas, most notably north of U.S. Route 36 and in the south-central area of the state.

- **Educational Attainment**: Educational attainment levels in the state show 29.2% of the population with a college degree or higher, slightly lower than the national share of 32.1%. This also contributes to lower household income and higher rates of poverty for Missourians, which can both limit job opportunities and reduce household purchasing power.

These factors point to the necessity of a resilient transportation network that can accommodate the mobility and consumer demands of residents aging in place, homeowners who are improving, selling or buying in Missouri, as well as education attainment that can contribute to a workforce that supports growth and innovation. Changing demographics impacts not only where Missouri's businesses choose to locate, but also where their products are transported and how much is consumed. It is estimated that total freight flows in Missouri will increase from 985.3 million to over 1.1 billion by 2040. During that same time, state population is projected to grow from 6.1 million to 6.4 million people, meaning that freight tonnage per capita is expected to increase from 160.9 tons to 173.3 tons, as shown in Table 3.1. The additional 12 tons per capita will be transported to, from, within and through Missouri, indicating that freight transportation investments across both Missouri's primary and local networks will be necessary to support growth in consumer demand and industry production.

TABLE 3.1 MISSOURI FREIGHT VOLUME AND POPULATION, 2018 AND 2040

Metric	2018	2040
Total Freight Tonnage	985.3 million	1.1 billion
Population	6.1 million	6.4 million
Freight Tons per Capita	160.9	173.3

[67] https://oa.mo.gov/sites/default/files/MoCoPop20010-2020.pdf

Source(s): Missouri 2021 State Freight and Rail Plan, Commodity Flow Profile; Missouri LRTP Update; Cambridge Systematics.

With this framework in mind, the next section focuses on emerging trends that, while expected, are still developing and have the potential to significantly impact future freight flows beyond what is currently forecasted. It identifies seven trends or "disrupters" that have a strong potential to affect Missouri based on its unique position in the current national freight network, including current demand for goods movement, industry base, population and employment.

3.1 Trends & Disruptors

Trends that have a high potential to impact macroeconomic conditions and freight flows across multiple industries are referred to as "disrupters." This section investigates seven disrupters that are relevant to Missouri, describing the general scenario conditions and key considerations. These forecast scenarios will help MoDOT inform its goals, objectives and strategies to ensure resilience in the state's freight network regardless of what the future holds.

Renewable Energy

Market shifts from fossil fuels to renewable energy sources and fuel types, such as battery electric vehicles, will impact Missouri's industries, freight flows and supporting infrastructure. Currently, coal is one of the top commodities moved throughout the state, but tonnage is projected to continue to decline by more than 70% between 2018 and 2045, while petroleum and natural gas movement is only expected to grow by 1%. As domestic and global markets shift to renewable energy, opportunities and challenges to the state's economy will arise, particularly in the automotive industry. Missouri currently has 15 businesses producing motor vehicles, 81 producing motor vehicle bodies and trailers including motor homes and campers, and 139 producing various motor vehicle parts. However, for Missouri's automotive industry to fully capitalize on this boom, it is essential to establish a resilient supply chain capable of handling the new inputs and components required to produce these vehicle types, as well as a freight transportation network capable of handling the inbound and outbound freight flows. Missouri would need to support a transportation network amid a sharp increase in industrial land use for battery manufacture and disposal, as well as mining and processing of lithium, nickel and cobalt.

Considerations

The primary considerations for adapting to renewable energy shifts in Missouri are:

- **Establishing a robust network of alternative fueling infrastructure**. To support the widespread deployment of zero-emission vehicles, it will be critical to establish a robust network of alternative fueling infrastructure not only in Missouri, but throughout the nation. Total battery electric vehicle sales reached nearly two million in 2020, with China and Europe comprising the two leading consumer markets, accounting for 80% of sales. Key drivers of this growth in China include the extension of EV state subsidies until 2022 and the continued push for EV adoption, both in corporate and leasing fleets and among Chinese private car buyers.[68] Similar mandates in the U.S. could accelerate domestic adoption of these vehicles as well. In response to growing demand, U.S. automakers have demonstrated commitment to EV manufacturing, and it is evident that the likely tipping point

[68] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/winning-the-chinese-bev-market-how-leading-international-oems-compete

for full adoption will depend on a strong and reliable network of EV fueling infrastructure. Missouri is currently on track; in 2022, the state has more than 2,300 public alternative fueling stations, with 87% of those for battery electric vehicles.[69] For comparison, Washington state, which is 4 percent smaller geographically, has about 4,000 public alternative fueling stations. Just as important as the number is the distribution of stations, depending on the population and the EV market locally and regionally. The current U.S. administration has expressed interest in providing incentives to drivers, EV charging stations and EV transit vehicles, providing an opportunity for Missouri to further build out its EV infrastructure with federal support. Other alternative fuels are also in the market, although they are not gaining as much traction nationally or in Missouri.

- **Securing alternative state revenue streams due to declining motor fuel tax collection**. In July 2021, Missouri enacted a motor fuel tax increase that will increase by 2.5 cent annual increments for six years. The first took effect in October 2021. However, with fewer gas-powered internal combustion engine automobiles on the road, transportation funding mechanisms must evolve. According to the 2018 LRTP, there were approximately 51,000 hybrid vehicles and an additional 6,740 all-electric vehicles on Missouri roads, more than triple from 2,000 reported in the long-range-transportation plan (LRTP) in 2018.[70] [71] The expansion of non-gasoline fleet requires the state to adjust how revenue is collected from users of the transportation system. Other funding options include user fees and taxes on sales, income and corporate entities. States are exploring and enacting changes in user fee collection to address current shortfalls in transportation funding. For example, 14 states, including Missouri, charge an electric vehicle registration fee. Missouri's fee is $75 per vehicle.[72] Recent legislation provides for alternative-fuel vehicles to pay a n annual decal fee. This discussion is also happening at the federal level as gasoline-powered vehicles became more fuel efficient. The change to renewable energy will widen the gap between revenue collected and infrastructure cost.

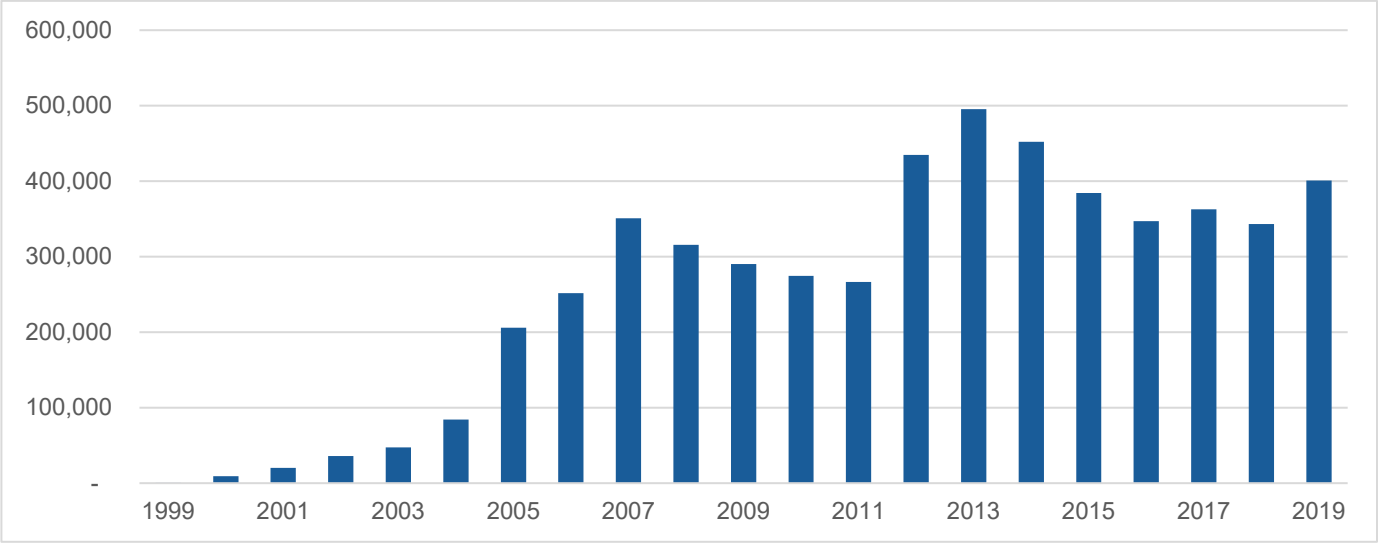
[69] U.S. Department of Energy Alternative Fuels Data Center, Missouri (April 2021). https://afdc.energy.gov/states/mo

[70] Ibid.

[71] https://www.modot.org/sites/default/files/documents/TechMemo_MoDOT_053018.pdf

[72] Ibid.

FIGURE 43 U.S. HYBRID VEHICLE SALES, 1999-2019



Source: Transportation Research Center at Argonne National Laboratory, http://anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates

- **Achieving strong supply chains for metal and parts for zero-emission automobile and parts manufacturers**. Supplier and stakeholder relationships at the regional and state level are crucial to establishing supply chains that can pivot from sourcing components for gasoline fleet to zero-emission vehicles. In the automotive industry, this includes the automakers, parts manufacturers, shipping, warehousing, transportation network, contracts and markets.[73] Missouri can play a key role in facilitating these relationships and MoDOT can address transportation infrastructure priorities.

Opportunities

The primary opportunities in renewable energy markets for MoDOT are:

- **Public-private partnerships among automobile manufacturers and states**. Partnerships between automakers and the states are key to making sure the electric vehicle infrastructure needs are met for the supply chain to succeed. As the demand for EVs continues to grow, there may be opportunities for Missouri's industries to capitalize on demand. Many automakers have announced goals of transitioning to electric and zero-emission vehicles, resulting in sustained demand for battery manufacturing materials and processes.[74] MoDOT partners and stakeholders can partner with automobile manufacturers and suppliers to fund needed multimodal transportation projects, support workforce training and development and establish other incentives with the state's economic development entities for businesses and industries to continue to grow in these areas. If engaged early in manufacturers' plans, MoDOT can discuss changes needed to existing infrastructure.

[73] https://www.cips.org/supply-management/opinion/2017/october/three-ways-to-build-a-strong-supply-chain/

[74] New York Times (2021). https://www.nytimes.com/2021/02/16/business/energy-environment/electric-car-batteries-investment.html

- **Adapt infrastructure to meet the needs of shifting supply chains and expanded industry opportunities**. Three of the primary elements in EV battery manufacturing include cobalt, lithium and nickel. In Missouri, there are approximately 40 cobalt miles and approximately 30 nickel mines[75] within Madison County alone, providing the state with an opportunity to grow these sectors to meet national and global demand.[76] In recent years, prices for palladium and rhodium metals for emissions-reducing catalytic converters spiked, driving up the cost of manufacturing internal combustion engine automobiles. These metals help turn harmful emissions such as carbon monoxide, hydrocarbons and nitrous oxides into carbon dioxide, steam and nitrogen, which help makers of internal combustion engine vehicles meet stricter emissions standards.[77] The soaring prices, coupled with increased consumer demand for these alternative and low-emission fuel types, may accelerate the shift to EVs. Missouri's businesses have an opportunity to not only leverage the state's natural resources to produce EVs, but also take advantage of capacity on the network as the transport of fossil fuels and ICE vehicle components declines across the network. If engaged early in mines' transportation plans, MoDOT can discuss changes needed to existing infrastructure.

- **Strong potential for manufacturing sector job growth.** Although demand for EV battery manufacturing could lead to increased manufacturing activity overall in Missouri, it is essential that strong supply chains for metals and parts are in place. This could involve modernizing infrastructure at multimodal and intermodal hubs, such as inland port terminals, and strengthening connections to freight rail service to facilitate the movement of raw and finished goods. Because the state already leads in auto manufacturing, partnering with automakers on the energy shift would not only induce jobs, but also strengthen related supply chains for battery processing.

Instability Due to Climate

Across the country, extreme weather events, such as extreme flooding in Missouri, are happening with greater frequency. This raises questions about the need to improve the resiliency of the state's transportation infrastructure. Flooding, tornadoes and other extreme weather events cost billions of dollars in damages annually in Missouri. This includes damage caused by tornadoes ($360 million), thunderstorms ($21 million), flooding ($79 million), extreme storms and cold ($19 million) as well as drought ($1 million). The total cost is an annualized average of $480 million in property damages (from 2009 to 2019), not including the costs of delays or re-routes as a result of these events.[78] This impacts the stability of the network's capacity to move goods across all modes.

In 2019, Missouri experienced record-setting flooding along the Mississippi River, which at one point resulted in the closure of 300 highway locations.[79] Between January and July of that year, flooding was so widespread that at least 11 states sought federal disaster funds across more than 400 counties. In 2018, Missouri experienced a severe

[75] The Diggings (accessed July 2021). "Missouri Nickel Mines." https://thediggings.com/usa/missouri/mines?development_status=mine&commodity=nickel

[76] Reuters (2021). https://www.reuters.com/article/us-usa-mining-missouricobalt-exclusive/exclusive-u-s-nickel-cobalt-miner-missouri-cobalt-hires-bank-to-go-public-through-spac-idUSKCN2DU23A

[77] https://www.wsj.com/articles/emissions-clampdown-sends-rhodium-prices-on-explosive-rally-11606737904

[78] U.S. Department of Energy State of Missouri Energy Risk Profile: https://www.energy.gov/sites/default/files/2021-09/Missouri%20Energy%20Sector%20Risk%20Profile.pdf

[79] "More than 300 Roads Closed in Flooding Across Missouri." Missourinet (2019). https://www.missourinet.com/2019/05/29/more-than-300-roads-closed-in-flooding-across-missouri-links-to-maps/

drought, forcing livestock producers to seek alternative feeding options, as the dry conditions raised the level of nitrates in crops to toxic levels.[80] The Missouri River is the longest in the United States, and a 2020 published study found that between 2000 and 2010, the basin supplying snow pack has seen its worst drought in 1,200 years.[81] This has downstream effects for Missouri and Mississippi river states. These and other hazards threaten human lives as well as economic prosperity.

A 2021 report released by the Intergovernmental Panel on Climate Change predict that increasing greenhouse gas emissions and rising global temperatures will lead to several key changes to the climate for Midwest states, including increases in continued droughts, extreme precipitation and river and pluvial flooding.[82] The report concludes that these conditions are expected to worsen during the next 20-30 years given current fossil fuel emissions levels, meaning that countries around the world will have to adapt to stronger, more frequent environmental hazards.

Considerations

The primary considerations for adapting to climate instability in Missouri are:

- **Existing multimodal assets in need of modernization**. Extreme weather wreaks havoc on the condition and operations of trucking, rail, port and air cargo modes. Damage and delays can increase costs for shippers, and ultimately consumers of goods. For highway modes, it is estimated that climate change could increase the cost of keeping roads in service in the U.S. by $2.8 billion in 2050.[83] Although the majority of Missouri's highway infrastructure is in good condition,[84] other aspects of the multimodal transportation network are needed to build in redundancy across other modes: rail, ports and airports. Rail networks can be washed out by floods or damaged by tornados. Flooding closes ports. Extreme heat causes buckling of highways and runways. These assets need maintenance, upgrades, and rehabilitation. Diversified mode choice for freight mitigates risk to the supply chain. Extreme weather results in cancellations or delays that can have a ripple effect across the multimodal network and impact rail shipments, barge movements and air cargo flights. For this reason, a modernized, diverse, interconnected transportation network provides the most resilience.

- **Increased pressure on a lock and dam network that is already strained across the Mississippi River System**. The USACE estimates that seven locks and dams along the Mississippi River need more than $1 billion in improvements.[85] Although moving more freight via barge will help reduce transportation emissions, the lock and dam network across the Mississippi River system is struggling to support current freight volumes. In

[80] "Drought-Related Issues in Forage, Silage and Baleage." Bailey, E. et al. (2020). https://extension.missouri.edu/agw1017

[81] "Increased drought severity tracks warming in the United States' largest river basin." Martin, J.T. et al. (2020) https://experts.umn.edu/en/publications/increased-drought-severity-tracks-warming-in-the-united-states-la

[82] https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_North_and_Central_America.pdf

[83] https://www.sciencedirect.com/science/article/abs/pii/S0959378013000514

[84] More information about highway condition and performance is available in Missouri Freight Profile – Volume 1 as part of the 2021 Missouri State Freight and Rail Plan.

[85] https://www.mvr.usace.army.mil/About/Offices/Programs-and-Project-Management/District-Projects/Projects/Article/1164618/backlog-of-maintenance-major-rehabilitation-and-major-maintenance-mississippi-r/

order to build resilience in the state's multimodal freight network, this need must be addressed or the commodities and products that move by barge will have to shift to rail and truck, accelerating congestion and bottlenecks. Conversely, shifting freight volumes from trucks to other modes can significantly reduce congestion across transportation networks. Barge transportation is both cost-effective and fuel-efficient; one standard 15-barge tow can move the equivalent of 216 rail cars or 1,050 trucks. In addition, on a single gallon of fuel, one barge can move freight more than four times farther than trucks, releasing 10 times fewer emissions.[86]

- **Impacts to agricultural sector are significant**. The agriculture sector is particularly vulnerable to extreme weather-related climate events and supply chain disruptions, which force producers and farmers to pay more to get their products to market. Excessive droughts or flooding can impact crop harvests and yields, shipments of goods and facilities located in flat, low-lying areas or areas near waterways. This increases the costs of agricultural products. Flooding not only can delay planting for Missouri farmers; in 2021, spring rains delayed corn and soybean planting in much of Missouri, with many soybean acres were planted well after the optimum date for yield.[87] After planting, moving product on lower-cost barge and rail can be disrupted by washed out rail networks or dangerous river levels. These supply chain disruptions can also be extremely costly for farmers. During the prolonged flooding in the first half of 2019, from March through June about 6.3 million tons of grains worth almost $1 billion were delayed due to disruptions to barge traffic.[88]

Opportunities

The primary opportunities in adapting to climate instability in Missouri are:

- **Establish a dedicated and resilient multimodal freight network.** Being better prepared for the growing threat of extreme weather in Missouri affords the state the opportunity to build a more resilient freight transportation system. This includes establishing redundancy across key north-south and east-west corridors across multiple modes in the event of a disruption, as well as bolstering access to key ports, airports and rail intermodal or transload facilities. For existing assets, using materials that are more durable and resistant to excessive heat and water will help maintain a state of good repair, as will considering drainage, elevation, unstable slopes and areas of erosion. For bridge upgrades, integrating improvements such as culvert replacements, drilled shaft bridges, seismic retrofits and other features can make these structures more resistant to extreme weather events. Rail infrastructure is also vulnerable to high temperatures that warp rail tracks and flooding and debris on railways. Raising rail track infrastructure whenever possible will also help make the network more resilient.

- **National and regional partnerships to invest in critical multistate assets.** The upgrades and enhancements described above will cost billions, if not trillions, of dollars to implement throughout the state of Missouri. For larger, regionally significant assets, Missouri can partner with partner states and the USDOT to

[86] http://www.nationalwaterwaysfoundation.org/HO_WaterwaysProfile_MO.pdf

[87] https://ipm.missouri.edu/IPCM/2021/7/cropFlooding-BW/

[88] U.S. Coast Guard Impacts of the 2019 Upper Mississippi River Flooding on Barge Movements in the Upper Midwest Region (2019). https://www.dco.uscg.mil/Portals/9/Impacts%20of%202019%20UMR%20Flooding_Barge%20Movements_Fahie_1.pdf

distribute the cost across multiple agencies or take advantage of federal discretionary grant opportunities. There is also potential for MoDOT to work with existing state agencies to identify partnerships. Missouri is a member of the Mid America Freight Coalition[89] and the Institute for Trade and Transportation Studies (ITTS),[90] leveraging regional partnerships to research and implement freight improvements on a larger scale. Both organizations have 2023 work plans and research projects to lay the groundwork for collaborative improvements to the network. Another example is the Missouri Partnership, a public-private economic development partnership, tracks company location and investment, educates prospective businesses on the state's strengths, and provides resources for site selection and incentives.[91] MoDOT can work with agencies like Missouri Partnership to bring more private sector agencies to the table to help prioritize and fund critical rail, port, highway, intermodal and air cargo projects.

- **New or relocated inland ports.** Missouri's public port network is particularly vulnerable due to proximity to the Missouri and Mississippi Rivers and the flooding that can arise along these waterways. When water levels are too high, barge traffic can be delayed or halted, disrupting shipments and increasing transportation costs for shippers. There may be opportunities to establish inland ports that complement and provide back-up services, such as Port KC's Kansas City commerce park, which is connected to Class I railroads and multiple interstate highways. For some intermodal facilities, relocating to a site with less flooding or better existing infrastructure may help mitigate damage and disruption during extreme weather events or flooding.

Retail and E-commerce

Growing demand for e-commerce continues to impact freight industry and employment, as well as land use changes. During the past decade, the promise of fast delivery for nearly every consumer product imaginable led the rise in air cargo demand nationally and transformed how people in the U.S. purchase many types of goods. This has translated into higher volumes of goods moved across modes, including aviation, the most high priced mode. St. Louis Lambert Airport saw a 24% increase in cargo (in landed weight) from 2019 to 2020; Kansas City International saw a 3.3% increase in the same period.[92] E-commerce allows consumers to shop at any time of day from the comfort of their home. Although air cargo providers face steep competition from lower-cost shipping modes such as trucks, container shipping and rail, retailers are increasingly using air cargo to fulfill overnight and same-day delivery options. Retailers and shippers may pass those costs on to the consumer in the form of higher prices. COVID-19 was a catalyst for e-commerce growth in the U.S., resulting in a jump in the share of e-commerce in total retail sales. During the initial months of the pandemic, lockdowns and store closures led even more people to opt to shop for essential and non-essential goods online. Americans spent $791.7 billion on e-commerce sales during 2020, an increase of 32.4% from 2019 spending, translating to e-commerce share of 14% of total retail sales as compared to 11% in 2019.[93] Another change in buyer behavior includes curbside pickup of online purchases,

[89] https://midamericafreight.org/index.php/about/

[90] https://www.ittsresearch.org/

[91] https://www.missouripartnership.com/

[92] https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy20-cargo-airports.pdf. Springfield-Branson airport saw an 8% decrease in freight volume. However, a recent MoDOT grant of $500,000 will match the airport's investment to total $1 million for a extension of the cargo apron and help remove a freight bottleneck (https://sbj.net/stories/1mcargo-area-expansion-okd-for-airport,76142).

[93] https://www.cnbc.com/2021/02/19/e-commerce-surged-during-covid-groceries-sporting-goods-top-gainers-.html

creating curbside congestion of both freight and passenger movement at stores. Although it is unclear whether the rapid adoption of e-commerce will be sustained in the long-term as COVID-19 restrictions are lifted, some shoppers' buying preferences may change permanently with certain online retailers or goods after a positive experience with e-commerce during the pandemic.

The acceleration of e-commerce adoption underscores the importance of stockpiling rather than relying on just-in-time distribution. Many businesses struggled from supply chain disruptions due to shortages of inputs from other businesses, which may have struggled to fulfil orders due to not having enough workers. For retailers, many struggled with billions of dollars in unsold goods during mandatory shutdowns in mid-2020, but even as the economy rebounded — gross domestic product (GDP) returned to pre-pandemic levels — and demand increased by the second quarter of 2021, many businesses are still unable to bring inventories back to pre-pandemic levels. Once businesses fully adapt from this volatility, further changes in land use, warehousing and the network of links and nodes might arise nationally, and in Missouri, the crossroads.

Considerations

The primary considerations for adapting to e-commerce growth in Missouri are:

- **Shifting warehouse strategies and its impact on local land use.** Freight warehousing strategies will likely change to pivot from just-in-time inventory to stockpiling goods, which will help businesses better manage inventory in the event of disruptions. Considering Missouri's position in the center of the nation with proximity to Canada and Mexico, and robust Mississippi River ports, some companies may expand warehousing and distribution activity to house inventory in location near to many critical markets. Because these facilities will add freight traffic to the network, it is important for MoDOT to communicate with local governments to anticipate and prepare for increased activity.

- **Continued intermodal investment where possible.** E-commerce goods have been heavily dependent on truck modes after arriving via container at U.S. coastal ports. Since the COVID pandemic, when trucks were limited in their capacity to move goods, rail provided companies with the option of moving more mixed freight.[94] Bulk markets remain a core business for rail but continued growth in intermodal traffic necessitates the infrastructure to transload.

- **Communication on work zones to mitigate delays on the last mile or final 50 feet.** Coined by the University of Washington's Urban Freight Lab, "final 50 feet" represents the last leg of a product's journey from warehouse to customer: beginning at the load/unload space located at the curb, in an alley, or a private loading bay; tracking the freight carrier as they maneuver sidewalks, intersections and security in buildings, and ending when the customer receives their goods. In Missouri's urban areas, such as Kansas City and St. Louis, denser transportation infrastructure is a challenge for urban freight. In rural areas, residents are heavily reliant on e-commerce for many products. For shippers, longer transport chains and low consumption density, is a cost-challenge in extra fuel and miles expended for fewer customers. Unmanned aviation vehicles, or drones, could be a solution for low-weight, high-value items, such as medicine. However, continued integration of an intermodal approach for private sector solutions and MoDOT transportation policies and infrastructure will

[94] https://www.transportation.northwestern.edu/docs/2021/20210614_aar-report-final-d-june-2021.pdf

mitigate bottlenecks and delays. E-commerce created unprecedented challenges for shippers to meet increased volume in a one- or two-day timeframe; overwhelming existing infrastructure due to delays, double-parking and blocking sidewalks and curbs.

Opportunities

The primary opportunities in adapting to e-commerce growth in Missouri are:

- **Improved curb management in urban cores and downtown areas.** Curb space in downtown areas is becoming increasingly difficult to manage as it is being used for multiple purposes: parking, ride share pick-up and drop-off, commercial deliveries, bike/scooter parking and even parklets for outdoor dining. Managing these spaces is vital to maximize goods movement, pedestrian and multimodal mobility, and economic development . It is an enormous challenge. The American Planning Association estimates the cost of not planning for the curb costs cities billions of dollars.[95] Kansas City's Mid-America Regional Council released a November 2020 Kansas City Curbside Management resource guide to help address this issue, which could be replicated in other Missouri cities and small towns.[96] The guidance includes Complete Streets design, that considers all road users in infrastructure design.

- **Stronger regional relationships to address warehousing and distribution networks.** Planning around warehousing and distribution often requires a regional framework that considers industry and logistics clusters. This is especially true for cities and towns with market hubs along state borders, such as St. Louis, Kansas City, Joplin, Sikeston, and St. Joseph. In terms of industrial hubs, one example is Springfield where manufacturing necessitates specific warehousing and distribution needs. Understanding the needs of the network of these industries beyond state lines is critical to getting the full picture of freight flows in, out and within Missouri's urban and rural nodes. MoDOT can partner with and encourage its MPOs and RPCs to study these networks for planning purposes.

Technology Adoption

Technology in freight has a few focus areas: connected and autonomous vehicles (CAVs), unmanned aerial vehicles (UAVs), automation, and the Internet of Things (IoT).

Adoption of connected and autonomous vehicles—systems that either assist the driver while operating a vehicle or control the vehicle outright—is already impacting the trucking industry. For instance, a Springfield, Mo.-based trucking company, Wilson Logistics launched a three-year pilot program in 2020 to use platooning in two-truck convoys in western states, where the driver in the lead truck controls the truck that is following.[97] Though there are

[95] American Planning Association (May 2021). "Poor Curb Management Is Costing Cities Billions." https://www.planning.org/planning/2021/spring/poor-curb-management-is-costing-cities-billions/

[96] Mid-America Regional Council (November 2020). "Kansas City Area Curbside Management Resource and Guide." https://www.marc.org/Regional-Planning/pdf/Curb-management-resource.aspx

[97] https://www.ttnews.com/articles/autonomous-tech-company-locomation-signs-deal-wilson-logistics?utm_source=technology&utm_medium=newsletter&utm_campaign=newsletter&mkt_tok=eyJpIjoiWTJJM1lqSTNObUk1WlRrdyIsInQiOiJXeVhiMG01Q3N4VURtM1NnNk8zUHdTZUE0bndMOVlDaXRMRmJRUUtzdlI1R01VbUZmUFlOTklwVXZUS3ZGS3Zhck12XC9XbE82SzFnTnJyMFluR2dUTkdua0dvRGJVVVp6cHBqbEdjRmRZUE1iYmZxXC9hV05xZWxndVd3TzFQWEJrIn0%3D

numerous firms expanding the use of CAV technologies, there are infrastructure, institutional and policy challenges that have limited their deployment, most notably broadband and transportation infrastructure as well as unsupportive state legislation.

The concept of drone delivery for freight purposes began in 2013 with an announcement from Amazon that drones, also known as unmanned aerial vehicles (UAVs), would be used to deliver lightweight commercial products.[98] [99] While drones have not advanced so far as to replace entire tractor-trailers on the nation's roadways, they can offer an advantage for last-mile deliveries. This reduces vehicle miles traveled on the roadway and offers a solution to truck driver shortages for limited markets, although drone pilots are needed to operate the UAVs. The allowable use of drones has continued to evolve with night operations allowed as of April 2021.[100] These changes to the FAA's Small Unmanned Aircraft Systems (UAS) Rule, Part 107 also allowed for drones under 0.55 pounds to fly over people and moving vehicles. Such changes can allow for remote traffic monitoring and surveying to enhance traffic information. For flight operations over vehicles restrictions include either:

- The UAV must remain within a closed or restricted-access site, and all individuals inside any moving vehicle within the designated area must be on notice of the operation; or
- The UAV does not maintain sustained flight over moving vehicles.

Missouri has added additional guidance in HB 1963—passed in 2021—which makes it a criminal offense to operate a UAV near a correctional center, mental health hospital or certain open-air facilities holding more than5,000 or more persons, without written consent. In March 2022, the state legislature was considering a bill to ban UAVs photographing people or property without written consent. Meanwhile Wal-Mart launched drone delivery service from Pea Ridge Ark., near the Missouri border.[101]

Personal delivery devices (also called delivery robots) are being deployed mostly in urban markets. Their adoption took off during the pandemic lockdowns, but regulation of the technology has been uneven across the nation. In Missouri, SB 176 allows delivery robots to use sidewalks, crosswalks, municipal and county roadways. "provided that the personal delivery device shall not unreasonably interfere with motor vehicles or traffic."

IoT, or the Internet of Things, is a network of objects ("things") that are embedded with sensors, software, and other technologies in order to connect with and exchange data with other systems or devices. In the simplest of terms, IoT has the potential to connect anything with the internet which can accelerate data-driven logistics. Recent advances in technology have made this type of connection possible, namely through the reduction in cost of sensor technologies, improvements in internet connectivity, and cloud computing platforms. For freight, three key areas of application are smart shipments, connected assets, and facility management. Smart shipments can allow for

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[98] BBC News. "Amazon Testing Drones for Deliveries." (December 2, 2013).

[99] Light commercial products. Drone deliveries are limited by the carrying capacity of the UAVs. While most hobby drones can only carry a few pounds, professional drones may be able to transport upwards of 200 pounds. However, as the allowable payload increases, so too does cost. For example, a Dragon X12 U11 Drone has a recommended payload of up to 100 pounds and costs over $30,000.

[100] Code of Federal Regulations. Title 14, Chapter I, Subchapter F, Part 107 – Small Unmanned Aircraft Systems. https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-107

[101] https://www.freightwaves.com/news/walmart-invests-in-droneup-plans-drone-deliveries-from-bentonville-store-this-summer

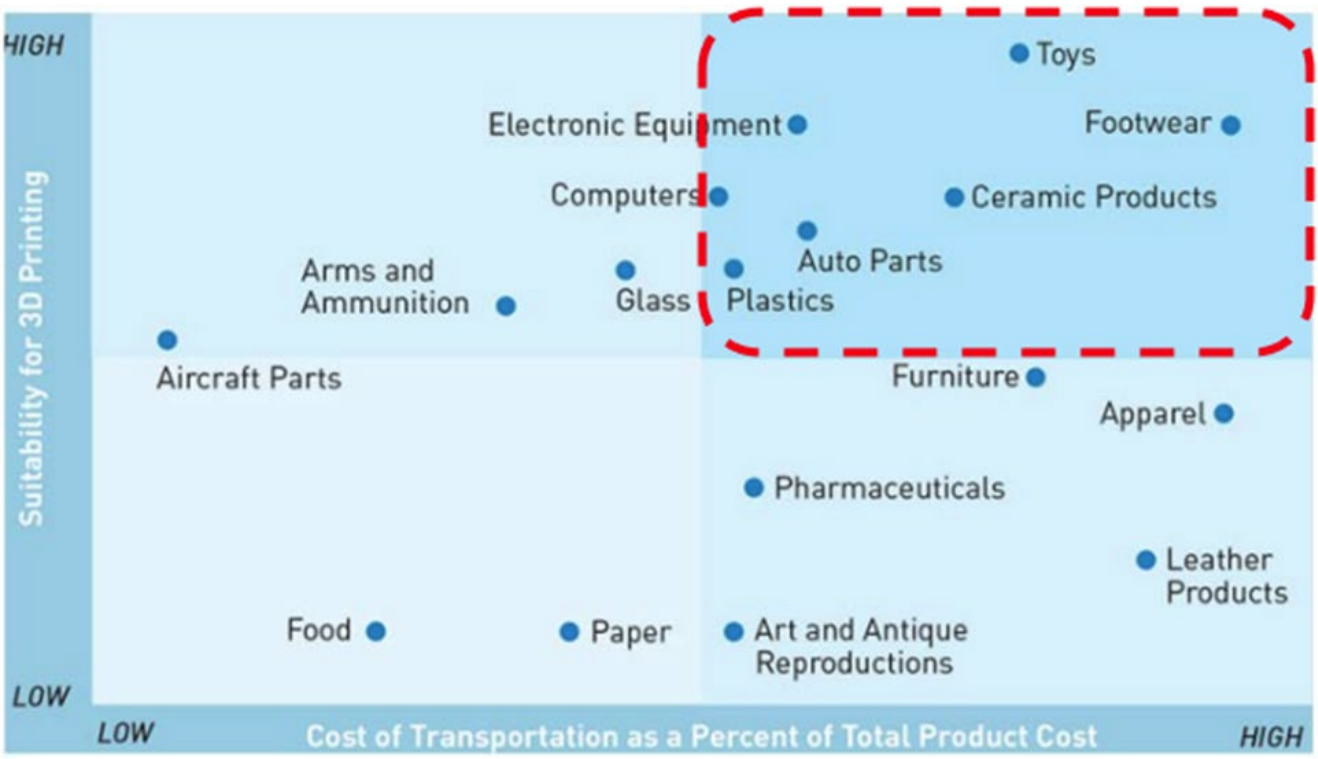
expedited services at international border crossings or foreign trade zones (such as St. Louis and Kansas City) while connected assets can help to track shipments and prevent losses. For facilities, IoT can monitor temperature fluctuations and maintain optimal conditions.[102] MoDOT conducted a 2020 study of asset types most

Manufacturing processes also stand to benefit from the use of robotics, as well as from other advances such as automation and 3D printing. Robots can fulfill roles such as automated picking or security within manufacturing and distribution facilities. The use of a robot for these roles can then allow humans to do more skillful or safer work instead. Automation can fulfill a similar purpose by completing more dangerous tasks, reducing costs, and optimizing workflows. An increasing dependence on such machines also opens the opportunity for more skilled jobs for the maintenance and development of such technology. 3D printing is less similar to these but allows for a shift where manufacturing may occur. That is, if a product can be printed in the United States instead of internationally, it would reduce the transportation costs associated with shipping that item to its final destination (see Section 5.2 for more analysis.) Likewise, by utilizing 3D printing, manufacturing can occur on-site and eliminate the need to move a finished product, such as with 3D printed homes and bridges. As an example, Apis Corp. is building 3D homes houses in the Ozarks.[103] Students at the University of Missouri College of Veterinary Medicine 3D- printed a breathing device for a horse who had undergone a tracheotomy. As shown in Figure 44, some products are more suited to production through 3D printing than other such as auto parts and electronic equipment.

[102] DHL. Internet of Things.

[103] https://www.ozarksfirst.com/top-stories/construction-company-3d-printing-new-homes-in-the-ozarks/

FIGURE 44 SUITABILITY AND COST OF 3D PRINTING



Source: A Study on 3D Printing and its Effects on the Future of Transportation

A study by Rutgers University suggests that the impacts on 3D printing could reduce the need by air cargo by as much as 41%, as well as 37% of ocean container traffic and 25% of trucking.[104] This technology has the potential to change the flows across the freight network because production can happen in more diverse spaces. Land use and traffic impacts will be key in rolling out this technology to add efficiency.

Considerations

The primary considerations for adapting to changing transportation technologies in Missouri are:

- **Fragmented broadband infrastructure in rural areas.** Although Missouri has made progress on expanding broadband access in recent years, there are still many parts of the state with limited or no access to broadband connection, particularly along key freight corridors (I-70, I-44, US Route 60 and US Route 36 and I-55) and predominantly rural areas across the state. Rural areas are crucial in connecting the Nation's freight network

[104] *A Study on 3D Printing and its Effects on the Future of Transportation.* Rutgers. September 2018. https://cait.rutgers.edu/wp-content/uploads/2018/05/cait-utc-nc19-final.pdf

and supporting CAV freight technologies, and the Missouri Department of Economic Development 2021 budget included $195 million in funding to address these challenges.[105]

- **Public policy hurdles.** One factor that makes the adoption of CAV complicated is that there is limited federal legislative or policy framework in place to guide consistent practices and govern the standards of this technology. Missouri law does not specifically address the operation of autonomous vehicles. As of March 2020, according to the National Conference of State Legislatures, 30 states have enacted legislation regarding CAVs, six states have executive orders in effect and five states have both. Presently, Missouri does not have legislation or an executive order related to CAVs,[106] and it is one of 13 states that does not allow truck platooning.[107] There have been pilots (2019) in the Kansas City and St. Louis districts, but industry needs corridors to work statewide, especially in rural areas, where truck platooning could prove advantageous. CAVs are impacting trucking in terms of labor, fuel savings and safety. Currently, the heaviest volumes of freight are through movements in truck and rail. A lack of supportive CAV policies will hinder economic development efforts by the states as firms will be more reliant on these technologies in their business operations. Without sufficient investment, the state could become a bottleneck given its location and role in the movement of cross-country freight movements.

Opportunities

The primary opportunities of adapting to changing transportation technologies in Missouri are:

- **Relief for portion of truck driver labor challenges.** As new modes emerge and evolve, they have the potential to alleviate the national issue of attracting and retaining truck drivers. For years, trucking companies have voiced concerns over labor shortages while truck drivers have noted low pay and poor working conditions, contributing to a tight labor market with high turnover rates. Some examples of technologies include autonomous drones and drivers; aircraft and truck platooning; and robot deliveries. However, these innovations will require plans, policies and updated regulations.

- **Increased technology adoption provides higher visibility of flows.** All of the technologies discussed—CAVs, UAVs, advanced manufacturing, and IoT, create data points along the freight network that can be analyzed for continued improvements that can be done efficiently. These data points also have a safety component, as cybersecurity efforts focus on maintaining the safety of sensor technologies and their data (internet of things, vehicle-to-vehicle, vehicle-to-infrastructure). The increased technology situates itself as a new element of infrastructure, and it will require MoDOT workforce to have greater understanding of technologies and how these technologies integrate with overall infrastructure needs.

Near-Shoring/Domestic Production

Over the past several decades, U.S. trade policy focused on supporting globalization, which allows businesses to buy and sell products more easily worldwide. Through the backing of free trade agreements, American companies

[105] Missouri Department of Economic Development (2021). “Broadband Infrastructure and Access.” https://cdn.missourinet.com/wp-content/uploads/2021/04/DED-Broadband-DESE-FINAL.pdf

[106] https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx

[107] https://peloton-tech.com/platooning-regulatory-status/

took advantage of lower costs of labor in Asia and Latin America. Supply chains for even the most basic essential items became complicated. The shift away from transglobal trade began in recent years but intensified since the onset of the COVID-19 pandemic. It exposed major weaknesses in the supply chains for manufactured items, resulting in prolonged shortages of essential, needed items such as personal protective equipment. A global supply chain model prioritizes cost reduction, just-in-time production and forecasting methods that do not consider major disruptions such as a global pandemic or other natural disasters. Reimagining supply chains that leverage local industries and transportation linkages could not only remediate the weaknesses exposed during the COVID-19 pandemic but could also increase jobs in manufacturing sectors and provide economic development opportunities for U.S. regions that are positioned to grow their advanced manufacturing base.[108]

The federal 2021 Infrastructure Investment and Jobs Act (IIJA) includes the Build America, Buy America Act. Guidance on application of the law includes an all manufactured products in the U.S. represent more than 55% domestic production.[109] A permanent and more decisive policy shift would translate into diverse sourcing of commodities and products to protect U.S. supply chains. In this scenario, an increase in investment in domestic sourcing and/or localized manufacturing would create exponential demand from Missouri firms, also referred to as "near-shoring." This may result in increasing inbound and outbound freight flows relative to through-state flows, which currently comprise most freight movements in the state. Advanced manufacturing employment could increase, especially in automotive industry and metal manufacturing, which are already strong sectors in Missouri. Demand for industrial space for new manufacturing or repurposed manufacturing sites would also increase. A strong workforce across agriculture, advanced manufacturing and transportation sectors will be essential as the state redefines its strengths to meet domestic demand for goods.

Considerations

The primary considerations for adapting to increased domestic manufacturing in Missouri are:

- **Intermodal connectors to support increased flows.** When measured by weight, shipments that pass through the state without stopping (known as "through" movements) accounted for 59% of the more than one billion tons moved in 2018, by far the largest type of movement. Missouri's freight infrastructure needs to evolve to support increased inbound flows for raw materials and outbound flows for distribution of finished goods or in-process inventory. This may include new intermodal or transload facilities to transfer goods to and from trucks, railcars, air cargo and barges. MoDOT should participate in planning for these facilities and the roads connecting them to support shifting freight flows across the multimodal network.

- **Continued need for modernized facilities**. In addition to new multimodal connectors, Missouri's freight transportation assets would require modernization at nodes such as ports, rail connections, airports and intersecting interstates, as well as regional centers of freight manufacturing, logistics and operations. In 2022, many of Missouri's port authorities have available sites for development of five to 250 acres.[110] In addition, the Department of Economic Development implements the Certified Sites Program, which lists ready-to-start

[108] https://www.brookings.edu/research/reshoring-advanced-manufacturing-supply-chains-to-generate-good-jobs/

[109] https://www.whitehouse.gov/wp-content/uploads/2022/04/M-22-11.pdf

[110] Missouri Port Authorities. https://www.missouriports.org/business-development/

industrial sites.[111] As of March 2022, there 27 sites across the state. The certification program's standards were developed through public and private stakeholder collaboration on the features of the sites. There may be high demand for this space and a resulting demand for a robust transportation network to support resulting freight flows.

- **Workforce training and development**. Without a skilled workforce able to take advantage of new job opportunities, this scenario is unlikely to be sustained. Missouri's educational institutions and target industries should partner to develop entry points to careers in agriculture, manufacturing, wholesale trade, logistics and transportation. KC SmartPort is a bi-state regional organization with freight focused programs to attract business to the area. The Workforce Development arm of the organization is a clearinghouse for training programs at different education levels, preparing the labor force for current and future employment in the transportation and logistics industry.[112]

Opportunities

The primary opportunities for adapting to increased domestic manufacturing in Missouri are:

- **Increased investment in domestic sourcing**. In 2019, Missouri exported $13.4 billion in goods worldwide, primarily to North American trade partners Canada and Mexico, ranking the state 27th in the U.S. in terms of exported goods.[113] The volumes moving out of Missouri could continue to grow to meet demand for domestically sourced inputs and American-made outputs. Farmers would not have to wait for equipment parts or farm chemicals, which rely on 40 percent of their ingredients from China, according to the Missouri Farm Bureau.[114]

- **Advanced manufacturing sector growth.** Domestic production could reduce the risk of production interruption. For example, in Spring 2021, a Wentzville assembly plant idled because of a global microchip shortage.[115] In a domestic sourced environment, those chips would be manufactured in the United States, ideally in or near Missouri, to bring efficiencies to the supply chain. Some signs of changes include Kawasaki Motors opening a new facility in Boonville.[116]

- **New and repurposed industrial space throughout the state**. An influx of new manufacturing businesses could increase demand for industrial space throughout the state, potentially necessitating land use changes to meet production and distribution demand for various industries (e.g., agriculture, manufacturing). One example of innovation in freight space include Missouri's underground sites, including a former limestone mine. SubTropolis in Kansas City was developed in a 270-million-year-old limestone deposit 150 feet below the city. There are over 2,000 employees across 55 companies that are based in SubTropolis, which supports e-

[111] https://ded.mo.gov/programs/business/missouri-certified-sites-program

[112] KC SmartPort. "Workforce Development." https://kcsmartport.thinkkc.com/workforce

[113] https://www.trade.gov/sites/default/files/2020-12/Missouri%20USMCA%20State%20Fact%20Sheet.pdf

[114] https://mofb.org/supply-chain-problems-impacting-farmers-across-missouri/#

[115] Automotive News (March 23, 2021). https://www.autonews.com/manufacturing/gm-honda-extend-production-cuts-some-na-plants

[116] https://ded.mo.gov/content/kawasaki-motors-open-new-facility-boonville-creating-more-270-new-jobs

commerce, pharmaceutical, animal health, automotive and food distribution sectors.[117] Missouri also has several adaptable vacant industrial spaces, particularly in the St. Louis area and has intermodal facilities with thousands of acres of shovel-ready sites.[118]

Demand for Increasing Multimodality

Highway networks are already over capacity in many states and regions. Growing population induces consumer demand. Demand is projected to increase in the coming decades. In Missouri, 32.5 million trucks transported more than 400 million tons of freight worth more than $495 billion in 2018. By 2045, it is projected that trucks will transport more than 550 million tons of freight valued at more than $849 billion in Missouri. In addition, projections show trucks overtaking rail as the leading freight mode in Missouri. Coupled with increased population, projected future demands on the highway system require innovative strategies to accommodate both passengers and freight. Strategic investment will address enhancement that diversify modes to mitigate congestion and foster resilience of the entire transportation network.

Considerations

The primary considerations for shifts in multimodal infrastructure priorities in Missouri are:

- **Modernizing critical transportation infrastructure assets**. Connectivity is the driving force in re-imagining the transportation network. Developing and growing multimodal facilities such as inland ports and rail terminals, while encouraging efficient highway use can help Missouri prepare for expected freight volumes. Ensuring all current multimodal assets are functioning as efficiently as possible is an important step in ensuring that Missouri's freight system can not only meet future demand, but also adapt to shifts in demand across freight modes.

- **Establishing strong and diverse multimodal connections**. After modernizing existing freight transportation infrastructure, establishing additional strong and diverse multimodal connections will provide increased opportunities for shippers to take advantage of alternate modes. In addition, building out more intermodal connectors benefits all shippers by increasing available freight transportation options, leading to reduced costs for all users.

- **Freight- and rail-supportive land use coordination at the local level**. The decision to build a new multimodal transportation asset or freight-generating facility is often made at the local level. Understanding land use patterns and restrictions throughout Missouri will help facilitate the process of identifying sites most optimal for new development. This may require partnership with the state and local economic development agencies, MPOs, RPCs and public port authorities to make those connections with local developers and identify opportunities to make the multimodal freight transportation network more robust.

[117] https://huntmidwest.com/industrial-space-for-lease/what-is-subtropolis/

[118] Missouri Department of Economic Development. "Missouri's Transportation and Logistics History." https://ded.mo.gov/transportation-and-logistics/why-missouri/established-success

Opportunities

The primary opportunities in shifts in multimodal infrastructure priorities in Missouri are:

- **Shifting more passenger traffic off roadway network and onto passenger rail and intercity rail**. The means of transportation to Missouri workers is primarily driving alone (82.1%), followed by carpooling (8.4%).[119] Public transit represents the lowest share of commute mode (1.1%), even behind walking (2.1%) and other means (1.2%). Focusing on developing more frequent and reliable passenger rail and intercity rail service could help shift some commuters and other travelers off Missouri's most congested highways, both freeing up capacity for truck traffic and providing a safe travel alternative for passengers.

- **Increased Class I railroad investments in existing freight and passenger rail assets**. Both freight and passenger rail offer potential mutual benefits in easing congestion. There is public and private investment necessary for rail infrastructure. In 2021, BNSF announced a $2.9 billion 2021 nationwide capital investment plan. In September 2021, Canadian Pacific purchased Kansas City Southern in a 29.6 billion deal.[120] This may strengthen access to Mexico and Canada. It also could have impacts on Amtrak passenger rail service between southern Illinois and New Orleans. With a view of the entire state's transportation system, MoDOT can help in developing policies that address investment in both passenger and freight rail transportation and presenting priorities and strategies that speak to freight and passenger demands, especially efficiencies that can be gained across the movement of both goods and people.

- **Federal infrastructure investment package**. The $1.2 trillion Infrastructure Investment and Jobs Act enacted in November 2021 calls for the following key funding mechanisms in freight:

  - $350 billion in highway programs for federal fiscal years (FFY) 2022-2026[121]
  - $17 billion in funding for port infrastructure and waterways for FFY 2022-2026[122]
  - $102 billion in total rail funding, including both passenger and freight rail for FFY 2022-2026[123]
  - $25 billion in aviation funding for FFY 2022-2026[124]
  - The new program, Promoting Resilient Operations for Transformative, Efficient, and Cost-Saving Transportation (PROTECT), provides both new formula funding ($7.3 Billion) and competitive funds ($1.4 Billion) to support planning, resilience improvements and community resilience.[125]

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[119] U.S. Census (2019 1-Year Estimate). "Missouri" https://data.census.gov/cedsci/profile?g=0400000US29

[120] https://www.reuters.com/business/canadian-national-scraps-296-billion-offer-kansas-city-southern-2021-09-15/

[121] https://www.fhwa.dot.gov/bipartisan-infrastructure-law/

[122] https://www.maritime.dot.gov/about-us/bipartisan-infrastructure-law-maritime-administration

[123] https://railroads.dot.gov/BIL

[124] https://www.faa.gov/bil

[125] https://policy.transportation.org/wp-content/uploads/sites/59/2021/09/2021-09-15-AASHTO-Comprehensive-Analysis-of-IIJA-FINAL.pdf

» Multimodal opportunities emphasize connectivity in the freight network in new programs such as the National Infrastructure Project Assistance (NIPA) program and existing programs such as the Rebuilding American Infrastructure with Sustainability and Equity (RAISE) program and the Infrastructure for Rebuilding America (INFRA) program. For INFRA, the maximum share of funds that may go to multimodal projects has been increased from 10 percent to 30 percent.

MoDOT is positioned to work with existing and new partners on applying for discretionary grants, and prioritizing formula funds with a multimodal focus.

Stakeholder Feedback on Trends & Disrupters

To determine the trends and disrupters most likely to impact Missouri, MoDOT conducted a series of regional stakeholder meetings to gather insight, input and feedback from Missouri planners and policymakers on regional economic and industry trends, as well as important freight transportation needs. These meetings were held on May 4, 5, 11 and 13 in 2021 and included public sector planners and policymakers based in Missouri. The meetings were grouped by district(s) to encourage discussion and focus on regional topics and concerns about the future of freight in Missouri. A summary of the feedback for each meeting is summarized as follows:

- Northwest and Northeast: Participants expressed concerns about the impacts of climate change and flooding along the Mississippi River; the future of electric vehicles and charging stations; and discussed the need for additional truck parking near Cameron, Mo. to meet existing demand.

- St. Louis and Southeast: Participants shared concerns about the importance of multimodal connections and safety on roadways. Congestion on I-70, I-44, I-55 and I-57 corridors were heavily cited as bottlenecks.

- Kansas City and Central: Participants discussed changes in workforce training and needs, partnerships with surrounding states, and the importance of increased port access. Discussion also focused on regional development of infrastructure and partnering with Kansas and private firms on connections to Canada and Mexico.

- Southwest District. Participants expressed concerns about manufacturing, with a focus on the shift to electric fleets and implementation of charging stations. Participants also discussed the importance of multimodal connectivity.

Freight transportation concerns that cut across the districts included statewide broadband expansion that would support connected and autonomous vehicles, blockchain and other innovations. There were also concerns that a lack of workforce development in freight industries could jeopardize positioning Missouri for success. Most stakeholders said Missouri was unprepared for emerging trends.

Based on the research and analysis presented in this section and feedback received by stakeholders, Section 5.0 evaluates the potential impacts of two trends — renewable energy and near-shoring/domestic production —on future freight flows throughout Missouri.

4.0 Existing Freight Needs Assessment

MoDOT's 2017 State Freight Plan included the development of performance measures for the state freight network. This section examines current performance measures and includes statewide stakeholder input. To start, the 2017 Missouri State Freight Plan correctly predicted an acceleration of freight transportation nationwide. In that plan, key industries included:

- Agriculture.
- Manufacturing.
- Transportation/Logistics.

Additional needs discussed in Section 2.0 demonstrated that additional commodities and industries are part of the state's freight portfolio. These include:

- Agriculture and Food & Goods Processing.
- Automotive Suppliers.
- Chemicals, Plastics and Rubbers.
- Aggregates and Non-Metallic Minerals.
- Advanced Manufacturing.
- Transportation & Logistics.
- Wholesale.
- Military and Defense.

Given this wider perspective of the freight industry in Missouri, analysis of the network shows some progress and some areas of potential improvement. Progress is seen in some measures of asset management and safety. Areas of improvement include provision for truck parking, as well as congestion on highways, rail and at the ports.

4.1 Highways

This section describes the needs assessment analysis process for Missouri's freight highway system. The needs assessment used a multi-variate scoring of safety, truck parking, technology, mobility and reliability, frontage roads, asset preservation and freight design needs.

Key Metrics

Table 4.1 provides all Key Metrics and data sources associated with the Freight Network Needs Assessment categories.

TABLE 4.1 KEY METRICS AND DATA SOURCES BY NEED CATEGORY

Need Category	Key Metrics
Safety Needs	• **Truck Involved Crash Rate**: Displays the number of truck involved crashes, per hundred million truck miles (HMTM). • **Truck Involved Severe Injuries or Fatalities**: Displays the number of truck crashes that resulted in a disabling injury and/or fatality, per hundred million truck miles (HMTM). • **At Grade Highway-Railroad Crossings**: Displays the number of trains per day for roadway segments with an at-grade railroad crossing.
Truck Parking Needs	• **Crashes Involving Parked Trucks**: Displays the number of crashes with parked trucks, per mile. • **Interstate Truck Parking Deficit**: Identifies the peak hour truck parking utilization within of authorized parking locations, considering both demand and capacity.
Technology Needs	• **Weigh-In-Motion (WIM):** Identifies roadway segments with higher-than-average truck tonnage within or outside a five-mile radius of an existing WIM location. • **Transportation Management Center (TMC) Needs:** Identifies roadway segments with TMC-associated ITS device, including dynamic message signs and CCTVs, within or outside a five-mile radius. This metric considers truck volumes to indicate the overall need for TMC coverage. • **Traveler Information Needs**: Identifies roadway segments with Dynamic Message Signs (DMS) within or outside a five-mile radius. This metrics considers truck travel time reliability as an indicator more DMS technology is needed. • **Traffic Incident Management Needs**: Identifies roadway segments with closed-circuit televisions within or outside a five-mile radius. This metric considers truck crash rates as an indicator more CCTV cameras are needed.
Mobility & Reliability Needs	• **Level of Service**: Displays the measure of capacity constraints of each roadway segment • **Truck Travel Time Reliability**: Displays the truck buffer time index. • **Connectivity to Strategic Industry Supply Chains**: Displays the connectivity to significant economic generators. • **Connectivity to Intermodal Terminals and Gateways**: Displays the connectivity to intermodal terminals and gateways. • **At-Grade Highway-Railroad Crossing**: Displays the annual average daily truck traffic for roadway segments with an at-grade railroad crossing.
Asset Preservation Needs	• **Bridge Weight Restrictions**: Identifies bridges with load restrictions, limiting the ability to accommodate vehicles of certain weights. • **Bridge Condition Issues**: Identifies bridges that could soon be weight restricted or closed due to structural condition requiring truck traffic to take alternative routes. • **Pavement Condition**: Identifies roadways with rough pavement conditions and significant truck traffic
Freight Design Needs	• **Freight Critical Two-Lane Highways**: Displays the freight critical undivided, two-lane roadways. • **Vertical Clearance Limitations**: Identifies the ability to accommodate vehicles of certain heights.

Scoring Approach

The MoFAS Freight Needs Assessment tool utilizes a data-driven process to determine the level of freight need on the state's roadway system. Each need category is summarized by a need rank (low/medium/high) within the MoFAS tool. Each rank is assigned based on a composite of several key metrics indicating the level of need for each category.

The MoFAS Freight Network Needs Assessment tool facilitates scoring recalibration based on user-defined geography. Specifically, this is applied to measures that designate a score based on continuous measures, instead of discrete (e.g., yes or no) measures.

For each key metric, scores are calculated based on the key metric's percentiles within the selected geography and within the roadway type, urban or rural. For example, a key metric that assigns one to three points is determined if the segment's score is within the 33rd, 66th or 100th percentile of all urban roadway segments or all rural roadway segments. Likewise, a measure that assigns one to four points is determined if the segment is within the 25th, 50th, 75th or 100th percentile of all urban roadway segments or all rural roadway segments. Depending on the user-defined geography, a segment's percentile may change; therefore, these scores are re-calculated for each geography change.

The final need rank is assigned based on the sum of the key metrics scores within the freight need category. The low/medium/high rank is assigned if the segment's composite score of key metrics is within the 33rd, 66th, or 100th percentile. The methodology is designed to indicate both the level of need and its significance to freight movement within the state. In some cases, key metrics are scored based on their significance to freight as determined by the Freight System Designation process, using the FSD score, an output of the MoFAS Freight System Designation module. The specific scoring methodology for each freight need category and each key metric is detailed in the following section.

Stakeholder Freight Highway Needs and Challenges

Stakeholder input was solicited on the need categories as well as for routes to be considered for the Freight System Highways.

For the need category comments, stakeholders were asked to place a pin at the location where their comment applies along with details of the comment they wanted to share. In total, 22 comments were received with the majority related to the Mobility/Reliability need (17 comments). Two comments were received on the Asset Preservation need and one comment each for the Truck Parking and Technology needs. One comment was for a route in Kansas and is therefore not included in this assessment. Stakeholders used an interactive map to place "pins" at locations of interest and were able to share comments about the needs at that location. A map of the locations specific to comments provided is shown in Figure 45**.** The specific stakeholder comments by location are shown in Table 4.2**.**

FIGURE 45 LOCATIONS OF SPECIFICS NEEDS COMMENTS

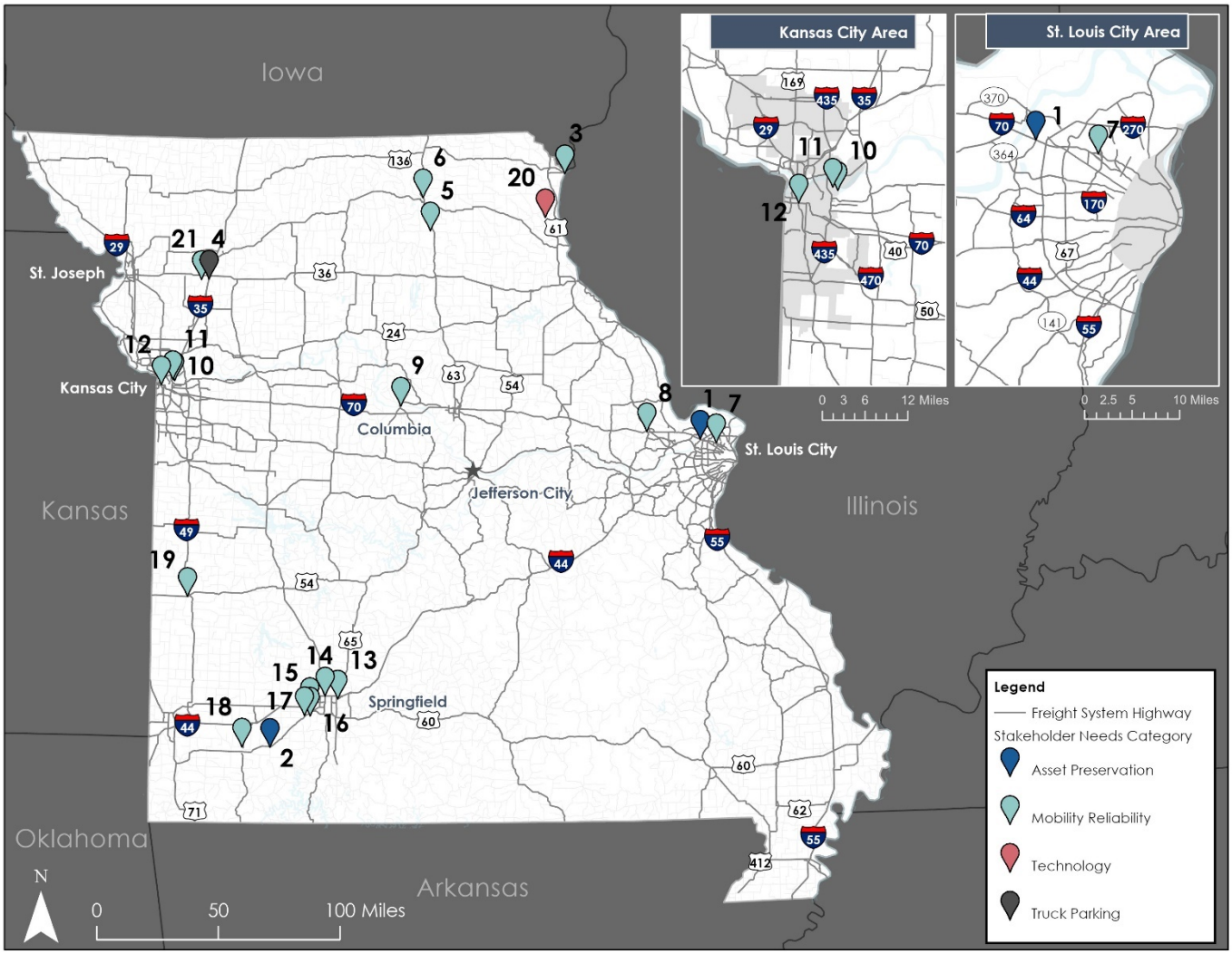


TABLE 4.2 SPECIFIC STAKEHOLDER COMMENTS BY LOCATION

#	Needs Category	County	Route	Comment
1	Asset Preservation	St. Louis	I-70	141 & I-70—bottleneck that impacts shift workers going to GM facility plant—delayed start.
2	Asset Preservation	Lawrence	MO 39	Upgrade roadway to support increased flows—connection to Northwest Arkansas.
3	Mobility/Reliability	Clark	US 61	Area with multimodal potential. Need for a plan and/or feasibility study. River is open year-round.
4	Mobility/Reliability	Clinton	Route A	Expand airport to accommodate air cargo & increased passenger volumes. Interchange at 36/35 is also a priority connection.

5	Mobility/Reliability	Macon	MO 156	Develop more rail spurs along this corridor (and throughout northern Missouri) to encourage businesses to locate and use rail services.
6	Mobility/Reliability	Adair	US 63	Continuing four-lane highway from Kirksville north to Iowa is a priority.
7	Mobility/Reliability	St. Louis	I-70	Congestion due to growth.
8	Mobility/Reliability	St. Charles	I-70	Congestion on the bridge due to curve, slows traffic flow.
9	Mobility/Reliability	Cooper	US 40	Demand for expansion at Howard-Cooper County port but communicating with landowner has been challenging.
10	Mobility/Reliability	Jackson	I-435	Expansion of Port KC—need to improved highway access on 435 to support growth.
11	Mobility/Reliability	Jackson	I-435	General comment—access to work force, identify opportunities to establish public access and workforce connection. Public transit access will help bridge this.
12	Mobility/Reliability	Jackson	I-70	Discussions of downsizing highway corridors like I-70—how will that impact freight flows? Competing interests that might impact freight and industry.
13	Mobility/Reliability	Greene	US 65	Roadway needs improvements to support increased freight activity and mobility.
14	Mobility/Reliability	Greene	MO 13	Concerns with congestion at this interchange. Industry and state representatives. Long term ideas (e.g., realignments). have been discussed. Needs to be reevaluated.
15	Mobility/Reliability	Greene	Route MM	Highway MM between I-44 and US 60—this entire corridor needs upgrades to support industry concentration and associated freight activity.
16	Mobility/Reliability	Greene	Route ZZ	Better connect ZZ to MM to provide linkage to I-44. Will help support entire industry corridor. Growth potential and land available for development.
17	Mobility/Reliability	Greene	Mo 174	US 60 from Republic to eastern MO state line. Significant number of safety improvement and at-grade crossings to upgrade. Identifying funding to upgrade to freeway status is a challenge.
18	Mobility/Reliability	Lawrence	MO 37	Need to identify better ways to connect Monett to I-44. Overall flow and mobility, significant concentration of industry. Attempts to grow it are contingent on establishing better IHS connection.
19	Mobility/Reliability	Vernon	US 54	Identifying a multimodal terminal or connection point would help grow transportation and distribution facilities to support industry. Intermodal connections.
20	Technology	Lewis	N/A	Broadband access can be limited/spotty in Lewis County.
21	Truck Parking	Clinton	I-35	Improvements to interchange to allow for more trucks to reach expanded truck parking site.

Detailed Methodology by Metric

Safety Needs

Reducing truck crashes resulting in fatal and severe injury is a high priority for MoDOT, which seeks to invest in projects that improve safety. Identifying locations/routes that have the highest crash rates assists in prioritizing

improvements with the greatest potential to address safety. A high score indicates that section of roadway having a greater safety need.

Safety considerations for freight operators are different than for the general traveling public. Elements that affect freight safety include:[126]

- Supply Chain Logistics - freight operators have a delivery and pick up schedule with minimal flexibility. This can increase the likelihood drivers may engage in risky driving behaviors.
- Distracted Driving—research has shown a strong positive correlation between total hours of driving and level of distraction.[127]
- Fatigue—long-haul drivers experience fatigue because of the monotony of long hours and limited engagement with others while short-haul drivers experience fatigue due to the pressure of having to carry out a large amount of driving and delivery during daytime hours.[128]
- Other road users—the behavior of other road users is a predominant risk for truck operators, with a particularly strong association of harm.
- Road conditions and design— lane width, steepness of hills, travel speed, condition of road and weather conditions influence carrier safety
- Vehicle condition and design—vehicle condition continues to remain a significant concern for crash risk[129] and vehicle design has been identified as an important area to focus on to make areas of safety improvement to prevent heavy truck rollover and serious impact on passengers in light motor vehicles.[130]

The safety needs key metrics and methodology are outlined in Table 4.3**.**

[126] Source: Risk Factors in the Road Freight Industry Literature Review, 2019, Dr. Charlene Matthern, Research and Evaluation, WorkSafe, Wellington, New Zealand

[127] Craft & Preslopsky, 2009

[128] Friswell et al., 2006

[129] Teoh et al., 2017

[130] Blower & Woodrooffe, 2012

TABLE 4.3 SAFETY NEEDS KEY METRICS METHODOLOGY

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Truck Involved Crash Rate	Displays the number of truck-involved crashes, per hundred million truck miles (HMTM).	MoDOT Crash Record Information System, 2016-2020.	Crash is on roadway if within a 0.01-mile buffer. Roadway inventory TRAVELWAY_ID is used to determine if crash is on the roadway segment. Truck VMT derived from roadway segment length *AADT* PERCENT_COMMERCIAL. The truck involved crash rate (TrkCrshRt) equals the 2019 annual crashes/ (365 * truck VMT) * 10^8.	0 to 4 points possible. Scoring ranges are dynamic based on crash per HMTM mile.
Truck Involved Severe Injuries or Fatalities	Displays the number of truck crashes that resulted in a disabling injury and/or fatality, per hundred million truck miles.	MoDOT Crash Record Information System, 2016-2020.	Need is identified for all segments based on disabling injury (TrkInj) and fatality (TrkFatal) crash rates. A crash is on roadway if within a 0.01-mile buffer. Roadway inventory TRAVELWAY_ID used to determine if crash is on the segment. Truck VMT derived from roadway segment length * AADT*PERCENT_COMMERCIAL. The truck involved crash rate (TrkCrshRt) equals the 2019 annual crashes/ (365 * truck VMT) * 10^8.	0 to 3 total points possible. Scoring ranges are dynamic based on crash per HMTM mile, as follows: • 0 = Zero crashes. • 1 = Above zero and below average disabling injury crash rate. • 2 = Above average number disabling injury crash rate. Combined with: • 0 = no fatal crashes • +1 = Above zero and below average number of fatal crash rate. • +2 = Above average fatal crash rate.
At Grade Highway-Railroad Crossings	Displays the number of trains per day for roadway segments with an at-grade railroad crossing.	Federal Railroad Administration Safety Data, 2020.	Potential conflict points between rail and highway are along at grade highways defined as CROSSING_GRADE_CD = 'AT GRADE' and STATUS = 'OPEN'. Crossing "on roadway" defined as within a 0.05-mile buffer. 'TrPerDay' is used as the number of trains per day.	0 to 3 points possible. Scoring ranges are dynamic based on number of trains per day.

FIGURE 46 FREIGHT SYSTEM HIGHWAY SAFETY NEEDS

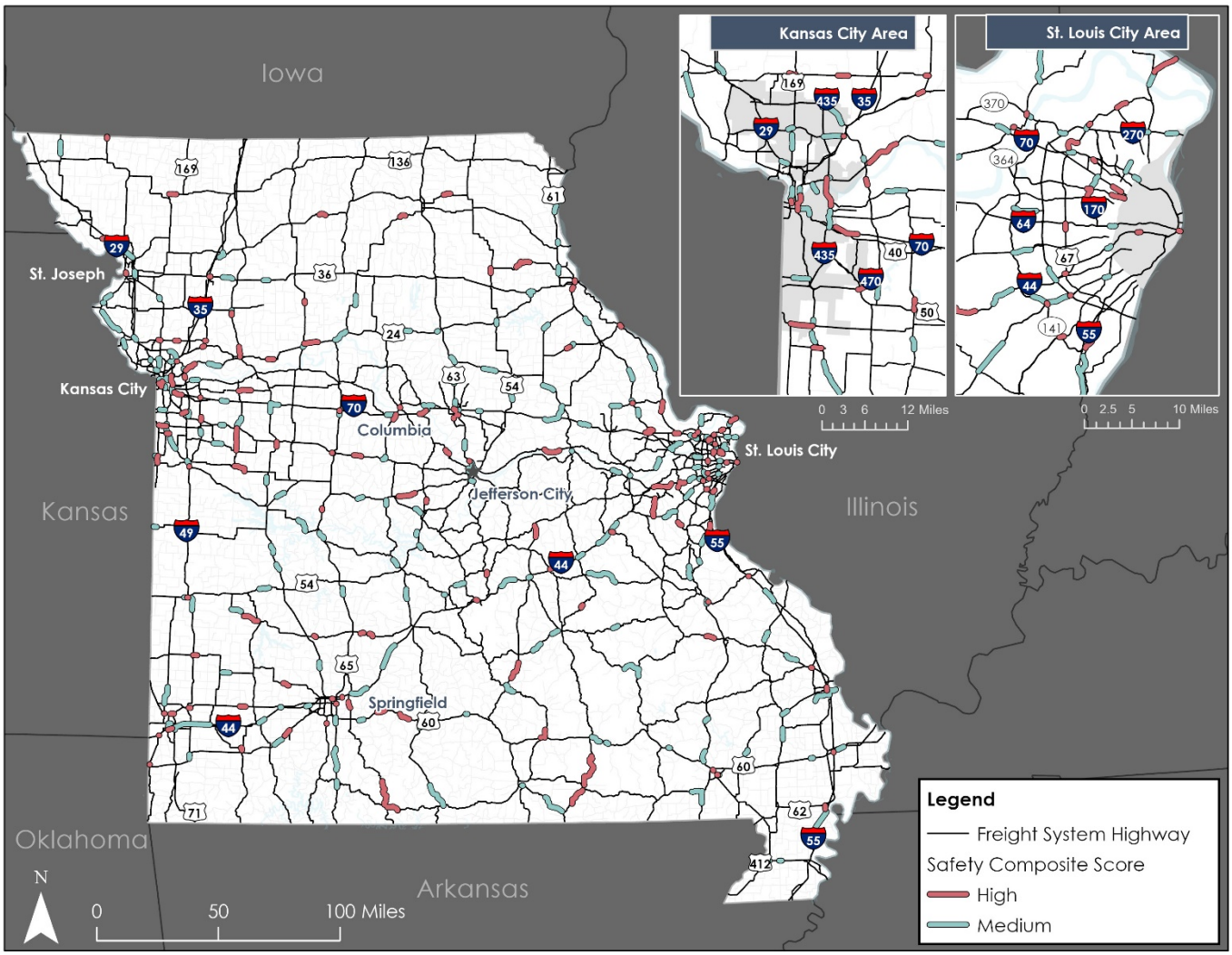


Figure 4.2 shows the high and medium safety needs for roadways on the Freight System Highway. High safety needs are shown in red and medium priority safety needs are shown in light blue.

As shown in Figure 4.2, high safety needs occur in the urban areas of St. Louis, Kansas City and Springfield and the wider regions surrounding these cities. Other routes in the state with high safety needs include long sections of Route 19 in far southcentral Missouri and Route 125 southeast of Springfield, Sections of the Freight System Highway with high safety composite scores are scattered throughout the state.

Medium safety composite score needs occur along long stretches of I-70, I-44 and I-29. Medium safety composite score needs also occur in the Kansas City, St. Louis, Springfield and Joplin regions as well as short stretches of Freight System Highways statewide.

Rural Interstate Truck Parking Needs

Truck parking is a challenge in the state as the demand of short-term and long-term truck parking locations often exceeds the capacity, particularly on the state's interstate system. Lack of adequate truck parking locations can lead to trucks parking on off-ramps and on-ramps along the state's routes. A high truck parking score indicates that truck parking expansion should be considered at these locations. One of the stakeholder comments received stated "Improvements to interchange to allow for more trucks to reach expanded truck parking site," referring to the junction of I-35 and U.S. Route 36 in Clinton County.

To determine truck parking needs for Freight System Highways in the state, the following metrics were assessed:

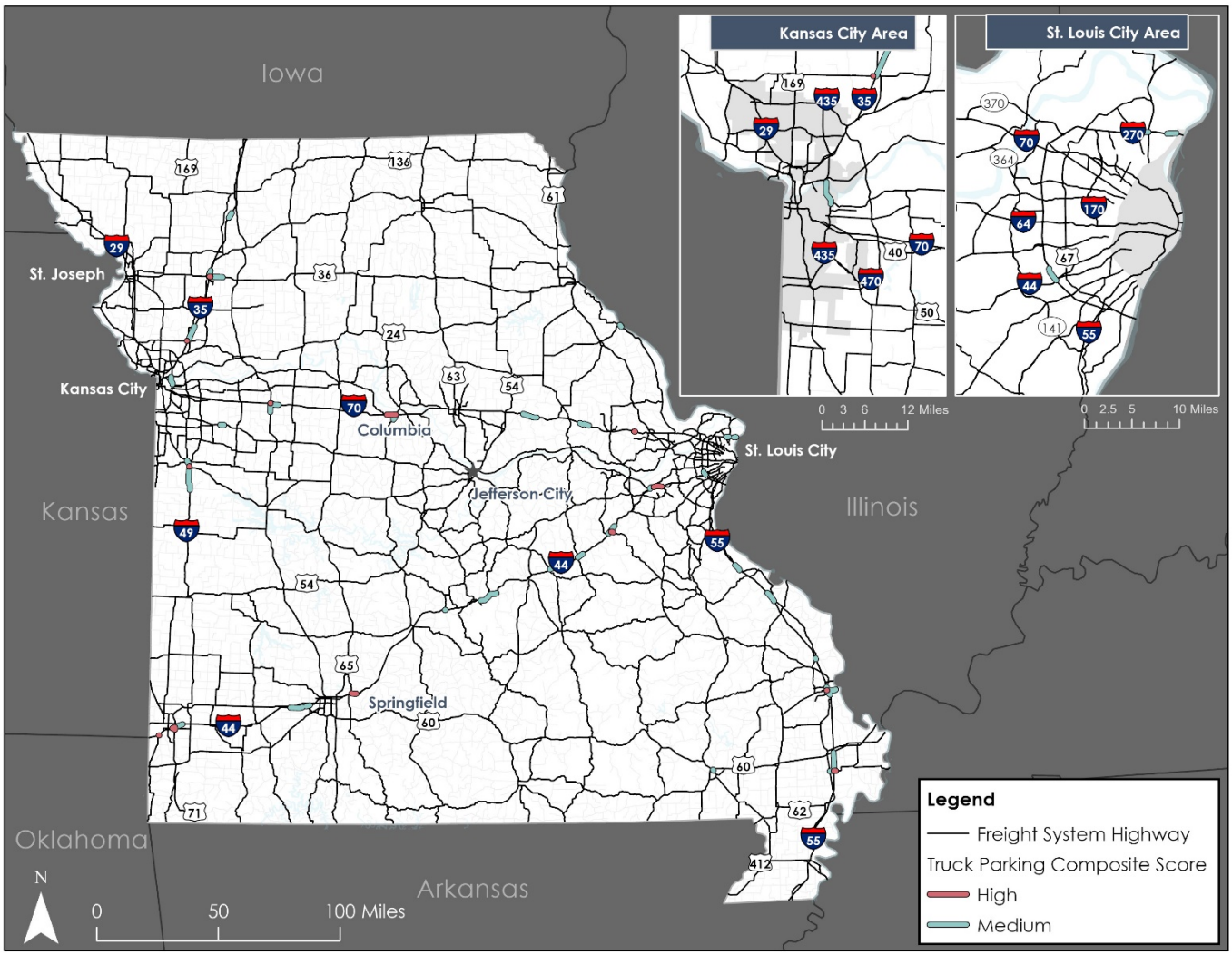
- Crashes involving parked trucks per mile.
- Interstate truck parking deficit—identifies the peak hour truck parking utilization within authorized parking locations, considering both demand and capacity.

Details of the metrics and data sources can be found in Table 4.4**.**

TABLE 4.4 TRUCK PARKING NEEDS KEY METRICS METHODOLOGY

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Crashes Involving Parked Trucks	Displays the number of crashes with parked trucks, per mile.	MoDOT Crash Record Information System, 2016-2020; Missouri STARS Crash Reporting System.	Roadway segments identify need by calculating the crash rates involved parked trucks. Calculated crashes involving parked trucks (where Parked = 1). Calculated both total crashes (CrshPrk = # of crashes) and crashes per mile (CrshPrkpM = per mile). Indicated all fatal crashes involving parked trucks (where Parked = 1 and SEVERITY = 'FATAL'). Calculated both total crashes (CrshPrkF = # of fatal crashes) and fatal crashes per mile (CrshPrkFpM = per mile).	0 to 3 points possible. Evaluated based on a weighted sum of crash counts per mile (4*fatal crashes + 1*all crashes). The data distribution of the product results in the dynamic score.
Interstate Truck Parking Deficit	Identifies the peak hour truck parking utilization within of authorized parking locations, considering both demand and capacity.	MoDOT Truck Parking Analysis, 2021.	Based truck parking analysis on Interstate Highways only. Uses absolute value of deficit at peak periods (GapatPeak). The negative value indicates the level of gap divided by centerline mile.	0 to 4 points possible. Scoring distribution based on peak hour utilization within authorized parking locations.

FIGURE 47 FREIGHT SYSTEM HIGHWAY TRUCK PARKING NEEDS



Note: This analysis only covers rural interstate highways, and it does not reflect parking needs on other freight routes.

Locations of high and medium truck parking needs on Freight System Highways are shown in Figure 47**.** The highest truck parking needs are in locations along I-44, I-70 and I-35 approaching the cities of St. Louis, Kansas City, Springfield and Columbia. Other locations of medium truck parking needs can be found scattered along the state's interstate system.

Technology Needs

Providing state-of-the-art technology for freight movement will improve the efficiency of, and lower the cost of, delivering goods. Technologies such as weigh-in-motion allow legally compliant trucks to continue to their destinations with fewer stops at a weigh station. Transportation management centers, using closed circuit televisions and other sources, can use dynamic message signs to inform truck drivers of upcoming delays due to incidents. This allows drivers to divert to another route and avoid delay. A high technology need indicates that

improved technology elements should be considered at these locations. One stakeholder commented: “Broadband access can be limited/spotty in Lewis County.”

To determine technology needs for Freight System Highway routes in the state, the following metrics were assessed:

- Weigh-in-Motion Location Needs.
- Transportation Management Center Needs.
- Traveler Information Needs.
- Traffic Incident Management Needs.

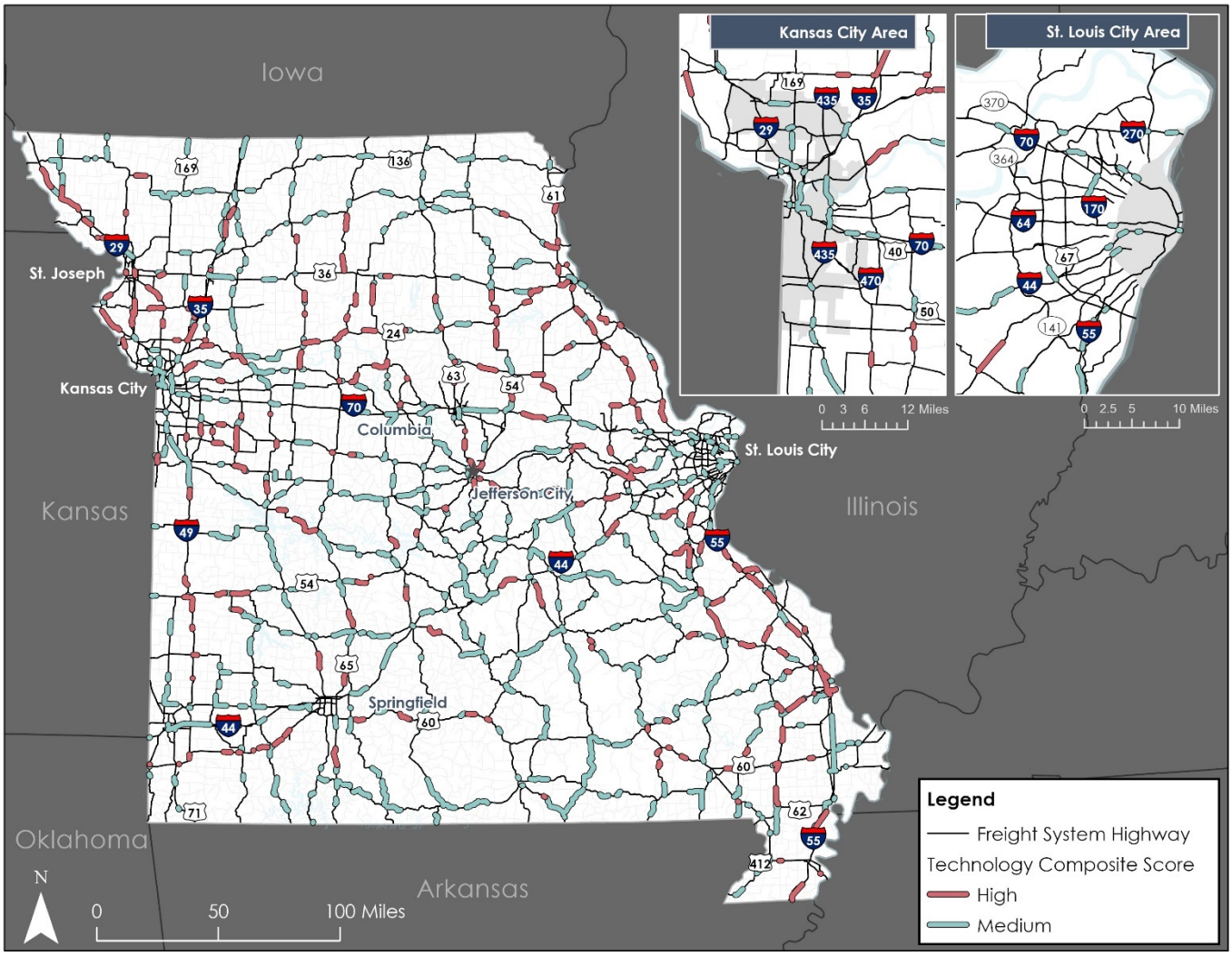
Details of the metrics and data sources can be found in Table 4.5.

TABLE 4.5 TECHNOLOGY NEEDS KEY METRICS METHODOLOGY

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Weigh-In-Motion (WIM)	Identifies roadway segments with higher-than-average truck tonnage within or outside a five-mile radius of an existing WIM location.	MoDOT WIM database, 2021, and MoDOT Freight System Designation 2021.	Roadway segments with WIMs present are considered low need. Roadway segments outside a five-mile radius of WIM are flagged (W_VC_TotSc).	0 to 1 points possible. Scoring based on if conditions are met (W_VC_TotSc) and the scoring ranges are dynamic based on if the truck tonnage is above average.
Transportation Management Center (TMC) Needs	Identifies roadway segments with TMC-associated ITS device, including dynamic message signs and CCTVs, within or outside a five-mile radius. This metric considers truck volumes to indicate the overall need for TMC coverage.	MoDOT, DMS and CCTV Inventory, 2021.	Roadway segments that already have TMC-associated ITS device coverage are indicated with a low need. Existing TMC coverage (TMC_Cov) is flagged as follows: • 0 = within five-mile of TMC coverage. • 1 = outside of five-mile coverage of TMC w/associated ITS devices. • 2= no TMC coverage or associated ITS devices.	1 to 3 points possible. Scoring based conditions met (TMC_Cov = 1) and scoring ranges are dynamic based on the data distribution of truck volume.
Traveler Information Needs	Identifies roadway segments with Dynamic Message Signs (DMS) within or outside a five-mile radius. This metrics considers truck travel time reliability as an indicator more DMS technology is needed.	MoDOT, DMS and CCTV Inventory, 2021.	Roadway segments with DMSs present are considered low need. Roadway segments with no DMS within five miles are flagged (DMS_Cov).	1 to 3 points possible. Scoring based conditions met (no DMS coverage) and scoring ranges are dynamic based on data distribution of the FSD score.

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Traffic Incident Management Needs	Identifies roadway segments with closed-circuit televisions CCTVs within or outside a five-mile radius. This metric considers truck crash rates as an indicator more CCTV cameras are needed.	MoDOT, DMS and CCTV Inventory, 2021.	Roadway segments with CCTVs present are considered low need. Roadway segments with no CCTVs within five miles are flagged (CCTV_Cov). While DMSs and vehicle detectors are also used for traffic incident management, these ITS devices are not considered in the analysis because CCTVs are significantly more useful for this purpose.	1 to 3 points possible. Scoring based conditions met (no CCTV coverage) and scoring ranges are dynamic based on data distribution of total crash rates (AllCrshRt).

FIGURE 48 FREIGHT SYSTEM HIGHWAY TECHNOLOGY NEEDS



Locations of high and medium technology needs on Freight System Highway routes are shown in Figure 48. Much of the state's interstates are classified as high or medium technology needs routes. In addition, in the northern part of the state, large portions of U.S. Routes 24, 36, 54, 61 and 63 have high and medium technology needs. In the southern portion of the state, large portions of Missouri Routes 7 and 13, and U. S Routes 54, 60, 63 and 65 have high or medium technology needs.

Mobility and Reliability Needs

Mobility and reliability needs indicate the ability to travel to truck destinations and the reliability of travel times in reaching these destinations. Mobility and reliability for trucks delivering goods to destinations are key elements in ensuring shipments are delivered on time. Without certainty in these measures, motor carriers may not allot enough time, or too much time, in their shipping schedules resulting in negative economic outcomes. A high mobility and reliability need indicates locations where improvements to mobility and reliability of the freight network should be considered.

Mobility and Reliability received the most stakeholder comments. Comments included congestion and capacity concerns, improved access to destinations, planning for future freight generators, and multimodal needs including airports, rail and river ports.

Freight highway mobility and reliability needs were scored on the following criteria:

- Level of service.
- Truck travel time reliability.
- Connectivity to strategic industry supply chains—considers connectivity to significant economic generators.
- Connectivity to intermodal terminals and gateways.
- At-grade highway-railroad crossings—considers the annual average daily truck traffic for roadway segments with an at-grade railroad crossing.

Details of the metrics and data sources can be found in Table 4.6.

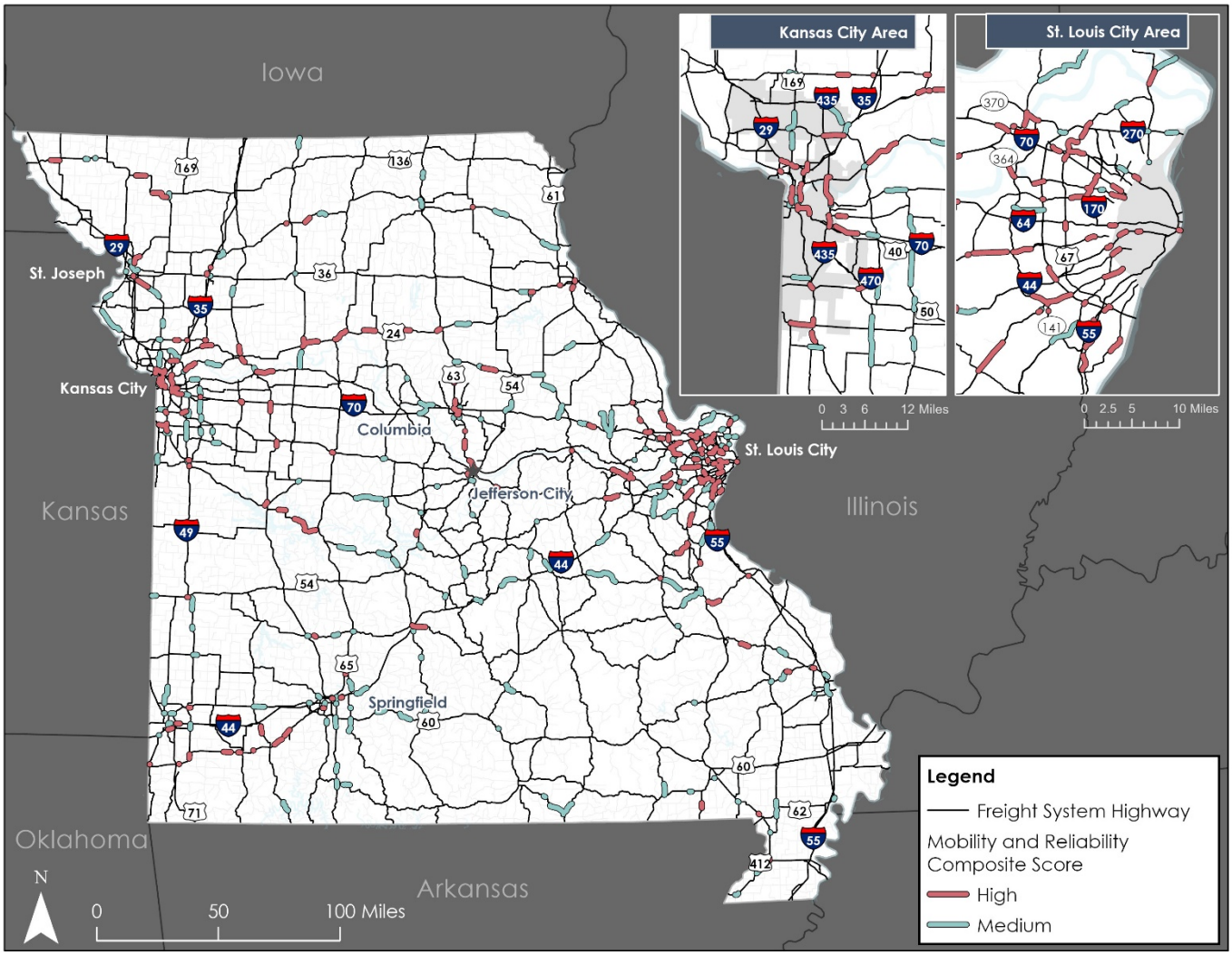
TABLE 4.6 MOBILITY AND RELIABILITY NEEDS KEY METRICS METHODOLOGY

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Level of Service	Displays the measure of capacity constraints of each roadway segment	MoDOT State System (SS) Pavement Inventory, 2021.	Capacity constraints identify need if urban roadway segments are LOS D or worse and if rural roadway segments are LOS C or worse (LOS).	1 to 3 points possible. Scoring applies where conditions are met and scoring ranges are dynamic based on the distribution of truck volume.
Truck Travel Time Reliability	Displays the truck buffer time index.	National Performance Management Research Data Set (NPMRDS), 2019	Roadway segments identify need based on TTTR. The maximum TTTR is applied to the corresponding roadway segment. Null is added for any roadway segments missing data.	0 to 4 points possible. Scoring ranges are dynamic based on distribution of TTTR.
Connectivity to Strategic Industry Supply Chains	Displays the connectivity to significant economic generators.	MoDOT Freight System Designation 2021, MoDOT State System (SS) Pavement Inventory.	Roadway segments identify need if LOS D or worse and if rural roadway segments are LOS C or worse (LOS) or worse and/or TTTR is greater than 2.	1 to 3 points possible. Roadway segments identifying need were scored based on FSD Strategic Supply Chains score (SCH_SC).
Connectivity to Intermodal Terminals & Gateways	Displays the connectivity to intermodal terminals and gateways.	MoDOT Freight System Designation, 2021, MoDOT State System	Roadway segments identify need if LOS D or worse and if rural roadway segments are LOS C or worse (LOS) or worse and/or TTTR is greater than 2.	1 to 3 points possible. Roadway segments identifying need were scored based on FSD Market Access and

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
		(SS) Pavement Inventory.		Connectivity score (MA_SC).
At-Grade Highway-Railroad Crossing	Displays the annual average daily truck traffic (AADTT) for roadway segments with an at-grade railroad crossing.	MoDOT Railroad Crossings Inventory, 2021.	Roadway segments identify need if rail crossing is "on roadway" defined as within a 0.05-mile buffer. Potential points of congestion along at grade highways defined as CROSSING_GRADE_CD = 'AT GRADE' and STATUS = 'OPEN'.	1 to 3 points possible. If at-grade crossing on roadway, scoring ranges are dynamic based on the distribution of truck volumes.

Figure 49 displays high and medium score locations for mobility and reliability needs on Freight System Highway routes. Mobility and reliability needs are highest in the urban areas of St. Louis and Kansas City, including every interstate route within these regions. Other routes with high and medium mobility and reliability needs include Missouri Route 22 and U.S. Route 24, north of Columbia, U. S. Routes 60 and 65, east of Springfield, and Missouri Routes 8 and 32, east of St. James.

FIGURE 49 FREIGHT SYSTEM HIGHWAY MOBILITY AND RELIABILITY NEEDS



Asset Preservation Needs

Asset preservation considers the condition of the state of Missouri's infrastructure. Bridges are analyzed for elements such as weight restrictions, vertical and width restrictions and overall condition, while roadways were analyzed for pavement conditions, vertical clearance and width restrictions. A high asset preservation need indicates that improvements to better accommodate freight should be considered at this location.

Freight highway asset preservation needs were scored on the following criteria:

- Vertical clearance limitations.
- Bridge weight restrictions.
- Bridge conditions.

- Pavement conditions.
- Restrictive vertical heights and widths.

Details of the metrics and data sources can be found in Table 4.7.

TABLE 4.7 ASSET PRESERVATION NEEDS KEY METRICS METHODOLOGY

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Bridge Weight Restrictions	Identifies bridges with load restrictions, limiting the ability to accommodate vehicles of certain weights.	MoDOT Bridge Inventory, 2021	Varying degree of need is identified for all segments with a bridge meeting the following criteria: • Multiple bridges approved for less than 40 tons = 2 • One bridge approved for less than 40 tons = 1 • All bridges approved for equal or above 40 tons = 0 Roadway segments are flagged for the lowest clearance issue on that segment (LdRstr). The minimum of the approved tonnage is used for the flag (minimum of APPROVED_TON1, APPROVED_TON2 and APPROVED_TON3)	0 to 3 points possible. Roadway segments with varying needs (LdRstr) are multiplied by the FSD designation score. The data distribution of the product results in the dynamic score.
Bridge Condition Issues	Identifies bridges where truck traffic could accelerate poor condition ratings for bridge decks.	MoDOT Bridge Inventory, 2021	Varying degree of need is identified for all segments with a bridge meeting the following criteria: • Multiple bridges with deck rating below fair (5) = 2 • One bridge with deck rating below fair (5) = 1 • All bridges with deck ratings no worse than fair = 0 The roadway inventory ID is used to join to roadway segments (TRAVELWAY_ID). The bridge deck rating code is used to determined above and below fair (DECK_RATING_CD = 5) and is flagged based on the criteria above (Cndtn).	0 to 3 points possible. Roadway segments with varying needs (Cndtn) are multiplied by the FSD designation score. The data distribution of the product results in the dynamic score.
Pavement Condition	Identifies roadways with rough pavement conditions and significant truck traffic.	MoDOT State System (SS) Pavement Inventory	The need is determined by the condition reported (TRACKER_CONDITION = NOT GOOD). Truck volumes are calculated as follows: AADTT = [AADT] * [PERCENT_COMMERCIAL]	0 to 4 points possible. Scoring based conditions met (PvCndtn = 1) and scoring ranges are dynamic based on the distribution of truck volumes.

FIGURE 50 FREIGHT SYSTEM HIGHWAY ASSET PRESERVATION NEEDS

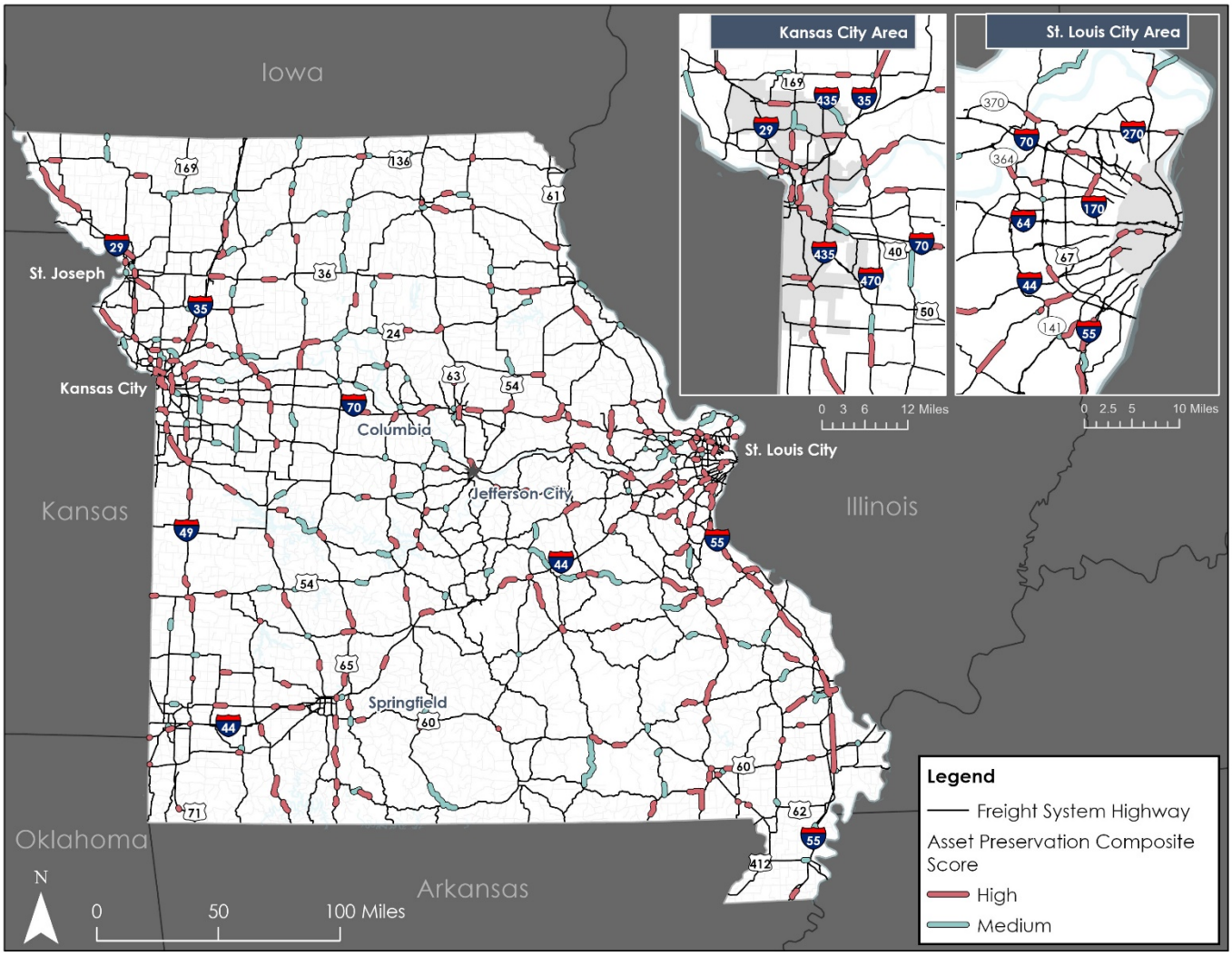


Figure 50 shows the high and medium asset management needs for Freight System Highway routes in Missouri. In St. Louis, short stretches of Interstates 44, 55, 70, 170, -270 and Missouri Route 370 have high asset preservation needs. Short sections of Interstates 29, 35, 49, 70, 435, 635 and Missouri Route 7 in the Kansas City area and portions of Routes I-44 and U.S. Route 65 have high asset preservation needs in the Springfield area. Other routes with high and medium asset preservation needs are found scattered throughout the state.

Freight Design Needs

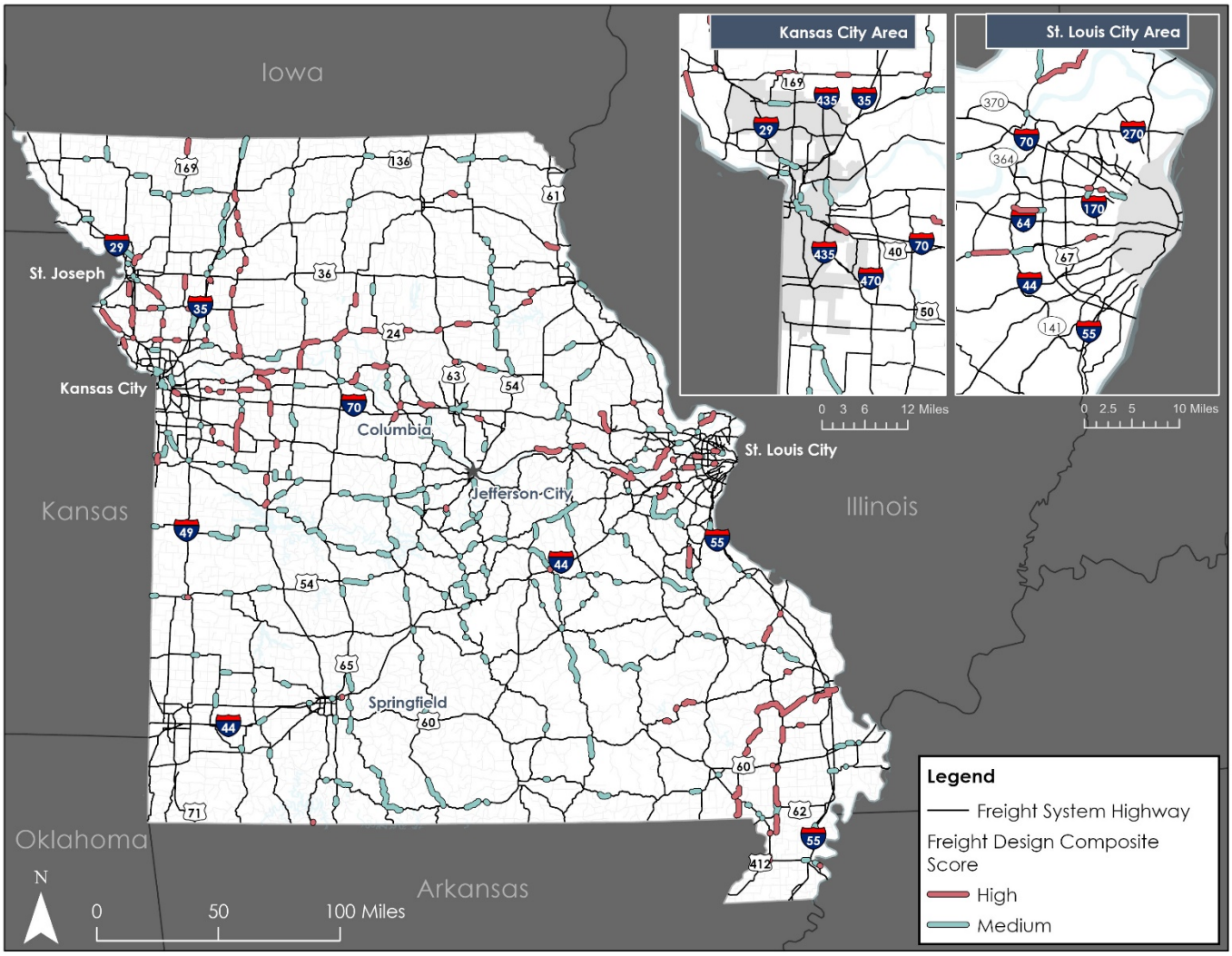
The Freight Design needs assessment focuses on freight-critical, undivided two-lane highways and locations of vertical clearance limitations. Sections of Freight System Highways that do not meet current design standards may pose challenges for the safe and efficient movement of freight traffic in Missouri.

The key metrics, data sources and methodology are provided in Table 4.8.

TABLE 4.8 FREIGHT DESIGN NEEDS KEY METRICS METHODOLOGY

Key Metric	Description	Data Source	Data Use Methodology	MoFAS Scoring Methodology
Freight Critical Two-Lane Highways	Displays the freight critical undivided, two-lane roadways.	MoDOT State System (SS) Pavement Inventory, 2021.	Roadway segments identify need if roadway attributes are undivided and two-lane roadways (DIVIDED_UNDIVIDED = 'UNDIVIDED' AND ROADWAY_TYPE_NAME = 'TWO-LANE'). This attribute is flagged in this metric's attribute (TwLn). Truck volumes are calculated as follows: AADTT = [AADT] * [PERCENT_COMMERCIAL]	0 to 4 points possible. Scoring applies where conditions are met (TwLn = 1) and scoring ranges are dynamic based on the distribution of FSD scores.
Vertical Clearance Limitations	Identifies the ability to accommodate vehicles of certain heights.	MoDOT Bridge Inventory, 2021.	Varying degree of need is identified for all segments with a bridge meeting the following criteria: • Less than 15 ft = 3 • Between 15 ft and 16'6" = 2 • Between 16'6" and 18'6" = 1 • Greater than 18'6" = 0 The roadway inventory ID is used to join to roadway segments (TRAVELWAY_ID). The minimum vertical clearance under the bridge determined the clearance (MIN_VERT_CLEAR_UNDER) The bridge inventory is filtered to only score bridges that are over a highway (LANES_UNDER >0). Roadway segments are flagged for the lowest clearance issue on that segment (VrtclClSC)	0 to 3 points possible. Roadway segments with varying needs (VrtclClSC) are multiplied by the FSD designation score. The data distribution of the product results in the dynamic score.

FIGURE 51 FREIGHT SYSTEM HIGHWAY DESIGN NEEDS



As shown in Figure 51, high and medium Freight System Highway design needs are scattered throughout the urban centers of St. Louis and Kansas City including I-70, and Missouri Routes 100, 109, 141 and 231 in St. Louis and Interstates 29, 35, 70 and 435; U.S. Routes 24, 40; and Missouri Route FF in Kansas City. Also, much of the length of U.S Route 24 and Missouri Route 13 have high or medium design needs.

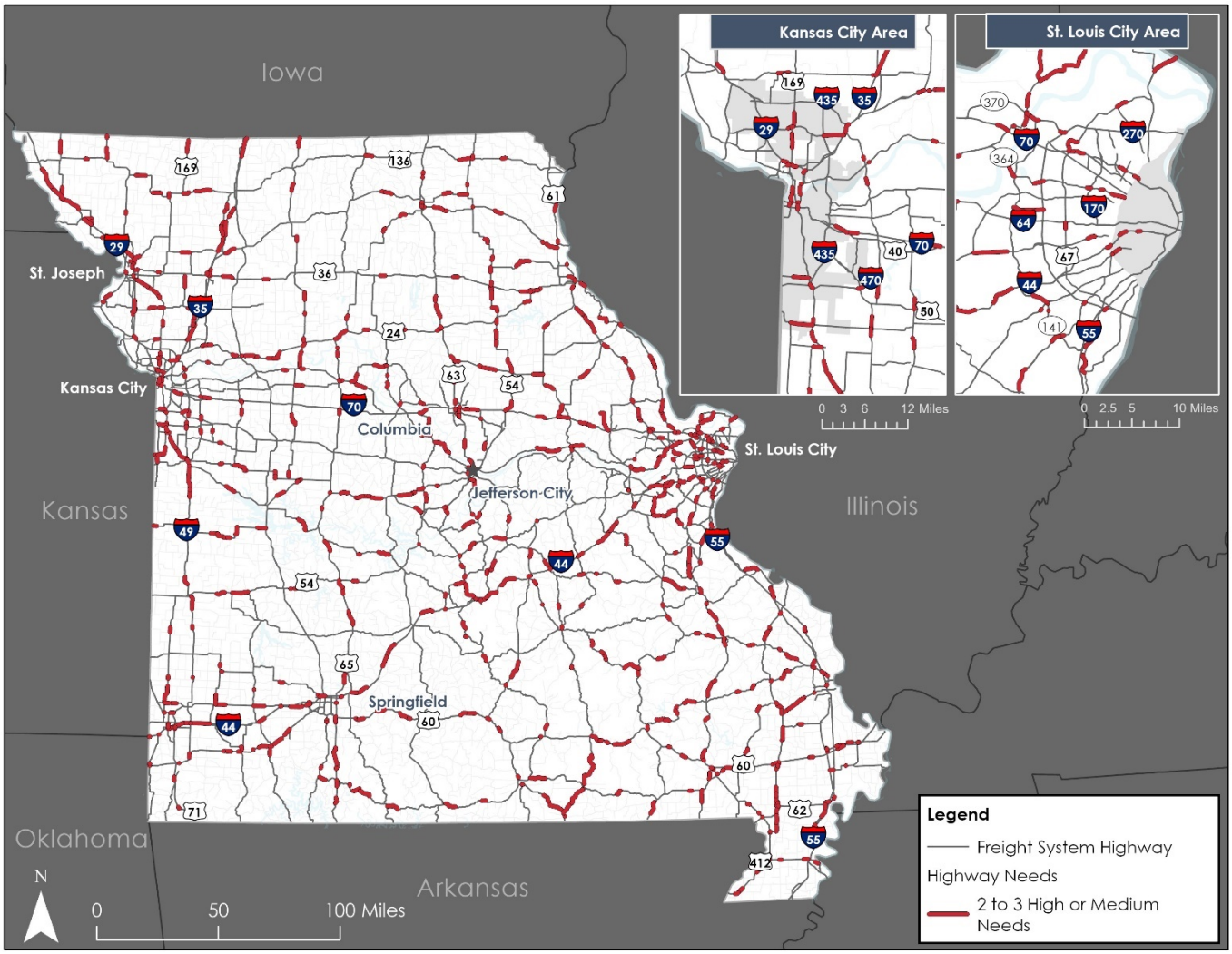
In southeast Missouri, large portions of Missouri Route 25 and Route 51 have high design needs. Medium design needs are found throughout the state including U.S. Routes 50, 54, 60 and 65.

Summary of Needs

After evaluating Missouri's highway network using the metrics associated with each of the six scoring categories, the next step is to identify highway segments with multiple freight needs. Figure 52 presents the freight system segments that scored medium or high with two or three needs categories. These segments are generally short in length and are found throughout Missouri's highway system in both urban and rural areas; however, there are some

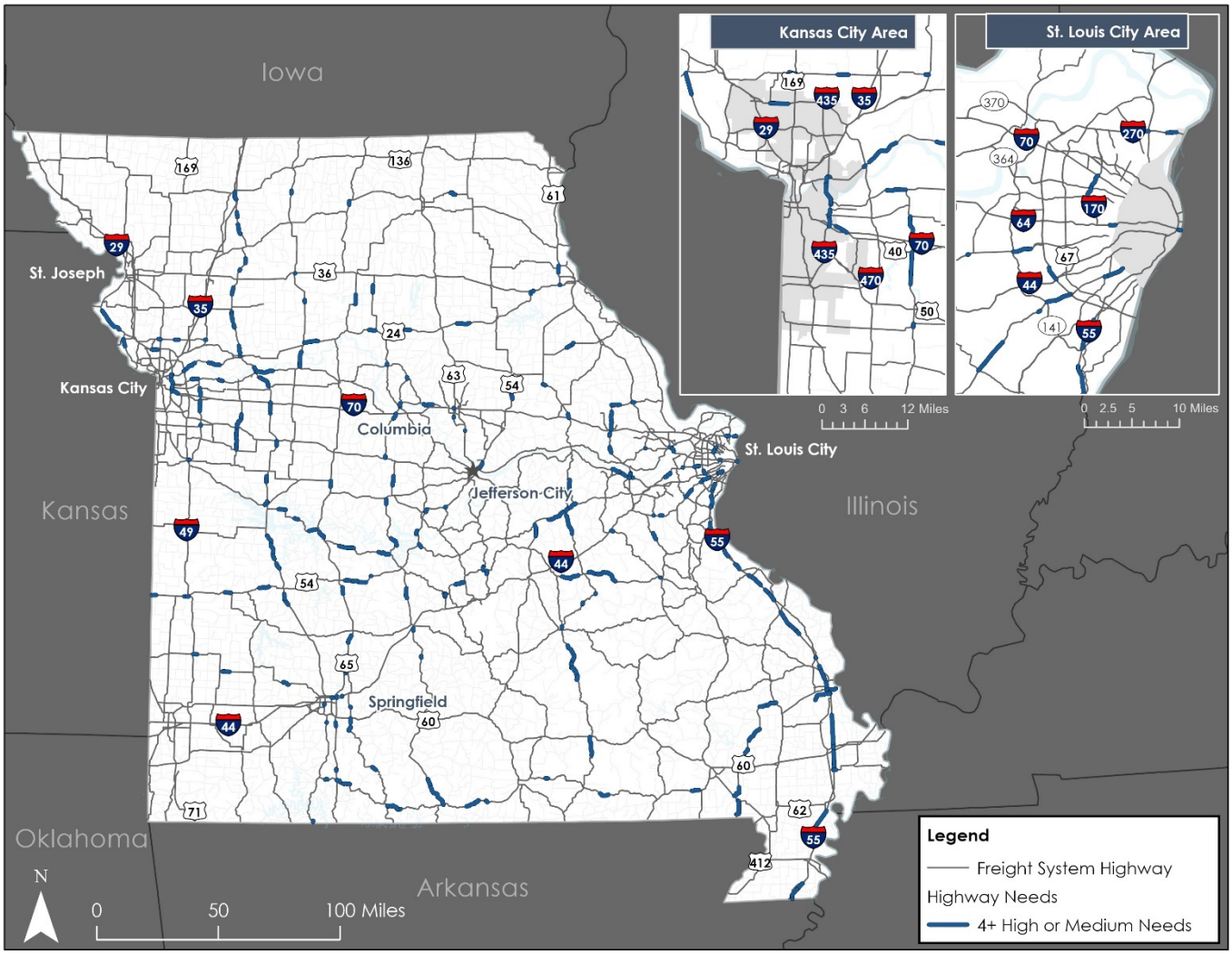
longer segments in northwest Missouri, such as Interstates 35, 29 and 49, as well as significant portions of U.S. Routes 54 and 67 and, Missouri Route 19.

FIGURE 52 FREIGHT SYSTEM HIGHWAY NEEDS – 2 TO 3 NEEDS CATEGORIES



The highest need highway segments are those that scored medium or high with four or greater needs categories, as shown in Figure 53. Although there are portions of larger freight-significant corridors, such as I-435 in Kansas City and I-70 in St. Louis, there are other distinct corridors that are considered to have the highest need relative to the rest of the highway freight system. These corridors include I-55 south of St. Louis, which is primarily a rural part of the state, as well as MO-13 and MO-19. There are also several east-west routes, such as U.S. 24 and U.S. 54, that scored medium or high on four or greater needs categories. Understanding which of Missouri's highway network has the greatest number of freight needs provides the foundation for developing SFRP recommendations and implementation plan, which will be developed in a later phase of the Plan.

FIGURE 53 FREIGHT SYSTEM HIGHWAY NEEDS – 4+ NEEDS CATEGORIES



4.2 Rail

The needs and opportunities for freight rail are born out of the supply chain and goods movement within the state. The existing rail infrastructure, both its condition and capacity, affects the quantity and speed at which goods can be moved. The availability of rail transportation supports significant efficiencies for Missouri's people and businesses. For many commodity shipments, and individual travel purposes, rail is more efficient in terms of travel time and cost advantages than other alternatives. While rail accounts for only a small share of Missouri's overall transportation system, the state has one of the largest rail systems in the U.S., and has significant economic stake in having a safe, efficient and well-maintained rail network and services..

Rail offers an attractive mode for freight with its ability to move high volumes in a cost-efficient manner across long distances. Rail is an important freight mode for Missouri and the country as it moves critically important goods such as grain, food products, and containerized freight. By monitoring the needs of the railroad network, MoDOT develops solutions and recommendations to ensure the freight rail network continues performing its essential duty.

Passenger rail presents a mode choice that can help to reduce roadway congestion and provide an alternative travel option. Monitoring the needs of the passenger rail network ensures that MoDOT is prepared to change and enhance services to provide an efficient and useful passenger rail system.

This section will examine the existing needs and opportunities for both the freight rail and passenger rail networks in Missouri. The analysis will build on the existing conditions and system inventory presented in the Missouri Freight Profile: Volume 2.

Freight Rail Needs and Opportunities

This section details the key issues, service gaps, improvement needs and financial deficits facing the state's freight rail network in Missouri, based on stakeholder outreach, the existing capacity analysis presented in the *Missouri Freight Profile: Volume 2* and commodity flow analysis summarized above.

Track Capacity

Several of Missouri's railroad corridors are close to or exceeding capacity, as detailed in the Missouri Freight Profile: Volume 2. Specific corridors may experience increased volumes above the capacity they can handle, resulting in congestion, delays and increased price to move freight as volumes increase. This may create inefficiencies and cause freight which would otherwise use rail to utilize other modes, such as highways. Maintaining freight rail capacity for new or growing businesses is important to the economic future of Missouri. Railroad interviewees mentioned the importance of strong public-private partnerships and access to federal and state support to maintain network efficiencies. Railroad corridors currently close to or exceeding capacity are presented in Table 4.9.

TABLE 4.9 CORRIDORS AT OR NEAR CAPACITY

Owner	Rail Segment
KCS	Kansas City—South
UPRR	Kansas City—Iowa
NS	Hannibal—St Louis
BNSF	Tulsa—Springfield—St Louis
BNSF	Kansas—Springfield—Jonesburg, AR
KCS	Kansas City—Iowa
BNSF	Burlington, IA—St Louis—Arkansas
UPRR	Kansas City—Jefferson City
BNSF	Cape Girardeau—Arkansas
UPRR	St Louis—Ste. Genevieve
UPRR	Cape Girardeau—Arkansas

Source: Carload Waybill Data, 2012-2018

Safety and Crossings

Safety of the freight rail network is a prominent need for MoDOT. Below are the key needs and opportunities to improve safety of the network:

- Forecasted increases in rail and roadway traffic in upcoming years could lead to increased interactions at rail-highway crossings. Passive crossings with no or limited signalization or signage exist throughout the Missouri rail network, resulting in potential safety concerns.
- Pedestrian trespassing is a key concern as people create a significant safety risk by crossing into private railroad right-of-way.
- One way MoDOT addresses safe freight rail transportation is through its inspection program. Currently MoDOT employs six rail inspectors to cover the thousands of miles of rail in Missouri. The mileage-per-inspector ratio is much higher in Missouri than in peer states, indicating an understaffing of this important program.

Funding for Spurs Serving Local Businesses

Local spurs into manufacturing facilities or industrial parks are owned and maintained by the business they serve. These spurs represent a major funding gap for most states, Missouri included, due to a lack of dedicated funding mechanisms. While industrial rail spurs are eligible for funding from the Freight Enhancement Program, the program is not able to cover a significant amount of costs. Such improvements are used to attract businesses, especially manufacturing, which rely on in- or out-bound rail shipments. These spurs increase the economic competitiveness of Missouri companies, connecting them to local service and/or the Class I rail lines. .

Intermodal Network, Facilities and Connectivity

Missouri's intermodal freight network and facilities are key to the state's economy as they efficiently deliver products and goods to industries and consumers. MoDOT heard the importance of this network and connectivity from a variety of users through stakeholder interviews and outreach. Areas of need include:

- Port improvements: Rail access to, from and within ports can facilitate rail movements and improve economic efficiencies.
- Transload facilities: Transload facilities allow businesses to utilize multiple modes to serve their needs most efficiently.
- Rail Infrastructure serving hubs: Improving and increasing supportive rail infrastructure in intermodal hubs such as Kansas City and St. Louis could reduce future bottlenecks and improve system resiliency.

Bottlenecks and Constraints

Bottlenecks and constraints limit the efficiency of the railroad network at specific locations as mentioned in the *Missouri Freight Profile: Volume 2*. This includes needs such as addressing congestion in St. Louis and Kansas City, creating or lengthening siding tracks to accommodate longer trains or examining existing subdivisions that create inefficiencies for carriers. An additional need seen throughout the state is blocked crossing as trains grow

longer. Reducing existing bottlenecks and constraints will help ensure businesses are able to rely on the rail network for their shipping needs. Certain improvements will be necessary to modernize the network and meet the demands of the future.

Maintaining and Expanding Short Line and Local railroads

Short line and local railroads are key economic development drivers as some businesses rely on these short lines to obtain goods or deliver products to market. MoDOT should work to coordinate with local economic development agencies and short line railroads to craft solutions to avoid the abandonment or reduced operations of short lines in the state. Additionally, some short lines in the state are candidates for expansion and increased access points to serve existing and future businesses.

Aging Structures and Clearance

Bridges represent a critical infrastructure asset on the freight rail network. Load restrictions, safety concerns and low clearances can severely limit the efficiency of freight movement as trains need to reduce speed, find alternative routes, or change load weights. Additionally, rail bridges can restrict other modes such as highways by limiting available area for expansion and imposing vertical clearance limits.

Passenger Rail Needs and Opportunities

The following needs and opportunities were identified for the state's intercity passenger rail network based on the existing conditions assessment in the *Missouri Freight Profile: Volume 2* and public and stakeholder outreach.

Public and stakeholder outreach conducted during plan development identified key needs for the passenger rail system. MoDOT conducted a public survey focusing on passenger rail and found enthusiastic support for current services and a desire for expansion of new services. See the Stakeholder Outreach Summary as part of the 2022 SFRP for more details regarding passenger rail.

Funding Shortfall for Missouri River Runner

A recent area of concern is funding for the *Missouri River Runner* service. During the last decade, contributions to Amtrak from Missouri for the service fell short of actual expenses. This shortfall resulted in increased debt owed to Amtrak. This challenge is likely to remain unless additional funding is authorized. The funding shortfall limits the ability for enhancements to the *Missouri River Runner* service.

Unserved and Underserved Communities

While Missouri's passenger rail system provides an alternative network for travelers, a number of large communities are either not served by passenger rail or have limited service. Missouri's third largest city, Springfield, is not connected to any passenger rail service. Missouri's fourth largest city, Columbia, is 32 miles north of the nearest passenger rail connection in Jefferson City. Many other cities in the state are a considerable distance from a the nearest station. The southwest portion of the state lacks any passenger rail service.

Infrastructure

Amtrak primarily operates over privately-owned railroads, meaning the infrastructure is the responsibility of the freight rail owners. The capacity of Missouri rail infrastructure is stressed as modern freight trains grow in length and number. This trend impacts existing passenger rail routes and operations. Improving the infrastructure of the existing passenger rail routes including addition of sidings and addressing capacity constraints and bottlenecks will ensure efficient operations for passenger trains.

Stations

Missouri's Amtrak stations are mostly locally owned. A number of these stations have deferred maintenance, lack basic enhancements like paved parking or have no station building at all. Improving or developing train stations will improve the passenger rail system by providing quality stations for passengers to prepare for their journey. Amtrak stations in the state vary greatly in their condition, size, amenities and the ability to comfortably meet travel demand. For example, the station building in Jefferson City was closed when it was ruled uninhabitable in 2019.

Service, Operations and Coordination

The service and operations of Missouri's existing passenger rail services are key considerations for the future of Missouri's passenger rail network. On-time performance remains a key indicator as it is often correlated with higher ridership. During outreach for the Plan, participants identified the schedule and frequency of existing routes as the largest barrier to choosing passenger rail service. The need for the passenger rail routes to interconnect with other forms of transportation to allow for efficient travel was also cited. Continued emphasis on the operations, service and marketing of the existing service are key needs of the system. To address these needs, MoDOT should continue to coordinate with Amtrak.

Rail Needs—Projects, Programs and Policies

Based on the broad needs and opportunities identified above, Table 4.10 highlights specific project and opportunities to address each need.

TABLE 4.10 MISSOURI RAIL NEEDS

Proposed Program	Description	Need Addressed[1]
St. Louis—Jefferson City—Kansas City (*Missouri River Runner* Corridor)		
Hermann Universal Crossover	Installation of a universal crossover to improve passenger and freight rail capacity	Infrastructure
Bonnots Mill Universal Crossover	Installation of a universal crossover to improve passenger and freight rail capacity	
Holden Siding	New siding track to improve passenger and freight rail capacity	
Knob Noster Siding	New siding track to improve passenger and freight rail capacity	
Second Main Line—Lee's Summit to Strasburg	Double track from Lee's Summit to Strasburg to improve capacity for both passenger and freight rail traffic	
Jefferson City Third Main Line Track Construction	Addition of a third main line track to increase fluidity through Jefferson City yard	
Independence Street Bridge (Kansas City) Improvements	Improve KCTR overpass on Independence Avenue to enhance freight and passenger rail service	
Pleasant Hill to Jefferson City Double Track	Addition of a second track to enhance capacity	

Kirkwood Station Upgrades	Updates to the station building and amenities to modernize and improve structural longevity	Stations
Independence Station Upgrades	Updates to the station building and amenities to modernize and improve structural longevity	
Jefferson City—New Station	Development of a new Jefferson City station necessary due to structural issues at the current station	
St. Louis—Jefferson City—Kansas City Corridor Enhancement Study	Study examining capacity, bottlenecks and constraints to determine future plans for the corridor related to speed and frequency	Unserved and Underserved Communities
Sedalia Station Bicycle/ Pedestrian Improvements	Addition of bicycle and pedestrian facilities connecting Sedalia's Amtrak station with the historic Katy Depot	Modal Connectivity
Warrensburg Station Bicycle/ Pedestrian Improvements	Addition of a sidewalk and ADA-compliant facilities at Warrensburg's Amtrak station	
St. Louis—Poplar Bluff (*Texas Eagle* Corridor)		
Poplar Bluff Station Upgrades	Updates to the station building and amenities to modernize and improve structural longevity	Stations
St. Louis—Southwest Missouri		
Updated Branson—Springfield—Joplin—St. Louis Service Study	Conducting an update to the *Report on Proposed Operation of Passenger Train Service Between St. Louis and Southwest Missouri* (2007)	Unserved and Underserved Communities
Kansas City—St. Joseph		
Kansas City—St. Joseph Service Study	Feasibility study examining the extension of passenger service north from Kansas City to St. Joseph	Unserved and Underserved Communities
Kansas City—Chicago (*Southwest Chief* Corridor)		
Carrollton Amtrak Station	Creation of a new Amtrak station between Kansas City and La Plata to be served by the *Southwest Chief*	Unserved and Underserved Communities
Kansas City—Southwest Missouri		
Branson—Springfield—Joplin—Kansas City Service Study	Feasibility study examining a new service connecting Kansas City to Springfield and other communities in southwestern Missouri	Unserved and Underserved Communities
Hannibal—Quincy, Ill.		
Carl Sandberg and *Illinois Zephyr* Service Extension to Hannibal Study	Feasibility study examining extension of *Carl Sandberg* and/or *Illinois Zephyr* service south from Quincy to Hannibal	Unserved and Underserved Communities
St. Louis Region		
Track Reconstruction—St. Louis	Construction of new track from N Market St to Biddle St to better accommodate *Texas Eagle* service	Infrastructure
Statewide		
Intercity Connection Service Feasibility Study	Study the feasibility of connecting service between station cities and non-served population centers	Unserved and Underserved Communities

4.3 Air Cargo

The economic recession of 2008 negatively impacted both air passenger and cargo, whereas the COVID-19 pandemic appears to have only negatively affect passenger travel while having a positive effect on air cargo. Demand for expedited air cargo services (i.e., UPS and FedEx) has exploded in recent years and continued this growth during the COVID-19 pandemic. As consumers increasingly purchase their goods online, expedited carriers have had to balance speed of delivery with transportation cost competitiveness to deliver these goods on time.

As a result of COVID-19, e-commerce increased air cargo volumes and the demand for expedited services has led to additional market demand for FedEx and UPS according to Missouri major airports. The companies have in turn improved their trucking/ground logistics supply chains and increased their use of air cargo, though any increases in air cargo have been mitigated by the advances in ground logistics. In Missouri, FedEx and UPS are the top air cargo carriers, however, representatives from Missouri's major airports in Kansas City (MCI), St. Louis (STL) and Springfield (SGF), report that Amazon's volume through their facilities grew significantly in the last five-years.

Support opportunities for air cargo growth in Missouri are many. Improvements could include infrastructure upgrades, master planning and facility expansion to increase air cargo activity at MCI, STL and SGF. As the value of goods shipped by air and demand for overnight or on-time services continues, access to air shipping via Missouri airports will be vital to support economic growth. Although capacity exists at airports in Missouri, it will be important to expand access to reach more parts of the state and provide service for highly time-sensitive commodities produced in Missouri. Top time-sensitive commodities, such as transportation equipment and pharmaceuticals, are well suited for air cargo transport and could take advantage of increased air cargo access to grow the manufacturing and distribution base in Missouri and nationwide. Missouri air cargo needs can be categorized into three areas: airport access, airport facilities and industrial development.

- **Airport access:** Air cargo access is critical to economic vitality, particularly for high value commodities. Consumer markets tied to e-commerce increased the demand for express package services, which were traditionally fulfilled by air cargo jets. However, because advances in ground logistics made trucks a viable option for express service, Missouri airports must ensure seamless access to air cargo facilities via the roadway network to stay competitive with other freight modes. I-70 congestion and reliable, efficient access from the STL airport to the freight highway network are examples of an airport access need.

- **Airport facilities:** There are opportunities for Missouri's airports to improve facility infrastructure, including runway and taxiway expansions, cargo aircraft aprons and more space for commercial vehicle staging. SGF identified cargo apron, ramp and facilities expansion for cargo movement and storage as examples of their facility needs.

- **Industrial development:** Focusing industrial development near airports can help increase the value of air cargo services. There are opportunities to increase industrial development around all three major Missouri airports. At MCI, air cargo growth revealed industrial development infrastructure needs at the KCI Intermodal Logistics Center southeast of the airport and on open ground on the west side of the runway.

Identifying Air Cargo Needs

Missouri air cargo needs were identified in three ways. First, air cargo needs from the *Missouri State Freight Plan, 2017* were included. Second, existing and forecasted air cargo trends and their impact on needs were evaluated. Finally, airport leadership from the three major Missouri airports of MCI, STL and SGF were interviewed.

The *2017 Missouri State Freight Plan* identified several air cargo needs[131] related to system operations, freight network and policy regulations. Those identified freight system air needs are:

- The cargo facilities at STL are limited and outdated. These facilities need updating and expansion.
- The safety and perimeter at MCI needs additional and improved fencing and gates for security enhancement.
- SGF has been identified has an airport that may have its tower hours reduced. The tower hours at SGF should not be reduced.
- Missouri does not currently have a designated freight network. A designated freight network, such as the highway freight network and maritime designation of cargo river systems is needed for the air modes..

As sourced from interviews with MCI, STL and SGF, the status of air cargo projects identified in the 2017 Missouri State Freight Plan was requested and is reported in Table 4.11 and Table 4.12**.**

TABLE 4.11 UNFUNDED FREIGHT NEEDS: PROJECTS IDENTIFIED DURING 2017 SFP

District	Type	Route	Project Description	Cost (Millions)	County	Completion Status
KC	Aviation	Aviation	Relocate POST 28 access gage and add new security structure, gate and pavement	$2.50	Platte	Yes
KC	Aviation	Aviation	Perimeter fence and gates around AOA to meet new standards	$6	Platte	Yes
SL	Aviation	Aviation	Connect Lambert International Airport cargo area with an industrial complex and connections to I-70	$10—$15	St. Louis	No
SL	Aviation	Aviation	Air cargo capacity is available, but the cargo facilities are dated, small, no refrigeration.	Unknown	St. Louis	No
SL	Aviation	Aviation	Improvements at Lambert Airport including expanding the cargo facility to the north side of the airport and redeveloping the former Boeing production facility for cargo development and expansion.	$3.10	St. Louis	Taxiway Victor was completed but the facility improvements were not completed.

Source: MoDOT 2017 Freight Plan, Appendix G: Freight Project List, p. 34, p. 53, p. 55

[131] Missouri State Freight Plan, 2017, Appendix B: Trends, Needs and Issues

TABLE 4.12 UNFUNDED FREIGHT NEEDS: PROJECTS IDENTIFIED AFTER 2015 SFP COMPLETION, FROM 2017 SFP

District	County	Route	Project Description	Cost ($1,000)	Job Number	Completion Status
SL	St. Louis City	Lambert International Airport	Increase strength of pavement in cargo area to accommodate cargo planes.	5,000	St. Louis City	Taxiway Victor was completed

Source: MoDOT 2017 Freight Plan, Appendix G: Freight Project List, p. 61

Overview of Air Cargo Needs and Challenges

Stakeholders identified air cargo strengths, weaknesses, opportunities and strengths during group meetings for this Plan. Information provided then was confirmed during one-on-one interviews with each of the major Missouri airports. Table 4.13 provides the results of the SWOT analysis.

TABLE 4.13 STRENGTHS, WEAKNESSES, OPPORTUNITIES AND THREATS ANALYSIS

	SWOT Analysis			
District (Airport)	Strengths	Weaknesses	Opportunities	Threats
St. Louis / Southeast (St. Louis Lambert International)	• Capacity availability via air • Central location within the state with access via the interstate and U.S. highway network.	• No Response	• Serve as a larger air freight hub • Strengthen preferred live animal port of embarkation • Look for opportunities for shippers to shift from Chicago to St. Louis for dedicated freighters	• No Response
Southwest (Springfield-Branson National)	• Rail and Airports • Amazon is currently building a 1M sq. ft. fulfillment facility about five miles south of airport and close to the BNSF rail line. • Primary deployment airport for Ft. Leonard Wood	• No response	• Connect rail to air facilities for shorter international transport times to central U.S. on high value goods. • Well-positioned with interstate and air as those modes grow in use • Foreign trade zone status 1 of 3 in the state	• No Response
Kansas City / Central / Kansas City International	• Metro and regional access to KCI and new industrial sites surrounding the airport.	• Capital costs for land and infrastructure development. Location of airport on N.W. corner of metro area.	• Availability of land surrounding the airport.	• Not having available facilities for lease.

Source: Menti questions during Missouri State Freight and Rail Plan Stakeholder Meetings, May 2021.

Key points from the SWOT analysis are that Missouri airports are well positioned geographically in the U.S. for air cargo success. All three airports have access to existing cargo facilities. KCI and SGF have an abundance of additional land to expand air cargo facilities. STL is more restricted in terms of land expansion but is focused on redevelopment of existing on-site cargo facilities. All three airports have good access to the interstate system and serve the three largest population centers in Missouri. The SWOT analysis and further interviews, identified air cargo needs at MCI, STL and SGF. Table 4.14 shows the needs at each of the major airports.

TABLE 4.14 MISSOURI AIR CARGO NEEDS

District (Airport)	Needs
St. Louis / Southeast (St. Louis Lambert International)	• Improvements to the I-70 corridor from Lindberg (U.S. 67) to I-170 in front of St. Louis airport where it supports industrial and manufacturing sites. Safety concerns arise from backups due to congestion and crashes. • St. Louis Lambert International Airport Access Improvements (MO) $30.3M[132]. • St. Louis Lambert International Airport North Cargo Improvements (MO) $15.2M. • Improvements to the 24-mile, I-270 corridor from I-70 to Route 157. One of the most important regional freight corridors in Missouri, it serves major freight generators, such as the Hazelwood Logistics Center, within and near St. Louis Lambert International Airport. • Demolition and site readiness of the northern track of the airfield for new state of the art cargo facility (Estimated $15M).
Southwest (Springfield-Branson National)	• Expand cargo apron for aircraft movement and GSE storage. (est. $1M)—planned construction in one year. • Major cargo ramp expansion. (est. $10M—$12M)—three to five years. • Expansion to existing air cargo facility (est. $5M)—three to five years.
Kansas City / Central (Kansas City International)	• Maintenance and new construction of hangers for air cargo. • KCI Intermodal Logistics Center infrastructure needs. • KCI westside power and other infrastructure needs to open ground for development. • Future improvements to I-435 Interchange at 120th Street (D Highway) to handle increased truck traffic coming from new industrial development on Airport Westside.

Source: Menti questions during Missouri State Freight and Rail Plan Stakeholder Meetings May 2021

4.4 Ports

Marine transportation is critical to the health of Missouri's economy. Missouri industries including agriculture, chemical manufacturing, aggregates and metals rely on the state's extensive port and waterway network to receive raw materials and to move goods to market. Barges traveling on the Mississippi and Missouri Rivers provide Missouri shippers with access to one of the most economical and environmentally friendly transportation modes available. These waterways connect the state to the entire Mississippi River system and its tributaries, including the Ohio, Tennessee and Illinois rivers. They also provide connections to Gulf Coast ports such as New Orleans and Mobile, providing Missouri shippers with waterborne access to global markets. Missouri ports give the state's

[132] 2022 PRIORITY FREIGHT PROJECTS, ST LOUIS REGIONAL FREIGHTWAY, May 2021

businesses a logistical advantage over other states without port access. Transporting freight by water is often the lowest cost method of transportation, which provides Missouri businesses an advantage in negotiating freight rates between rail, truck and barge modes.

Maintaining and enhancing Missouri's port system is critical for continued statewide economic vitality and competition with global markets. Despite these clear benefits for the state and nation, Missouri's public ports have limited funding streams, making it difficult to finance and prioritize maintenance, rehabilitation and expansion projects. Even modest investments in the port system can yield even significant benefits for Missouri's economy. It is critical for the state to continue providing financial support for public port authorities, and also assist in promoting their economic benefits by helping to position them for additional federal discretionary grant opportunities.

Identifying Port Needs

The process of identifying port transportation needs involved the following elements:

- **Review of previous studies—**this review included the 2018 *Economic Impact of Public Ports* study, as well as the previous 2017 *SFP*.
- **Technical analysis—**Analysis of IHS Markit TRANSEARCH database and U.S. Army Corps of Engineers' Waterborne Commerce Statistics Center data. Also incorporated findings from MoDOT's 2018 *Economic Impact Study for Public Ports* study.
- **Stakeholder outreach—**MoDOT is in regular communication with many ports. Targeted outreach related to this plan was conducted with: Port of Lewis County, Port of Mississippi County, Marion-Ralls Regional Port Authority, Port of Howard-Cooper County and Port of Jefferson County.

The evaluation also considered the port needs identified during the 2017 State Freight Plan. These needs are still relevant to Missouri's ports and waterways network:

- At ports throughout the state, increased maintenance activities are needed on both the land and water sides of the operations.
- Upgrades and rehabilitation are needed on many of the locks and dams in the state. Coordination with the U.S. Army Corps of Engineers is required.
- Sufficient depth for navigation is needed in channels and at harbors. This is achieved through additional dredging or through increased water releases from upstream dams.
- Numerous emerging port candidates were identified. Support for their development is needed.

To maintain and improve their condition and performance, ports rely on the Port Capital Improvement Program to assist with expenditures such as dock construction, mooring, site development, access improvements and other capital needs.[133] As of the 2020-2024 planned CIP, Missouri's ports identified more than $100 million in current port

133 https://www.modot.org/sites/default/files/documents/Sec07Multimodal_2.pdf

capital improvement needs. MoDOT annual CIP funding enables ports to take on otherwise unaffordable maintenance and improvement projects. Funding challenges are also the result of extreme weather events in recent years; for example, the extensive flooding that occurred in 2019 had an economic cost estimate of more than $383 million due to delays, closures and infrastructure damage.

Several ports successfully applied for federal discretionary funding opportunities in recent years. For example, in September 2020 the St. Louis Port Authority was awarded U.S. DOT funding, along with America's Central Port in Granite City, Ill., to support the construction of 7,300 linear feet of new railroad track, barge loading equipment modernization, conveyor replacement, loading shed updates and flood mitigation work in and around the Municipal River Terminal.[134] However, there is still a great need to address the aging lock and dam infrastructure along the Mississippi River, which requires coordination with the U.S. Army Corps of Engineers and funding authorization by Congress. Backlog in maintenance was estimated to be over $1 billion as of FY2019. Many locks and dams are undersized by modern standards and cannot accommodate a standard 15-barge tow. Continued partnership and reliance on federal funding and resources are needed to address these significant investments across Missouri's ports and waterways system.

Overview of Port Needs and Challenges

Based on this evaluation of previous studies, technical analysis and stakeholder outreach, the following themes emerged for Missouri's port and waterways needs:

- **Environmental sustainability and resiliency.** Ports are affected by the natural environment more frequently than any other mode. Changes in water levels and river conditions influence operations, affecting costs and reliability. Natural hazards also have the potential to damage port facilities, as shown by the flooding in 2019. Furthermore, it is important to consider and mitigate negative environmental impacts that ports and shipping can have on the surrounding environment.

- **Intermodal connectivity.** Many ports have potential to better interface with other modes of transportation, notably rail, pipelines and highways. Investment in these components has potential for a significant return on investment.

- **Emerging Port Development.** Missouri has many ports in the early stages of development and others are being revitalized after a period of underutilization. Investment can help these ports reach their potential and best access markets that have a need for their services.

- **Decline in Coal and Increase in Agricultural Commodities.** Coal is a major commodity at a few of Missouri's ports, most notably the Port of St. Louis. It is projected to decline significantly in the long-term. On the other hand, shipments of agricultural commodities like grain and livestock feed are projected to increase over the same period. Shifting commodity trends will impact port demand into the future.

Table 4.15 presents a summary of port needs and challenges in Missouri based on the process described in the previous section. Each port is in a unique position and has facility-specific needs and challenges. Many of the

134 https://www.transportation.gov/sites/dot.gov/files/2020-09/BUILD%202020%20Fact%20Sheets.pdf

needs are multimodal in nature, such as facilitating rail or transload service, and many ports are in the process of developing and/or expanding.

TABLE 4.15 SUMMARY OF PORT NEEDS AND CHALLENGES IN MISSOURI

Port	Summary of Needs
Heartland Port Authority of Central Missouri	• Planned port near Jefferson City on the Missouri River. Recent market study suggests that this port is a viable option for public-private partnership for construction and operations. • Original port feasibility study notes the need to establish reliable navigation season length on the Missouri river as well as address unpredictable water levels.
Marion-Ralls Regional Port Authority	• Developing port near Hannibal, MO. Foreign trade zone status pending. Port authority is working with an engineering firm to assess potential sites for development and market strategies.
Pike-Lincoln County Port Authority	• Developing port near Louisiana, MO on two industrial park sites. Port authority has received grant funding from MoDOT.
Port of Howard Cooper County	• Significant investment in progress, including rehabbing dock facilities (to be completed in June 2021) and grain elevators, purchasing a conveyor to load barges with grain, and developing a tract for additional grain storage or other uses. • Port has land available for second dock. Recently received 60/40 match and has indicated further need to achieve development goals. • Need for wing dam relocation.
Port of Jefferson County	• Signed MOU with Plaquemines Port Harbor and Terminal District in Louisiana in 2018 to facilitate container vessel service at the port. • Need for additional docks to help with bridge clearance issues that arise further north on the Mississippi River. • Need for additional property acquisition.
Port of Kansas City	• Recent infrastructure improvements have made it one of the fastest growing ports in the Midwest. • Needs support for its recent e-commerce and warehousing/distribution initiatives. • Currently developing Municipal River Terminal, slated to open by 2023.
Port of Lewis County	• Issued bid to construct a transloading facility. • Exploring secondary dock in Lewis County; site not yet chosen. • Need for access roads/utilities, rail access and riverfront development
Port of Metropolitan St. Louis	• Coal is a top commodity; port will be affected by the long-term trend toward a decrease in coal. • FY2020 BUILD grant will modernize a significant amount of the equipment at the Municipal River Terminal. • Need for several rail connectivity upgrades
Port of Mississippi County	• Small port with a ferry and a dry dock repair facility and barge repair facility. • Need for Missouri landing improvements.
Port of New Bourbon	• Experienced damage from flooding in 2019; repairs have since been completed. • Need for improved connectivity with nearby BNSF main line.
Port of New Madrid	• Dependent on maintenance dredging conducted by the USACE. The port would not be able to operate without it. • In 2019, construction began to expand the port to over 80 acres north of its current facilities.

Port	Summary of Needs
	• Need for road/platform and crane system.
Port of Pemiscot County	• Rapidly expanding port with reliable operations, even in low water. • Has direct access to BNSF railways through a five-mile spur and needs continued support for intermodal operation. • Need for construction of a port office.
Port of St. Joseph	• Past has been influenced by delays that can arise during periods of drought or flooding. Traffic was paused between 2011 and 2018 because of the high barge rates that resulted from this. • Traffic has increased since then, notably to transport wind turbine components. The trend toward wind energy suggests future need to support this element of port operations. • Need for investment in conveyor systems.
Southeast Missouri Regional Port	• Continued need for support of intermodal development. It is located near BNSF and UP rail lines as well as three major pipelines. Recently awarded $19.8 million grant to construct two 12,000-foot-long loops of rail track to improve intermodal connectivity.
St. Charles County Port Authority	• Created in January 2020. Site identification in St. Charles is still in progress. Has potential as a strategic location for operational support, fueling services and fleeting.

In addition to the summary of needs and challenges compiled, the Missouri Port Authority Association worked closely with all of Missouri's port authorities to compile a list of unfunded needs throughout the state. This list is shown in Table 4.16.

TABLE 4.16 MPAA UNFUNDED NEEDS LIST FOR MISSOURI PORT AUTHORITIES, FY2022—FY2026

Port Authority	Description	Project Cost	Amount Requested
	FY2022		
Port of Kansas City	Mooring Replacement	$750,000	$400,000
Port of Howard Cooper County	Grain Bins and Grain Handling Equipment	$1,000,000	$800,000
Port of New Bourbon	Improve grade and pave aprons at the Burlington Northern & Santa Fe Railroad Crossing	$263,500	$210,800
Port of Mississippi County	Site Study	$80,000	$64,000
Pike-Lincoln County Port Authority	Port Development NDA in place	$1,400,000	$1,000,000
	Port Development NDA in place	$1,375,000	$1,000,000
Southeast Missouri Regional Port	Loop Track Terminal—Earthwork of Loop No 1 (BUILD Grant match)	$1,250,000	$1,000,000
	Loop Track Terminal—Construction of Loop No 1 (BUILD Grant match)	$1,000,000	$800,000
Port of St. Joseph	A holding bin that would contain approximately two railcars would allow a fluid transition between railcar deliveries of fertilizer and other products to outbound truck. A small leg with the ability to fill the holding bin or spout directly to a truck would be included.	$220,000	$176,000

	A general storage building (wood or steel construction) would house the more expensive equipment—trucks, tractors, loaders and allow pre-storage of palletized products that would be shipped. A dock could also be constructed at one end to the building. Project would also involve the installation of a third winch to help support loading of freight on the river.	$225,000	$180,000
Port of Pemiscot County	Roads/Rail/Conveyor/Dump Pits/Dock Infrastructure	$6,000,000	$1,000,000
	Roads/Rail/Conveyor/Dump Pits/Dock Infrastructure	$6,000,000	$1,000,000
Port of Lewis County	Property Acquisition 500-acre site	$2,500,000	$2,000,000
St. Louis City Port	MRT Rail Upgrade—Phase IV	$1,250,000	$1,000,000
	#5 Clinton Warehouse Improvements—Phase II	$1,250,000	$1,000,000
Port of Jefferson County	Crystal City—Property Acquisition	$2,300,000	$1,000,000
	Kimmswick—At grade RR Crossing full build out Mississippi Ave	$1,200,000	$1,000,000
Port of New Madrid	Conveyor/Crane System	$1,110,000	$888,000
	Port Land Improvements	$1,249,000	$999,200
Heartland Port Authority of Central Missouri	Property Acquisition North and South Port Sites	$725,000	$580,000
	Preliminary Design of the Proposed Port Development and Infrastructure	$976,000	$780,800
	FY2022 Total	**$32,123,500**	**$16,878,800**
FY2023			
Port of Kansas City	Paving & Stormwater Improvements	$750,000	$600,000
Port of Howard Cooper County	Grain Bins	$1,000,000	$800,000
Port of New Bourbon	Complete paving balance of internal road system	$687,000	$549,600
Port of Mississippi County	Lot Paving	$150,000	$120,000
Pike-Lincoln County Port Authority	Site prep, warehouse, utility extension, engineering	$1,106,250	$885,000
	Engineering, rail, site utility improvements	$867,845	$694,276
Southeast Missouri Regional Port	River Road Extension & Utility Installation (BUILD Grant match)	$400,000	$320,000
	Loop Track Terminal—Loop 2 & Storage Track Grading (BUILD Grant match)	$1,000,000	$800,000
Port of St. Joseph	Containment and pumping equipment. With engineering and construction management.	$1,300,000	$1,040,000
Port of Pemiscot County	Roads/Rail/Conveyor/Dump Pits/Dock Infrastructure	$6,000,000	$1,000,000
	Roads/Rail/Conveyor/Dump Pits/Dock Infrastructure	$6,000,000	$1,000,000
Port of Lewis County	400' of sheet wall with RO/RO ramp	$5,500,000	$2,000,000
St. Louis City Port	MRT Rail Upgrade Phase V	$1,500,000	$1,000,000
	MRT Yard Lighting for 24/7 Operations	$1,300,000	$1,000,000
Port of Jefferson County	Kimmswick—Reconstruction Hoppie Marina	$2,500,000	$1,000,000

	Kimmswick Landing Full Build out	$5,100,000	$1,000,000
Port of New Madrid	Port Land Improvements	$1,249,000	$999,200
	Port Land Improvements	$1,249,000	$999,200
Heartland Port Authority of Central Missouri	Extend Utility Services into South Site to serve Infrastructure (electricity, water, sewer)	$831,563	$665,250
	FY2023 Total	**$38,490,658**	**$16,472,526**
FY2024			
Port of Kansas City	Railcar Unloading Pit Conveyor	$300,000	$180,000
Port of Howard Cooper County	Grain Bins and Road Upgrades	$1,000,000	$800,000
Port of New Bourbon	Excavate balance of harbor using dredge material to fill remainder of dredge disposal basin 2	$1,700,000	$1,000,000
Port of Mississippi County	Water Improvements	$250,000	$200,000
Pike-Lincoln County Port Authority	Warehouse/port improvements	$778,000	$622,400
	Port Improvements	$369,250	$295,400
Southeast Missouri Regional Port	Loop Track Terminal—Roadbed Northeast & Wye/Utility Upgrades (BUILD Grant match)	$1,125,000	$900,000
	Loop Track Terminal—Loop No 2 Track Construction (BUILD Grant match)	$1,250,000	$1,000,000
Port of St. Joseph	Preliminary Engineering—Begin preparation for dock expansion to accommodate additional room of cranes for unloading.	$100,000	$80,000
Port of Pemiscot County	Rail Line Acquisition	$700,000	$560,000
	Rail Line Rehabilitation	$1,800,000	$1,440,000
Port of Lewis County	Grade Improvements, Concrete Landing Areas & Roadways	$1,250,000	$1,000,000
St. Louis City Port	MRT Rail Upgrade Phase VI	$1,250,000	$1,000,000
	MRT 90K SF Warehouse: New Solar Roof	$1,500,000	$1,000,000
Port of Jefferson County	Herculaneum —Bridge over Jouchim Creek	$3,500,000	$1,000,000
	Crystal City Rail loop	$8,000,000	$1,000,000
Port of New Madrid	Warehousing	$1,235,000	$988,000
	Port Land Improvements	$1,249,000	$999,200
Heartland Port Authority of Central Missouri	Bridge and Road Infrastructure into South Site (Phase 1)	$6,250,000	$3,125,000
	FY2024 Total	**$33,606,250**	**$17,190,000**
FY2025			
Port of Kansas City	Dock Replacement	$14,700,000	$1,000,000
Port of Howard Cooper County	Grain Bins/Fertilizer Storage	$1,000,000	$800,000

Port of New Bourbon	Widen and pave New Bourbon Port Road from U.S. Highway 61 to Burlington Northern & Santa Fe Railroad crossing (Phase I)	$280,000	$224,000
Port of Mississippi County	Dorena II Improvements	$295,000	$236,000
Pike-Lincoln County Port Authority	Port Utility/Road Improvements/Engineering	$331,250	$265,000
	Building Improvements land prep	$625,000	$500,000
Southeast Missouri Regional Port	Loop Track Terminal—Harbor Wye Demo / Grading / Reconstruction (BUILD Grant match)	$1,500,000	$1,000,000
	Loop Track Terminal—Channel Wye Grading & Drainage (BUILD Grant match)	$1,000,000	$800,000
Port of St. Joseph	Additional room of cranes for unloading large and heavy items. The dock's weight and pressure capacity will also be increased	$1,600,000	$955,000
	Pavement—Fill and pavement the length of the expanded dock to the east and adjoining to the concreate roadway.	$900,000	$715,000
Port of Pemiscot County	New Port Office	$500,000	$400,000
	Rail Loop	$5,000,000	$1,600,000
Port of Lewis County	Rail System	$10,000,000	$3,000,000
St. Louis City Port	MRT New 10M ton Warehouse—Phase I	$11,000,000	$1,000,000
	20-ACRE South Riverfront Site Prep—Phase I	$1,500,000	$1,000,000
Port of Jefferson County	Crystal City Rail loop	$8,000,000	$1,000,000
	Crystal City Slack Water Harbor Phase One	$11,200,000	$1,000,000
Port of New Madrid	Port Land Improvements	$1,249,000	$999,200
	Port Land Improvements	$1,249,000	$999,200
Heartland Port Authority of Central Missouri	Bridge and Road Infrastructure into South Site (Phase 2)	$5,156,250	$2,578,125
	FY2025 Total	**$77,085,500**	**$20,071,525**
FY2026			
Port of Kansas City	Paving	$500,000	$300,000
	Warehouse Rehab	$750,000	$480,000
Port of Howard Cooper County	Grain Bins Upgrade Grain Handling Equipment	$1,000,000	$800,000
Port of New Bourbon	Burlington Northern & Santa Fe Railroad crossing to port entrance (Phase 2)	$1,760,000	$1,000,000
Port of Mississippi County	New Tug	$1,500,000	$1,200,000
Pike-Lincoln County Port Authority	Engineering/site plan/grading	$235,000	$188,000
	Dock/Site Improvements	$285,000	$228,000
Southeast Missouri Regional Port	Railroad Bridge Upgrades	$800,000	$640,000
	SE Middle Main Construction	$1,500,000	$1,000,000
Port of St. Joseph	Land acquisition—Land acquisition of land to the north of the port for additional storage, clean-up and clearing.	$500,000	$375,000

	Pavement—Hard surface paving for additional storage of acquired land.	$500,000	$375,000
Port of Pemiscot County	Rail Loop	$3,500,000	$1,000,000
	Rail Loop	$2,500,000	$1,000,000
Port of Lewis County	Product Storage/Warehouse/Barge Construction	$8,000,000	$3,000,000
St. Louis City Port	MRT New 10M ton Warehouse—Phase II	$11,000,000	$1,000,000
	20-ACRE South Riverfront Site Prep—Phase II	$1,500,000	$1,000,000
Port of Jefferson County	Crystal City Rail Loop	$8,000,000	$1,000,000
	Crystal City Slack Water Harbor Phase one continued	$11,200,000	$1,000,000
Port of New Madrid	Port Land Improvements	$1,249,000	$999,200
	Port Land Improvements	$1,249,000	$999,200
Heartland Port Authority of Central Missouri	Dock Infrastructure and Conveying System	$7,875,000	$3,937,500
	FY2026 Total	**$65,403,000**	**$21,521,900**

5.0 Scenario Planning and Impacts on Future Freight Demand

As exemplified by significant changes that occurred because of the COVID-19 pandemic, it can be difficult to predict how disruptor events and changes to trends will impact freight demand and freight flows. It is impossible to know what the future holds and how world events will change the economic forces behind freight movements and affect commodity flows on Missouri's freight network. It remains useful to manipulate future commodity flow forecasts using a set of assumptions and currently known information as part of a scenario planning exercise to analyze where disruptor impacts may show up. This section will summarize the results of two such analyses.

This section examines the impacts on future commodity flows of two trends and disruptors (the context of which are both described in greater detail in Section 3.0):

- **Scenario A: Renewable Energy**—This trend accelerates a shift in energy commodities away from fossil fuels such as coal, crude oil and petroleum products and towards renewable energy products, leading to an increase in metallic ore commodities such as cobalt, lithium and nickel ores.

- **Scenario B: Near-shoring**—This trend accelerates a shift in the design of trade policies and supply chains that encourage domestic production of certain manufacturing and apparel commodities.

These scenarios use assumptions about impacts on the commodity flow forecast for the Transearch database provided by IHS Markit, Inc. Transearch is an annual database of U.S. county-level freight movement data organized by Standard Transportation Commodity Code commodity types. This database was supplemented by the 2018 Carload Waybill Sample for Missouri.[135] The Transearch database used in this scenario planning analysis was aggregated to the two-digit STCC commodity group level.

5.1 Scenario A: Renewable Energy

The first scenario examines a shift away from fossil fuel commodities such as coal, crude oil and petroleum and toward renewable energy commodities, which would increase the number of metallic ore commodities. This section analyzes the impacts of this scenario on freight in Missouri.

To model these scenario impacts, it was assumed that, compared with the baseline forecast, there would be a 0.5% shift (compounded year-over-year) away from fossil fuel commodities and toward renewable energy commodities. This shift would decrease the commodity flows of the following STCC2 commodity groups: 11 (Coal), 13 (Crude Oil, Liquified Natural Gas and Natural Gas) and 29 (Petroleum and Coal Products). It would also increase the commodity flows of STCC2 commodity group 10 (Metallic Ores). Compared to the original forecast and using 2018 as the base year, by 2030 this shift would cumulatively lead to a 5.8% decrease in the tons and value of STCC 11, STCC 13 and STCC 29 commodities and a 6.2% increase in STCC 10 commodities. By 2045,

[135] For more details on the Transearch and Carload Waybill datasets, as well as specifics on STCC commodity code types, please see the Commodity Flow Profile of the 2022 SFRP.

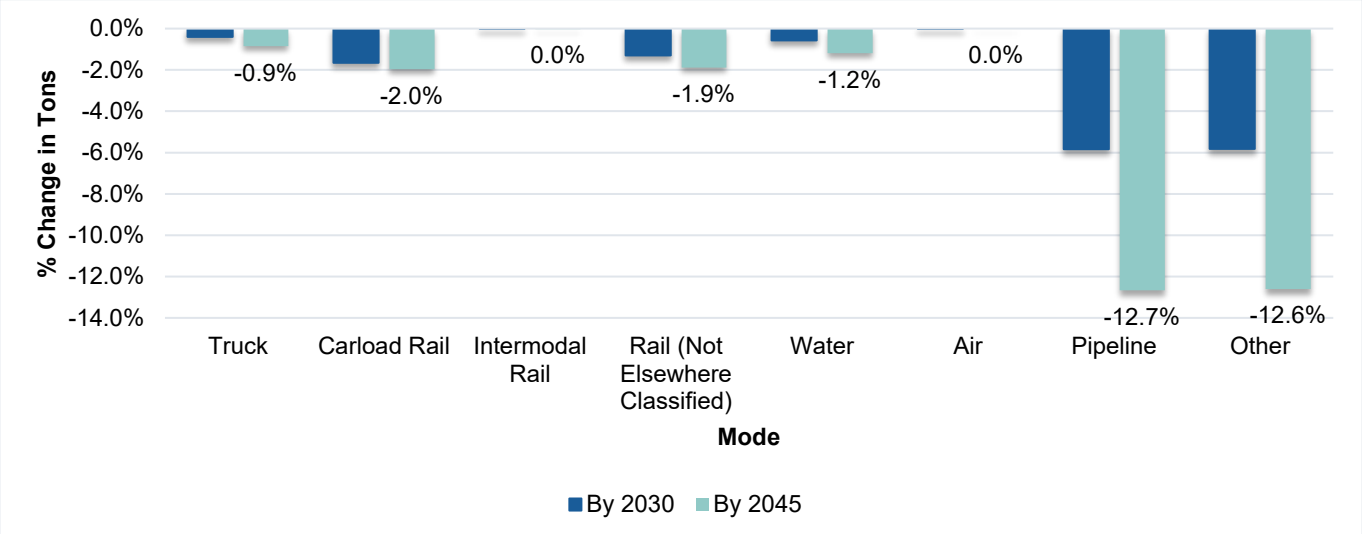
this would cumulatively lead to a 12.7% decrease in the tons and value of STCC 11, STCC 13 and STCC 29 commodities and a 14.4% increase in STCC 10 commodities.

One limitation of this analysis is that, though we know that fossil fuel commodities will decrease, we know less about what commodities will increase because of this shift. As such, this analysis may be biased toward a decrease in commodity flows. The only commodity projected to increase in this model is STCC10, Metallic Ores. However, as discussed in Section 3.0, changes to this trend are likely to impact other commodities, notably transportation and motor vehicle manufacturing. For this model, it was assumed that these commodities would neither increase nor decrease and that this shift would appear in the *kinds* of commodities being produced rather than the *amount and value* of those commodities.

In total, by 2030, this shift would lead to 1.3% decrease in the total tons (977.8 million tons vs. 990.9 million tons) and a 0.3% decrease in total freight value ($1,289.7 billion vs. $1,293.2 billion). By 2045, this shift would lead to 2.2% decrease in the total tons (1,146.1 million tons vs. 1,171.3 million tons) and a 0.4% decrease in total freight value ($1,784.7 billion vs. $1,792.6 billion).

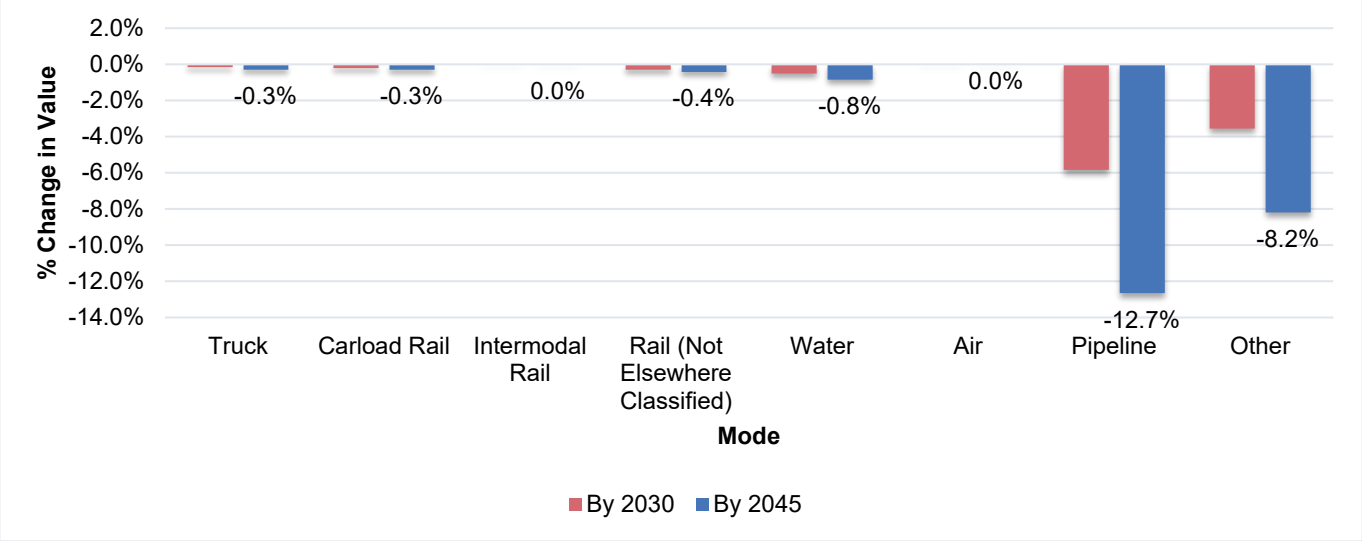
By mode, this would lead to the most significant decreases in tons and value transported on pipelines. This is because, as discussed in the Pipeline Freight Modal Profile, crude oil comprises 99.9% of commodities transported on pipelines. This shift would also impact freight rail flows, leading to decreases in carload rail and rail (not elsewhere classified) tons and value. Truck and water flows would also see modest decreases in both tons and value, and air and intermodal rail would not see any shift. Figure 54 and Figure 55 show more detail about the impact of this shift on mode.

FIGURE 54 MODAL IMPACTS OF SHIFT TO RENEWABLES, BY TONS



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

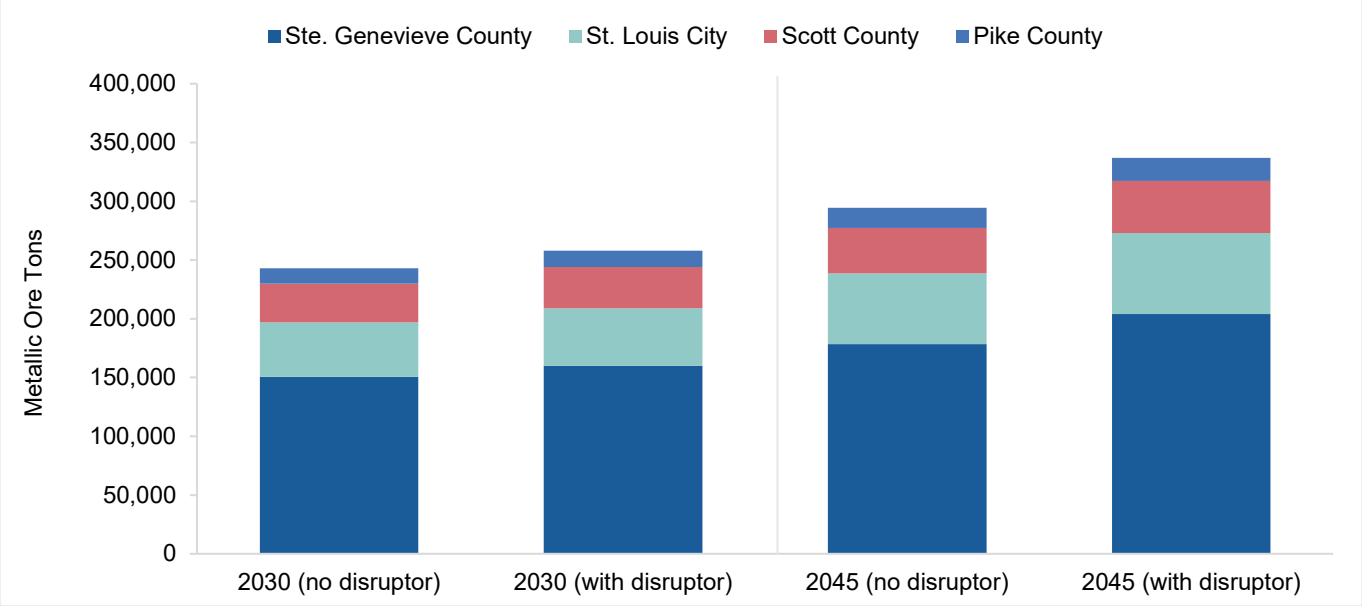
FIGURE 55 MODAL IMPACTS OF A SHIFT TO RENEWABLES, BY VALUE



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

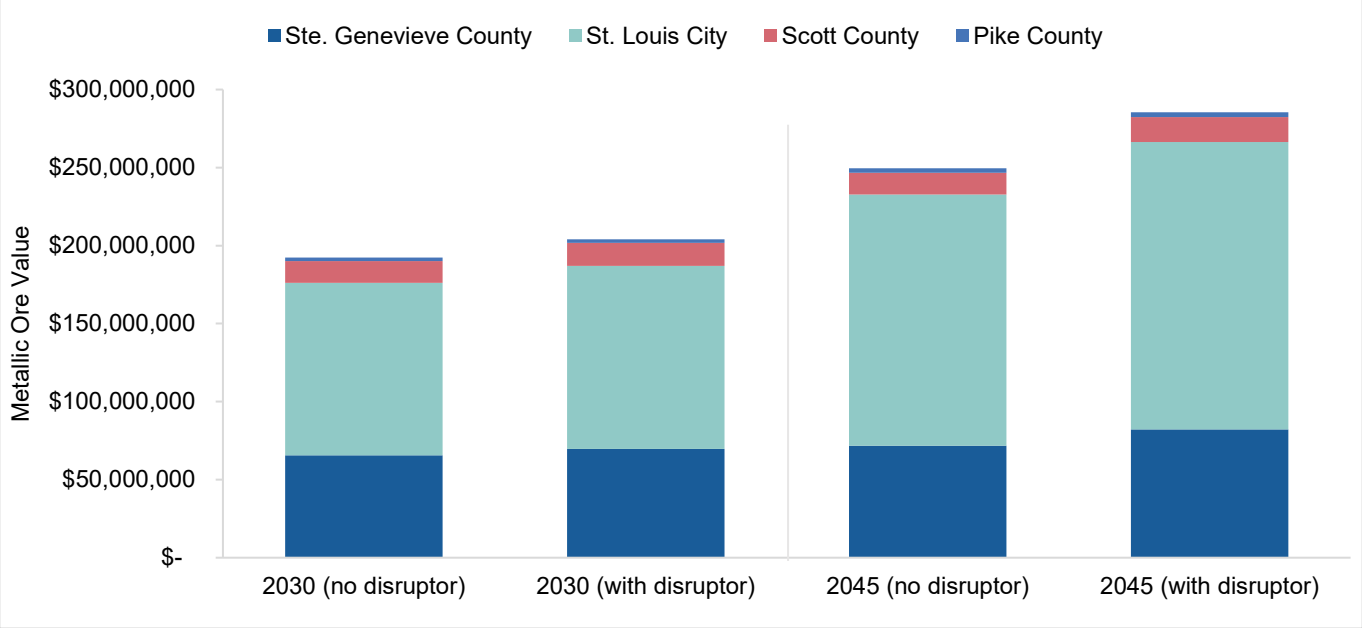
In the Transearch database, 99% of the STCC10 Metallic Ore commodities that originate in Missouri come from four regions: Ste. Genevieve County, St. Louis City, Scott County and Pike County. These regions could potentially see increases in the tonnage and value of the STCC10 Metallic Ore commodities. Ste. Genevieve County sees the highest tons of originating commodities, while St. Louis City see the highest value of originating commodities. The total tons and value of STCC10 commodities originating in these counties are shown in Figure 56 and Figure 57.

FIGURE 56 IMPACT OF A SHIFT TO RENEWABLES ON METALLIC ORE ORIGINATING FLOWS, BY TONS



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

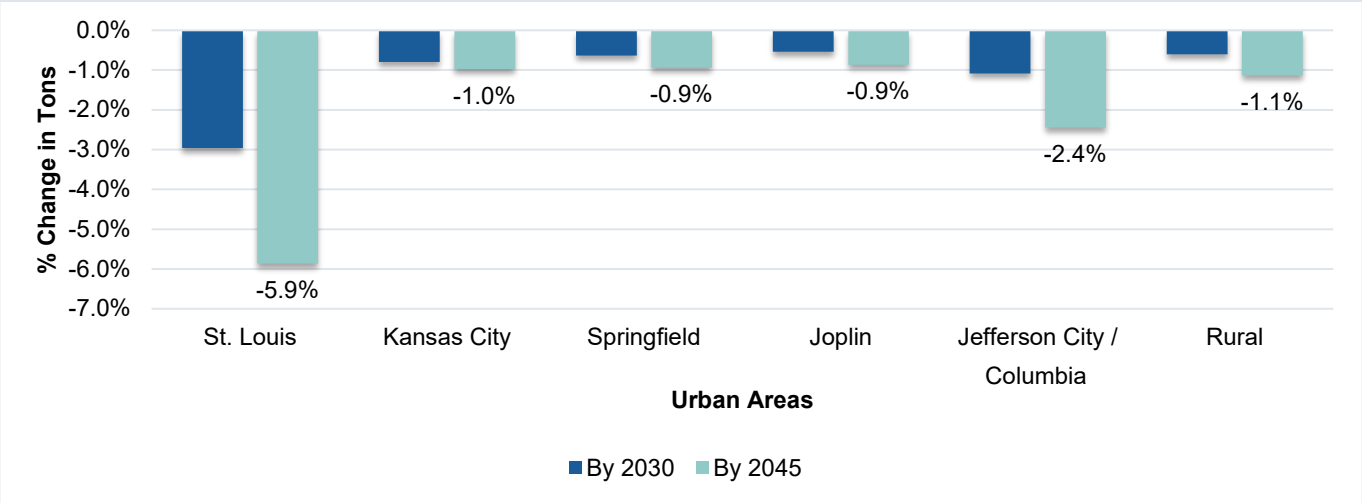
FIGURE 57 IMPACT OF A SHIFT TO RENEWABLES ON METALLIC ORE ORIGINATING FLOWS, BY VALUE



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

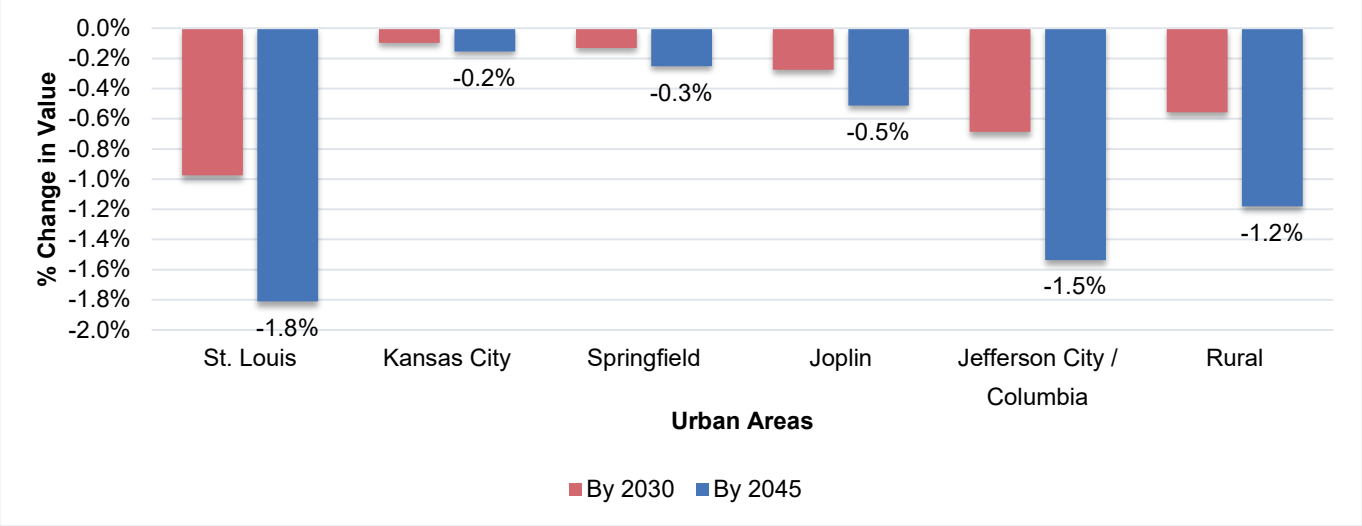
Finally, the shift toward renewables is likely to have disparate impacts on Missouri's urban areas and rural counties. The St. Louis region may see the largest decrease both in terms of tons and value of goods because of this shift. The Jefferson City/Columbia area may also see a significant decrease in total commodity tons and value, as well as Missouri's rural counties. The decrease of freight flows in Kansas City, Springfield and Joplin are likely to be more modest. Details about these impacts are shown in Figure 58 and Figure 59.

FIGURE 58 IMPACT OF A SHIFT TO RENEWABLES ON MISSOURI URBAN AREAS, BY TONS



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

FIGURE 59 IMPACT OF A SHIFT TO RENEWABLES ON MISSOURI URBAN AREAS, BY VALUE



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

5.2 Scenario B: Near-Shoring

The second scenario considers the potential changes to commodity flows from a shift toward certain manufacturing and apparel commodities being produced in North America and importation of fewer of those same commodities. As discussed in Section 3.0, supply chain globalization in the past several decades led to significant increases in certain goods being imported rather than being produced domestically. The shift away from transglobal trade has intensified since the onset of the COVID-19 pandemic. As such, this scenario contemplates a reversal in this trend back toward domestically manufactured goods.

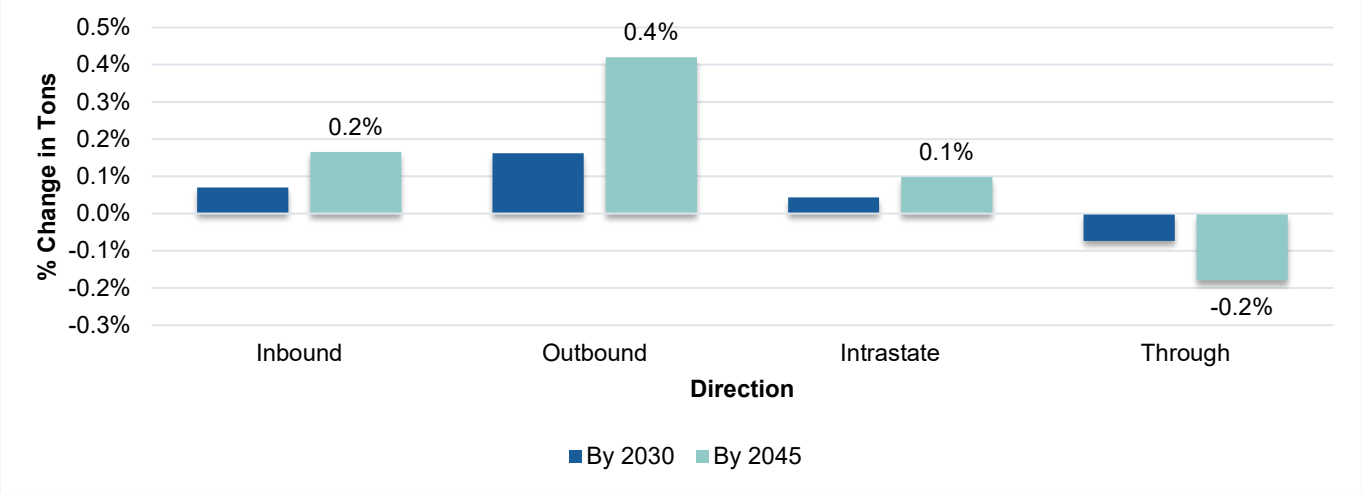
To model these scenario impacts, a 0.5% shift was modeled (compounded year-over-year) away from imported goods and toward domestic production. This model specifically applies to the manufacturing of commodities related to apparel, machinery, electrical equipment, transportation equipment and instruments and optical goods. This corresponds with the following STCC2 commodity groups: 23 (Apparel and Finished Textile), 35 (Machinery [Excluding Electrical]), 36 (Electrical Machines and Equipment), 37 (Transportation Equipment), and 38 (Instruments and Optical Goods). These commodities were chosen as the most likely to be affected by a shift in manufacturing trends where more commodities are produced in the United States and fewer are imported.

A difference between this scenario and Scenario A is that, in this case, there are existing import flows for each of these commodities that are being shifted toward domestic flows. Therefore, the tons and value that would have been imported are moved from imported origins to domestic origins. This means that the total tons and value of freight on Missouri's freight system would be the same; what has changed is where those freight flows begin and where they are headed.

One aspect that this scenario will likely impact is a shift in the direction of freight flows. In the baseline forecast, through flows, which proceed through the state of Missouri, make up most flows based on both tons and value. If there is a shift away from imports and toward domestic production, this will likely result in a decrease in the tons

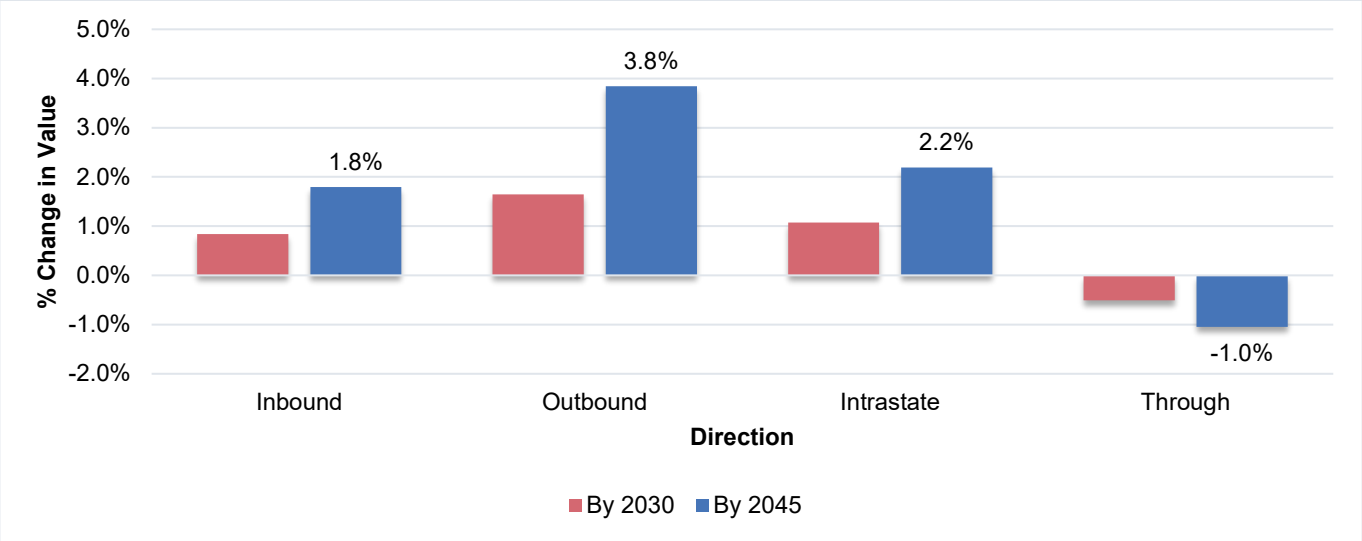
and value of through flows and an increase in flows that are outbound from Missouri, inbound to Missouri, or intrastate within Missouri. The model for this scenario estimates that the shift in terms of tons will be relatively small while the shift in terms of value will be larger. Additionally, the model suggests that the largest increase will occur for outbound freight flows. These changes are summarized in Figure 60 and Figure 61.

FIGURE 60 IMPACT OF SHIFT TOWARD NEAR-SHORING GOODS ON FREIGHT FLOW DIRECTION, BY TONS



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

FIGURE 61 IMPACT OF SHIFT TOWARD NEAR-SHORING GOODS ON FREIGHT FLOW DIRECTION, BY VALUE

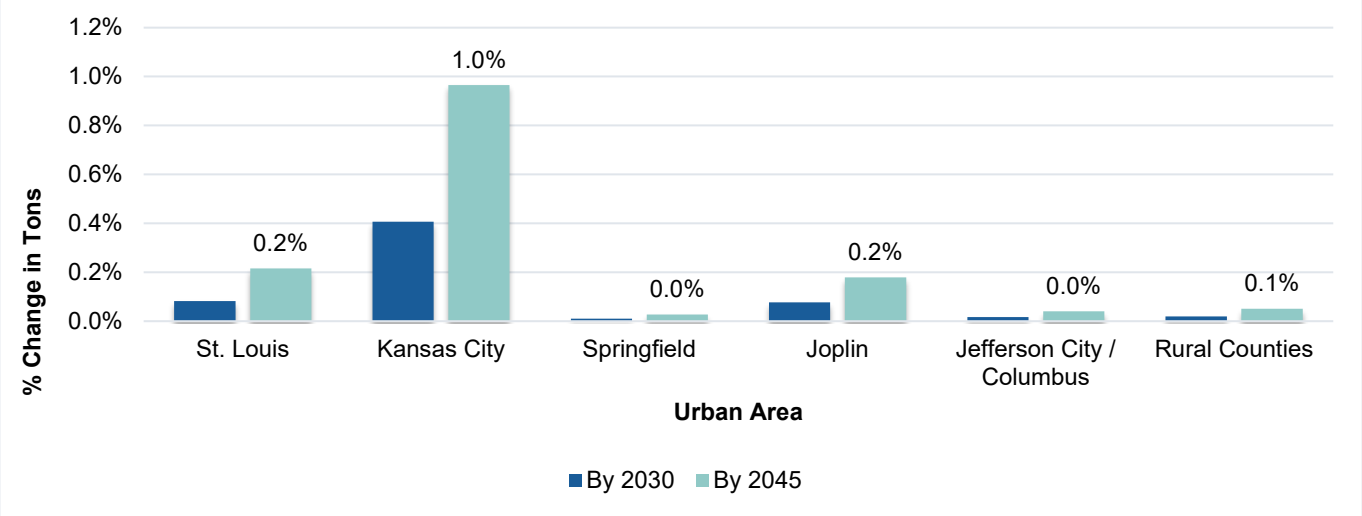


Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

The general shift from through flows and to inbound/outbound/intrastate flows translates to a general increase in the value and tons of freight in Missouri's urban areas and rural counties. In particular, the Kansas City area may

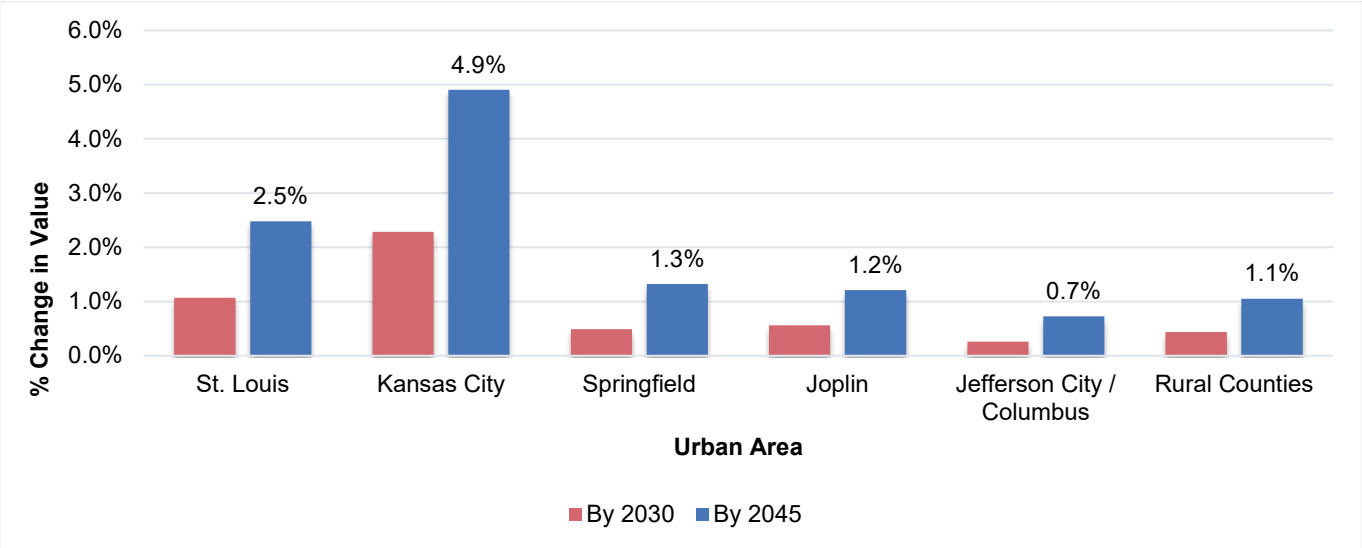
see the highest relative increase in freight tons and value, though St. Louis is also likely to see a significant increase in freight tons and value. Additional results for Missouri's urban areas are shown in Figure 62 and Figure 63.

FIGURE 62 IMPACT OF SHIFT TOWARD NEAR-SHORING GOODS ON MISSOURI URBAN AREAS, BY TONS



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

FIGURE 63 IMPACT OF SHIFT TOWARD NEAR-SHORING GOODS ON MISSOURI URBAN AREAS, BY VALUE

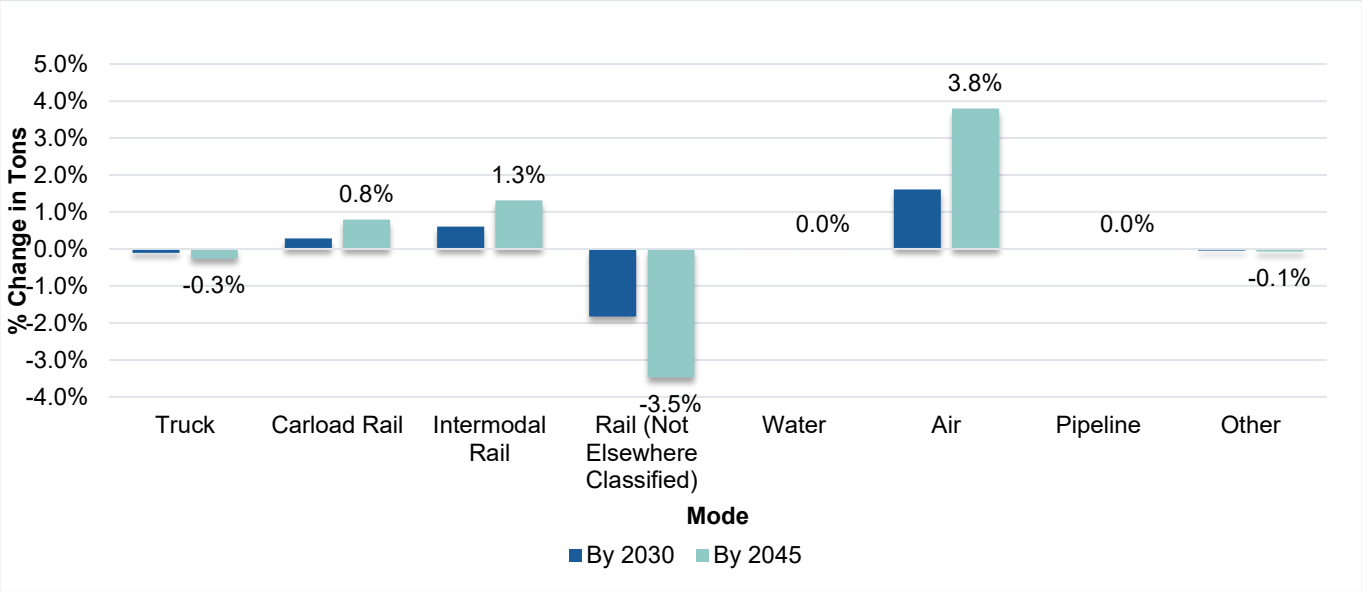


Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

Finally, a shift toward domestic production will impact flow mode. As this scenario envisions a decrease in imports, the largest decrease in mode is for rail (not elsewhere classified) flows, which are rail movements where

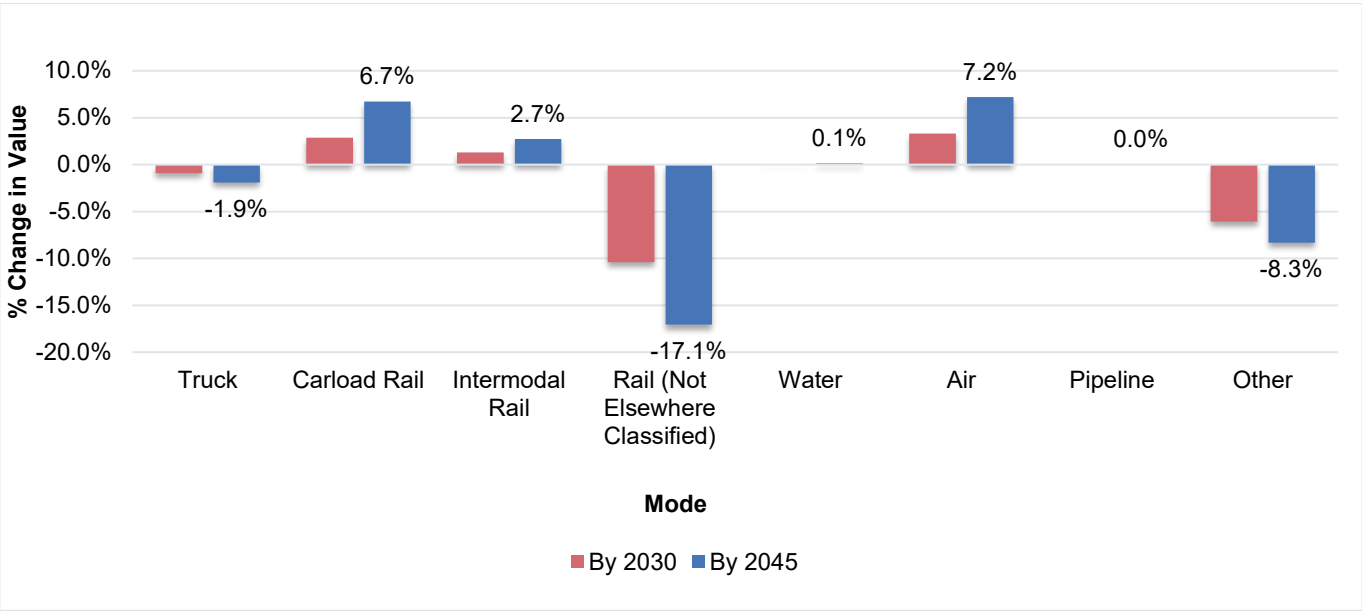
Transearch does not specify if they are carload or intermodal rail flows. These flows are typically composed of shipments from Canada or Mexico under the United States-Mexico-Canada Agreement, so it would be expected that these flows would decrease in a near-shoring scenario. Additionally, there will be an increase carload and intermodal rail flows as well as air flows. Finally, there may be a modest decrease in tons or value of truck flows. Detailed modal impacts are shown in Figure 64 and Figure 65.

FIGURE 64 IMPACT OF SHIFT TOWARD NEAR-SHORING GOODS ON MODE, BY TONS



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

FIGURE 65 IMPACT OF SHIFT TOWARD NEAR-SHORING GOODS ON MODE, BY VALUE



Source: IHS Transearch, Analysis By Cambridge Systematics, Inc. (2021)

6.0 Future Needs & Challenges

One of Missouri's biggest challenges for the future of its multimodal freight system is keeping pace with growing and changing demand. As discussed in Section 3.0, Missouri is expected to be impacted by changes in socioeconomic, macroeconomic and societal trends. The share of Missourians aged 65+ is growing and it is projected that 10 counties will have greater than 30% of their population over the age of 65 by 2030. In addition, recent migration trends indicate that the next 30 years will bring large growth in the suburban counties surrounding Kansas City, St. Louis and Springfield, with significant declines continuing in the rural areas, most notably north of U.S. Route 36 and in the south-central area of the state. These shifting demographics will have an impact of freight demand and the needs of the multimodal freight transportation network.

Today, Missouri's interstate highway system is largely reliable for freight mobility across the interstate system, apart from the state's urban centers of St. Louis and Kansas City, which are home to larger, more concentrated populations and denser highway infrastructure relative to the rest of the state. As part of the 2022 SFRP, MoDOT gave particular focus to three freight bottlenecks—two in St. Louis and one in Kansas City—to better understand average truck speeds and reliability at those locations.[136] Missouri's non-interstate highways are less reliable than the interstates, in large part because they are not designed to provide the same level of efficiency in terms of the free flow of traffic. This impacts rural freight generators throughout the state—particularly in the agriculture and manufacturing sectors—which benefit from large sites for business and manufacturing activity but may struggle with access and reliability to some sites due to reliability and congestion concerns along some rural U.S. routes and state corridors.

In addition to the highway system, Missouri has a robust multimodal freight network. Rail offers an attractive mode for freight with its ability to move high volumes in a cost-efficient manner across long distances, and barges traveling on the Mississippi and Missouri Rivers provide Missouri shippers with access to one of the most economical and environmentally friendly transportation modes available. However, several of Missouri's railroad corridors are close to or exceeding capacity, and some corridors may see increased volumes above their capacity as freight volumes increase. By contrast, there is ample capacity across the inland waterways network and at Missouri's public ports, but many facilities struggle with insufficient infrastructure, unstable river levels and limited multimodal connectivity, which limits their ability to attract tenants and capture increased freight volumes. Demand for air cargo, another critical freight mode, has increased in recent years and especially after the onset of the COVID-19 global pandemic, leading to additional market demand for FedEx and UPS at Missouri's major airports. Despite this, Missouri's airports require upgrades to airport access, airport facilities and industrial development to compete with other freight modes.

It is almost certain that future freight flows in Missouri will increase, but the demand for certain types of commodities and modes has the potential to evolve because of changing macroeconomic conditions. Baseline projections for future freight flows in Missouri estimate that total freight flows in Missouri will increase from 985.3 million to over 1.1 billion tons by 2040. The scenarios described in Section 5.0 describe two notable trends—increased adoption of renewable energy and near-shoring domestic manufacturing growth—that have the potential

[136] The complete analysis and discussion of highway freight condition and performance in Missouri is available in Section 3.0 of the Missouri Freight Profile: Volume 1, produced as part of the 2021 State Freight and Rail Plan.

either further increase or mitigate those projected increases. For example, the renewable energy scenario projects reduced future freight volumes of energy products across all modes but may result in increased mining and transport of heavy metals and minerals because of new types of automobile components, such as batteries. The near-shoring scenario envisions more inbound and outbound freight, especially in Missouri's urban areas, and even greater demand for rail and air cargo modes. These projections require a connected, modernized system that can meet whatever the future needs of Missouri's businesses and consumers may be.

Balancing the demands of freight and passengers across Missouri's multimodal system will be critical to accomplish these goals. The future freight needs identified in this document as part of the 2022 SFRP are aligned with the state's 2018 Long Range Transportation Plan Update, which identified the following needs to address current and future transportation mobility throughout the state:

- Improve bridge and road conditions.
- Grow and stabilize MoDOT maintenance and operations resources.
- Invest in projects that increase economic growth and improve safety and reliability.
- Major interstate reconstruction. The nation's interstate system is over 60 years old, and Missouri's oldest interstates were built with a 20-year life expectancy. Missouri's highway system includes nine primary interstates and nine auxiliary interstates for a total of 1,380 miles—the fifth most in the nation. These routes are important for all travelers, but especially crucial for the freight industry. As the demand for freight shipments continues to increase, interstate reliability is essential for the freight industry.
- Improve multimodal transportation options to improve economic development, safety and provide improved mobility and access to opportunities for all Missourians and businesses.
- Long-term uncertainty. The future of transportation will bring improvements to technology in both passenger movement and freight movement including autonomous or connected vehicles. Though the exact impacts on the transportation system and project needs is unknown, it is anticipated there will be tradeoffs in the spending, and needs will most likely evolve toward the latter half of this planning horizon.

7.0 Conclusion

This report described Missouri's current and future industry outlook, freight drivers, trends and disrupters and the needs across the state's multimodal freight and passenger rail system. It also considered two trends that are likely to impact future freight flows in Missouri in ways that differ from baseline projections, indicating that Missouri's most freight-intensive industries may adjust their supply chains to adapt to macroeconomic forces. The state is in a favorable position to adapt to meet anticipated future freight demand, with strong existing access to a robust highway, rail, air cargo and waterways network. However, it is critical for MoDOT to maintain a safe, efficient and resilient highway freight system, as well as support the development of and access to multimodal rail, port, air cargo and pipeline infrastructure, to best position the state's businesses and industries for future growth and success.