# TABLE OF CONTENTS

INTRODUCTION ............................................................................................................................... 3  
PROJECT ...................................................................................................................................... 3  
SCOPE AND PURPOSE .............................................................................................................. 3  
ECONOMIC DRIVERS OF HEARTLAND REGION ........................................................................ 4  
  COMPOSITION OF THE REGIONAL ECONOMY .................................................................... 4  
  COMPOSITION OF REGIONAL FREIGHT TRAFFIC ............................................................... 11  
NODAL ANALYSIS .................................................................................................................. 20  
  Rural Node Analysis ............................................................................................................. 22  
CONNECTION BETWEEN STATE AND METROPOLITAN ECONOMIES ............................ 27  
IMPLICATIONS FOR FREIGHT TECHNOLOGY ...................................................................... 45  
APPENDIX A – HEARTLAND AND EXTERNAL REGIONS ..................................................... 47
INTRODUCTION

PROJECT BACKGROUND
The Heartland Region is a national hub for agriculture, manufacturing and freight distribution that includes the states of southwestern Illinois, Iowa, Kansas, Missouri, and Nebraska. Changes in the freight industry are creating a paradigm shift in how all participants in goods movement (from supplier to end consumer) interface with transportation infrastructure. To address the need that this shift presents, the Heartland Region has created this project to develop a freight technology plan (Heartland Freight Technology Plan) that will deliver:

• A prioritization framework for new technologies;
• Goals and strategies for harmonizing regulation;
• Recommendations for data management and sharing, and;
• A blueprint for action and implementation.

The Heartland Freight Technology Plan (plan) is part of FHWA’s National Economic Partnership grant program, and is being developed through a partnership of six MPOs, five state DOTs, the Heartland Civic Collaborative and other academic, business and industry leaders.

To assist the Heartland Freight Technology Consortium (Consortium) in engaging key public and private stakeholders around a regional freight technology plan, the following engagement strategy outlines roles, responsibilities, and communication methods to foster input, buy-in and sustained collaboration throughout the plan development, implementation and beyond.

SCOPE AND PURPOSE
This task of the Heartland Freight Technology Plan provides a description of the freight flows, economies, supply chains and market linkages within the study area that helps to define the needs and opportunities in future tasks. Specifically, this task,

• Identifies the top economic drivers of the region
• Defines the major urban and rural nodes within the study area
• Defines the connections between state and metropolitan economies

The area of study for this task includes all counties in Missouri, Nebraska, Kansas, and Iowa, as well as counties in Illinois that are part of Region 5 of the Illinois Department of Transportation (IDOT).
ECONOMIC DRIVERS OF HEARTLAND REGION

The composition of the Heartland regional economy and its freight traffic provides a basis for identifying the industrial drivers for the region and the economic contribution represented by the commodities they produce and transport. This section defines the major industries in urban and rural areas, their economic significance, their commodities, geographic clusters and their traffic patterns, all setting the stage for defining the economic and transport nodes of the region in the subsequent section.

COMPOSITION OF THE REGIONAL ECONOMY

Figure 1 below displays the percentage of population living in rural and urban areas by county within the Heartland region. The determining factor is the percent of each county’s population residing outside of towns in rural territory. The counties are classified into three categories based on this rural population percentage, requiring 70 percent of county population to live outside of towns as the threshold for classification as mostly rural:

- Mostly Urban – 0-69% county rural population
- Mostly Rural – 70%-99% county rural population
- Completely Rural – 100% county rural population

As shown in Figure 1, the majority of the county population lives in mostly or completely rural territory for the preponderance of counties in the Heartland region. As expected, counties classified as mostly urban typically are part of metropolitan areas, with some exceptions. The instances of 100 percent rural counties tend to increase in the western portion of the study area and along the Iowa/Missouri border.
Gross domestic product (GDP) measures the value of goods and services that occurs in a region. It is the difference between an industry’s economic output, and the value of purchased inputs. Value added includes labor costs, taxes, and property income. Freight-dominant industries analyzed include manufacturing, wholesale trade, retail trade, transportation and warehousing, mining and extraction, construction, accommodation and food service, agriculture, forestry, fishing, and hunting. Of these industries, manufacturing accounts for the largest share at 35 percent of GDP, followed by retail trade (15 percent) and wholesale trade (14 percent) as shown in Figure 2. Manufacturing includes not just the manufacture of durable goods, but also a range of non-durable goods, including processing of agricultural products. For example, a meat packing plant would be included within manufacturing, as would dairy processing facilities.
Table 1 presents a breakdown of the share of manufacturing GDP by subsector in the Heartland Region. GDP data broken down by subsectors of the manufacturing industry are available by state but not by county, the data presented in Table 1 below is for the four states included in the study region, but not including Illinois counties. Durable product manufacturing has a slightly higher share of GDP than non-durable product manufacturing in the four-state region. However, several non-durable products are among the largest subsectors in each state, including food and beverage manufacturing, followed by chemical manufacturing. Overall, machinery manufacturing is the largest subset of durable goods manufacturing.

** Mining, Quarrying, and Oil and Gas Extraction $3B (1%) **
Table 1: Share of Manufacturing Gross Domestic Product in Four State Region

<table>
<thead>
<tr>
<th>Manufacturing Subsector</th>
<th>Iowa</th>
<th>Kansas</th>
<th>Missouri</th>
<th>Nebraska</th>
<th>4 State</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Durable goods manufacturing</strong></td>
<td>52%</td>
<td>52%</td>
<td>54%</td>
<td>45%</td>
<td>52%</td>
</tr>
<tr>
<td>Machinery manufacturing</td>
<td>18%</td>
<td>7%</td>
<td>7%</td>
<td>9%</td>
<td>10%</td>
</tr>
<tr>
<td>Other transportation equipment manufacturing</td>
<td>1%</td>
<td>26%</td>
<td>6%</td>
<td>1%</td>
<td>9%</td>
</tr>
<tr>
<td>Fabricated metal product manufacturing</td>
<td>6%</td>
<td>5%</td>
<td>8%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Computer and electronic product manufacturing</td>
<td>8%</td>
<td>3%</td>
<td>7%</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>Motor vehicles, bodies and trailers, and parts manufacturing</td>
<td>3%</td>
<td>3%</td>
<td>10%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Electrical equipment, appliance, and component manufacturing</td>
<td>3%</td>
<td>2%</td>
<td>5%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Miscellaneous manufacturing</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>11%</td>
<td>3%</td>
</tr>
<tr>
<td>Nonmetallic mineral product manufacturing</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Primary metal manufacturing</td>
<td>4%</td>
<td>1%</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Furniture and related product manufacturing</td>
<td>3%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Wood product manufacturing</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Nondurable goods manufacturing</strong></td>
<td>48%</td>
<td>48%</td>
<td>46%</td>
<td>55%</td>
<td>48%</td>
</tr>
<tr>
<td>Food and beverage and tobacco product manufacturing</td>
<td>23%</td>
<td>16%</td>
<td>18%</td>
<td>33%</td>
<td>21%</td>
</tr>
<tr>
<td>Chemical manufacturing</td>
<td>15%</td>
<td>7%</td>
<td>15%</td>
<td>15%</td>
<td>13%</td>
</tr>
<tr>
<td>Petroleum and coal products manufacturing</td>
<td>1%</td>
<td>16%</td>
<td>3%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Plastics and rubber products manufacturing</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Printing and related support activities</td>
<td>2%</td>
<td>3%</td>
<td>3%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Paper manufacturing</td>
<td>2%</td>
<td>1%</td>
<td>3%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Textile mills and textile product mills</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Apparel, leather, and allied product manufacturing</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Source: U.S. Bureau of Economic Analysis

While manufacturing has a higher share of GDP in the Heartland Region than agriculture, these sectors are interconnected. For example, the largest subsector of manufacturing is food manufacturing, which uses agricultural products. Other large subsectors include chemical and machinery manufacturing which provide inputs to agriculture. Chemical manufacturing encompasses ethanol and biodiesel production, which rely on agricultural inputs. These multiple subsectors are interconnected as a continuous value chain where agricultural products are produced on farms, but manufacturing companies provide both the inputs and process the outputs. This

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2 Specifically, 74% of Heartland outbound agricultural tonnage goes to Heartland counties with food manufacturing, and 58% of inbound chemicals and machinery tonnage comes from Heartland counties.
input/output relationship is illustrated in Figure 3, which shows the inputs and outputs to two sets of agricultural commodities: grain & oilseeds, beef cattle and calves. As shown, for example, the largest inputs to grain and oilseeds are fertilizer and other farm products, but petroleum, vehicles and other machinery manufacturing are important as well. Outputs are either for export, grain and oilseed milling, chemicals and energy product manufacturing, animal production, or a range of other uses.

Figure 3: Input and Output Relationships of Grain and Oilseeds, Beef Cattle and Calves

When considering the economic drivers of the Heartland Region, it is useful to not only consider the size of the industry and how it fits into an economic value chain, but also to consider the distinction between traded and local industries. Traded industries are those that concentrate in a given region but sell products or services across regions and countries. In contrast, local industries are dispersed throughout the nation and are typically present within a region in proportion to the region’s size, in order to serve the local market. Examples of local industries would be real estate services, hospitals, or personal services such as drycleaners. Traded industries are important because they are exposed to competition from other regions and because they help regions to achieve high levels of economic performance. Traded industries are often associated with high levels of productivity, higher wages, and higher innovation. This is significant to the Heartland because – as is shown in Figure 21 later in this document – other parts of the
country and world consistently are the largest or second largest markets by value for the region’s goods. This pattern is a strong positive for the health of the Heartland economy.

Most of the economic activity in the region occurs in the more urban areas. Almost two-thirds of the region’s GDP is generated in counties that are mostly urban. Just five percent is generated in counties that are completely rural, and the remainder of GDP is generated in counties that are mostly rural. This is shown below at the top of Figure 4, followed by the breakdown of GDP by industrial sector for urban and (mostly or completely) rural areas. Manufacturing is a large part of both urban and rural counties in the Heartland Region, accounting for 35 percent of the GDP associated with freight dependent industries in both urban and rural counties. Rural areas have significant contributions from the agricultural industry, while urban areas have a higher contribution from wholesale trade. Retail is the third largest of freight dependent industries in both urban and rural areas.

Figure 4: Heartland Region 2017 Gross Domestic Product by Urban and Rural Areas – Freight Dependent Industries

Much of the Heartland Region’s employment and GDP is concentrated in metropolitan areas, including the six metropolitan regions sponsoring this study, as well as Cedar
Rapids/Iowa City, IA; Lincoln, NE; and Columbia, MO (as shown in Figure 5 and Figure 6).

**Figure 5: Heartland Region Employment**

![Heartland Region Employment Map](image)

*Source: U.S. Census Bureau*

(1) – Utilities $6B (3%)  |  (2) – Agriculture, Forestry and Fishing $2B (1%)  |  (3) – Mining, Quarrying, O&G $1B (0.5%)  
(4) – Accommodation and Food Services $5B (4%)  |  (5) – Mining, Quarrying and O&G $3B (2%)
Figure 6: Heartland Region 2017 Gross Domestic Product

Source: U.S. Bureau of Economic Analysis

COMPOSITION OF REGIONAL FREIGHT TRAFFIC
The movement of freight traffic – by location, direction, mode, and commodity – is an expression of how the economic activity characterized above translates into transportation in service to industrial and consumer markets. Metropolitan areas tend to be the largest origins and destinations of the region’s freight tonnage, as shown in Figure 7 below. However, some major origins within the study region are outside of metropolitan areas. One example is McPherson County, KS just north of Wichita, which appears as a major freight origin in Figure 7 due to the presence of an oil refinery, although the county otherwise does not have a large employment or population base.
As shown in Figure 8:

- The majority (57 percent) of freight flow by tonnage is contained within the Heartland Region, yet the majority by value (61 percent) is external.
- Most freight travels by truck, constituting 73 percent by tonnage and 79 percent by value of all freight flow.
- Rail freight is more prominent (44 percent inbound, 39 percent outbound tonnage) for freight flows into/out of the region.
- The majority (93 percent of tonnage, 92 percent of value) of intra-Heartland regional flow occurs by truck.
Agriculture-related commodities, particularly cereal grains, dominate total tonnages transported within the Heartland Region, as shown in Figure 9. A breakdown by value shows that agriculture is still important in dollar terms but that manufacturing-oriented commodities such as vehicles, mixed freight, machinery, and electronics are also significant. This is supported by the GDP analysis (Figure 2), indicating the prominence of the manufacturing industry within the region.

Source: WSP Disaggregation of Freight Analysis Framework-4
The modal composition of the top commodities by tonnage and value appears in Figure 10. The dependence of all commodities except coal on highway transport – whether the measure is tonnage or value – is the first thing that stands out. The second is the reliance of cereal grains, the largest commodity and a mainstay of the rural economy, on multimodal transport. Rail, water and multiple modes (combinations of highway, rail and water) together carry about one-third of the traffic, and the lower transport costs associated with these modes is important to the competitiveness of Heartland Region agriculture in commodity markets. Other agricultural products have a comparable modal pattern and similar needs.
Waterborne transport is not available equally across the region but always makes a vital contribution to competitiveness for the commodities that can use it. While navigability on the Missouri River typically is limited, the Mississippi River runs along the region’s eastern border and is the backbone of the nation’s inland waterway system. Bulk products are brought by truck and rail to its ports, most notably around St. Louis from whence barges have lock-free passage to the Gulf of Mexico. St. Louis also is an expected node for new river vessel technology, which could add containerized goods to waterborne commodities.

Rail has a larger role and crisscrosses the region. As shown in Figure 11, coal and cereal grains are the major Heartland Region commodities transported by rail. As shown in Figure 11, the vast majority of the coal is transported into the region from outside.
figure also shows that cereal grains and other food items, as well as gasoline are the primary rail-oriented goods shipped to markets outside the region.

*Figure 11: Heartland Region 2017 Tonnage by Rail*

Freight traffic passing through the Heartland Region between other areas of the country is an additional source of demand on infrastructure. Pass-through traffic is of interest to proponents of truck platooning because the technology’s gains in fuel economy can be accumulated over long distances. Very large tonnages of crude oil and coal traverse the region by pipeline and rail. The highway profile appears in Figure 12, revealing the prominent involvement in this traffic of markets in the eastern U.S. An estimated 136M tons of pass-through traffic travels on Heartland Region highways, which accounts for 7 percent of truck tonnage in the region (estimated 1830M tons). In comparison, pass-through traffic freight has an estimated value of $522B, which accounts for more than one-quarter of the dollar value of all freight traffic in the region. Two points should be noted: first, the term “pass-through” is defined here by the entire multi-state region, so that the proportion for any individual state should be higher; and second, a

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4 This graphic and several subsequent ones makes use of a division into regions of the areas of the United States external to the Heartland Region. A map of these regions appears in Appendix A.
significant volume of higher value goods is moving long distances across the region, some of which should be sensitive to, and perhaps able to pay for, technology-enabled service improvements.

Figure 12: Heartland Region 2017 Pass Through Freight

The commodity composition of pass-through truck freight in tonnage and value terms is depicted in Figure 13. Other foodstuffs – which are products manufactured from agricultural inputs – are a familiar class of goods in the Heartland Region; they are the top category by tonnage and significant by value. Motorized vehicles and machinery also stand out by both measures, suggesting a material volume on the roads as well as economic importance to shippers and receivers. Electronics represent the largest class of traffic by value and move primarily on highways connecting the Southwest and Gulf to eastern markets (Figure 14).
Figure 13: Heartland Region 2017 Pass Through Freight Commodities

<table>
<thead>
<tr>
<th>Description</th>
<th>Heartland Passthrough tonnage (Thousands of Tons)</th>
<th>Heartland Passthrough value ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other foodstuffs</td>
<td>9K</td>
<td>$26K</td>
</tr>
<tr>
<td>Nonmetal min. prod.</td>
<td>8K</td>
<td>$17K</td>
</tr>
<tr>
<td>Motorized vehicles</td>
<td>7K</td>
<td>$56K</td>
</tr>
<tr>
<td>Base metals</td>
<td>7K</td>
<td>$29K</td>
</tr>
<tr>
<td>Plastics/rubber</td>
<td>6K</td>
<td>$10K</td>
</tr>
<tr>
<td>Other ag prod.</td>
<td>6K</td>
<td>$50K</td>
</tr>
<tr>
<td>Machinery</td>
<td>5K</td>
<td>$6K</td>
</tr>
<tr>
<td>Newsprint/paper</td>
<td>5K</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Heartland Passthrough tonnage (Thousands of Tons)</th>
<th>Heartland Passthrough value ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronics</td>
<td>4K</td>
<td>$73K</td>
</tr>
<tr>
<td>Motorized vehicles</td>
<td>8K</td>
<td>$56K</td>
</tr>
<tr>
<td>Machinery</td>
<td>6K</td>
<td>$50K</td>
</tr>
<tr>
<td>Misc. mfg. prod.</td>
<td>3K</td>
<td>$31K</td>
</tr>
<tr>
<td>Plastics/rubber</td>
<td>7K</td>
<td>$29K</td>
</tr>
<tr>
<td>Other foodstuffs</td>
<td>14K</td>
<td>$26K</td>
</tr>
<tr>
<td>Textiles/leather</td>
<td>2K</td>
<td>$26K</td>
</tr>
<tr>
<td>Mixed freight</td>
<td>5K</td>
<td>$23K</td>
</tr>
</tbody>
</table>

Source: WSP Disaggregation of Freight Analysis Framework-4
### Figure 14: Heartland Region 2017 Pass Through Electronics Flow

<table>
<thead>
<tr>
<th>Destination Region</th>
<th>Origin Region</th>
<th>East</th>
<th>Gulf</th>
<th>Hawaii &amp; Alaska</th>
<th>Heartland Region</th>
<th>North</th>
<th>North West</th>
<th>South East</th>
<th>South West</th>
</tr>
</thead>
<tbody>
<tr>
<td>East</td>
<td>East</td>
<td>0</td>
<td>25,828</td>
<td>0</td>
<td>0</td>
<td>4,321</td>
<td>4,995</td>
<td>0</td>
<td>35,192</td>
</tr>
<tr>
<td>Gulf</td>
<td>17,568</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2,262</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hawaii &amp; Alaska</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Heartland Region</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>North</td>
<td>3,726</td>
<td>2,648</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,075</td>
<td>2,662</td>
<td>0</td>
</tr>
<tr>
<td>North West</td>
<td>4,475</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,831</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South East</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1,265</td>
<td>2,631</td>
<td>0</td>
<td>18,572</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>South West</td>
<td>35,396</td>
<td>0</td>
<td>0</td>
<td>1,986</td>
<td>0</td>
<td>9,398</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Source: WSP Disaggregation of Freight Analysis Framework-4*
NODAL ANALYSIS

In order to identify urban and rural nodes that are driving the regional economy, economically influential counties and clusters of counties were identified considering the following factors:

- GDP & Employment
- Freight Flow by value

These factors (displayed in Figure 15) were selected for their obvious and direct connection to economic output. By these criteria, the major urban areas, including those of the MPO sponsors of this project, emerge as the primary nodes of the region. No rural nodes stand out with any clarity by these measures.

Figure 15: Summary of Indicators of Urban Economic Nodes

Source: WSP Disaggregation of Freight Analysis Framework-4, U.S. Census Bureau, U.S. Bureau of Economic Analysis
The urban nodes identified include the six metropolitan areas represented by the six member MPOs for this study, in addition to the Cedar Rapids metropolitan area as shown in Figure 16. These seven locations constitute the principal economic nodes of the region according to the criteria applied.

*Figure 16: Summary of Indicators of Urban Economic Nodes*

Source: WSP Disaggregation of Freight Analysis Framework-4, U.S. Census Bureau, U.S. Bureau of Economic Analysis
Rural Node Analysis

Because so much of the physical territory of the Heartland region is rural, the absence of rural areas among the seven nodes identified above suggests that further probing is warranted, using additional criteria tailored to rural activity. The region’s agriculture obviously is in rural territory, as Figure 4 corroborates; there is also a substantial amount of food production and other manufacturing generating outbound freight in these areas. To explore the geographic concentration of such activity, rural counties were evaluated according to five aspects of freight volume:

- Farm products freight outbound
- Farm products freight inbound
- Food production freight outbound
- The combination of the above 3 freight volumes
- All manufacturing freight outbound

The same twenty counties proved prominent under each of these five aspects, whether measured by tonnage or by value of goods. Changing the definition of rural counties to 50% rural instead of 70% did not affect the results. The twenty key rural counties emerging from this analysis are displayed in Figure 17.

Figure 17: Key Rural Counties Across 5 Aspects
The following Figure 18 helps to place the twenty rural counties into context by displaying them (in pink) alongside a) the region’s top counties for outbound food manufacturing; and b) the seven urban nodes previously defined. Some fall in the orbit of the urban nodes, some are isolated, and two lie between the Cedar Rapids node and the Quad Cities district straddling Iowa and Illinois. However, two new and significant concentrations of activity appear: five Heartland counties adjacent to the food producing areas of Sioux City, IA and Sioux Falls, SD; and two counties next to food producing locations that run along the I-80 corridor west from Grand Island, NE. These two areas – Sioux City/Sioux Falls and Grand Island/I-80 - constitute important additional nodes, making nine total nodes of economic activity for the Heartland region.

*Figure 18: Rural node identification*
The nine nodes cover most of the region’s GDP and jobs, much of the value of originating or terminating freight, but only one-third of the tonnage as indicated in Table 2. Tonnage (as the previous figure displays) is far more dispersed, consistent with the prominence of agriculture across the large rural territory.

**Table 2: Node Contribution to Regional Economy and Freight Flow**

<table>
<thead>
<tr>
<th>Regional Nodes</th>
<th>2017 GDP</th>
<th>2017 Employment</th>
<th>2017 Freight Flow Tons (Thousands)</th>
<th>2017 Freight Flow Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>East-West COG</td>
<td>20%</td>
<td>20%</td>
<td>10%</td>
<td>15%</td>
</tr>
<tr>
<td>MARC</td>
<td>16%</td>
<td>16%</td>
<td>6%</td>
<td>12%</td>
</tr>
<tr>
<td>Omaha Metropolitan Area</td>
<td>8%</td>
<td>7%</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>Des Moines Metropolitan Area</td>
<td>6%</td>
<td>5%</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Wichita Area MPO</td>
<td>4%</td>
<td>4%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Ozark Transportation Org</td>
<td>2%</td>
<td>3%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Cedar Rapids MSA</td>
<td>4%</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Sioux City/Sioux Falls</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>Grand Island/I-80</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Rest of Heartland</td>
<td>37%</td>
<td>39%</td>
<td>67%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Source: WSP Disaggregation of Freight Analysis Framework-4, U.S. Census Bureau, U.S. Bureau of Economic Analysis
Manufacturing, Wholesale Trade and Retail were the primary freight-oriented industrial sectors in the Heartland nodes, as defined by industrial contribution to 2017 GDP (shown in Figure 19). These sectors account for two-thirds of GDP from freight dependent industries for the nine nodes together, and for most of them individually.

**Figure 19: Regional Node Industry Profile – Percentage of Freight-Dependent Gross Domestic Product**

Source: U.S. Bureau of Economic Analysis
As shown in Figure 19, motorized vehicles, mixed freight and pharmaceuticals are the top three commodities overall by value that originate or terminate in the identified nodes. The Wichita Area MPO has significant contributions from transportation equipment (notably in aviation) and “coal not elsewhere classified”, which is a catch-all energy category that includes asphalt, propane and lube oils. The rest of the Heartland Region trades in cereal grain, other foodstuffs, and agriculture-related commodities.

Figure 20: Regional Node Commodity Profile by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
CONNECTION BETWEEN STATE AND METROPOLITAN ECONOMIES

The function of the nodes in serving the regional economy and connecting locations within and outside Heartland territory is explored in this section. This is done by examining the relative size of trading partners in terms of the freight tonnage and product value carried by truck, as presented in Figure 21\(^5\). The region is broken down into flows between each of the eight nodes and five geographic groups: with the node itself and between nodes; with the surrounding state and with the rest of Heartland; and with national and global markets.

Considered by tonnage (at the top of the Figure), Heartland nodes primarily trade with their respective states, followed by intra-nodal (local) trade and trade with the rest of the U.S. and world. Trade with the rest of Heartland is comparatively weak. The main exception to this pattern is that the three nodes with smaller GDP (Ozark Transportation Organization, Sioux City/Sioux Falls, and Grand Island/I-80) trade less locally - presumably because the local area is a smaller market; instead, two of them trade more with the other Heartland nodes, and one with the rest of Heartland. The rest of state(s) is consistently the largest trading partner by tonnage for each metropolitan area except the Kansas City metropolitan area, for which rest of state is second to the local area as the largest trading partner.

Considered by value (at the bottom of the Figure), the major difference is that external markets in the U.S. and foreign countries rise to become the top trading partner for most nodes, and the second largest (after rest of state) for the remainder. While rest of state traffic continues to rank highly, local trade is less prominent and rest of Heartland traffic is somewhat more prominent.

The broad patterns visible from tonnage and value metrics are:

- Traffic by physical volume (tonnage) is local and with the surrounding state
- Traffic by dollar value is with national and global markets, and with the surrounding state as well
- Traffic between nodes tends to be stronger when local markets are smaller, and weaker when local markets are large

\(^5\) The figure is a matrix of market relationships for the nodes. It shows the proportion (at right) and the rank (at left) of each trading partner, according to tonnage (top) and value (bottom).
• Rest of Heartland traffic varies in prominence but is lower ranked

**Figure 21: Regional Node Trade Partners by Truck**

The implication from the geographic patterns is that the Heartland today functions more as a collection of nodes serving adjacent territory and trading with the outside world, and less as an integrated region. This is further illustrated by maps of the nodal freight flows, presented below. The first two maps depict flows to/from the St. Louis metropolitan area (Figure 22 and Figure 23) by tonnage and value, and can act as examples. The width of the flow lines (or size of the circle for local traffic) represents the volume. As previewed in Figure 21, the largest flows by tonnage are between the St. Louis node and other parts of Illinois and Missouri, while the top flows by value are between St. Louis and areas outside of the Heartland region. Maps for the remaining seven nodes appear in Figure 24 - Figure 37 and show similar and consistent patterns.
Figure 22: St. Louis Metropolitan Area Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 23: St. Louis Metropolitan Area Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 24: Kansas City Metropolitan Area Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 25: Kansas City Metropolitan Area Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 26: Des Moines Metropolitan Area Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 27: Des Moines Metropolitan Area Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 28: Omaha Metropolitan Area Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 29: Omaha Metropolitan Area Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 30: Wichita Metropolitan Area Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 31: Wichita Metropolitan Area Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 32: Springfield Metropolitan Area Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 33: Springfield Metropolitan Area Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 34: Sioux City/Sioux Falls Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 35: Sioux City/Sioux Falls Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 36: Grand Island/I-80 Freight Flows by Tonnage

Source: WSP Disaggregation of Freight Analysis Framework-4
Figure 37: Grand Island/I-80 Freight Flows by Value

Source: WSP Disaggregation of Freight Analysis Framework-4
IMPLICATIONS FOR FREIGHT TECHNOLOGY

From the data presented in this technical memorandum, certain themes point to potential shared outcomes.

• Much of the economic activity within the Heartland Region occurs within the region’s nodal metropolitan areas, given that these are locations of population and employment concentration. Urban delivery technologies for conventional and e-commerce applications thus are significant, robotics being one example. While local traffic by definition does not reach across the region, its issues and opportunities can be addressed in coordinated fashion. This could range from pilots in multiple locations - or in one location producing shared results – to policies developed in common that help technology providers to standardize.

• The hinterlands adjacent to Heartland nodes rank as their largest or second largest trading partner by freight tonnage and value. Therefore, connections between the nodes and surrounding areas is a strategic consideration. One technology these connections are suited to is electric trucks, because the relatively short travel distances align with the operating range of contemporary batteries. Adoption of electrics opens up such questions as power grid capacity for charging stations, and revenue replacement for gas taxes.

• Rural areas account for the majority of Heartland territory. In addition to the hinterland service they depend on and their need for long-distance links for agricultural products (discussed below), they are low density areas for freight with local connections via farm-to-market roads. Unmanned aerial vehicles (UAVs, or drones) have uses in these districts, whether for road inspection or for e-commerce deliveries to farms. A contemporary task for road inspection is determining the presence and condition of lane striping, which is relied on by the safety systems in new model cars and trucks, and will be later by driverless vehicles.

• Trade between the region’s nodes is relatively weak. The top trading partners by value are mainly outside of the region. Therefore, long-distance connections between the region and other parts of the nation are a key consideration, and are used by pass-through freight as well. The backbone for these connections is shared multimodal infrastructure whose condition in one state affects the performance of shipments for another, and whose operating technology shapes the quality and cost of service. Technologies ranging from truck platooning to positive train control and its influence on railroad crew sizes are relevant, as are multistate information systems for uses such as truck parking availability and regulatory compliance.
• The Heartland Region is well known for its agricultural production. These states have among the highest agriculture production in the nation. However, agriculture contributes a relatively small share of the region’s GDP. Overall, manufacturing, wholesale and retail trade represent a larger share of economic activity among freight dependent industries. While the overall economic contribution of farms do not put them at the top of the region’s economy in terms of GDP, they are part of an overall cluster of related industries that are sizeable and important. Furthermore, food and agriculture products are traded industries, meaning that these industries compete with other regions and nations. Traded industries often have economic implications beyond their portion of a region’s GDP so their importance must be maintained. Other related industries are key elements within the area, including chemical and machinery manufacturing. Delivered cost is crucial to the competitiveness of Heartland products in national and global markets. Technological innovations in the lower cost rail and water modes that have key roles for those markets thus are important; container vessels for inland waterways are one example that Heartland agencies have been tracking.

• Data and data systems are an essential enabler of most new technology. Examples and issues are numerous; a few of them are: a) driver information systems for communication of conditions and ultimately for vehicle-to-infrastructure networks; b) private-public data sharing, such as hard-braking locations collected from truck telematics; c) highspeed data capacity for rural areas, supporting participation in e-commerce and distributed manufacturing, and for supply chain visibility everywhere.
External regions were defined by their orientation to the Heartland, using whole states for simplicity. Thus, Minnesota and the Dakotas are the states directly north of the Heartland and form the North region.