Final Report

Regional Freight Delay and Commodities Movement Study

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Prepared for
Metro Regional Government

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EXECUTIVE SUMMARY

The Commodities Movement Study (CMS) used Metro's new freight model to summarize the general types of commodities, and the volume and value of those groupings of commodities that are using these freight facilities within each of the mobility corridors.

In addition, The Study performed research and analysis to account for the potential effects of recent, transformative trends, specifically the effects of the COVID-19 pandemic and of growth e-commerce and home deliveries of goods.

The COVID-19 pandemic has had far-reaching effects, and those effects have been observed in nearly every aspect of our social interactions, how and where we work and perform our jobs, how we shop and what we purchase, and how those goods are distributed and delivered. During the COVID-19 era, e-commerce, which refers to the purchase of goods using the internet, has rapidly matured from a means used by businesses to order goods and materials from other businesses and a popular way for the tech-savvy consumers to shop for apparel and household products, to be mainstreamed into the regular shopping routines of tens of millions of American households.

The rapid growth of e-commerce demand during the COVID-19 era, combined with labor shortages, equipment availability, and last-mile delivery challenges, has presented manufacturers, retailers, and transportation companies with the tremendous task of building capacity to meet rising demand that does not appear to be abating anytime soon.

Goals and Objectives of the Study

The purpose of the CMS was to evaluate the level and value of commodity movement on the regional freight network within each of the mobility corridors identified in the Regional Transportation Plan's Mobility Corridor Atlas. The overall objectives of the CMS were as follows:

- Create a policy framework for commodity movement in the Portland Region; and make recommendations related to transportation policy and regional corridors as a result of the study.
- Identify regional mobility corridors that are carrying the highest volume of commodities, and highest value of commodities;
- Identify how groups of certain types of commodities flow through the transportation system in the Metro Region.
- Explore how the increase in e-commerce is changing commodity flow in the Portland Region and how e-commerce is impacting and benefiting the transportation system and regional economy.
- Examine how congestion, unreliability and mobility on the regional transportation system impacts commodity movement; identifying how groups of commodities (by value and volume) are being impacted.

- Make recommendations for future regional policy and planning efforts, such as the next Regional Transportation Planning update, to improve commodities movement on a regional, state and national level.

Regional Freight Policy Questions

In consultation with the Project Management Team, Stakeholder Advisory Committee, and Metro's Transportation Policy Alternatives Committee (TPAC), a list of four regional freight policy questions was developed. The research and analysis performed in this study aimed to answer these questions.

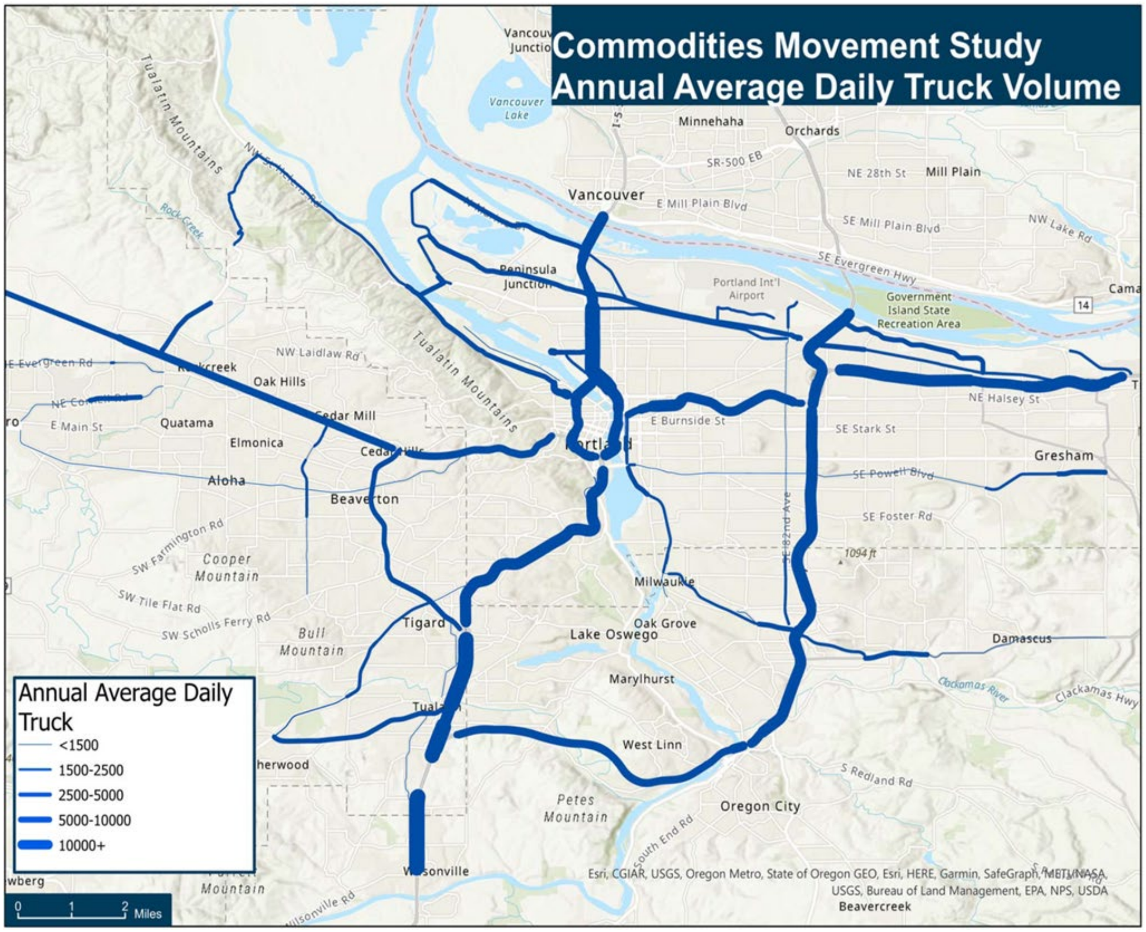
Figure ES.1 Key Findings Relevant to the Regional Freight Policy Questions

What are emerging trends in the freight sector that have certain types of impacts on the transportation system?	**Key emerging trends include:** • Supply chain uncertainty and risk mitigation • Continued technological advancement • Continued growth in e-commerce demand
When and how should the public sector play a role in addressing the growth impacts that e-commerce and goods delivery is having?	**When e-commerce impacts public infrastructure or policy. Potential actions include:** • Transportation system and curb management strategies • Land use policies to manage and guide development • Improve data and understanding of trends and impacts
Are there new ways to address goods movement performance and what is relevant to know about freight and goods movement?	**Key measures related to performance include:** • Travel time and reliability • Safety (fatal and serious injury crashes in freight corridors) • Risk and resilience (natural disaster risk, flood data, wildfire risk) • Equity (impacts and opportunities, best practices re: data and methods being developed)
What are ways in which the freight sector can reduce greenhouse gas emissions?	**Freight sector emissions reduction strategies include:** • Alternative fuels and electrification • Mode shift and alternative last-mile delivery solutions • More efficient routing and delivery

Commodities Movement

The regional freight system includes both important freight locations within the region (industrial areas, employment areas, marine facilities, etc.) and the transportation system that connects them. Daily truck volumes on these corridors range from a couple thousand vehicles per day (both directions combined) on some of the arterial routes to over ten thousand vehicles a day (both directions combined) on interstate routes. Some locations on I-5 carry over six thousand vehicles per day in each direction.

Figure ES.2 2018-2019 Regional Truck Volumes (Daily Combined Directions)



Metro's new regional freight model was used to understand where certain commodities move within the regional system. For example, the movements of electronics and motor vehicles each are predominant in certain locations. The Sunset Highway (US 26) has a dominant role in moving electronics. This should be expected, since it is the major freeway serving the computer and electronics hub in the North Hillsboro Industrial Area. The Sunset Highway carries the same or more daily dollar value for electronics by direction ($7.3 to $8.5 million) than locations along I-205 by direction, and has nearly as much daily dollar values by direction for electronics compared to I-5 at Jantzen Beach. Another example is 'Motor Vehicle' which includes passenger cars, trucks, and commercial vehicles. The majority of goods in this category are passenger cars and trucks traveling through our region and that are imported and exported in our region at the marine terminals in Portland. Corridor-level summaries are provided in Section 4.2.

Network Performance

The performance of the freight system impacts the ability to provide timely and reliable goods movement. The performance of the system can be monitored through various transportation data to determine where recurring congestion or reliability concerns may be influencing the ability to move freight. The corridors were evaluated to identify locations that were most frequently congested and/or had the worst travel time reliability (TTR). This evaluation grouped performance into three tiers of issues *(relative to other facilities)* based on the hours of congestion (HOC) and state of travel time reliability as listed in Table ES.1.

Table ES.1 Existing Mobility and Reliability Based on Performance

Issue Tier	HOC	TTR (AM or MIDDAY)
Top Tier Issue (Relative to Other Facilities)	7+ Hours	3+ Times as long
Second Tier Issue (Relative to Other Facilities)	4 to 7 Hours	2 to 3 Times as long
Third Tier Issue (Relative to Other Facilities)	3 to 4 Hours	Under 2 Times as long

Section 5.2 summarizes the corridor performance for each tier and yields the following findings:

- Tier 1 findings
  - OR 217 has both the top tier of daily speed reduction and reliability issues – particularly southbound from Walker Road to Denney Road (project currently under construction)
  - US26 eastbound has one of the longest durations of daily speed reduction under the threshold and also has reliability issues
- Tier 2 findings
  - I-405 has Tier 2 duration of low speeds, but higher degree of unreliability
  - I-5 North has generally longer duration of low speed (Tier 1 and Tier 2) and high midday unreliability
  - I-84 also has longer duration of lower speed, though reliability is better than I-5 North
  - I-5 South generally has few hours of low speed, but unreliability is higher in some segments

- I-205 does not have any segments that fall into the Tier 1 speed threshold, but some segments have up to six hours below the speed threshold and many locations have travel time reliability ranging from 2 to 3 times the normal travel time

- Arterial summaries – Three arterials stand out as having 7 or more hours with speeds below the threshold (20 mph for signalized roadways)
    - Columbia Boulevard had the longest duration under the speed threshold and identified reliability issues in the morning and midday
    - Powell Boulevard has some reliability issues while Airport Way generally does not have reliability issues except for the westbound during the midday

Key Trends Impacting Goods Movement

This study has considered several key emerging trends in the freight sector that have real or potential impacts on the transportation system in the Portland Region. Most of these trends also have implications for the region's economy. These trends and implications are listed in Table ES.2.

Table ES.2 Emerging Freight Trends and Impacts

Trend	Description	Global "Big Picture" Impact(s)	Regional Impact(s)
Uncertainty and Emphasis on Risk Mitigation	» Disruptions such as COVID-19 had far-reaching supply chain impacts. » Many companies would like to mitigate risk	» Some companies are seeking to diversify production locations » Some companies are "re-shoring" production and materials sourcing to reduce risks	» **Economic:** Potential opportunities for new manufacturing jobs » **Transportation:** Origins and destinations (and hence modes and routes) of freight flows may change

Trend	Description	Global "Big Picture" Impact(s)	Regional Impact(s)
Technological advancement	» Technological advancement in goods movement and supply chain management aims to improve efficiencies and reduce costs. Such advancements include: » Artificial intelligence to manage inventories and routing » Automation of warehousing and trucks » 3D printing or "distributed manufacturing" can re-shore some production and/or support a small-scale "cottage" manufacturing industry	» The technological advancements listed to the left could reduce transportation costs and facilitate more diverse and resilient supply chains	» **Economic:** Potential opportunities to facilitate cost reductions in the Portland region relative to others (economic competitiveness) » **Transportation:** Improved efficiency, reduced truck delay
Growth in e-commerce demand	» E-commerce sales in the U.S. increased significantly during the COVID-19 pandemic. Although many stores re-opened after the height of the pandemic, many Americans prefer to shop for certain goods online. E-commerce is expected to represent a larger share of U.S. retail sales in the future.	» Transition from "just in time" to "time definite" delivery; » Increase in foreign imports to the U.S. » Development of networks of fulfillment and delivery centers to position product, fulfill orders, and facilitate quick delivery in metro areas	» **Economic:** Increased jobs in warehousing and courier/messenger sectors, loss in retail sector » **Economic:** Increased pressure on an already-tight industrial real estate market in the region » **Transportation:** Net effects of e-commerce (added delivery trips and avoided consumer trips to the store) are not well understood » **Transportation:** Challenges completing deliveries in many Portland neighborhoods and other urban/mixed-use centers

Addressing Goods Movement Performance

There are several key measures of freight and goods movement performance that stakeholders in the public and private sectors tend to agree are important, and where data to measure them either exist or are in various stages of being developed. Four key measures considered in the CMS include:

- Travel time and travel time reliability;
- Safety defined as the number of fatal and serious injury crashes on the freight system;
- Risk due to disasters or other disruptions; and
- Equity, admittedly more emphasized in public sector conversations and planning at this time.

Study Recommendations and Freight Policy

The data analysis and modeling, stakeholder engagement, and literature research performed during the course of this study have led to three sets of recommendations for Metro to consider advancing. These recommendations would help to address issues and needs related to the Regional Freight Policy Questions described in Section 3 of this report. The three groups of recommendations include:

1. When and how to address the effects of growth in e-commerce demand and last-mile deliveries;
2. How to identify, and where there are evident needs to improve freight access to industrial lands and terminals; and
3. What enhancements or additions ought to be incorporated into Metro's Regional Freight Policy and Action Items.

Addressing the Effects of E-Commerce. Growth in consumer demand for goods purchased via e-commerce has had several impacts nationally and within the Portland Region. E-commerce growth is likely contributing to growth in employment in economic sectors such as warehousing and storage and couriers and messengers. It is also likely driving growth in demand for industrial real estate in the region.

E-commerce, and the delivery trips it generates, are increasing the logistics costs for retailers and freight carriers, and generating more demand for curbside loading and unloading zones. These curbside impacts are of especially great interest at a time when expansions of bicycle and pedestrian infrastructure, outdoor sidewalk and parking-space dining, and other uses are also vying for space at or near curbs.

Figure ES.3 B-Line Cargo Bicycle in Portland

Source: Portland Bureau of Transportation, image captured from a video titled "2040 Freight Featured Perspective: B-Line Sustainable Urban Delivery, 2022".

The public sector should play a role in addressing the growth impacts that e-commerce and goods delivery are having:

- **When?** When those impacts are affecting transportation infrastructure performance and/or public policy goals; and
- **How?** Through strategies to manage curb access and utilization, land use policies that accommodate deliveries and facilitate or direct fulfillment center development to preferred locations, and policies that support workforce and economic development.

Table ES.3 How and When to Address E-Commerce Issues and Impacts

Issue/Impact	How to Address the Issue	When Should Actions be Taken?
Curb access, double-parking, etc.	» Context-sensitive curb management and parking strategies, including right-sizing loading zones, flexible curb zones, and reservation systems (see Appendix C)	» If and when evidence of insufficient curb access is present or likely to occur. Review of best practices is an immediate/ongoing action; Piloting and/or implementing strategies is a potential near-term (within 5 years) action.
Land use: Warehouse and fulfillment center development	» Conduct an inventory of land use appropriate for warehouse and fulfillment center development and assess capacity versus need. » Monitor development and redevelopment trends in industrial districts. Might changes to land use policies be needed to promote or discourage certain development types?	» Conducting an inventory of land use is an immediate action that can be taken. » Monitoring development and redevelopment trends can begin immediately and continue indefinitely.

Issue/Impact	How to Address the Issue	When Should Actions be Taken?
Land use: Converting vacant retail stores (aka “dark stores”) to distribution centers	» Review land use regulations to determine if dark store conversions are feasible. Conduct outreach to determine if and where such conversions may be desirable or undesirable. Adjust land use regulations as necessary.	» Review, analysis, and outreach can be an immediate action, with any necessary regulation adjustments to follow.
Augment the public’s understanding of e-commerce trends and impacts	» Purchase available data, perform analysis and integrate with existing modeling tools in order to estimate the transportation system effects of e-commerce and last-mile deliveries » Incorporate findings into planning documents and public/stakeholder engagement activities	» Acquiring data and developing more advanced analysis tools could begin in the near-term. Within 0–5 years, more research on net effects of e-commerce on transportation performance and emissions should be available.

Improving Freight Access. Freight access to industrial lands and terminals in the Portland region is compromised by congestion, delay, and unreliability. In addition, considerations related to safety, equity and community impacts, and economic development could potentially be addressed through freight access improvements. Addressing the issues identified in these corridor segments could improve the efficiency of goods movement, reduce negative externalities, and support economic development in the region. The five criteria for improving access to industrial sites and/or intermodal terminals include:

- **Reduce delay and improve reliability.**
- **Addressing network gaps.**
- **Reduce truck-involved and non-truck-involved crashes.**
- **Address community impacts associated with truck movements, especially in Equity Focus Areas.**
- **Access developable (or re-developable) industrial parcels within the Urban Growth Boundary (UGB).**

Reviewing key corridors and segments in the Portland region, in light of the access criteria, led to the identification of 16 locations where improved access may be needed. The four highlighted rows, including the I-5 corridor from I-84 to Vancouver, the “Gateway to Troutdale corridor,” I-205 between I-84 and OR 99E, and OR 8 between OR 217 and Hillsboro, stand out as having some of the most substantial congestion, unreliability, safety, and/or equity issues. Table ES.4 lists the locations and the criterion/criteria applicable to each.

Table ES.4 Locations Where Improved Access is Needed, Based Upon Access Criteria

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017–2021)	No. of Fatal Crashes (2017–2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
I-5 from I-405 to OR 217	**Top-Tier**		**19**	**2**	**3**	
I-5 from OR 217 to Wilsonville	**Top-Tier**		**26**	**2**	**2**	✓
I-5 from I-84 to Vancouver (including N. Going St. and OR 99E north of Columbia Blvd.	**Top-Tier**	✓	**30**	**14**	**8**	✓
I-84 from I-5 to I-205	**Top-Tier**		**20**	**7**	**11**	
SE Powell from Ross Island Br. to I-205	**Top-Tier**		**28**	**7**	**5**	
US 30 from I-405 to (and including) the St. Johns Br.	**N/A**		**10**	**3**	**0**	
Gateway to Troutdale corridor (I-84, Sandy Blvd. and Airport Way east of I-205)	**Top-Tier**		**48**	**31**	**13**	✓
US 26 from I-405 to OR 217	**Top-Tier**		**27**	**0**	**1**	
OR 217 (US 26 to I-5)	**Top-Tier**		**23**	**0**	**6**	✓
I-205 from I-84 to OR 99E	**Top-Tier**		**42**	**10**	**13**	
I-205 from OR 99E to I-5	**Second-Tier**		**8**	**1**	**0**	✓
Marine Dr. – truck queuing at Terminal 6	**N/A**		**7**	**2**	**0**	✓
Murray Blvd. from US 26 to SW Allen Blvd.	**Top-Tier**		**10**	**3**	**4**	
OR 99W from OR 217 to SW 124th Ave	**Second-Tier**		**15**	**7**	**2**	✓
OR 8 from OR 217 to Hillsboro	**Top-Tier**		**40**	**11**	**16**	✓
OR 224 from OR 99E to SE 122nd Ave and OR 212 from I-205 to SE 122nd Ave	**Second-Tier**		**15**	**3**	**1**	✓

Regional Freight Policy Recommendations. Metro's Regional Freight Strategy, published in 2018, listed 7 Regional Freight Policies that are supported by a range of near-term and long-term Action Items. The Regional Freight Policies and Action Items are listed in Chapter 3 of this report. The data analysis and modeling, literature research, and stakeholder engagement conducted during the course of this study have provided Metro with a fuller understanding of the effects of recent trends and issues associated with e-commerce growth, supply chain resiliency, and COVID-19 pandemic. This knowledge has led to the identification of several enhancements and/or additions to the Action Items that support the Regional Freight Policies.

The Action Items associated with the Regional Freight Policies should be updated or enhanced to incorporate the findings of this study.

Acting Upon the Findings of the CMS

The findings and recommendations of this study suggest certain actions and next steps that Metro can take in order to keep its understanding of freight trends and issues current over time, develop and apply cutting-edge data and analysis methods, and address existing and anticipate future needs. These next steps include:

- Committed actions include implementing and completing a Regional Industrial Land Use Inventory Study to assess the availability, readiness, and suitability of land supply in the region to meet present and future needs; and helping the 2040 Refresh Study to incorporate the findings of this study.
- Recommendations include monitoring and applying new and emerging data and methods. The research conducted as part of this study identified some new data sources that could be useful for answering the Regional Freight Policy questions and/or addressing other freight-related issues and needs in the Portland region. In addition, there is room for improvement in the state of the practice related to several issues, such as net traffic and environmental effects of e-commerce and consensus on what variables and methodologies are needed to develop and monitor performance measures related to freight equity.
- Also among recommended next steps is adopting updates to the Regional Freight Policy and associated Action Items in order to incorporate the findings discovered in this study.

These committed and recommended actions are summarized in Figure ES.4 and described in greater detail in Sections 9.1 through 9.3 of the CMS report.

Figure ES.4 Recommended Next Steps for Implementing the Findings of the Commodities Movement Study

COMMITTED: Advancing Programmed Planning Studies (Section 9.1)

- Initiate and Complete the Regional Industrial Land Use Inventory Study
- Refresh of the 2040 Study

RECOMMENDED: Monitoring and Applying New and Emerging Data and Methods (Section 9.2)

- E-Commerce Delivery Trip and Impact Estimation
- Best Practices in Managing Curbs and Last-Mile Delivery Impacts
- Equity Performance Measures
- Land Use Needs
- Effects of Office Vacancies in Portland's Central City on Freight Needs

RECOMMENDED: Adopting Regional Freight Policy and Action Item Updates (Section 9.3)

- Modify Action Item 1.5 to focus on data acquisition and exploring emerging methodologies.
- Add a new action (4.5) to develop freight equity performance measures.
- Update Action Item 5.3 to reference the Regional Industrial Land Use Inventory Study.
- Add a new action (5.4) to examine land use regulations associated with converting vacant retail to distribution facilities supporting e-commerce.

1.0 INTRODUCTION

In 2016 and 2017, the Regional Freight Work Group was one of eight technical work groups identified to provide input and technical expertise to support the 2018 Regional Transportation Plan (RTP) update. In this role, the work groups were convened to advise Metro staff on implementing policy direction from the Metro Council, the Metro Policy Advisory Committee (MPAC) and the Joint Policy Advisory Committee on Transportation (JPACT). The Regional Freight Work Group met nine times from January 2016 through early 2018. In October 2017, the Regional Freight Work Group (RFWG) discussed the need for future freight studies that should be in the 2018 Regional Freight Strategy. The RFWG recommended that the Regional Freight Delay and Commodities Movement Study (hereafter, "the Commodities Movement Study," or "CMS") should be included as a future freight study.

In 2018, Metro began work on a new Freight Model, designed to replace the trip-based truck model previously developed. The model simulates movement of individual shipments throughout the supply chain including both direct shipments and shipments traveling through transshipment facilities. Shipments are allocated to trucks of various classes and the movements of all freight vehicles are simulated over the course of a typical weekday. The freight model includes 26 types of freight. The freight model development project included an array of participants including Metro, the Oregon Department of Transportation (ODOT), the Port of Portland, and local agencies throughout the region. The freight model development project was completed February 2018.

The new freight model represents a new generation of "hybrid" models that micro-simulate both commodity supply chains and local truck tours. Similar applications have been successful in Chicago, Baltimore, Phoenix and the State of Florida. With the addition of new truck behavior data, the model is able to simulate truck movements. Truck data was obtained by GPS traces of truck movements by vehicle class, dispatch data maintained by businesses, and detailed business establishment surveys with truck itineraries, along with data based on the Freight Analysis Framework (FAF). In addition to all the above improvements the new Freight Model has the ability to take a more holistic approach to modeling. It has the ability to focus on major regional export sectors and produce data to evaluate the economic costs of bottlenecks.

The new freight model also expands the truck classes to include light, medium and heavy. The freight model also incorporates non-freight trucks, an option unavailable in the previous freight mode. It includes both service trucks and mail/parcel delivery trucks which are believed to account for over half of local truck vehicle miles traveled (VMT).

The CMS used Metro's new freight model to summarize the general types of commodities, and the volume and value of those groupings of commodities that are using these freight facilities within each of the mobility corridors.

In addition, The Study performed research and analysis to account for the potential effects of recent, transformative trends, specifically the effects of the COVID-19 pandemic and of growth e-commerce and home deliveries of goods.

The COVID-19 pandemic has had far-reaching effects, and those effects have been observed in nearly every aspect of our social interactions, how and where we work and perform our jobs, how we shop and what we purchase, and how those goods are distributed and delivered. During the COVID-19 era, e-commerce, which refers to the purchase of goods using the internet, has rapidly matured from a means used by businesses to order goods and materials from other businesses and a popular way for the tech-savvy consumers to shop for apparel and household products, to be mainstreamed into the regular shopping routines of tens of millions of American households.

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1.1 Goals and Objectives of the Study

The purpose of the CMS was to evaluate the level and value of commodity movement on the regional freight network within each of the mobility corridors identified in the Regional Transportation Plan's Mobility Corridor Atlas. The overall objectives of the CMS were as follows:

- Create a policy framework for commodity movement in the Portland Region; and make recommendations related to transportation policy and regional corridors as a result of the study.
- Identify regional mobility corridors that are carrying the highest volume of commodities, and highest value of commodities;
- Identify how groups of certain types of commodities flow through the transportation system in the Metro Region.
- Explore how the increase in e-commerce is changing commodity flow in the Portland Region and how e-commerce is impacting and benefiting the transportation system and regional economy.
- Examine how congestion, unreliability and mobility on the regional transportation system impacts commodity movement; identifying how groups of commodities (by value and volume) are being impacted.
- Make recommendations for future regional policy and planning efforts, such as the next Regional Transportation Planning update, to improve commodities movement on a regional, state and national level.

1.2 Organization of This Report

This report is organized into nine (9) chapters. Exclusive of this introductory chapter, the remaining chapters include:

1. **Project Team and Stakeholder Participation.** This includes a description of the CMS's Project Management Team, Stakeholder Advisory Committee, engagement with Metro's Transportation Policy Advisory Committee, and stakeholder interviews.
2. **Regional Freight Policy Framework and Policy Questions** includes an overview of Metro's Regional Freight Policies and a list of relevant Policy Questions that Metro staff and the Project Management Team developed to guide the CMS toward the development of relevant and valuable findings.
3. **Commodities Movement by Trucks** introduces the key segments of the region's highway system that are used to move freight and key commodity flows on the Regional Freight Mobility Corridors system.
4. **Network Performance** describes travel speeds and travel time reliability for trucks on the region's highway network.
5. **Trends Impacting Current and Future Commodity Movements** describes three key trends and their effects on goods movement globally and within the region. The three trends include uncertainty and emphasis on risk mitigation, technological advancement, and growth in e-commerce demand.
6. **Addressing Goods Movement Performance** describes four key measures of freight and goods movement performance and available data and methods, as well as gaps where emerging data and methods are needed.
7. **Study Recommendations and Freight Policy** includes a description of approaches Metro and other stakeholders can implement to address issues and needs.
8. **Acting Upon the Findings of the CMS** includes a list of next steps, including advancing planning studies, monitoring and applying new and emerging data and methods, and adopting some key updates to the Regional Freight Policy and Action Items.

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2.0 PROJECT TEAM AND STAKEHOLDER PARTICIPATION

The study team engaged a variety of public-sector and private-sector stakeholders over the course of the study in order to gather data and insights to inform the development of the study, and to solicit reviews and validations of draft findings. Engagement activities included:

- Formation of the Project Management Team (PMT), which included representatives from the Oregon Department of Transportation, Washington State Department of Transportation, Portland Bureau of Transportation, Clackamas County, Washington County, Multnomah County, Southwest Washington Regional Transportation Council (RTC), Port of Portland, and Port of Vancouver. The PMT met seven (7) times over the course of the study in virtual meetings to offer information, input, and recommendations on aspects of the technical approach and implementation of the study's scope of work, and to ensure the study is progressing toward its goals.
- The study team joined Metro's Transportation Policy Alternatives Committee (TPAC) during four of their workshops during the course of the study. TPAC members were briefed on the status and interim findings of the study and offered opportunities to ask questions and provide feedback on the approach, findings, and next steps.
- A Stakeholder Advisory Committee (SAC) was formed, including members of the PMT and a broader group of public-sector and private-sector representatives who have an interest in goods movement. Such organizations include freight shippers and carriers, economic development and business organizations, and transit. Organizations represented on the SAC (listed alphabetically) include:
    - Amplify Group, Inc.
    - B-Line Urban Delivery
    - Clackamas County Business Alliance
    - Columbia Distributing
    - FedEx
    - Greater Portland Inc
    - Highway Heavy Hauling (HWY)
    - Intel
    - Oregon Dept. of Environmental Quality
    - Oregon Environmental Council
    - Oregon Trucking Associations
    - Transportation Research and Education Center, Portland State University
    - Prosper Portland
    - Republic Services
    - The Street Trust
    - TriMet
    - Westside Economic Alliance
- Interviews with key stakeholders were conducted in 2022 to gather information about the effects of e-commerce deliveries and the COVID-19 pandemic in the Portland region, and to affirm and supplement the findings of data analysis and secondary research. Organizations interviewed include FedEx, Old Dominion Freight Line, and Windermere Real Estate. The findings of these interviews are summarized in Appendix D.

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3.0 REGIONAL FREIGHT POLICY FRAMEWORK AND POLICY QUESTIONS

Metro's Regional Freight Strategy, published in 2018, identified seven (7) regional freight policies.[1] Associated with each policy is a list of action items, collectively considered to be a "tool kit" of activities that support, or help to implement, the policies.

Section 3.1 provides a listing of the seven regional freight policies in the 2018 Regional Freight Strategy, along with an assessment of what freight action items (associated with each of the regional freight policies) are applicable and useful for development of the regional freight policy framework.

3.1 Regional Freight Policies

The Regional Freight Policies, last updated in 2018 as part of the Regional Freight Strategy update, guide strategic planning for freight in the region. There are seven Regional Freight Policies, each supported by a list of near-term and long-term action items. The Regional Freight Policies and associated action items include:

Policy 1: Plan and manage our multimodal freight transportation infrastructure using a systems approach, coordinating regional and local decisions to maintain seamless freight movement and access to industrial areas, and intermodal facilities.

- Near-term actions:
  - 1.1: Better define, preserve and enhance freight function in mobility corridors
  - 1.2: Maintain private sector cooperation with Metro's planning and technical coordination, and with goods movement policy
  - 1.3: Continue baseline freight and goods movement data collection and reporting activities
  - 1.4: Coordinate research, modeling and planning with Oregon Department of Transportation (ODOT)
- Long-term actions:
  - 1.5: Develop and conduct a freight and goods movement research program

Policy 2: Manage first-rate multi-modal freight networks to reduce delay, increase reliability, improve safety and provide shipping choices.

- Near-term actions:
  - 2.1: Assess the need to develop and fund better incident management and traveler information

[1] "Regional Freight Strategy," Metro, September 19, 2018, available from: https://www.oregonmetro.gov/regional-freight-plan (accessed November 7, 2023).

- 2.2: Continue support for use and expansion of ITS system management tools
- 2.3: Support workforce access to the region's industrial jobs through Metro Regional Travel Options (RTO)/Transportation Demand Management (TDM) programs

- Long-term actions:
  - 2.4: Identify key mobility corridors for testing and development of Connected Vehicle (CV) infrastructure and other intelligent transportation systems (ITS) strategies

Policy 3: Better integrate freight issues in regional and local planning and communication to inform the public and decision-makers on the importance of freight and goods movement issues.

- Near-term actions:
  - 3.1: Establish a freight stakeholder outreach program
  - 3.2: Provide support for topical fact sheets, and other published media that expands awareness of freight issues
  - 3.3: Coordinate with Economic Value Atlas work which includes the economic development community

Policy 4: Pursue a sustainable multimodal freight transportation system that supports the health of the economy, communities and the environment through clean, green and smart technologies and practices.

- Near-term actions:
  - 4.1: Provide useful "green freight" links from Metro's freight program webpage
  - 4.2: Pursue greenhouse gas and other pollutant reduction policies and strategies for freight that transitions the region to lower or zero emission freight vehicles and equipment
  - 4.3: Incorporate updated DEQ diesel emissions inventory data into regional and local freight plans
  - 4.4: Support and partner with local jurisdictions to develop policies to phase out older and dirtier diesel truck engines and diesel equipment used in the transport of freight

Policy 5: Protect critical freight corridors and access to industrial lands by integrating freight mobility and access needs into land use and transportation plans and street design.

- Near-term actions:
  - 5.1: Continue to implement land use strategies to protect the existing supply of industrial land

- 5.2: Provide a freight perspective to the revision of Metro's 'Creating Livable Streets' design guidelines
- Long-term actions:
  - 5.3: Examine the need for additional industrial land and the availability and readiness of industrial lands

Policy 6: Invest in our multi-modal freight transportation system, including road, air, marine and rail facilities, to ensure that the region and its businesses stay economically competitive.

- Near-term actions:
  - 6.1: Work toward implementation of the RTP freight priority projects
  - 6.2: Strengthen the tie between project prioritization and the framework for freight performance
  - 6.3: When appropriate, focus regional funds on large capital projects
  - 6.4: Make strategic incremental improvements when large capital projects are unfunded
  - 6.5: Ensure that unfunded freight projects are on an aspirational or strategic RTP project list
  - 6.6: Develop a regional freight rail strategy
- Long-term actions:
  - 6.7 Develop policy and evaluation tools to guide public investment in private freight infrastructure, focused on rail projects

Policy 7: Eliminate fatalities and serious injuries caused by freight vehicle crashes with passenger vehicles, bicycles, and pedestrians, by improving roadway and freight operational safety.

- Near-term actions:
  - 7.1: Promote and advocate with the cities and counties for the implementation of truck side guards on large freight trucks providing public services (i.e., sanitation and recycling), consistent with USDOT specifications
  - 7.2: Develop design guidance for identifying and prioritizing improvements to regional intermodal connectors that should have bike and pedestrian facilities that are separated from the roadway, and other design treatments to enhance the safety of non-motorized modes

3.2 Regional Freight Policy Questions

In consultation with the Project Management Team, Stakeholder Advisory Committee, and Metro's Transportation Policy Alternatives Committee (TPAC), a list of four regional freight policy questions was developed. The research and analysis performed in this study aimed to answer these questions.

Figure 3.1 Regional Freight Policy Questions

An overview of this study's key findings related to the policy questions is shown in Figure 3.2. These findings are described in greater detail throughout this report, and in Appendix E.

Figure 3.2 Key Findings Relevant to the Regional Freight Policy Questions

What are emerging trends in the freight sector that have certain types of impacts on the transportation system?

Key emerging trends include:
- Supply chain uncertainty and risk mitigation
- Continued technological advancement
- Continued growth in e-commerce demand

When and how should the public sector play a role in addressing the growth impacts that e-commerce and goods delivery is having?

When e-commerce impacts public infrastructure or policy. Potential actions include:
- Transportation system and curb management strategies
- Land use policies to manage and guide development
- Improve data and understanding of trends and impacts

Are there new ways to address goods movement performance and what is relevant to know about freight and goods movement?

Key measures related to performance include:
- Travel time and reliability
- Safety (fatal and serious injury crashes in freight corridors)
- Risk and resilience (natural disaster risk, flood data, wildfire risk)
- Equity (impacts and opportunities, best practices re: data and methods being developed)

What are ways in which the freight sector can reduce greenhouse gas emissions?

Freight sector emissions reduction strategies include:
- Alternative fuels and electrification
- Mode shift and alternative last-mile delivery solutions
- More efficient routing and delivery

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4.0 COMMODITIES MOVEMENT BY TRUCKS

Trucks move various commodities to, from, and through the region using the regional street system. Understanding the types and locations of commodity movements within the region provides context for the pivotal role that the roadway network plays on our economy.

4.1 Regional Freight System

The regional freight system includes both important freight locations within the region (industrial areas, employment areas, marine facilities, etc.) and the transportation system that connects them. Metro has a designated regional freight system (Figure 4.1 shown on page 26) that identifies these locations and corridors for planning purposes.

For the purposes of this study, Figure 4.2 shows the corridors that were identified for freight system evaluation, including truck volumes, commodity flow, and system performance. These corridors include controlled access main freeways, roadway connectors, and intermodal connectors.

The daily truck volume on these corridors can be used as a simple metric to compare the amount of freight that moves in various locations. Other common metrics include the total weight of commodities moved and the total value of commodities. Understanding where these trucks use the system is important for system planning, including the consideration of potential policies or projects that may influence freight movement.

As shown in Figure 4.3, 2018-2019 daily truck volumes on these corridors range from a couple thousand vehicles per day (both directions combined) on some of the arterial routes to over ten thousand vehicles a day (both directions combined) on interstate routes. Some locations on I-5 carry over six thousand vehicles per day in each direction.

Regional Freight Network

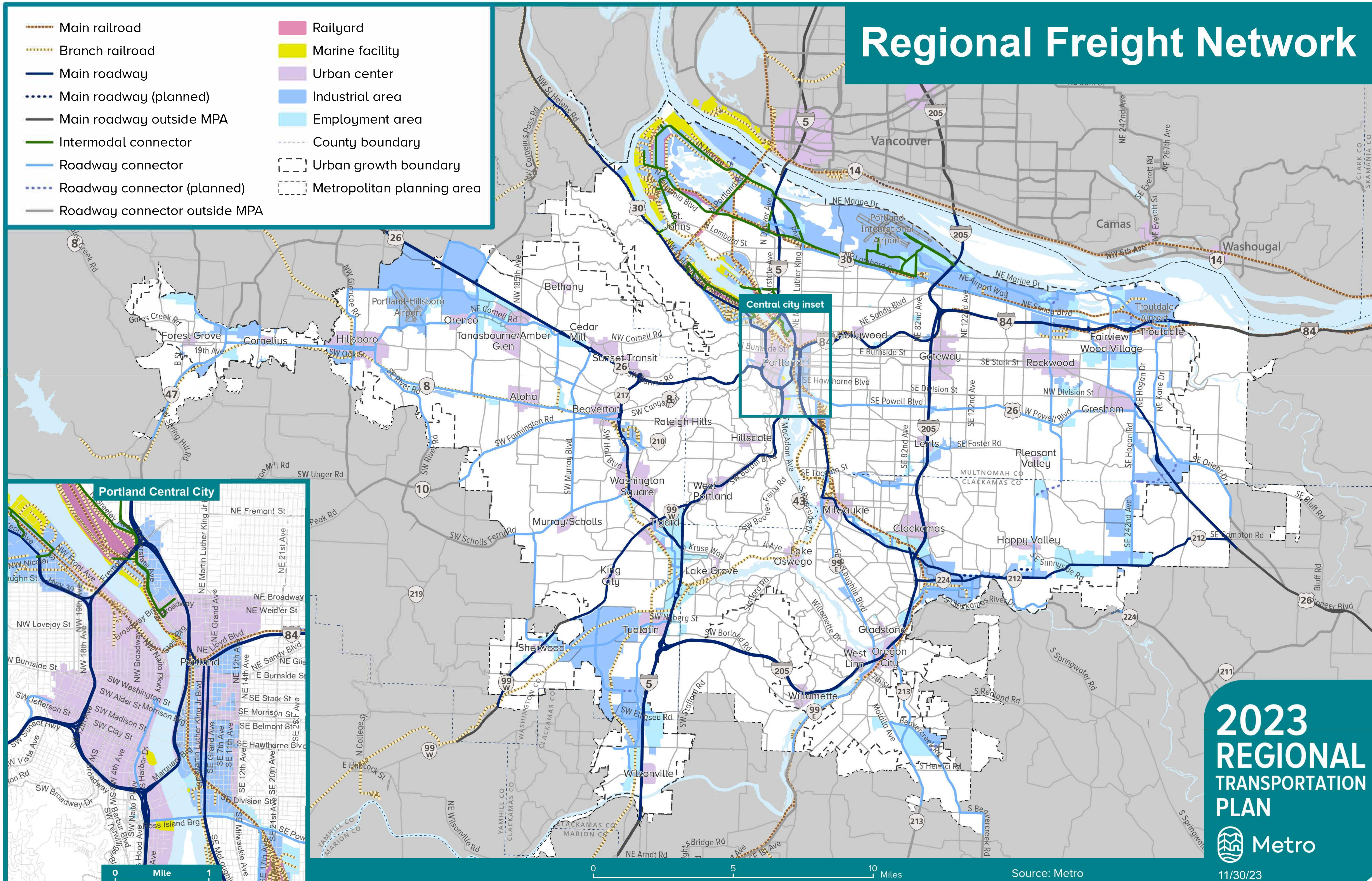


Figure 4.2 Regional Freight Focus Corridors

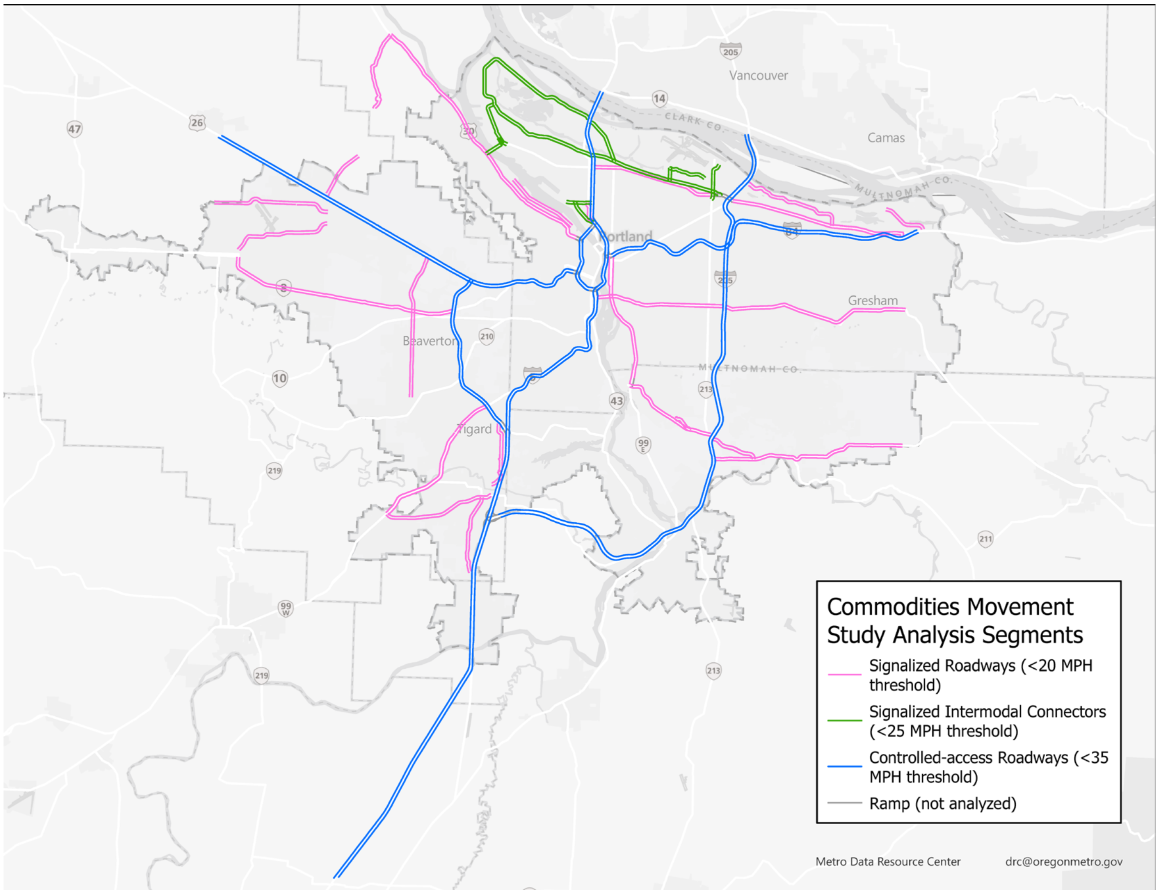
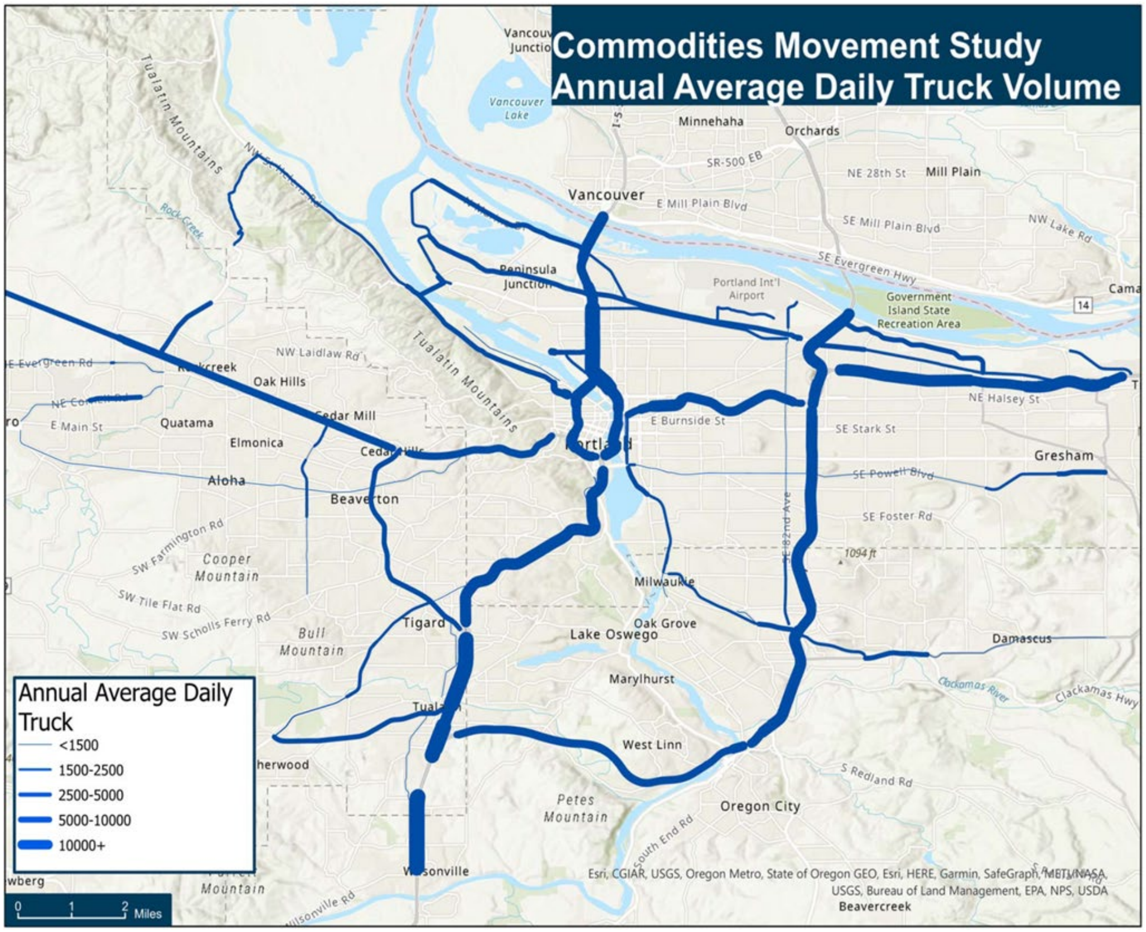


Figure 4.3 2018-2019 Regional Truck Volumes (Daily Combined Directions)



4.2 Regional Freight Model

In 2018, Metro began work on a new Freight Model, designed to replace the trip-based truck model previously developed. The model simulates movement of individual shipments throughout the supply chain including both direct shipments and shipments traveling through transshipment facilities. Shipments are allocated to trucks of various classes and the movements of all freight vehicles are simulated over the course of a typical weekday.

The new freight model represents a new generation of "hybrid" models that micro-simulate both commodity supply chains and local truck tours. Similar applications have been successful in Chicago, Baltimore, Phoenix and the State of Florida. With the addition of new truck behavior data, the model is able to simulate truck movements. Truck data was obtained by GPS traces of truck movements by vehicle class, dispatch data maintained by businesses, and detailed business establishment surveys with truck itineraries, along with data based on the Freight Analysis Framework (FAF). In addition to all the above improvements the new Freight Model has the ability to take a more holistic approach to modeling. It has the ability to focus on major regional export sectors and produce data to evaluate the economic costs of bottlenecks.

The new freight model also expands the truck classes to include light, medium and heavy. The freight model also incorporates non-freight trucks, an option unavailable in the previous freight model. It includes both service trucks and mail/parcel delivery trucks which are believed to account for over half of local truck vehicle miles traveled (VMT). Additional information about the freight model development is included in Appendix G.

Commodity Movement Overview. The freight model includes 26 types of freight that were grouped into ten categories for tracking movement through the system:

1. Agriculture (includes live animals, cereal grains and animal feed);
2. Chemicals Products (includes fertilizer, pharmaceutical products, plastics and rubber);
3. Coal, Oil, Waste/Scrap (includes gasoline, fuel oils, minerals and metallic ores);
4. Electronics (including computer microchips);
5. Food (includes alcohol, tobacco, bakery goods, and other prepared foods);
6. Gravel, Sand, Rock products;
7. Machinery (includes fabricated metals and precision instruments);
8. Misc. manufactured goods (includes mixed freight like restaurant food, hardware, plumbing and office supplies);
9. Motor Vehicles and other commercial vehicles; and
10. Wood, Paper, etc.

The model can be used to understand where certain commodities move within the regional system. For example, the movements of electronics and motor vehicles each are predominant in certain locations. The Sunset Highway (US 26) has a dominant role in moving electronics. This should be expected, since it is the major freeway serving the computer and electronics hub in the North Hillsboro Industrial Area. The Sunset Highway carries the same or more daily dollar value for electronics by direction ($7.3 to $8.5 million) than locations along I-205 by direction, and has nearly as much daily dollar values by direction for electronics compared to I-5 at Jantzen Beach.

Another example is ‘Motor Vehicle’ which includes passenger cars, trucks, and commercial vehicles. The majority of goods in this category are passenger cars and trucks traveling through our region and that are imported and exported in our region at the marine terminals in Portland. The major interstate highways in the region are carrying the largest daily dollar value of the motor vehicle category, such as portions of I-5 which carries as much as $28 million worth of motor vehicles and I-84, which carries as much as $18 million of motor vehicles daily. However, N. Lombard southbound at Terminal 4 is also a significant corridor segment for this commodity, and has a daily value of $9.9 million. Columbia Blvd. eastbound at Chimney Park (east of Burgard) has a daily value of $9.5 million for the motor vehicle category. Primarily this shows the daily dollar value of imported cars coming out of both the marine terminals (4 and 6) that receive imported cars that are destined for locations both inside and outside the region.

Metro produced summary reports (located in Appendix G) for three commodities that are significant to the region on a national scale: electronics, food, and motor vehicles. These additional reports used national Freight Analysis Framework (FAF) data to compare the commodities to other urban areas.

Corridor Summaries. The freight model was used to summarize commodity flows along each of the freight corridors. The corridors were grouped into four tiers based on the daily value of commodity flows (both directions combined):

- Tier 1: $130M or more daily value
- Tier 2: $58M to $129M daily value
- Tier 3: $23M to $57M daily value
- Tier 4: $22M or less daily value

Each corridor carries a mix of commodities that vary by location along the corridor. Table 4.1 summarizes the top commodity groups by corridor segment. Commodity groups are reported by direction since some commodities have a directional flow (e.g., raw materials used for manufacturing or agricultural exports).

Table 4.1 Top Commodity Groups—Tier 1 Corridors

Corridor/Segment	Top Commodity Groups
Portland Central City to Tigard ($203M to $260M)	
Northbound I-5 from OR 217 to Terwilliger Blvd.	**Misc. Manufacturing** **Food** **Electronics**
Southbound I-5 from Terwilliger Blvd. to OR 217	**Motor Vehicles** **Misc. Manufacturing** **Electronics** **Machinery**
Tigard to Wilsonville ($220M to $225M)	
Northbound I-5 from Wilsonville to south of OR 217	**Misc. Manufacturing** **Food**
Southbound I-5 from south of OR 217 to Wilsonville	**Motor Vehicles** **Misc. Manufacturing** **Electronics**
Portland Central City Loop ($177.5M to $225M)	

Corridor/Segment	Top Commodity Groups
Northbound I-5 from I-405 (on Marquam Br.) to Fremont Br.	**Misc. Manufacturing** **Food** **Electronics**
Southbound I-5 from Fremont Br. to I-405 (on Marquam Br.)	**Motor Vehicles, Misc. Manufacturing** **Electronics** **Machinery**
Northbound I-405 on Fremont Br.	**Electronics** **Energy (Oil, Gas, etc.)** **Motor Vehicles**
Southbound I-405 on Fremont Br.	**Electronics** **Machinery**
Gateway to Troutdale/Wood Village ($139M to $175M)	
Eastbound I-84 between I-205 and Marine Dr	**Motor Vehicles** **Electronics**
Westbound I-84 between Marine Dr. and I-205	**Electronics** **Food**
Portland Central City to Vancouver, WA ($133M to $170M)	
Northbound I-5 from Fremont Br. (I-405) to Hayden Is	**Misc. Manufacturing** **Food** **Electronics**
Southbound I-5 from Hayden Is. to Lombard St	**Misc. Manufacturing** **Electronics** **Food** **Machinery**
Southbound I-5 at Fremont Street (south of Going St.)	**Misc. Manufacturing** **Motor Vehicles** **Machinery**

Table 4.2 Top Commodity Groups—Tier 2 Corridors

Corridor/Segment	Top Commodity Groups
Portland Central City to Gateway (I-84) ($106M to $111M)	
Eastbound I-84 from I-5 to I-205	Electronics Food Energy Misc. Manufacturing
Westbound I-84 from I-205 to I-5	Electronics Food Machinery Misc. Manufacturing
I-5 to Rivergate Corridor ($100 M both directions west of I-5 - including Swan Island; and $90 M both directions on Columbia Blvd., Marine Drive and Lombard St. near marine terminals)	
Eastbound/Southbound Columbia Blvd., and Lombard St. near Terminal 4	**Motor Vehicles** **Machinery** **Chemicals**
Westbound/Northbound Columbia Blvd., and Lombard St. near Terminal 4	**Chemicals** **Motor Vehicles** **Agriculture**
Eastbound Marine Dr. near Terminal 6	**Motor Vehicles** **Machinery**
Westbound Marine Dr. near Terminal 6	**Motor Vehicles** **Food**
Eastbound Marine Dr. and Columbia Blvd. west of I-5	**Motor Vehicles** **Food** **Machinery** **Electronics**
Westbound Marine Dr. and Columbia Blvd. west of I-5	**Motor Vehicles** **Machinery**

Corridor/Segment	Top Commodity Groups
Eastbound Going Street at bridge to Swan Island	**Electronics** **Energy** **Machinery**
Westbound Going Street at bridge to Swan Island	**Electronics** **Energy** **Machinery**
Gateway to Clark County (I-205) ($64M to $86M)	
Northbound I-205 I-84 to Glen Jackson Br.	**Food** **Electronics** **Machinery** **Misc. Manufacturing**
Southbound I-205 Glen Jackson Br to I-84	**Motor Vehicles** **Machinery** **Electronics** **Misc. Manufacturing**
Gateway to Oregon City (I-205) ($58M to $67M)	
Northbound I-205 from OR 212 to Stark St.	**Food** **Electronics**
Northbound I-205 from Stark St. To Sunnyside Rd.	**Food** **Misc. Manufacturing**
Southbound I-205 north of OR 212	**Food** **Electronics** **Misc. Manufacturing**

4.3 Commodity Flow Forecasts, 2020-2045

The table below shows growth rates in daily regional commodity values and amounts, from 2020 to 2045 using model outputs at locations on the freight system for all 10 categories of commodities (‘All Goods’).

Table 4.3 Corridors with 70% or Greater Increase in Value of All Goods, 2020-2045

Location of Freight Flows	Direction	Increase in Daily Dollars	Increase in Daily Tons
I-5 at NE Fremont	Northbound	84.1%	45.5%
I-5 at NE Fremont	Southbound	72.9%	31.7%
I-5 south of OR 217	Northbound	71.8%	31.8%
I-5 south of Fremont Br.	Northbound	71.3%	42.3%
I-405 on Fremont Br.	Northbound	71.8%	33.8%
I-205 south of Sandy Blvd.	Northbound	108.7%	57.8%
I-205 south of Sandy Blvd.	Southbound	102.0%	45.0%
I-205 south of OR 224	Northbound	99.7%	50.6%
I-205 north of SE Sunnyside	Northbound	90.0%	64.0%
I-205 north of SE Sunnyside	Southbound	87.4%	50.2%
OR 224 (Sunrise Hwy.) plus OR 212 at SE 102nd	Eastbound	170.8%	95.7%
OR 224 (Sunrise Hwy.) plus OR 212 at SE 102nd	Westbound	226.2%	98.3%
OR 224 west of OR 213 (82nd Ave.)	Eastbound	113.0%	136.4%
OR 224 west of OR 213 (82nd Ave.)	Westbound	290.0%	157.6%
US 26 (Sunset Hwy.) east of OR 217	Eastbound	95.9%	53.2%
US 26 (Sunset Hwy.) west of Cedar Hills Blvd.	Eastbound	93.9%	36.8%
OR 217 at Scholls Ferry Road	Northbound	125.4%	32.4%
OR 217 at Scholls Ferry Road	Southbound	117.9%	12.3%
N. Marine Drive west of I-5	Eastbound	147.3%	83.6%
N. Marine Drive west of I-5	Westbound	120.5%	30.6%
N. Columbia Blvd. plus N. Lombard St. near Terminal 4	Westbound/ Northbound	154.5%	133.1%
NE Columbia Blvd. + NE Lombard east of 99E	Eastbound	100.2%	36.9%
NE Columbia Blvd. + NE Lombard east of 99E	Westbound	115.8%	70.0%
OR30 west of I-405	Westbound	77.2%	61.0%
St. Johns Bridge	Eastbound	123.4%	120.1%
Nyberg Rd./Tualatin-Sherwood Rd. west of I-5	Eastbound	79.3%	46.7%
Nyberg Rd./Tualatin-Sherwood Rd. west of I-5	Westbound	78.0%	25.6%

Table 4.2 shows growth rates of 'All Goods' as a percentage increase from 2020 to 2045, for both daily dollar value and daily tonnage on segments of the Regional Freight Network where projected growth in total freight value (measured in daily dollars) is expected to exceed 70% between 2020 and 2045. A full list of growth rates on all corridors on the Regional Freight Network is included in Appendix G.

In 2020, I-5, I-84 and I-205 (in that order) have the most dollar value and tonnage of commodities within the interstate and state highways that the Commodities Movement Study is examining. However, other locations like OR 30 west of I-405 and Marine Drive west of I-5 also have high dollar values and tonnage that are larger than those on US 26 (Sunset Highway), and various on locations on I-205. Other locations in the Rivergate to I-5 corridor also have significant 2020 dollar value and tonnage.

As the table above illustrates, the percentage increases for daily dollars are greater than the percentage increases for daily tons. This is an indication that the value of commodities traveling in the region will continue to be weighted by high-value commodities (like electronics or motor vehicles) growing faster than heavy commodities (like fertilizer, coal, oil or wood). The percentages for dollar value and tonnage that show a growth of 70% or more within the 25-year period are highlighted in yellow. Most selected locations along I-205 in both directions, three locations on I-5 and the locations on US 26 eastbound, have met that 70% or higher increase for daily dollar value. OR 224 (Sunrise Highway) and OR 212 combined (around 102nd) have directional percentage increases for daily dollars that exceed 170%; and percentage increases for daily tonnage that exceed 95%. This indicates strong industrial growth and more medium-heavy trucks using this corridor in the future. Marine Drive west of I-5 (in both directions) has percentage increases for daily dollar value that exceed 120%. N. Columbia Blvd and N. Lombard Street (combined) near Terminal 4 (Westbound/Northbound) has percentage increases for both dollar value and tonnage that exceed 130%. This indicates a robust growth in commodities traveling by truck into and out of the marine terminals (4,5, and 6) and the industrial businesses in the Rivergate area.

OR 224 west of 82nd Avenue (in both directions) has percentage increases for daily dollar value that exceed 110%, and percentage increases for daily tonnage that exceed 130%. OR 217 at SW Scholls Ferry Road (in both directions) has percentage increases for daily dollar value that exceed 117%. On OR 217 the growth in the daily dollar value of all goods is driven by the increased daily dollar value of the electronics category; which more than triples in value at SW Scholls Ferry Road. In the Columbia Corridor, NE Columbia Blvd. and NE Lombard combined east of OR 99E (in both directions) has percentage increases for daily dollar value that exceed 100%.

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5.0 NETWORK PERFORMANCE

The performance of the freight system impacts the ability to provide timely and reliable goods movement. The performance of the system can be monitored through various transportation data to determine where recurring congestion or reliability concerns may be influencing the ability to move freight. The performance of the regional freight network was evaluated to determine the system ability to meet the regional mobility policy and provide reliable travel.

5.1 Methodology and Data

The performance of the regional freight network was evaluated using travel speed-based performance metrics.[2] These metrics were based on summaries of observed (year 2019) travel data to reflect typical, pre-pandemic travel conditions to avoid initial and continued travel disruptions. The data were based on actual travel data from a combination of the National Performance Management Research Data Set (NPMRDS) and the commercial INRIX dataset based on corridor coverage and availability. Data were aggregated and measured in 15-minute periods. Data were spatially aggregated from off-ramp to off-ramp.

Average Travel Speed. The average travel speed performance was evaluated to determine the duration of time that each corridor fell below the regional performance target speed. Performance was compared for each 15-minute period and the total duration that the speeds fell below regional targets were reported as the hours of congestion. The regional mobility target is to have facilities operating below these speeds for less than four hours per day. These regional targets for corridors designated as regional throughways include:

- 35 mph (controlled access freeways)
- 20 mph (non-freeways with traffic signals)

In addition, corridors that were not designated as regional throughways but serve as intermodal freight connectors were compared with a 25 mph speed threshold for purposes of this study.

Travel Time Reliability. Travel time reliability metrics were calculated using a modified version of the Truck Travel Time Reliability (TTTR) measure from NHS reporting, focusing on the a.m. (6 a.m. to 10 a.m. on weekdays) and midday (10 a.m. to 4 p.m. on weekdays) periods. These metrics were calculated using statistical values derived from the data that represented typical (50^{th} percentile) and the heavily congested (95^{th} percentile) travel speeds. Note that both values were based on a variety of conditions throughout the year to account for both recurring and non-recurring (incident) travel speeds and congestion. The ratio of $50^{th}/95^{th}$ (or typical/congested) speeds represent the degree of variation or "reliability" of the corridor travel speeds. A high value indicates a greater ratio between typical and congested conditions, while a lower value indicates better reliability.

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2 Travel Speed Analysis for Throughways and Regional Freight Routes in the 2023 Regional Transportation Plan, Metro, March 2023.

5.2 Corridor Performance

The regional freight corridor performance was reported using the following measures:

- Hours of congestion – The duration of time on a typical day that a corridor segment falls below the performance speed target. A higher value indicates more hours of the day experiencing travel speeds below the target.
- AM Travel Time Reliability – The consistency of travel time between typical and congested conditions (lower values indicate more consistency, or reliability) during the morning period
- Midday Travel Time Reliability – The consistency of travel time between typical and congested conditions (lower values indicate more consistency, or reliability) during the midday period

The following maps summarize the corridor performance at a regional scale.

Figure 5.1 Hours of Congestion

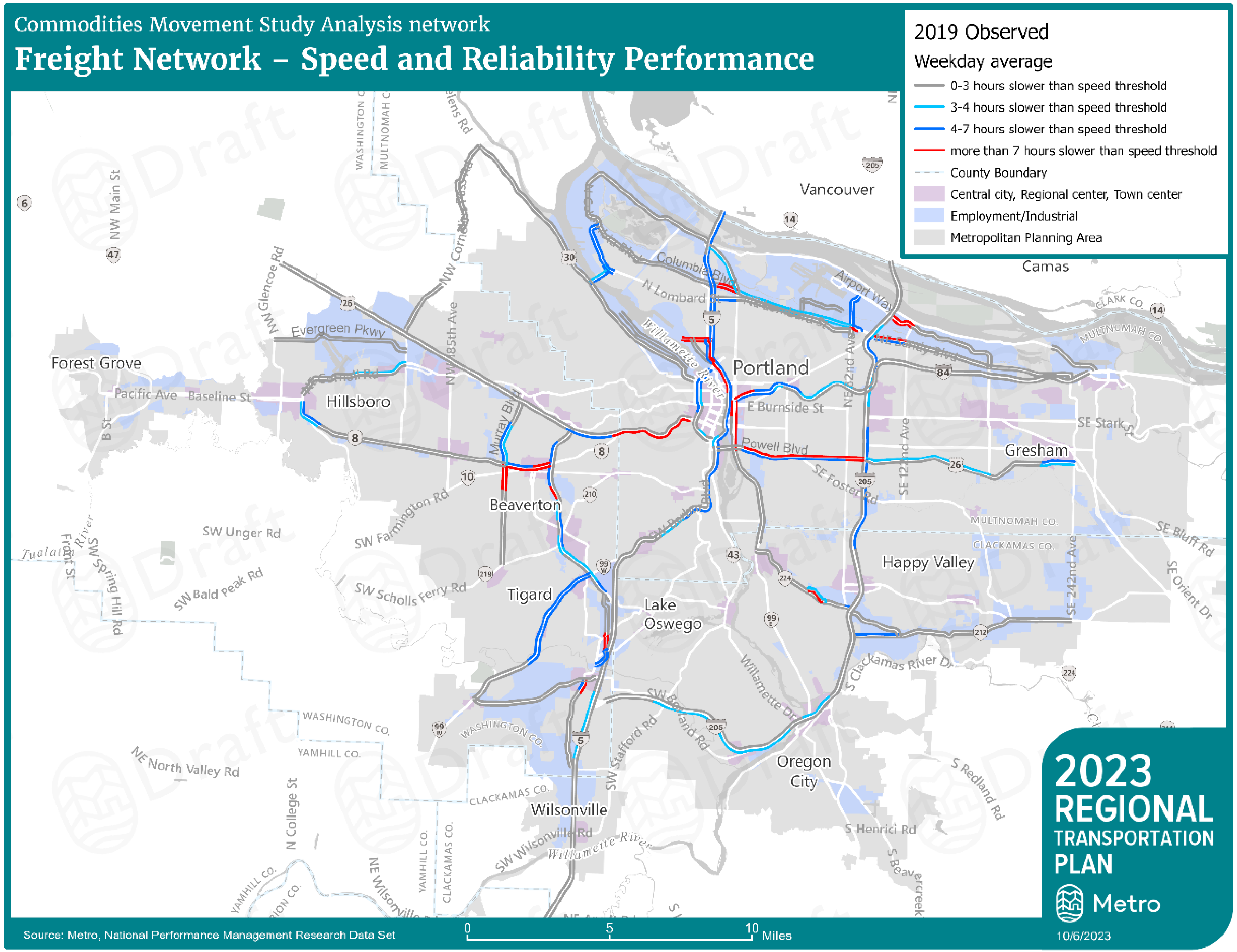


Figure 5.2 Travel Time Reliability—AM Period

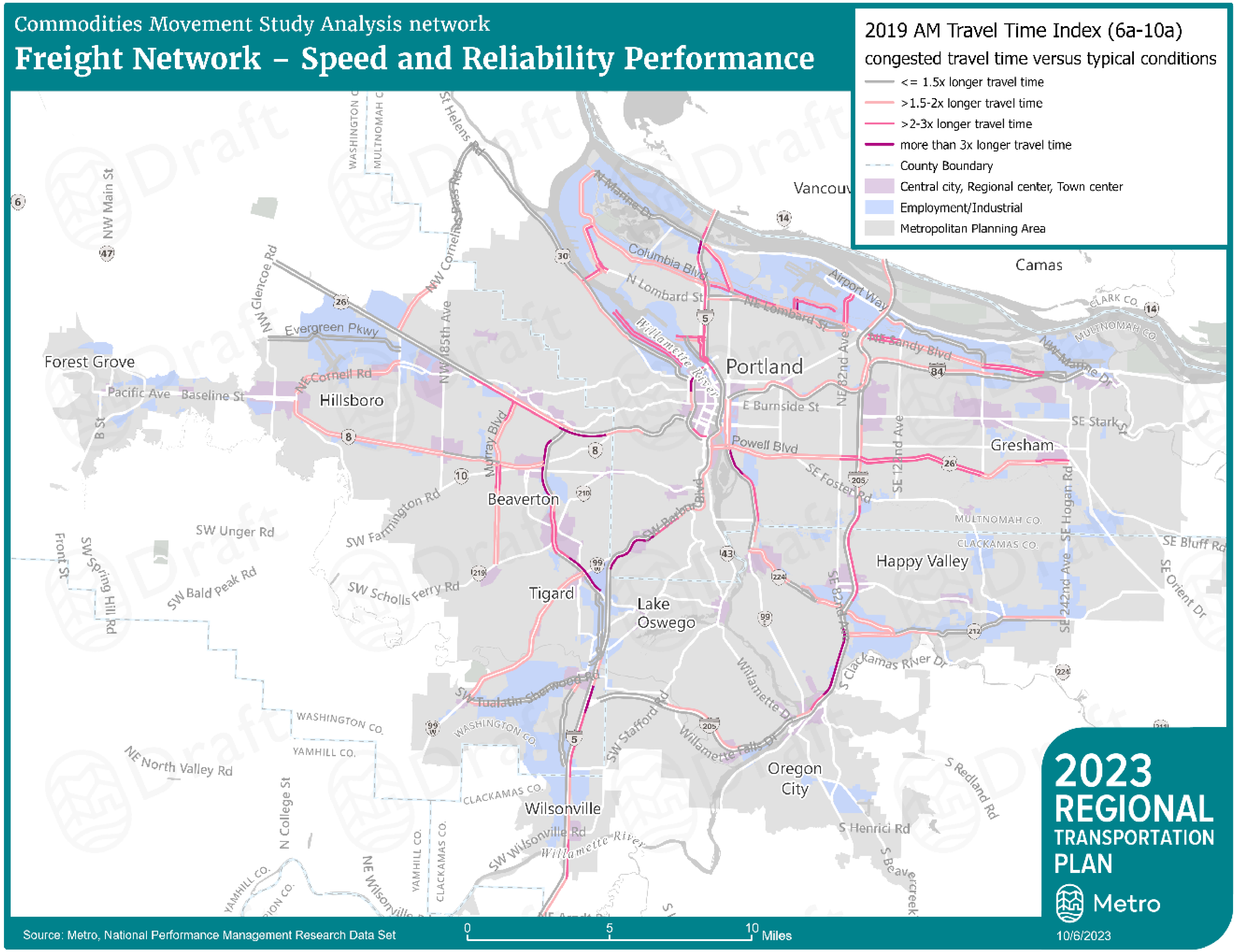
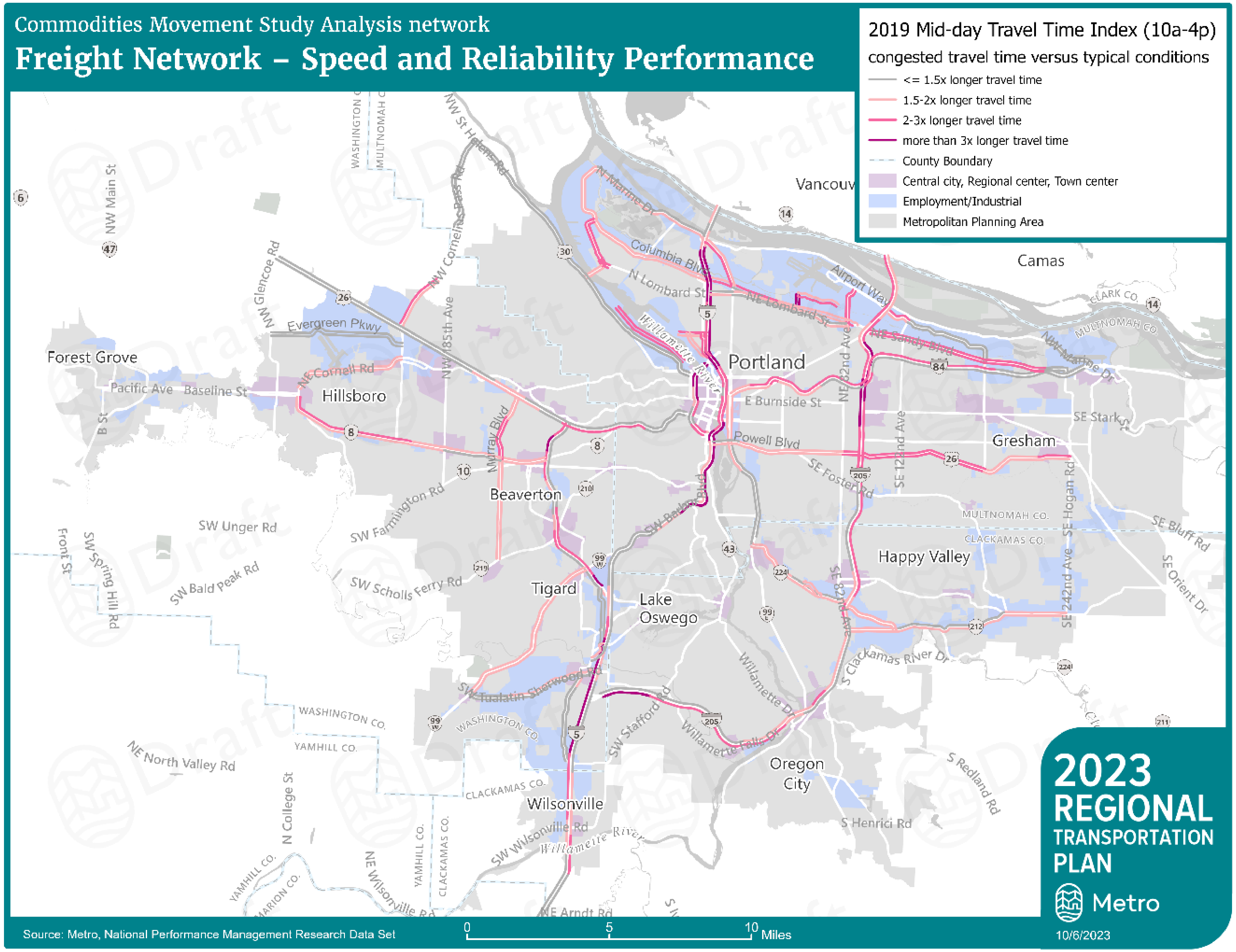


Figure 5.3 Travel Time Reliability—Midday Period



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The corridors were evaluated across these three measures to identify locations that were most frequently congested and/or had the worst reliability. This evaluation grouped performance into three tiers of issues *(relative to other facilities)* based on the hours of congestion (HOC) and state of travel time reliability as listed in Table 5.1.

Table 5.1 Existing Mobility and Reliability Based on Performance

Issue Tier	HOC	TTR (AM or MIDDAY)
Top Tier Issue (Relative to Other Facilities)	7+ Hours	3+ Times as long
Second Tier Issue (Relative to Other Facilities)	4 to 7 Hours	2 to 3 Times as long
Third Tier Issue (Relative to Other Facilities)	3 to 4 Hours	Under 2 Times as long

Table 5.2 and Table 5.3 summarize the corridor performance for each tier and yields the following findings:

- Tier 1 findings
    - OR 217 has both the top tier of daily speed reduction and reliability issues – particularly southbound from Walker Road to Denney Road (project currently under construction)
    - US26 eastbound has one of the longest durations of daily speed reduction under the threshold and also has reliability issues
- Tier 2 findings
    - I-405 has Tier 2 duration of low speeds, but higher degree of unreliability
    - I-5 North has generally longer duration of low speed (Tier 1 and Tier 2) and high midday unreliability
    - I-84 also has longer duration of lower speed, though reliability better than I-5 North
    - I-5 South generally few hours of low speed, but unreliability higher in some segments
    - I-205 does not have any segments that fall into the Tier 1 speed threshold, but some segments have up to six hours below the speed threshold and many locations have travel time reliability ranging from 2 to 3 times the normal travel time
- Arterial summaries – Three arterials stand out as having 7 or more hours with speeds below the threshold (20 mph for signalized roadways)
    - Columbia Boulevard had the longest duration under the speed threshold and identified reliability issues in the morning and midday

- Powell Boulevard has some reliability issues while Airport Way generally does not have reliability issues except for the westbound during the midday

Table 5.2 Tier 1 Corridor Issues

Corridor	Location	Speed (HOC)	TTR (AM)	TTR (Midday)
OR 217	SB (Walker to Denny)	4.7 to 7.2	3.8 to 4.8	2.6 to 4.8
	NB (72nd to Hall)	3.3 to 4.6	2.6 to 4.6	2.0 to 3.8
	SB (Denney to Scholls Ferry)	2.5 to 3.6	2.0 to 2.9	N/A
US 26	EB (Canyon to Vista)	8.4 to 12.3	N/A	2.8
	EB (217 to Canyon)	4.5	3.6	2.6

Table 5.3 Tier 2 Corridor Issues

Corridor	Location	Speed (HOC)	TTR (AM)	TTR (Midday)
OR 217	SB (Walker to Denny)	4.7 to 7.2	3.8 to 4.8	2.6 to 4.8
	NB (72nd to Hall)	3.3 to 4.6	2.6 to 4.6	2.0 to 3.8
	SB (Denney to Scholls Ferry)	2.5 to 3.6	2.0 to 2.9	N/A
US 26	EB (Canyon to Vista)	8.4 to 12.3	N/A	2.8
	EB (217 to Canyon)	4.5	3.6	2.6
I-205	NB (J. Cr to Stark)	4.9 to 5.4	2.6	2.4 to 3.0
	NB (Glisan to AW)	3.3 to 4.8	N/A	2.1 to 4.0
	NB (Stafford to OR43)	3.1 to 3.5	N/A	2.2 to 2.7
	SB (82nd to OR99E)	3.2	2.4	2.0 to 2.6
	NB (Sunnyside to J Cr)	N/A	2.3	3.0
	SB (OR212 to 82nd)	N/A	4.1	1.9
	SB (WA to Powell)	N/A	N/A	2.3 to 3.1

6.0 TRENDS IMPACTING CURRENT AND FUTURE COMMODITY MOVEMENTS

This study has considered several key emerging trends in the freight sector that have real or potential impacts on the transportation system in the Portland Region. Most of these trends also have implications for the region's economy. These trends and implications are listed in Table 6.1.

Table 6.1 Emerging Freight Trends and Impacts

Trend	Description	Global "Big Picture" Impact(s)	Regional Impact(s)
Uncertainty and Emphasis on Risk Mitigation	» Disruptions such as COVID-19 had far-reaching supply chain impacts. » Many companies would like to mitigate risk	» Some companies are seeking to diversify production locations » Some companies are "re-shoring" production and materials sourcing to reduce risks	» **Economic:** Potential opportunities for new manufacturing jobs » **Transportation:** Origins and destinations (and hence modes and routes) of freight flows may change
Technological advancement	» Technological advancement in goods movement and supply chain management aims to improve efficiencies and reduce costs. Such advancements include: » Artificial intelligence to manage inventories and routing » Automation of warehousing and trucks » 3D printing or "distributed manufacturing" can re-shore some production and/or support a small-scale "cottage" manufacturing industry	» The technological advancements listed to the left could reduce transportation costs and facilitate more diverse and resilient supply chains	» **Economic:** Potential opportunities to facilitate cost reductions in the Portland region relative to others (economic competitiveness) » **Transportation:** Improved efficiency, reduced truck delay

Trend	Description	Global "Big Picture" Impact(s)	Regional Impact(s)
Growth in e-commerce demand	» E-commerce sales in the U.S. increased significantly during the COVID-19 pandemic. Although many stores re-opened after the height of the pandemic, many Americans prefer to shop for certain goods online. E-commerce is expected to represent a larger share of U.S. retail sales in the future.	» Transition from "just in time" to "time definite" delivery; » Increase in foreign imports to the U.S. » Development of networks of fulfillment and delivery centers to position product, fulfill orders, and facilitate quick delivery in metro areas	» **Economic:** Increased jobs in warehousing and courier/messenger sectors, loss in retail sector » **Economic:** Increased pressure on an already-tight industrial real estate market in the region » **Transportation:** Net effects of e-commerce (added delivery trips and avoided consumer trips to the store) are not well understood » **Transportation:** Challenges completing deliveries in many Portland neighborhoods and other urban/mixed-use centers

6.1 Uncertainty and Emphasis on Risk Mitigation

Growth in demand for consumer products and other goods, combined with the challenges of producing, transporting, and processing shipments of those goods in a COVID-19 environment, has presented many challenges to logistics companies, carriers, and shippers. These challenges have led many companies to reevaluate their sourcing decisions in order to mitigate the risk of disruption.

The initial effects of the pandemic were impacting supply chains as early as late 2019, when the virus was spreading through parts of China. For decades, manufacturing of many classes of goods has grown substantially in China, due to relatively inexpensive labor, few regulations and taxes, and being home to the world's largest workforce. By 2019, Chinese manufacturing accounted for 29% of global manufacturing.[3] The pandemic disrupted that production and the operations of logistics systems and ports in China. Because China is a supplier to so much of the world's consumer markets, disruptions in that country affect supply chains that stretch across the globe.

As the pandemic spread throughout the world in early 2020, new challenges arose. Mandated "lockdowns" in many countries, and social distancing measures in the U.S. led to widespread shutdowns or slow-downs affecting every industry, including manufacturing,

[3] https://www.statista.com/chart/20858/top-10-countries-by-share-of-global-manufacturing-output/

warehousing, and transportation. As consumer demand increased during the pandemic, meeting the challenges of manufacturing, transporting, distributing, and delivering goods with depleted workforces and limited capacity was a daunting task.

Prior to the onset of the pandemic, an ocean container could travel from China to the West Coast of the United States in approximately two weeks. During 2020 and into 2021, the two week transit time was followed by up to two weeks at anchorage awaiting an available berth at the ports. The marine terminal crunch appeared to be most acute at the ports of Los Angeles and Long Beach, but capacity was a challenge at many ports throughout the U.S. Vessels returning to Asia were met with crowded ports and long anchorage times there as well. Figure 6.1 shows the number of ships anchored outside of the ports of Los Angeles and Long Beach in January 2021.

The turnaround time for an Asia-to-America-and-back journey therefore extended from four weeks to seven weeks, eight weeks, or more in some cases. [4] In effect, the capacity of the ocean liner industry was limited due to the delays, at a time when demand was rebounding and soaring. This, along with the uneven growth between imports and exports through 2020 and 2021, led to record-high shipping container costs (topping $15,000 from China to the West Coast in Fall of 2020 and $20,000 in the Fall of 2021).[5] Figure 6.2 shows the global container shipping rates from July 2019-December 2021.

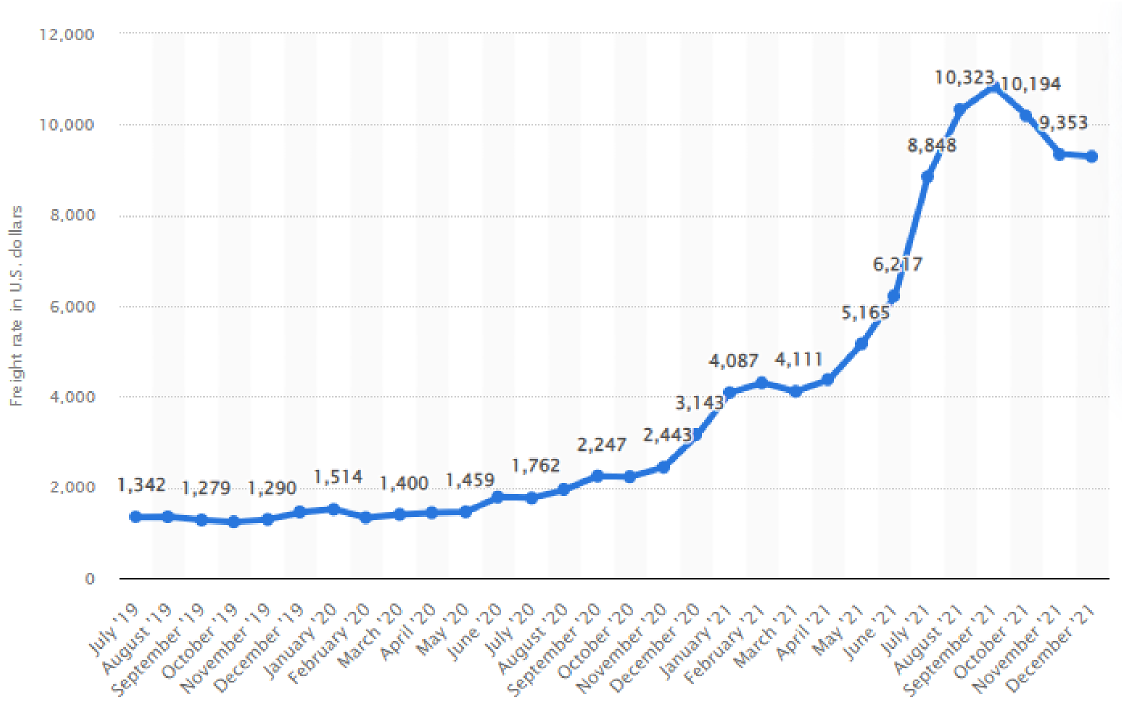
Figure 6.1 Ships at Anchorage off the Coast of Southern California, January 28, 2021

[4] https://www.bloomberg.com/graphics/2021-congestion-at-americas-busiest-port-strains-global-supply-chain/

[5] https://www.washingtonpost.com/business/interactive/2021/supply-chain-issues/

Source: marinetraffic.com

Figure 6.2 Global Container Freight Rate Index, July 2019–December 2021



Source: Statista.com

The global supply chain disruptions have led many logisticians to consider the merits of diversifying production locations by seeking additional production capacity in other Asian countries, and/or bringing more production back to the United States (a.k.a., "onshoring") or to Mexico or Central America (a.k.a., "nearshoring") in order to reduce exposure to disruption risks. Such decisions may take years to implement. Production capacity would have to be expanded in the new production locations, and transportation capacity may need to be reallocated in order to improve service to/from those locations. And in some cases, it may be simpler to build up inventory reserves than to relocate production facilities in order to mitigate supply risks.6 These decisions also impact the cost of production and transportation (and therefore, the cost consumers pay in the marketplace), and the economies (including output, employment, wages and earnings) of the locations where production is expanded or reduced.

If and when the pandemic becomes a distant memory, quarter-over-quarter cost and profit could once more be the most important driving factor, and that could pressure production to relocate offshore in China or other low-cost locations once again. Apart from the pandemic, other issues such as rising labor costs in China, transit times, global politics and

[6] https://www.mckinsey.com/business-functions/operations/our-insights/how-covid-19-is-reshaping-supply-chains

trade relationship issues, and other considerations may also come to bear.7 It is therefore uncertain as to whether considerations of diversifying production and mitigating risk in the wake of the COVID-19 disruptions are short-term topics of interesting discussion, or long-term trends that could re-shape global supply chains.

6.2 Technological Advancement

Freight carriers, shippers, and logistics companies are advancing the technologies used to move and to manage the movement of goods with the objectives of improving reliability, reducing transit times, and reducing costs. Key advancements, described below, include the application of artificial intelligence to delivery tour planning and management, automation of warehouse operations and trucks, and the potential implications of 3D printing, also known as "distributed manufacturing," with regard to supply chain management and freight logistics.

Artificial Intelligence for Tour Optimization. Many carriers, or companies that deliver e-commerce shipments to consumers' doorsteps, are developing and applying technological solutions in order to improve the efficiency and reduce the cost of performing last-mile deliveries. For many years, carriers have used various software packages to help them plan delivery routes and tours to minimize trip miles and/or planned travel times. However, conditions on the ground can lead to travel times that vary from static planned estimates. If a specific tour can take 50% longer to complete on a "bad day" of congestion, the carrier may have to budget a buffer of an extra 50% when assigning resources (drivers, vehicles, etc.) to routes. This buffer is an inefficiency. For example, carriers may have to budget more time and/or hire additional drivers so that deliveries are made on schedule on days when delays are significant, however, this may be too much labor capacity on average days.

Using artificial intelligence (AI) for the purpose of managing drivers' tours and routes is an emerging trend in the logistics industry. Some companies are using or experimenting with AI that can better optimize delivery route options. Standard routing systems and applications use mathematics to analyze all potential routes and select a best route based upon shortest estimated travel time and/or distance. Commercial routing applications, such as Google, bring in historic and real-time operations data to adjust route estimations. AI pushes the envelope further by predicting the best route over time, using a combination of traffic information, load and customer information, and driver behaviors. AI also "learns" from observations over time, and can adjust predictions accordingly.[8] Some providers of AI-supported route optimization software claim that the AI can also incorporate drivers' needs for rest stops, refueling, and other activities into the routing and navigation calculations, and adjust estimated delivery times accordingly. The estimated delivery times can be shared with the customer in real time.[9]

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[7] https://link.springer.com/article/10.1057/s42214-020-00075-5

[8] https://nexocode.com/blog/posts/ai-in-last-mile-delivery-optimization-vehicle-routing-problem/

[9] https://www.dispatchtrack.com/blog/ai-powered-routing?hs_amp=true

In addition, AI-enabled information systems are linking delivery performance with inventory management systems in order to manage distribution center operations, i.e., managing loading dock capacity for inbound and outbound shipments, determining the rates certain products go from arrival at the distribution center to out for delivery, etc.[10] The "big three" private delivery companies—UPS, FedEx, and Amazon—are using, or are experimenting with, AI-enabled route optimization and navigation systems. The delivery robots briefly piloted by FedEx and Amazon also used AI and machine learning to optimize routes and to help the robots identify and avoid hazards and obstacles. While both FedEx's Roxo and Amazon's Scout robot programs have been discontinued, AI appears to be in the future of delivery planning and operations for human-performed and autonomous deliveries.

Automation of Warehouses. Warehouse automation refers to the process of automating the movement of inventory into, within, and out of warehouses to customers with minimal human assistance. Warehouse automation works by using software and technology like robotics and sensors to automate tasks. These products work in concert with existing tools like inventory management software.

Automated warehouses can increase throughput per square foot (and thus per acre) by as much as three times. Aisles between storage racks can be narrower and the height of the racks taller, because robotics replace forklifts. This allows more product to be handled and stored horizontally and vertically. Combinations of material handling and optical equipment enable greater precision in picking and packing of inventory, which enables management of larger volumes and greater varieties of products. Companies interested in warehouse automation must weigh the high initial costs of acquiring the equipment and management systems, relative to the reductions in operating costs over time. As more companies have adopted automation, and the technology becomes ubiquitous, the barrier to entry into automation will likely continue to decline over time.

[10] https://www.infosys.com/insights/ai-automation/documents/moving-goalposts.pdf

Figure 6.3 Automated Warehouse Robots

Source: JD.com

E-commerce fulfillment centers differ from traditional DCs in their requirement for greater labor input. This results from the small order sizes and varied inventory content typical of on-line consumer purchases. They are nevertheless significantly automated facilities. Equipment is used for material handling and to direct work flow, divert pass-through orders (where inbound product can be repackaged for outbound without further handling), and to limit labor involvement where possible.

Automation of Trucks. Connected vehicle (CV) technology utilizes short-range communications (commonly referred to as V2X or vehicle-to-everything) to sense what other travelers are doing and to identify potential hazards. Vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) allow vehicles to be aware of each other's location. An increasing number of trucks use connected and autonomous technologies, including sensors, communications, and/or processing software for steering and braking assistance. Due to ongoing industry challenges to attract new drivers and the continued need to improve safety, the benefits of greater vehicle automation to the trucking industry are substantial. The Society of Automation Engineers' automation levels classification scheme is the industry standard for measuring the degree of automation in a vehicle, as shown in Table 6.2.

Table 6.2 Society of Engineers (SAE) Automation Levels

Level	Title	Description
0	No Automation	Zero autonomy: the driver performs all driving tasks.
1	Driver Assistance	The driver controls the vehicle, but the vehicle design may include some driving assist features.

Level	Title	Description
2	Partial Automation	The vehicle has combined automated functions, like acceleration and steering, but the driver must be ready to take control of the vehicle at all times with notice.
3	Conditional Automation	Driver is a necessity but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.
4	High Automation	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.
5	Full Automation	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

Source: Society of Automotive Engineers.

Currently, there are no viable commercial systems for fully autonomous trucks. The highest level of truck automation commercially available is “advanced driver assistance” (Level 1). Partial and conditional automation are in the pre-commercial stage, and high and full automation are in research and development and are not likely to be available over the medium term. Advanced driver assistance systems (ADAS) are commercially available for trucks. ADAS enhances the safety, efficiency, or experience of driving by assisting in or automating real-time functions traditionally performed by the driver. They use a variety of internal and external sensors (such as GPS, video, radar, and lidar) to inform drivers about navigation and potential conflicts. Examples of ADAS include electronic stability control (ESC) and roll stability control (RSC), which use real-time information such as weight, speed, acceleration, and steering to detect the potential for a vehicle rollover or loss of steering control; forward collision warning (FCW) systems which provide a warning to the driver if the distance or time to the lead vehicle falls below a certain threshold; and autonomous emergency braking (AEB) which allows the vehicle to brake independently of the driver to avoid or mitigate an imminent rear-end collision. ADAS forms the foundation of autonomy and represents a significant advance in vehicle safety even without full autonomy. Multiple studies have found these technologies to be effective at reducing truck crashes. [11,12,13,14]

Though fully connected and automated trucks may not be considered an emerging trend, the enabling technologies are an emerging trend that will impact how goods are moved across the Portland region and throughout the nation.

Besides safety, fuel cost savings and greater operational efficiencies are primary motivating factors for equipping trucks with connected and automated technologies. In particular, fleet operators that can deploy trucks in platoons can potentially realize these benefits. Truck platoons use V2V communications and autonomous vehicle control technology to electronically "tether" tractor-trailers together in a convoy formation.[15] These vehicles automatically maintain a set, close distance between each other while connected (about 20 to 75 feet[16]). The truck at the head of the platoon acts as the leader, with the trailing vehicles reacting and changing in its movement. Platooning can decrease the aerodynamic drag on the following vehicle(s), generating estimated fuel savings of up to nearly 5 percent for the lead truck and almost 10 percent for trailing trucks.[17] It can yield labor cost savings if humans do not operate the following trucks in the convoy but are tethered to a lead truck with a human driver.

3D Printing, or "Distributed Manufacturing." Distributed manufacturing refers to the potential for three-dimensional (3D) printing to permit efficient production of goods near the points of demand, leading to many small factories situated in and serving many local markets. This contrasts with the long-standing imperative for factories to achieve economies of scale through mass production, and to locate large plants in limited numbers where the availability of raw materials, affordable skilled labor, vendors, or other factors of production make the achievement most efficient. Shipments of large volumes from some external sites in the U.S. or abroad to the multi-state region, might be replaced by local shipments from points of production inside the region.

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[11] Hickman, J. et al., "Onboard Safety Systems Effectiveness Evaluation Final Report," Federal Motor Carrier Safety Administration, FMCSA-RRT-12-012, 2013, https://rosap.ntl.bts.gov/view/dot/10.

[12] Woodroofe, J. et al., "Safety Benefits of Stability Control Systems for Tractor-Semitrailers," National Highway Traffic Safety Administration, DOT HS 811 205, 2009, https://deepblue.lib.umich.edu/handle/2027.42/64283.

[13] Federal Motor Carrier Safety Administration, "Benefit-Cost Analyses of Onboard Safety Systems," Tech Brief, FMCSA-RRT-09-023, February 2009

[14] National Transportation Safety Board, "The Use of Forward Collision Avoidance Systems to Prevent and Mitigate Rear-End Crashes," 2015, https://www.ntsb.gov/safety/safety-studies/Documents/SIR1501.pdf.

[15] European Automobile Manufacturers Association, https://www.acea.be/uploads/publications/Platooning_roadmap.pdf.

[16] Lammert, M., Duran, A., Diez, J., Burton, K. et al., "Effect of Platooning on Fuel Consumption of Class 8 Vehicles Over a Range of Speeds, Following Distances, and Mass," SAE Int. J. Commer. Veh. 7(2):2014, doi:10.4271/2014-01-2438

[17] Ibid.

Although 3D printing remains a niche in the overall manufacturing picture, it is growing, and with that growth comes increased demand for transportation of "inks" to feed 3D processes. These materials include plastics, resins, various synthetic powders, and metals.[18] There could also be a reduction in freight moves carrying parts and products produced overseas through ports of entry and the logistics chain to customers. The “inks” are commodities that are generally conducive to rail transportation, in large quantities. Rail could be used to move ink materials long distances, with trucks or other modes used to distribute smaller shipments to end users.

Distributed manufacturing could potentially facilitate the establishment of more (and potentially smaller) manufacturing facilities throughout the region. Alternatively, or in addition, future 3D printing locations could be in the home, commercial buildings, industrial buildings, almost anywhere, thus reducing the need for consolidated manufacturing. Larger-scale 3D printing facilities or ink suppliers could seek (i.e., higher demand for) rail-served industrial sites.

6.3 Growth in E-Commerce Demand

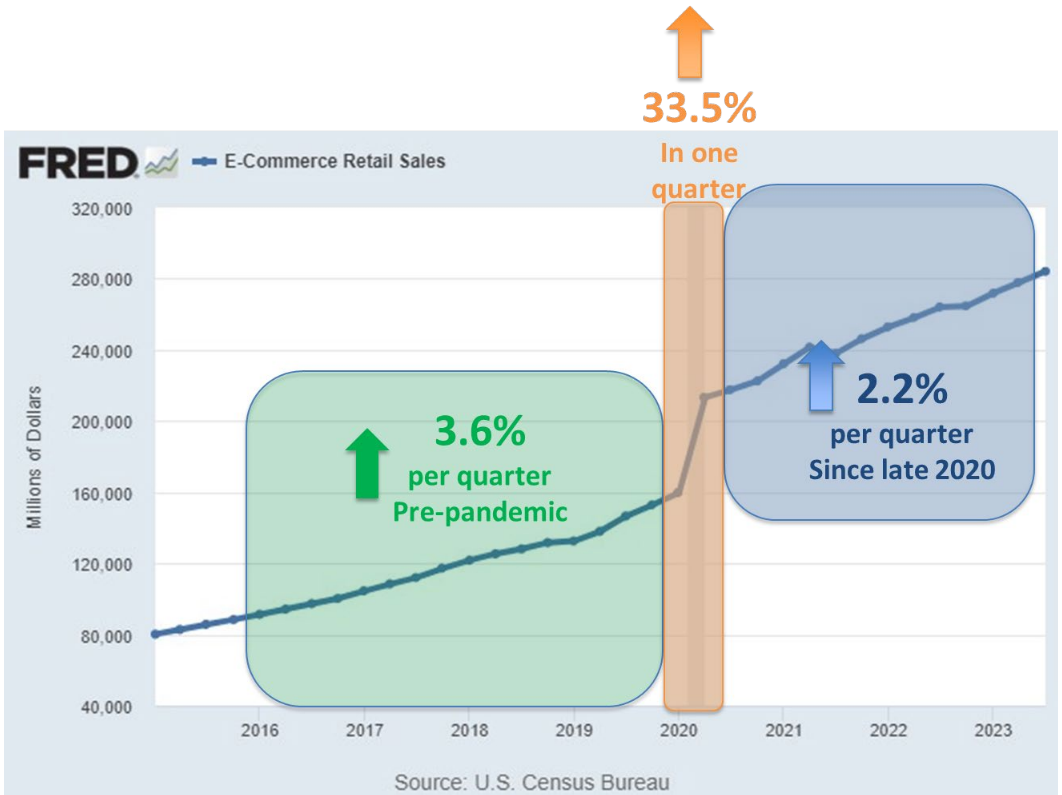
E-commerce, or the sales of retail goods via the internet, has become a mainstream channel for consumers across the nation to shop for various consumer goods—including home furnishings, appliances, clothing and accessories, and food, among others. The COVID-19 pandemic rapidly accelerated the volume of e-commerce sales made in the United States. With that, a substantial increase of employment in key industrial sector that support these operations – including transportation and warehouse. Also, an increased warehouse capacity and new development of fulfillment and other distribution centers close to the urban center has been observed between 2020 and 2022.

National Trends. In late 2011, e-commerce sales in the United States totaled approximately $50.2 billion. This represented about 4.9% of total retail sales in the U.S. By the 1st quarter of 2020, on the eve of the COVID-19 pandemic’s spread through the U.S., e-commerce sales totaled $159.8 billion, and represented 11.9% of total retail sales. As Figure 6.4 and Figure 6.5 show, e-commerce sales spiked by 33.5% (to $213.3 billion, and 16.5% of total retail sales, as shown in Figure 6.6) in the second quarter of 2020, when the pandemic was spreading across the U.S., and stay-at-home order and social distancing was the federal, state, and local authorities’ recommendations.

Since the spike in demand in the second quarter of 2020, e-commerce sales have continued to increase each quarter through 2023, at an average rate of 2.2% per quarter, a lower rate than the 3.6% per quarter average between 2011 and the first quarter of 2020. This slowed rate of growth can be attributed to several factors, including a logical deceleration after the 2020 spike, supply shortages, price inflation of consumer goods, and changes in consumer spending in anticipation of an economic slowdown in the near future.

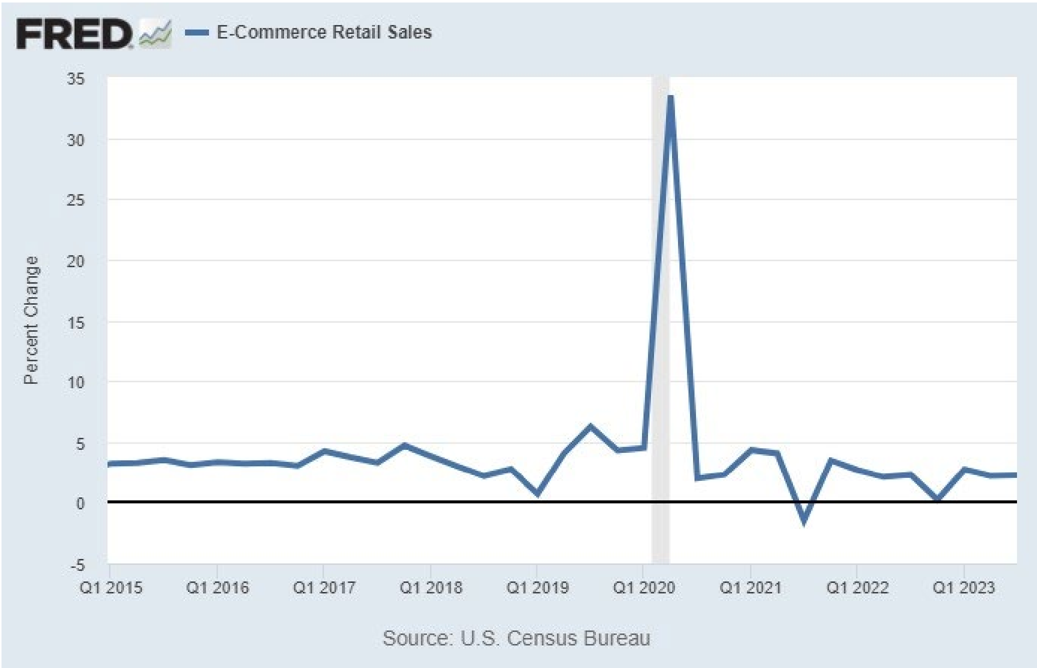
[18] What Materials Are Used for 3D Printing? | Sharretts Plating Company

Figure 6.4 U.S. E-Commerce Retail Sales by Quarter, Q1 2015–Q3 2023



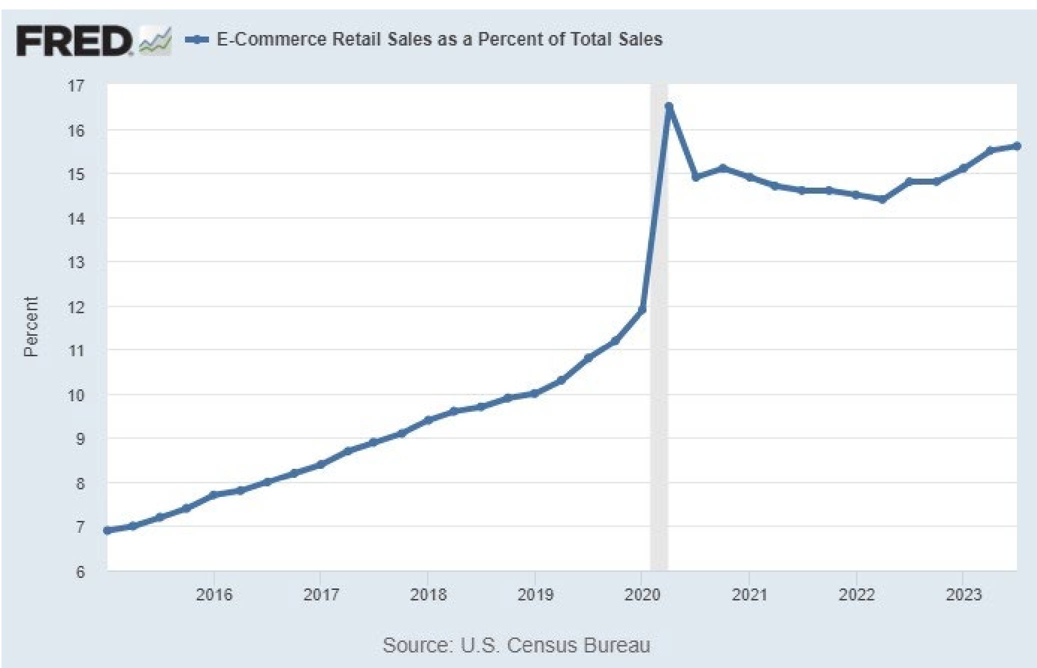
Source: U.S. Census Bureau, E-Commerce Retail Sales [ECOMSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECOMSA.

Figure 6.5 Compounded Rate of Change in E-Commerce Retail Sales by Quarter, Q1 2015–Q3 2023



Source: U.S. Census Bureau, E-Commerce Retail Sales [ECOMSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECOMSA.

Figure 6.6 E-Commerce as a Percent of Total U.S. Retail Sales by Quarter, Q1 2015–Q3 2023



Source: U.S. Census Bureau, E-Commerce Retail Sales as a Percent of Total Sales [ECOMPCTSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECOMPCTSA.

State and Metro Regional Trends. Data on e-commerce sales and the number of parcels delivered within the region are outside the reach of the budget of this study, and the net transportation system effects (i.e., whether the addition of delivery vehicle trips replaces household trips to brick-and-mortar retail stores) are still debated. However, data showing national trends in e-commerce sales, and state-level consumer spending and retail sales suggest that e-commerce purchasing is growing. Further, port container volumes at the Port of Portland, increased employment in key industry sub-sectors linked to e-commerce, and industrial real estate occupancy and development suggest that growth in e-commerce demand and augmentation of the logistics systems needed to fulfill orders and deliver parcels, are having impacts in the Portland region.

A summary of key data points and statistics demonstrates that the growth in e-commerce demand is likely having impacts on employment and wages, the industrial real estate market. Key relevant findings include:

- Statewide (Oregon), growth in personal consumption expenditures between 2019 and 2021 exceeded the national average. Consumer spending on food and beverages, furniture and home furnishings, and miscellaneous retail items increased at a greater rate in Oregon than in the nation as a whole. Spending on motor vehicles and parts, health and personal care, sporting goods/hobbies/books/etc., and general merchandise did not increase in Oregon as much as nationally. Oregonians spending more on consumer goods than the national average suggests that e-commerce growth (as an increasingly popular retail channel) may be increasing at or above the national average rate of growth as well.
- Ocean container traffic moving through the Port of Portland increased 137% between August 2021 and August 2022. Much of this growth may be attributable to congestion at other west coast ports and increased charter service to the Port. However, increased consumer spending in stores and online in this region and nationally is likely a major contributor to increased international trade and congestion at many of the nation's international gateways.
- Key economic sub-sectors related to e-commerce experienced substantial increases in employment between 2019 and 2022, particularly couriers and messengers (53% increase) and warehousing and storage (65% increase), during a time when total private sector employment in the Portland-Vancouver metropolitan area decreased by 2% or 18,000 jobs. These two sub-sectors are a small share of the region's total employment, but are representing a larger share now (3.7%) than in 2019 (2.6%). Wages in these sectors have also increased during this time to over $400 million in 2022, representing 2.5% of wages paid in the region.

- E-commerce requires more industrial real estate space than traditional brick-and-mortar retail, and thus, the boom of e-commerce during the COVID-19 pandemic brought a surge in demand for industrial real estate in the Portland-Vancouver region. Vacancy rates have decreased from 5% in 2020 to 3.5% in late 2022. Lease rates are at record levels, and more than 10 million square feet of space are under construction. An Amazon fulfillment center in the Salem area accounts for 3.8 million square feet of that space under construction.

What remains unknown/opportunities for further research:

- The number of e-commerce shipments delivered or the value of sales made in the Portland region is unknown at this time. There are some data sources that estimate these types of statistics, but they are expensive to acquire.
- E-commerce deliveries are not included in the data and long-range forecast packages most often used for public sector freight transportation planning. This may change over time as e-commerce continues to grow and data and analysis approaches are enhanced.

The net effects of e-commerce on travel demand, vehicle-miles traveled, and emissions have been the subject of many research efforts in recent years, but conclusions are difficult to draw based upon the outcomes of these efforts. There are many variables, including demographics, shopping behaviors, automobile ownership, transit utilization, logistics networks and distribution center locations, and personal auto and delivery fleet characteristics that would influence the net effects of e-commerce on VMT, delay, and emissions. More research and analysis, particularly within this region, would be needed in order to determine the contributions e-commerce may make to better or worse transportation system performance and environmental and community impacts of transportation.

7.0 ADDRESSING GOODS MOVEMENT PERFORMANCE

There are several key measures of freight and goods movement performance that stakeholders in the public and private sectors tend to agree are important, and where data to measure them either exist or are in various stages of being developed. Four key measures considered in this section include:

- Speed and travel time reliability;
- Safety, defined as the number of fatal and serious injury crashes on the freight system;
- Risk due to disasters or other disruptions; and
- Equity, admittedly more emphasized in public sector conversations and planning at this time.

7.1 Speed and Travel Time Reliability

Among the key performance indicators for freight and goods movement are measures of the delay and the cost of that delay to the users of the freight system. The travel time between any given origin and destination (aka "speed") is an indicator of predictable delay. Travel time reliability indicates unpredictable delay. Both types of delay incur costs to the users of the freight system (i.e., truck drivers and/or trucking companies). Highway segments or interchanges where delay is concentrated are often referred to as bottlenecks, which are major generators of elevated costs to freight system users. These congestion costs contribute to the overall cost of transporting goods and can impact the prices consumers pay for certain products, and the economic competitiveness of a region or state relative to other areas where transportation costs may be lower.

While predictable and unpredictable delay contribute to higher costs, they do so for different reasons. Predictable, or recurring, delay occurs all or most days. When rush hour traffic occurs every weekday between certain times of the day, commuters and truck drivers alike plan their trips to account for that predictable delay. The cost—including driver wages, fuel use, and other expenses—is anticipated. Unpredictable, or non-recurring, delay may happen less frequently. It could occur due to a crash, poor weather, or another event that impacts traffic intermittently. This unpredictable delay incurs a cost, but not on every trip. Truck drivers and trucking companies must consider the probability of such a delay and plan a "buffer" of time and cost to account for the possibility that such a delay occurs. Therefore, the trucking companies' customers may have to pay a price that is based upon a significant delay, even if that delay does not happen on each trip.

Measuring speed and travel time reliability was performed as part of the Task 4 efforts in this study using the National Performance Measures Research Data Set (NPMRDS), which estimates vehicle speeds using probe data on 19 of the 23 Regional Mobility Corridors in the Portland region. Further analysis could be done to estimate the costs associated with current and potential future delays, using hourly truck operating cost factors applied to the estimated hours of delay or unreliability, following methodologies detailed in national research[19] and other best practices. That information could inform policies aimed at addressing congestion, help economic development or workforce policymakers weigh the region's economic competitiveness in certain industry sectors.

7.2 Safety

Nationally, there were over 5,700 fatalities in crashes involving large trucks in 2021. That was an 18% increase from 2020 and a 49% increase since 2012. The increased number of crashes may be attributable to a combination of causes, including, but not limited to, increased traffic volumes and increased congestion in urban areas (note that urban areas accounted for about 55% of large truck-involved crashes in 2021).

Analysis of safety related to goods movement should also consider crashes that occur at at-grade highway-rail crossings. Over the past decade, freight trains have become longer, resulting in longer durations of closure at many crossings. In addition, the volume of automobile and other road traffic has also increased over the past decade. This means that the delays and congestion resulting from trains passing through crossings is increasing in many areas. This may be resulting in more dangerous behavior on the part of drivers trying to "beat" the crossing gates, and/or instances of pedestrians attempting to climb over or through stalled trains.

The increasing number and severity of crashes and grade crossing-related delays are troubling trends, and helpful performance measures to track the safety of the freight transportation system would be useful for assessing the effectiveness of physical improvements, Vision Zero policies and strategies as they relate to goods movement, and other projects and policies that address safety. Key performance measures could include:

- Number and severity of large truck-involved crashes by corridor, corridor segment, or area, using crash data from ODOT's Crash Analysis Reporting Unit, and/or the WSDOT Crash Data Portal.[20]
    - Further analysis could focus on crashes involving large trucks and cyclists or pedestrians to identify areas where active transportation users are more exposed to the risk of collisions with trucks. This could inform bicycle and pedestrian infrastructure design, truck routing and site access considerations, etc.
- Number and severity of at-grade crossing crashes by corridor and crossing using data available from the Federal Railroad Administration (FRA) Office of Safety Analysis.[21]

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[19] NCHRP Report 925: Estimating the Value of Truck Travel Time Reliability, Transportation Research Board, 2019, available from: https://www.trb.org/NCHRP/Blurbs/180007.aspx (accessed August 3, 2023).

[20] Oregon Department of Transportation Crash Analysis Reporting Unit, available from: https://www.oregon.gov/odot/data/pages/crash.aspx (accessed August 2, 2023); Washington State Department of Transportation Crash Data Portal, available from: https://remoteapps.wsdot.wa.gov/highwaysafety/collision/data/portal/public/ (accessed August 2, 2023).

[21] https://safetydata.fra.dot.gov/OfficeofSafety/default.aspx (note, this site will no longer be active after May 1, 2024).

Note, the FRA grade crossing data will transition to a new website, and will offer new data analysis tools effective early 2024.

7.3 Risk and Resiliency

Because many supply chains have national or global reach, disruptions anywhere along the chain, from localized congestion on one of the Regional Freight Mobility Corridors to a blocked global trade route like the Suez Canal, can have impacts upon where, how, and at what cost goods move. The ability of industry to plan for and mitigate the impacts of these disruptions is critical for supply chain resiliency and ultimately for the on-time, efficient delivery of raw materials and finished products. When these disruptions cannot successfully be mitigated, businesses and consumers are faced with materials shortage and production shutdowns. Effects of the COVID-19 pandemic on overseas production and international trade gateways were described in Appendix A as an example of a recent disruption with effects that rippled throughout the entire economy and supply chain.

Supply chain disruptions can be categorized in many ways and include:

- **Physical:** natural and manmade impediments to use of transportation infrastructure. Floods, wildfires, and increasingly, extreme heat, can have significant impacts on roads, highways, bridges, and rail lines in the Portland region and surrounding areas.
- **Economic:** changes in the state, national or global economy impacting freight flows in the Portland region.
- **Institutional:** changes in policy that facilitate or hinder efficient freight movement.

Resiliency refers to the ability of a system to absorb or withstand an event, operate or maintain continuously, and recover or adapt following a disruption. In the context of the Portland region, a resilient system involves infrastructure design and maintenance; connectivity within and between modal networks to provide alternatives; and institutional capacity for communication and coordination across jurisdictions or between public and private sectors.

Measures of risk and resiliency may include:

- Measuring resiliency against physical disruptions, including natural disasters. Data sources include:
    - Federal Emergency Management Agency (FEMA) National Risk Index, which measures the risk of certain types of natural disasters at the county level, using historic information. This can provide a high-level assessment of risk at a level of geography (county level) that is fairly coarse for a metropolitan region;[22]
    - FEMA National Flood Hazard Layer (NFHL) shows localized areas of flood risk and can be used for link-level analysis of corridors and networks.[23] This database

[22] https://hazards.fema.gov/nri/

[23] https://www.fema.gov/flood-maps/national-flood-hazard-layer

could be used to track mileage of Regional Freight Mobility Corridors that exist within areas of high risk, and/or track projects that harden or otherwise mitigate the risk of flooding in high-risk areas.

  - Oregon Wildfire Risk Explorer, developed by the Oregon Department of Forestry, Oregon State University, and U.S. Forest Service, maps the risk of wildfires throughout the State of Oregon.[24] This tool uses data from the 2018 Quantitative Wildfire Risk Assessment, and it appears (as of August 2023) that an update may be forthcoming. This tool may be used to assess risk of wildfires along freight corridors in the region, and to track projects that harden or otherwise mitigate the risk of wildfire disruptions and damage to the infrastructure. The Washington State Department of Natural Resources has mapping tools and other information focused more upon active fires and burn risk due to current and recent fire events than assessing risk based upon historical information.[25]

- Measuring resiliency against economic and/or institutional disruptions is a task that could be best supported by scenario analysis and/or developing a freight scenario planning tool. Such tools allow a user to select alternative economic forecasts and/or apply one or more "what-if" scenarios that are tailored to key economic or institutional priorities or risks in a region. The tool then generates alternative freight forecasts and trip tables that could be processed using the regional travel demand model to illustrate the effects of each scenario on the volume of trucks and performance on the regional network. The North Jersey Transportation Planning Authority (NJTPA) and several state DOTs have developed these tools in recent years.[26]

7.4 Equity

Transportation equity seeks fairness in mobility and accessibility to meet the needs of all community members.[27] A core tenet of transportation equity is ensuring that the benefits and burdens of the transportation system are equitably distributed. Advancing transportation equity within a freight context is challenging. The benefits of freight are diffuse as they are broadly distributed across geography and stakeholders. Meanwhile, the burdens of freight tend to be localized and disproportionately borne by communities adjacent to freight assets, such as highways, rail lines and terminals, marine terminals, and warehouses. Goods movement has historically contributed to—and continues to exacerbate—uneven distribution of benefits and burdens on disadvantaged communities. International trade requires large shipping vessels, airplanes, trucks, trains, and other vehicles, as well as large industrial and warehousing facilities. Both the vehicles and facilities create air, noise, and other pollutants, and increase health and safety concerns—

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[24] https://tools.oregonexplorer.info/OE_HtmlViewer/index.html?viewer=wildfire

[25] https://www.dnr.wa.gov/Wildfires

[26] https://www.njtpa.org/2050FreightForecasts.aspx

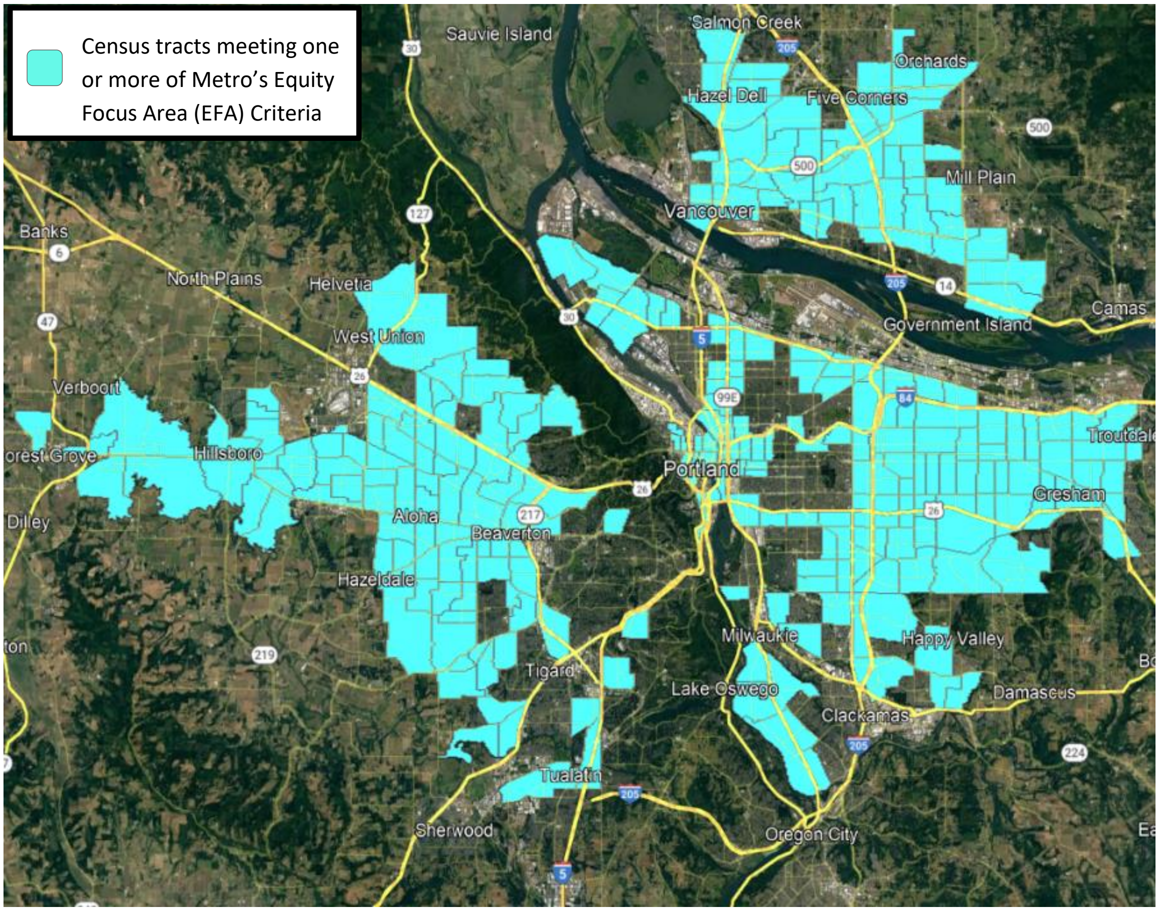
[27] U.S. Department of Transportation Federal Highway Administration (FHWA), "Transportation Planning and Capacity Building, Transportation Equity," available from: https://www.planning.dot.gov/planning/topic_transportationequity.aspx (accessed July 15, 2023).

burdens of which are partially or completely borne by local populations, often in lower-income and communities of color.

Measuring freight equity is challenging, and best practices are few and far between as of 2023. For example, the Bipartisan Infrastructure Law (BIL) required that state DOTs consider equity in their state freight plans, but the federal government has provided little technical guidance. In the 2021-2023 round of state freight plans, only 39% of the plans conducted a quantitative or qualitative analysis of freight equity. Most used proximity analyses to determine the proportion or concentration of equity focus areas (i.e., communities of concern) near the multimodal freight network. While useful, these approaches did not incorporate methods to estimate impacts to target communities, such as measuring or estimating freight-related congestion or emissions. Measuring these impacts is an important next step for state freight plans, but adoption of more robust methodological approaches will likely require more guidance at the federal level, a set of "first mover" states or MPOs to adopt robust equity analyses methodologies, or both.

Further, few states or MPOs have established performance measures to support freight equity goals and objectives. Without quantitative measures, states and MPOs will struggle to take a proactive approach to freight equity as they cannot fully assess the efficacy of interventions and detect trends in how their freight-related investments and decision-making impact equity concerns.

Figure 7.1 Metro's Equity Focus Areas, 2023



Source: Cambridge Systematics, using geodata from Metro and Google Earth

8.0 STUDY RECOMMENDATIONS AND FREIGHT POLICY

The data analysis and modeling, stakeholder engagement, and literature research performed during the course of this study have led to three sets of recommendations for Metro to consider advancing. These recommendations would help to address issues and needs related to the Regional Freight Policy Questions described in Section 3 of this report. The three groups of recommendations include:

1. When and how to address the effects of growth in e-commerce demand and last-mile deliveries;
2. How to identify, and where there are evident needs to improve freight access to industrial lands and terminals; and
3. What enhancements or additions ought to be incorporated into Metro's Regional Freight Policy and Action Items.

8.1 Addressing the Effects of E-Commerce

As presented in Appendix B, growth in consumer demand for goods purchased via e-commerce has had several impacts nationally and within the Portland Region. E-commerce growth is likely contributing to growth in employment in economic sectors such as warehousing and storage and couriers and messengers. It is also likely driving growth in demand for industrial real estate in the region.

E-commerce, and the delivery trips it generates, are increasing the logistics costs for retailers and freight carriers; and generating more demand for curbside loading and unloading zones. These curbside impacts are of especially great interest at a time when expansions of bicycle and pedestrian infrastructure, outdoor sidewalk and parking-space dining, and other uses are also vying for space at or near curbs.

Appendix C presents a summary of strategies that are being implemented or tested by actors in both the private and public sectors to address the impacts e-commerce is having on their respective priorities.

Relevant to this policy question, the public sector should play a role in addressing the growth impacts that e-commerce and goods delivery are having:

- **When?** When those impacts are affecting transportation infrastructure performance and/or public policy goals; and
- **How?** Through strategies to manage curb access and utilization, land use policies that accommodate deliveries and facilitate or direct fulfillment center development to preferred locations, and policies that support workforce and economic development.

On the **"when"** side of this question, there remains much research and analysis to be done in order to determine the net effects e-commerce and deliveries have on the performance of the Portland region's transportation system. For example, how many e-commerce orders that are delivered to a given household actually replace a trip to a retail store, and how frequently households receive e-commerce deliveries versus taking a trip to a store are the subjects of ongoing research by a number of organizations across the country. However, the analysis presented in Appendix B points to other data and trends that suggest that e-commerce sales are continuing to increase, and a logical conclusion is that the number of delivery trips required to deliver a rising number of shipments is also increasing. Industry interviews, summarized in Appendix D, suggest that access to the curb, particularly in urban and mixed-use districts throughout the region, has become more difficult in recent years.

On the **"how"** side of the question, Appendix C describes several best practices that have been tested and/or applied in order to address some of the key issues and impacts associated with growth in e-commerce and last-mile deliveries.

Table 8.1 lists some of these key issues and impacts, some strategies demonstrating "how" they can be addressed, and notes regarding "when" certain actions can be programmed.

Table 8.1 How and When to Address E-Commerce Issues and Impacts

Issue/Impact	How to Address the Issue	When Should Actions be Taken?
Curb access, double-parking, etc.	» Context-sensitive curb management and parking strategies, including right-sizing loading zones, flexible curb zones, and reservation systems (see Appendix C)	» If and when evidence of insufficient curb access is present or likely to occur. Review of best practices is an immediate/ongoing action; Piloting and/or implementing strategies is a potential near-term (within 5 years) action.
Land use: Warehouse and fulfillment center development	» Conduct an inventory of land use appropriate for warehouse and fulfillment center development and assess capacity versus need. » Monitor development and redevelopment trends in industrial districts. Might changes to land use policies be needed to promote or discourage certain development types?	» Conducting an inventory of land use is an immediate action that can be taken. » Monitoring development and redevelopment trends can begin immediately and continue indefinitely.
Land use: Converting vacant retail stores (aka "dark stores") to distribution centers	» Review land use regulations to determine if dark store conversions are feasible. Conduct outreach to determine if and where such conversions may be desirable or undesirable. Adjust land use regulations as necessary.	» Review, analysis, and outreach can be an immediate action, with any necessary regulation adjustments to follow.
Augment the public's understanding of e-commerce trends and impacts	» Purchase available data, perform analysis and integrate with existing modeling tools in order to estimate the transportation system effects of e-commerce and last-mile deliveries » Incorporate findings into planning documents and public/stakeholder engagement activities	» Acquiring data and developing more advanced analysis tools could begin in the near-term. Within 0-5 years, more research on net effects of e-commerce on transportation performance and emissions should be available.

8.2 Improving Freight Access

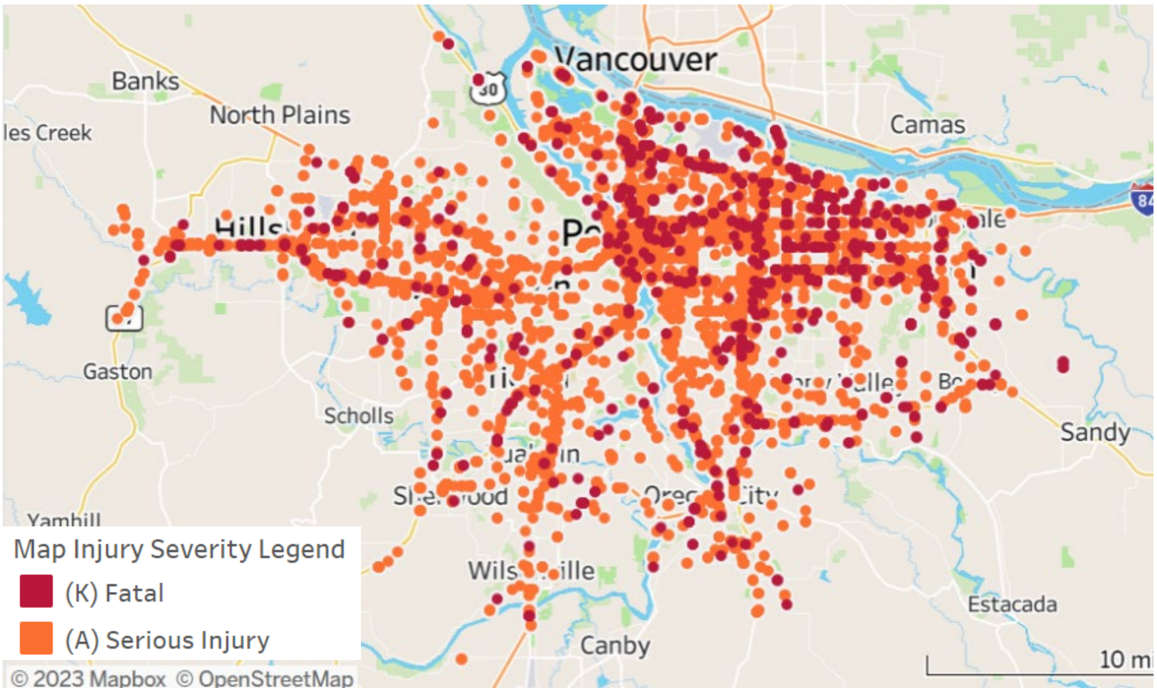
Freight access to industrial lands and terminals in the Portland region is compromised by congestion, delay, and unreliability. In addition, considerations related to safety, equity and community impacts, and economic development could potentially be addressed through freight access improvements. This section identifies and describes a set of criteria for identifying where freight access improvements may be needed, and a list of corridor segments that meet those criteria. Addressing the issues identified in these corridor segments could improve the efficiency of goods movement, reduce negative externalities, and support economic development in the region.

Criteria for Improving Freight Access. "Improving access" to industrial lands and intermodal terminals in the Portland region is an objective that can be achieved by addressing a variety of issues related to the movement of goods in the region. In consultation with Metro, several criteria were developed to address not only delay and reliability issues, but also important issues such as safety, equity, and economic development and competitiveness. The five criteria for improving access to industrial sites and/or intermodal terminals include:

- **Reduce delay and improve reliability.** Delay and unreliability on the highway network impedes access to industrial lands and intermodal terminals by increasing the time it takes to move goods, increasing the cost of moving those goods, and increasing environmental and community effects of goods movement. Congestion and unreliability often results in truck drivers being dispatched at less-than-ideal times, in trucking companies charging customers higher rates to cover real or potential delays, and in some truck trips diverting off of preferred routes and into communities and neighborhoods. These consequences can lead to undesirable results, such as higher emissions, more noise and community impacts, and a higher cost of doing business for companies in the Portland region. Reducing delay and improving reliability can help shippers and carriers optimize their operations, control costs, and lead to desirable economic, environmental, and quality of life outcomes.
- **Addressing network gaps.** Network gaps is a term referring to locations where a road, ramp, bridge, or other connection is needed in order to more effectively link industrial sites and/or intermodal terminals with the regional freight network and/or other key transportation corridors. The existence of a gap may lead to circuitous routing, increasing truck vehicle-miles traveled, congestion, emissions, and/or other community impacts. Addressing network gaps can lead to more direct truck routing and avoid or mitigate some of the aforementioned effects.
- **Reduce truck-involved and non-truck-involved crashes.** Improving access includes addressing safety issues along access routes that trucks use. While truck-involved crashes are often the focus of freight studies, all crashes have an impact on the safety and reliability of the freight transportation system. Analysis has been performed to identify where some of the most severe crashes have occurred—those involving serious injuries and fatalities—over a five year period between 2017 and 2021, using

the data available in the Oregon Crash Data Viewer.[28] Addressing the factors that contribute to crashes, including design and operational factors, can thus improve freight access by reducing fatalities, injuries, costs, and delays associated with crashes.

Figure 8.1 Serious Injury and Fatal Crashes in the Portland Urbanized Area, 2017–2021



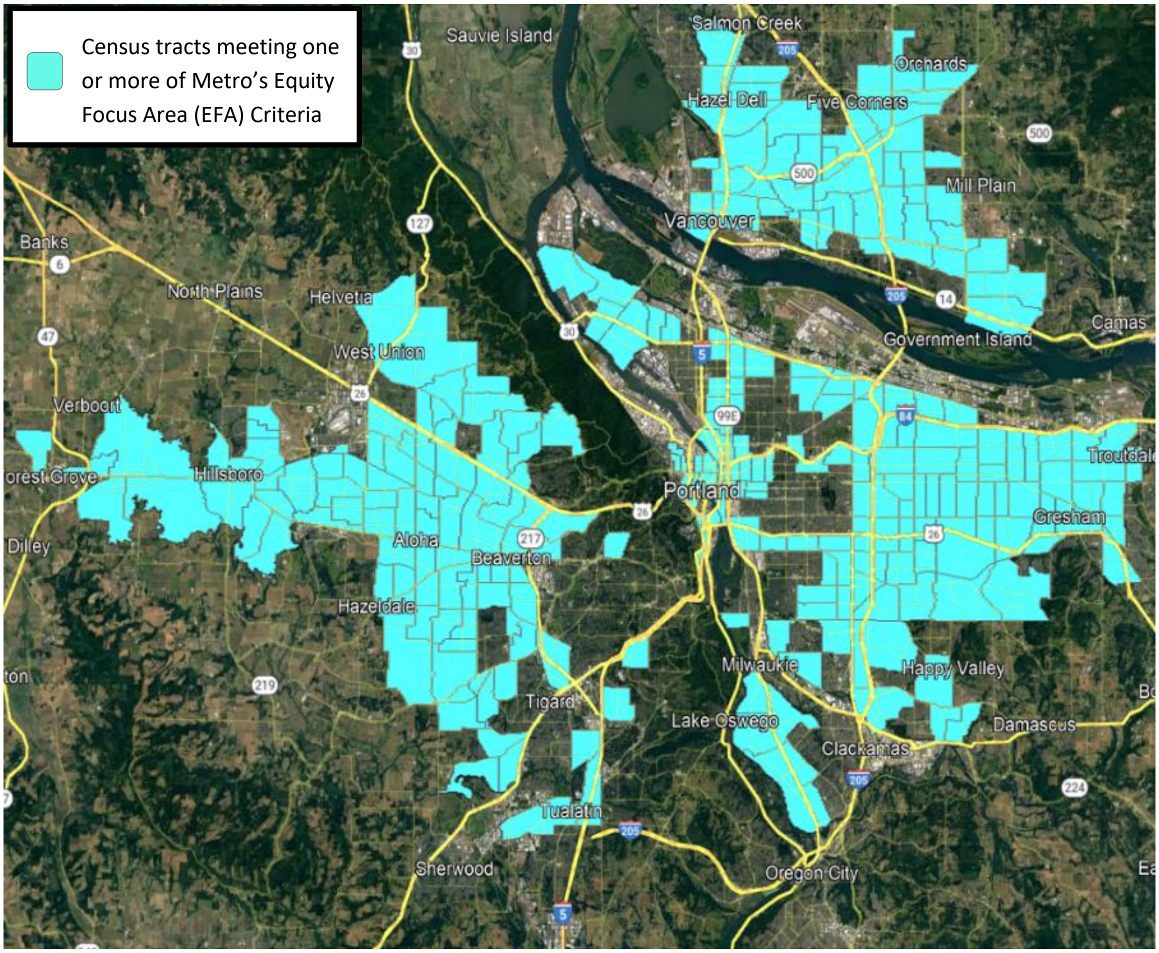
Source: Crash Data Viewer, ODOT

- **Address community impacts associated with truck movements, especially in Equity Focus Areas.** In some parts of the region, industrial sites, intermodal terminals, and/or the routes that trucks use to access such facilities are located in or adjacent to communities with vulnerable populations. The benefits of freight in the Portland region, including supporting economic growth and development and residents' quality of life, are typically regional in scale. However, the negative effects of freight-generating and freight-handling facilities, such as noise, particulate emissions, odors and light pollution, are typically borne by the community immediately adjacent to the facilities where freight is handled and the transportation network where freight moves. Strategies to avoid or mitigate these negative effects can help to ensure that vulnerable populations can share in the benefits of freight without being overburdened by the negative externalities. Analysis was performed to identify the number of Census tracts that each corridor passes through or adjacent to, which meet one or more of Metro's Equity Focus Area (EFA) criteria. Metro's EFA criteria include Census tracts that represent communities where the rate of Black, Indigenous, or People of Color (BIPOC),

[28] "Crash Data Viewer," Oregon Department of Transportation, available from: https://www.oregon.gov/odot/data/pages/crash-da ta-viewer.aspx (accessed October 13, 2023).

people with limited English proficiency (LEP), or people with low income (LI) is greater than the regional average. Additionally, the density (persons per acre) of one or more of these populations must be double the regional average.[29]

Figure 8.2 Metro-Defined Equity Focus Areas (EFA)



Source: Metro and Google Earth

- **Access developable (or re-developable) industrial parcels within the Urban Growth Boundary (UGB).** The needs of manufacturing, retail and e-commerce distribution, and intermodal transfer of shipments (e.g., seaport and rail terminals) are key drivers in demand for industrial land and buildings in the Portland region. The rise of e-commerce and demand for microchip manufacturing, in particular, have introduced more real or potential demand for modern distribution and manufacturing facilities. Consumer demands for next-day or same-day delivery of e-commerce orders necessitates having facilities located in, or very close to, major population centers. Opportunities may be emerging to assemble land parcels in mature industrial parks

[29] "Equity Focus Area (EFA) 2020," Metro, available from: https://rlisdiscovery.oregonmetro.gov/datasets/drcMetro::equity-focus-areas-efa-2020/about (accessed October 31, 2023).

and clusters and to develop or redevelop modern manufacturing or distribution buildings. Some of these sites may need improved transportation access in order to realize their potential. Analysis was performed to identify where new industrial development or redevelopment is occurring within the Portland region, according to recent Colliers industrial real estate reports.[30]

Locations Where Improved Access Is Needed. Reviewing key corridors and segments in the Portland region, in light of the access criteria, led to the identification of 16 locations where improved access may be needed. Table 8.2 lists the locations and the criterion/criteria applicable to each. Addressing these access needs can help to reduce the delay and cost associated with moving goods in the region, improve safety by reducing crashes, address the equity of freight externalities such as emissions and noise, and support economic development by improving access to developable or re-developable industrial sites within the Urban Growth Boundary.

For delay/reliability issues, “top-tier” corridors refer to locations where 7 or more hours of congestion are observed daily and/or travel time reliability during the morning and/or midday periods can result in travel times 3+ times as long relative to “normal” conditions. “Second-tier” delay or reliability occurs where 4-7 hours of congestion daily and/or reliability issues resulting in travel time that is 2-3 times greater than “normal” are observed during the morning and/or midday periods.

The remainder of Section 8.2 describes relevant conditions at each location. The four rows highlighted in yellow, including the I-5 corridor from I-84 to Vancouver, the “Gateway to Troutdale corridor,” I-205 between I-84 and OR 99E, and OR 8 between OR 217 and Hillsboro, stand out as having some of the most substantial congestion, unreliability, safety, and/or equity issues.

Table 8.2 Locations Where Improved Access is Needed, Based Upon Access Criteria

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017–2021)	No. of Fatal Crashes (2017–2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
I-5 from I-405 to OR 217	**Top-Tier**		**19**	**2**	**3**	
I-5 from OR 217 to Wilsonville	**Top-Tier**		**26**	**2**	**2**	✓
I-5 from I-84 to Vancouver (including N. Going St. and OR 99E north of Columbia Blvd.	**Top-Tier**	✓	**30**	**14**	**8**	✓

[30] Portland Metro Industrial Market Reports, available from: https://www.colliers.com/en/research/portland/2023-q2-portland-metro-industrial-market-report (accessed October 13, 2023).

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017–2021)	No. of Fatal Crashes (2017–2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
I-84 from I-5 to I-205	**Top-Tier**		**20**	**7**	**11**	
SE Powell from Ross Island Br. to I-205	**Top-Tier**		**28**	**7**	**5**	
US 30 from I-405 to (and including) the St. Johns Br.	**N/A**		**10**	**3**	**0**	
Gateway to Troutdale corridor (I-84, Sandy Blvd. and Airport Way east of I-205)	**Top-Tier**		**48**	**31**	**13**	✓
US 26 from I-405 to OR 217	**Top-Tier**		**27**	**0**	**1**	
OR 217 (US 26 to I-5)	**Top-Tier**		**23**	**0**	**6**	✓
I-205 from I-84 to OR 99E	**Top-Tier**		**42**	**10**	**13**	
I-205 from OR 99E to I-5	**Second-Tier**		**8**	**1**	**0**	✓
Marine Dr. – truck queuing at Terminal 6	**N/A**		**7**	**2**	**0**	✓
Murray Blvd. from US 26 to SW Allen Blvd.	**Top-Tier**		**10**	**3**	**4**	
OR 99W from OR 217 to SW 124th Ave	**Second-Tier**		**15**	**7**	**2**	✓
OR 8 from OR 217 to Hillsboro	**Top-Tier**		**40**	**11**	**16**	✓
OR 224 from OR 99E to SE 122nd Ave and OR 212 from I-205 to SE 122nd Ave	**Second-Tier**		**15**	**3**	**1**	✓

I-5 from I-405 to OR-217 connects the central city of Portland with the southwest corner of the city and Lake Oswego. Northbound, between SW Dartmouth St and SW Capitol Highway, travel time reliability is a top-tier issue during the morning hours, as travel time can be more than 3 times longer during that period than "normal" times. There is a medium-tier reliability issue in the morning between SW Capitol Highway and SW Multnomah Blvd. I-5 between I-405 and OR 217 has been the site of 19 crashes involving serious injuries and two crashes involving fatalities during a five-year period from 2017 through 2021. There are three Census tracts adjacent to this highway segment that meet Metro's Equity Focus

Area (EFA) criteria, including tracts 5701 and 5901 in South Portland and tract 6403 in West Portland Park, all of which meet Metro's low income thresholds to qualify as EFAs.

I-5 from OR-217 to Wilsonville. South of Oregon Route 217, there is a substantial reliability issue between I-205 and Boones Ferry Rd during midday hours, when travel time can be 4.7 times the "normal" travel time. Twenty-six serious injury crashes and two fatal crashes have occurred on this corridor segment between 2017 and 2021. There are two Census tracts meeting Metro's EFA criteria. Tract 30806 in Tigard meets the threshold for limited English proficiency, and Tract 32005 meets the thresholds for Black, Indigenous, People of Color (BIPOC) and low income. This segment provides highway access to a mature cluster of industrial buildings in and around Tualatin, and a growing cluster near Wilsonville.

I-5 from I-84 to Vancouver (including N. Going St. and OR 99E north of Columbia Blvd.). This corridor segment provides an important highway connection to/from Portland's industrial north, including the Port of Portland's marine terminals and the airport (PDX). In the southbound direction, between Marine Drive and I-84, there is delay for 5.3 to 9.1 hours per day, and travel time during the midday is up to 3.3 times the normal travel time, suggesting a top-tier congestion and unreliability issue on this corridor segment. Northbound, between I-84 and the Washington state line, there are fewer hours of congestion, but midday unreliability is far more pronounced, with travel taking 4.5 to 6.7 times the normal travel time. In the five year period between 2017 and 2021, 30 serious injury and 14 fatal crashes have occurred. This corridor passes through or adjacent to 8 Census tracts that meet one or more of Metro's EFA criteria. There are sites in this are of the region where industrial development and/or redevelopment could occur.

I-84 from I-5 to I-205. This portion of I-84 experiences between 3.9 and 7.7 hours of congested conditions daily in the westbound direction, which qualifies as a top-tier congested corridor. Reliability is a second-tier issue, as I-84 appears to be reliably congested during much of the day. There were 20 crashes involving serious injuries and 7 crashes involving fatalities on these two roadways between 2017 and 2021. There are 11 Census tracts meeting Metro's EFA criteria that these segments of I-84 pass through or adjacent to.

SE Powell from Ross Island Br. to I-205. This corridor experiences between 7.3 and 9.9 hours of congested conditions daily in both directions. Reliability is a second-tier issue, as SE Powell Blvd. is reliably congested during much of the day. There were 28 crashes involving serious injuries and 7 crashes involving fatalities on these two roadways between 2017 and 2021. There are 5 Census tracts meeting Metro's EFA criteria that these segments SE Powell pass through or adjacent to.

US 30 from I-405 to (and including) the St. Johns Bridge. This segment of US Route 30 provides access to and from Portland's industrial Northwest. Congestion and reliability are not major issues along this corridor segment, relative to other corridors evaluated throughout the region. There were 10 serious injury crashes and 3 fatal crashes in this corridor between 2017 and 2021. There are no Census tracts in this corridor that meet any of Metro's EFA criteria.

Gateway to Troutdale corridor (I-84, Sandy Blvd. and Airport Way east of I-205). This corridor consists of three facilities—I-84, Sandy Blvd., and Airport Way—heading east from I-205 to Troutdale. Airport Way experiences 7.7 hours of congestion westbound and 8.4 hours of congestion eastbound daily. There are second-tier reliability issues on this corridor during the midday hours, particularly on Airport Way, where travel times can exceed twice the normal travel time in the westbound direction. The sum total of serious injury crashes on all three road segments in this corridor was 48 between 2017 and 2021. There were 31 fatal crashes during the same period. There are 13 Census tracts in Portland's eastern neighborhoods that meet one or more of Metro's EFA criteria. There are some developable or potentially re-developable industrial parcels along or near this corridor, where improved access could potentially support such investments.

US 26 from I-405 to OR 217 is a key highway facility connecting Central City Portland to Beaverton and points west. Delay and reliability issues along this corridor are primarily observed in the eastbound direction. Between SW Canyon Rd and SW Vista Ave, eastbound traffic is congested between 8.4 and 12.3 hours daily. Between Route 217 and SW Canyon Rd., eastbound travel speeds are unreliable during the morning and midday periods, when travel time can be 3.6 times and 2.6 times the normal travel time, respectively. There were 27 crashes involving serious injuries in this corridor between 2017 and 2021, and no crashes involving fatalities. There is one Census tract that meets Metro's EFA criteria. Census tract 30200, which includes the interchange of US 26 and OR 217, meets Metro's EFA criteria for limited English proficiency.

OR 217 (US 26 to I-5). Oregon Route 217 provides a limited-access highway link between US 26 near Beaverton and I-5 in Tigard. There are several sites along this corridor where industrial development has recently occurred or is underway. Southbound traffic is congested between Walker Rd. and SW Denney Rd. for 4.7 to 7.2 hours per day, which places this segment in the top tier for daily speed performance issues. Reliability during the morning and midday periods are in the top tier southbound between Walker and Denney and northbound between SW 72nd Ave. and SW Hall Blvd. Between 2017 and 2021 there were 23 crashes involving serious injuries and no fatal crashes. There are six (6) Census tracts meeting one or more of Metro's EFA criteria along this corridor.

I-205 from I-84 to OR 99E provides a north-south alternative to I-5 east of central Portland. North of OR 99E in Oregon City, I-205 experiences second-tier levels of congestion northbound between Johnson Creek and SE Stark St. and between NE Glisan St. and I-84. Travel time reliability is a major issue northbound north of Glisan and between Sunnyside and Johnson Creek, and southbound near SE Powell, during the midday period. Other segments along this corridor observe second-tier levels of unreliability during the morning and/or midday periods. Between 2017 and 2021, 42 crashes involving serious injuries, and 10 crashes involving fatalities, have occurred on this corridor. There are 13 Census tracts that meet one or more of Metro's EFA criteria along this corridor.

I-205 from OR 99E to I-5. Between OR 99E in Oregon City and I-5 in Tualatin, northbound traffic between SW Stafford Rd. and OR 43 experiences second-tier travel time reliability issues during midday hours. Travel can take 2.2 to 2.7 times as long as during “normal” times. Between 2017 and 2021, 8 crashes involving serious injuries and 1 fatal crash occurred on this segment of I-205. There are no equity focus areas located along this corridor. There are some developable, or potentially developable, industrial sites along this corridor in the vicinity of Tualatin.

Marine Dr. – truck queuing at Terminal 6. North Marine Drive is the primary route trucks use to access Terminal 6 in the Port of Portland. During the supply chain disruptions of 2020-2021, occasional lengthy truck queues outside the terminal gate were observed. However, queueing has become less frequent as of 2023. Seven serious-injury crashes and two fatal crashes occurred in this corridor between 2017 and 2021. There are no equity focus areas along this corridor.

Murray Blvd. between US Route 26 and SW Allen Blvd. provides north-south truck access to retail districts, including Tualatin Valley Highway (OR 8), and the Nike World Headquarters campus. The portion of this corridor south of OR 8 experiences more than 7 hours of congestion daily. The same segment experiences significant travel time reliability issues in the morning period, as does the segment between US 26 and Walker. The segment between Walker and OR 8 experiences significant reliability issues during the midday period. Between 2017 and 2021, 10 serious injury crashes and 4 fatal crashes occurred along this corridor. Four equity focus area Census tracts are located along this corridor.

OR 99W from OR 217 to SW 124th Ave in Tualatin provides access to industrial clusters in the Tualatin and Sherwood areas. Congested conditions in this corridor are observed between 4-7 hours daily, and second-tier reliability issues exist in the morning and midday periods. This corridor was the scene of 15 serious injury crashes and 7 fatal crashes between 2017 and 2021. Two equity focus area Census tracts are located along this corridor.

OR 8 from OR 217 in Beaverton to Main Street in Hillsboro is a major east-west arterial corridor connecting Beaverton with Hillsboro. There are several major retail complexes located along this corridor. Congestion is a significant issue between Murray Blvd. and OR 217 for more than 7 hours daily. Travel time reliability is a second-tier issue along most of the corridor during morning and midday periods, however, significant travel time reliability issues, in which travel times can take more than 3 times “normal” travel time, are observed in the westbound direction between SE 209th Ave and Hillsboro. There were 40 severe injury crashes and 11 fatal crashes on this corridor between 2017 and 2021. There are 16 equity focus area tracts located along this corridor.

OR 224 from OR 99E in Milwaukie to SE 122nd Ave in Clackamas, and OR 212 from I-205 to SE 122nd Ave. This corridor provides access between Milwaukie and I-205, and between a cluster of distribution centers in Clackamas and I-205. Congestion and reliability are second-tier issues in this corridor during the morning and midday periods. There were

15 serious injury crashes and 3 fatal crashes in this corridor between 2017 and 2021. Three equity focus area Census tracts are located along this corridor.

8.3 Regional Freight Policy Recommendations

Metro's Regional Freight Strategy, published in 2018, listed 7 Regional Freight Policies that are supported by a range of near-term and long-term Action Items. The Regional Freight Policies and Action Items are listed in Chapter 3 of this report. The data analysis and modeling, literature research, and stakeholder engagement conducted during the course of this study have provided Metro with a fuller understanding of the effects of recent trends and issues associated with e-commerce growth, supply chain resiliency, and COVID-19 pandemic. This knowledge has led to the identification of several enhancements and/or additions to the Action Items that support the Regional Freight Policies.

The Action Items associated with the Regional Freight Policies should be updated or enhanced to incorporate the findings of this study. Proposed language is provided in the next chapter of this report. A summary of the recommended updates include:

- Updating Action Item 1.5 to incorporate findings regarding data on last-mile deliveries, and to transition the action from "exploring data sources" to an action that encourages data procurement, analysis, and developing findings.
- Incorporate equity into Regional Freight Policy #4 and describe ways Metro could define performance measures related to freight equity in the action items related to Policy #4.
- Action Item 5.3, which calls for an assessment of demand for industrial land, ought to be promoted from a long-term action to a near-term action, supported by a regional industrial land use study and an assessment of the transportation system effects (i.e., trip generation factors) of e-commerce fulfillment centers. Metro should perform a Regional Industrial Land Use Inventory Study in order to achieve this desired action.
- Add a new action, Action Item 5.4, which would be a near-term action to investigate the feasibility and desirability of converting vacant retail buildings to use for distribution. This could be done as part of the Regional Industrial Land Use Inventory Study or as a separate initiative.

9.0 ACTING UPON THE FINDINGS OF THE CMS

The findings and recommendations of this study suggest certain actions and next steps that Metro can take in order to keep its understanding of freight trends and issues current over time, develop and apply cutting-edge data and analysis methods, and address existing and anticipate future needs. These next steps include advancing planning studies, monitoring and applying new and emerging data and methods, and adopting some key updates to the Regional Freight Policy and Action Items. As Figure 9.1 shows, items listed in Section 9.1 are actions Metro has committed to advancing. Actions listed in sections 9.2 and 9.3 are recommendations of this study that Metro and/or other stakeholder organizations may choose to advance.

Figure 9.1 Recommended Next Steps for Implementing the Findings of the Commodities Movement Study

COMMITTED: Advancing Programmed Planning Studies (Section 9.1)

- Initiate and Complete the Regional Industrial Land Use Inventory Study
- Refresh of the 2040 Study

RECOMMENDED: Monitoring and Applying New and Emerging Data and Methods (Section 9.2)

- E-Commerce Delivery Trip and Impact Estimation
- Best Practices in Managing Curbs and Last-Mile Delivery Impacts
- Equity Performance Measures
- Land Use Needs
- Effects of Office Vacancies in Portland's Central City on Freight Needs

RECOMMENDED: Adopting Regional Freight Policy and Action Item Updates (Section 9.3)

- Modify Action Item 1.5 to focus on data acquisition and exploring emerging methodologies.
- Add a new action (4.5) to develop freight equity performance measures.
- Update Action Item 5.3 to reference the Regional Industrial Land Use Inventory Study.
- Add a new action (5.4) to examine land use regulations associated with converting vacant retail to distribution facilities supporting e-commerce.

9.1 Advancing Planning Studies

Metro is expecting to initiate two regional studies that will address and/or incorporate findings of this study—the Regional Industrial Lands Availability and Intermodal Facilities Access Study and the "2040 Refresh." Both studies are included in Metro's 2024-25 Unified Planning Work Program (UPWP) and are described below.

Regional Industrial Lands Availability and Intermodal Facilities Access Study. The purpose of this study would be to further work on data collection, transportation impacts, and land use and transportation policy issues around the growing need for larger distribution centers and fulfillment centers, and the potential shortage and/or lack of readiness for industrial land in the region that will meet that need. This study was identified as part of the key findings and recommendations of the CMS, which looked at the need for improved access and mobility to and from regional industrial lands and intermodal facilities.

The scope of the Regional Freight Delay and Commodities Movement Study did not allow for studying the future availability, need, and readiness of large industrial sites that may be needed to accommodate the growth in distribution centers and warehousing that meet customer demand for e-commerce deliveries and other industrial products. The Regional Freight Delay and Commodities Movement Study did not address the potential localized and regional transportation impacts of the growth in fulfillment centers and large disruption centers. The Regional Industrial Lands Availability and Intermodal Facilities Access Study is needed to address these land use and transportation issues, and further study the need for new regional freight and land use policy.

The Regional Industrial Lands Availability and Intermodal Facilities Access Study will inform the '2040 Refresh' work that Metro will be commencing in FY 2024-25; and is outlined in Chapter 8 of the 2023 Regional Transportation Plan.

9.2 Monitoring and Applying New and Emerging Data and Methods

The research conducted as part of this study identified some new data sources that could be useful for answering the Regional Freight Policy questions and/or addressing other freight-related issues and needs in the Portland region. In addition, there is room for improvement in the state of the practice related to several issues, such as net traffic and environmental effects of e-commerce and consensus on what variables and methodologies are needed to develop and monitor performance measures related to freight equity.

E-commerce Delivery Trip and Impact Estimation. Some of the effects of e-commerce still need to be fully understood. To develop a better understanding and quantification the e-commerce impact, further research, development and/or enhancement of data and analysis tools, and better private sector engagement is required. The following are three key areas of opportunities for research:

- E-commerce parcels delivered in the region. There are several data vendors, including Axciom, BDEX, FreightWaves, and Nielsen IQ (formerly Rakuten Intelligence, acquired by Nielsen in 2022) providing market research data on e-commerce purchases and/or shipments delivered. Each source has varying limitations due to sample sizes, data attributes collected, and/or cost. Nielsen IQ is perhaps the most often used for public sector freight planning purposes due to its robust sample and estimates of total e-commerce shipments in a given area. Nielsen IQ collects data on online orders from users of specific shopping and shipment tracking apps. Their research team expands the relatively robust sample to estimate total parcels in an area of interest, based upon market research and demographic factors. The data can be provided to the zip code level (delivery location), over any desired historic time period. Information about the products ordered and carriers making the deliveries (e.g., U.S. Postal Service, UPS, FedEx, Amazon, etc.) are generally available. These data do not, however, indicate the origin of the delivery trip, so to use these data to estimate the transportation is limited without tapping other data or information sources. This data is available for a fee, and was too expensive to acquire within the budget of this study, and the limitations of the other data sources make them unattractive for use in this study.

- Forecasting future e-commerce parcels. Retail market researchers may publish near-term forecasts or annual outlooks. However, forecasts that align with the forecasting horizons used in long-range transportation planning, state freight plans, etc., are not produced by the vendors. S&P Global, the vendor of Transearch, a popular freight commodity flow forecasting data product, has made strides to account for the growth of e-commerce demand in its forecasts. However, those flows are interplant—or warehouse-to-warehouse, and do not include estimates of last-mile delivery trips. As e-commerce demand continues to increase over time, and data and analysis approaches to estimate its effects improve, data vendors such as S&P Global, or U.S. DOT, the sponsor of the Freight Analysis Framework database, may seek to enhance their methodologies to account for, and identify, the contributions of e-commerce to freight flows and delivery trips.
- Net effects of e-commerce deliveries on in-store shopping. Much research has been carried out to discover whether e-commerce replaces, complements, or modifies consumers' in-store shopping behaviors. In other words, does e-commerce replace trips to the store or would/are those trips to the store still happening as they would otherwise? Some of this research suggests that there is a complementary relationship between e-commerce and in-store purchasing, and that the more consumers buy online, the more they buy in stores as well. Whether a household makes fewer, more, or the same number of trips to a retail store as they purchase goods online, may depend upon the specific shopping habits of that household. For instance, a consumer may purchase clothing online that they would have otherwise bought at a big box retail store. However, that consumer may still go to purchase other items at the big box retail store. With the emergence of "BOPIS" (buy online, pick-up in-store) models that gained traction during the COVID-19 pandemic, the line between e-commerce and brick-and-mortar retail is, in some cases, becoming blurred.
- Net effects of e-commerce deliveries on transportation system performance and the environment. The consumer's online shopping behaviors may have significant impacts upon the net effects on the transportation system and the environment. The same consumer described above may have ordered five clothing items as discrete, separate orders. Each order will be packaged individually and delivered on five different days. The transportation system impact of that purchasing behavior would suggest a greater trip generation and emissions impact than had the consumer traveled to a store to buy five items at once.

In addition, the built environment of a city or neighborhood can be a factor in determining the net vehicle-miles traveled (VMT) and emissions effects of e-commerce. A 2022 study by the Center for Sustainable Transportation estimated, using a model, that growth in online shopping is likely to reduce VMT and emissions in the Dallas, TX metropolitan area, where automobile ownership is high and alternative transportation usership is low, but that online shopping could have a negative impact (increasing VMT and emissions) in New York City, where automobile ownership is low and many consumers use transit, walking, or other modes to shop in stores.

In sum, despite recent research on this topic, there are many variables, including demographics, shopping behaviors, automobile ownership, transit utilization, logistics networks and distribution center locations, and personal auto and delivery fleet characteristics that would influence the net effects of e-commerce on VMT, delay, and emissions. More research and analysis, would be needed in order to determine the contributions e-commerce may make to better or worse transportation system performance and the environmental and community impacts of transportation within this region. Metro should monitor advancements in the state of the practice in order to assess new data and methods as they emerge and determine best approaches to estimating these effects in the Portland region.

Best Practices in Managing Curbs and Last-Mile Delivery Impacts. Public-sector agencies are typically concerned with addressing the impacts last-mile delivery trips have on transportation system operations, curbside parking availability, economic development considerations associated with distribution center development, and other community effects. Key strategies include curb management strategies such as right-sizing and managing curbside loading zones, and land use considerations involving industrial land use and potential conversions of vacant storefronts (or "dark stores") into e-commerce fulfillment centers.

The City of Portland promotes the consideration of delivery needs in designating and managing its Truck Loading Zones (TLZ), including the use of flexible, or combination, spaces which allow loading and customer parking at different times of the day, based upon demand. The New York City and Southern California metropolitan regions provide good examples of how to assess regional freight land use and warehousing needs in a metropolitan area.

There are not any confirmed dark store conversions identified in this study's research in the Portland region, however, there are some issues that municipalities ought to consider if such conversions are proposed or desired. These include whether warehousing and storage is a permitted use in the area where the site is located, whether zoning changes are needed within industrial or commercial zones to cover the intended use, and whether the conversion of a retail storefront to fulfillment center use would have adverse impacts on foot traffic for adjacent retail spaces, tax revenues, etc.

Metro should continue to monitor best practices and work with other public agencies to advance studies, pilot programs, and other initiatives, as needed.

Equity Performance Measures. As noted in Section 7.4 of this report, advancing transportation equity within a freight context is challenging. The benefits of freight are diffuse as they are broadly distributed across geography and stakeholders. Meanwhile, the burdens of freight tend to be localized and disproportionately borne by communities adjacent to freight assets, such as highways, rail lines and terminals, marine terminals, and warehouses. Goods movement has historically contributed to—and continues to exacerbate—uneven distribution of benefits and burdens on disadvantaged communities.

Measuring freight equity is challenging, and best practices are few and far between as of 2023. For example, the Bipartisan Infrastructure Law (BIL) required that state DOTs consider equity in their state freight plans, but the federal government has provided little technical guidance. In the 2021-2023 round of state freight plans, only 39% of the plans conducted a quantitative or qualitative analysis of freight equity. Most used proximity analyses to determine the proportion or concentration of equity focus areas (i.e., communities of concern) near the multimodal freight network. While useful, these approaches did not incorporate methods to estimate impacts to target communities, such as measuring or estimating freight-related congestion or emissions. Measuring these impacts is an important next step for state freight plans and the next Regional Transportation Plan, but adoption of more robust methodological approaches will likely require more guidance at the federal level, a set of "first mover" states or MPOs to adopt robust equity analyses methodologies, or both.

Further, few states or MPOs have established performance measures to support freight equity goals and objectives. Without quantitative measures, states and MPOs will struggle to take a proactive approach to freight equity as they cannot fully assess the efficacy of interventions and detect trends in how their freight-related investments and decision-making impact equity concerns. Metro should monitor developments in data and methodological approaches to assess freight equity.

Land Use Needs. Metro conducts periodic inventories of land supply and utilization within the Urban Growth Boundary (UGB) and considers municipalities' requests to expand the UGB to meet specific regional goals. The most recently completed UGB report, published in 2018, found that there were 8,600 net buildable acres of industrial land inside the Metro UGB. The 2018 report also noted that there had been no requests from municipalities to expand the UGB area for industrial purposes, as all requests made that year were to accommodate residential development. The assessment of industrial land supply and needs was determined based upon existing and forecasted future employment in "industrial jobs." The employment density for industrial properties can vary by wide margins. For example, Lam Research employs 4,000 people at its 600,000-square-foot manufacturing facility in Tualatin, while Amazon's Project Basie is expected to employ less than 1,000 in more than 3 million square feet of distribution center space. Looking into the future, further advancements in the automation of both manufacturing and warehousing and distribution activities are likely to have impacts on employment density of industrial properties as well.

As the development and absorption of industrial space suggests, the demand for space is outpacing the growth in employment in industrial sectors. Metro could account for this phenomenon by shifting to a methodology that estimates the need for industrial space based upon the volume of goods moved through the facilities, potentially with breakdowns by broad categories of industrial space (e.g., high-value manufacturing, low-value manufacturing, e-commerce fulfillment, warehousing, etc.). The Southern California Association of Governments (SCAG) developed a Warehouse Space Forecasting Model that estimates warehousing demand based upon the volume of goods moving, and forecasted to move, in the region.[31] This is an example of a methodological approach that Metro could take and/or expand upon in order to estimate industrial space needs based upon goods movement trends and forecasts.

To assess whether the supply of industrial land can meet current and future demand, Metro ought to consider:

- The supply of undeveloped industrial land that exists within the UGB and what the development potential of that land is;
- The potential for parcel assemblage and redevelopment of older, less marketable industrial buildings into larger, newer buildings that meet modern industrial needs. Compared to greenfield sites outside the UGB, sites in established industrial clusters typically have good transportation system access and utility connections. Industrial redevelopment examples include:
    - FedEx's redevelopment of its own facility in Maspeth, Queens, NY into a larger, modern distribution facility;
    - Real estate developer ProLogis's acquisition of adjacent parcels in a legacy industrial cluster in Chicago for the purpose of building a speculative distribution center; and
    - A realty company's acquisition of a shuddered factory in Oakland for proposed redevelopment into a speculative distribution center.[32]
- Consider opportunities to facilitate development on sites that require some investment in order to realize their full potential. This may include brownfields that require substantial and expensive environmental remediation, accommodation of on-site truck parking, and/or addressing site access issues for trucks and/or rail. As the value of industrial real estate continues to increase, there may be more willingness among private sector actors to fund or contribute to the costs of addressing such needs.

[31] https://scag.ca.gov/sites/main/files/file-attachments/task4_understandingfacilityoperations.pdf

[32] https://southsideweekly.com/a-planned-amazon-warehouse-in-bridgeport-is-the-latest-site-in-the-fight-against-an-inequitable-distribution-of-warehouses-on-the-citys-south-and-southwest-sides/; https://www.costar.com/article/1329283780/developer-with-close-ties-to-amazon-pitches-industrial-redevelopment-plan-for-east-bay-site

In addition to assessing land development and redevelopment potential, Metro could consider various policy initiatives that support desired industrial development outcomes. Such initiatives could include:

- Limiting rezoning of land from industrial to other uses that are not compatible with industrial use, in order to preserve the region's supply of industrial land.
- Reviewing and, if necessary, revising land use regulations to ensure that industrial land is used primarily for industrial purposes, and that accessory uses, such as office, do not predominate. While many if not most manufacturing and warehousing buildings include some office or flex space, the primary use should be the use(s) that facilitate the production and/or distribution of goods.
- Reviewing, and if necessary, revising land use regulations to accommodate the transformation of vacant retail stores, often referred to as "dark stores," into last-mile delivery centers for e-commerce, if and where desired. Dark store conversions are rare, though there are some examples in the Midwest, Texas, and other parts of the country. However, they represent an interesting opportunity to reactivate vacant commercial space and provide logistics companies with space for goods distribution within metropolitan areas. There are a number of potential land use regulation conflicts, however, including determining whether such uses are permitted in commercial zones, parking and loading area needs and requirements, accounting for any window coverage and "active" frontage requirements that may exist in local zoning, etc.

Figure 9.2 Former Kmart "Dark Store" Converted to an Amazon Delivery Center in Virginia

Source: Christopher Lamm, author's personal collection, 2022

As Metro considers a new assessment of the UGB, it is important to consider the capacity of the region's industrial lands to provide for modern manufacturing, warehousing, and distribution needs. These needs include modern building specifications, proximity and access to customers and consumers, utility and transportation access. This assessment may include identifying capacity for new development on greenfields within the UGB, potential assemblage and redevelopment of legacy industrial parcels, and the remediation of brownfields.

Effects of Office Vacancies in Portland's Central City. The COVID-19 pandemic has had lasting effects on where and when people work, especially people who have higher-income office jobs and the flexibility to work remotely. Nationally, the office real estate market is facing record-high vacancy rates (approximately 19%)[33] and a slowdown in new development proposals. In the Portland metropolitan area, 20.3% of the office space was available for lease, as of the second quarter of 2023. In Portland's Central City, office vacancy is near 30%.[34]

Vacancy only tells part of the story. Because a company is leasing space, that does not mean its employees are using it. For example, Kastle Systems, a company that tracks card swipes through its security systems in many office buildings, estimates that while New York City's vacancy rate is 16%, only about 49% of the office space in the city is being used. Because many office leases have terms of 10 years or more, the effects of remote work are going to show up in lease and absorption statistics for several years to come.

If the future of Portland's Central City is more focused on being a center for housing, retail, and entertainment, with less emphasis on office space, there may be some implications for how goods move into, and are delivered in, that district. Office buildings receive inbound shipments of office supplies, office equipment and furniture, and generate outbound shipments of solid waste. When converted from office to residential, a building would generate some truck and commercial van traffic during the renovation/retrofit period, as vehicles would bring construction supplies, equipment, and personnel to the site to perform the renovations. Once the residential units become available, moving trucks would bring new tenants' belongings to the site, and daily deliveries of e-commerce orders, trucks and vans belonging to contractors who perform day-to-day maintenance and repair, and outbound shipments of solid waste would be generated.

To facilitate such transitions, the Portland Bureau of Transportation (PBOT) may consider how its policies and initiatives regarding curb access and on-street parking and loading may be impacted by the change in use and resulting changes in delivery needs. This may include the identification of new or modified on-street loading zones. The city's planners may need to consider development requirements that promote off-street loading and building lobby retrofits to accommodate package holding rooms. If the character of the Central City changes substantially, there may be impacts on the composition of retail tenants as well. There may be greater demand for grocery stores, dry cleaning and laundry, and other businesses to support a larger residential population. The delivery needs of these businesses may necessitate further consideration of commercial vehicle parking and loading.

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[33] https://rejournals.com/jll-reports-a-new-high-in-the-u-s-office-vacancy-rate-18-9/

[34] https://www.colliers.com/en/research/portland/2023-q2-portland-metro-office-market-report

9.3 Adopting Regional Freight Policy and Action Item Updates

As discussed in Section 8.3, Metro may consider adopting updates to the Regional Freight Policy and associated Action Items in order to incorporate the findings discovered in this study. Recommended updates to the Regional Freight Policy and Action Items are listed in Table 9.1. New text is highlighted in yellow in the table.

Table 9.1 Recommended Updates to Regional Freight Policy and Action Items

Section	Current Text	Recommended Text
Action Item 1.5	• Exploring multiple data sources on the impacts that on-demand delivery (via Amazon, FedEx and other home deliveries) is having on transportation demand, and identifying ways to keep goods moving efficiently	• Procuring data to estimate the number of last-mile deliveries performed in the region. • Monitoring and exploring emerging analysis methodologies to estimate the impacts that on-demand delivery (via Amazon, FedEx and other home deliveries) is having on transportation demand, and identifying ways to keep goods moving efficiently
Add a New Near-Term Action Item 4.5	N/A	4.5: Monitor the development of best practices for estimating performance measures related to the equitable distribution of benefits and disbenefits of freight. • The benefits of freight are diffuse as they are broadly distributed across geography and stakeholders. Meanwhile, the burdens of freight tend to be localized and disproportionately borne by communities adjacent to freight assets, such as highways, rail lines and terminals, marine terminals, and warehouses. Goods movement has historically contributed to—and continues to exacerbate—uneven distribution of benefits and burdens on disadvantaged communities. Metro will monitor developments in data and methodological approaches to assess freight equity.

Section	Current Text	Recommended Text
Action Item 5.3	Long-Term Actions: 5.3: Examine need for additional industrial land and the availability and readiness of industrial lands • The region must ensure a continued adequate supply of appropriate industrial land. In addition to internal coordination between Metro's planning and land use staff, and coordination with local jurisdictions and industry sectors, an understanding of how cities and counties have been successful in maintaining and improving the availability and readiness of industrial lands will be pursued. Metro currently tracks the availability and readiness of industrial tracks in the region that are 25 acres or larger through the Regional Industrial Inventory Project.	Near-Term Actions: 5.3: Examine need for additional industrial land and the availability and readiness of industrial lands by completing the Regional Industrial Lands Availability and Intermodal Facilities Access Study. • The region must ensure a continued adequate supply of appropriate industrial land. In addition to internal coordination between Metro's planning and land use staff, and coordination with local jurisdictions and industry sectors, an understanding of how cities and counties have been successful in maintaining and improving the availability and readiness of industrial lands will be pursued. Metro currently tracks the availability and readiness of industrial tracts in the region that are 25 acres or larger through the Regional Industrial Inventory Project.

Section	Current Text	Recommended Text
Add a new near-term Action Item 5.4	N/A	5.4 Examine land use regulations to determine the feasibility of converting vacant retail stores (a.k.a., "dark stores") to distribution and fulfillment center uses to support last-mile deliveries. • Dark store conversions could help to accommodate industrial space demand associated with e-commerce deliveries, while limiting pressure on existing industrial land supply. Metro will evaluate the feasibility of such conversions in the region, identify key impacts and considerations, and develop policy guidance. This could be done as part of the Regional Industrial Lands Availability and Intermodal Facilities Access Study or as a separate initiative.

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Regional Freight Delay and Commodities Movement Study

Appendix A: Global and National COVID Impacts on E-commerce Deliveries

submitted to

Metro Regional Government

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with DKS Associates

Table of Contents

Key Findings and Considerations

This memorandum presents a summary of key data points and statistics that demonstrate the effects that the COVID-19 pandemic has had on the national economy and the economy of the Portland Metropolitan region, and the growth in e-commerce demand nationally since the onset of the pandemic. Key findings, explained in more detail in the body of the memorandum, include:

Effects the COVID-19 pandemic has had on the economy:

- Employment recovery has been uneven, as higher-wage employment has largely recovered (both in the Portland region and nationally), while lower-wage employment remained well below pre-pandemic levels well into 2021. Substantial growth (33% and 40%, respectively, in the Portland-Vancouver region) has been observed among couriers and messengers and warehouse and storage workers, two key roles in the e-commerce supply and delivery chain.

- Nationally, personal expenditures increased 13% between 2019 and 2021, including a 35% increase in spending on durable goods (including home furnishings, recreational equipment, etc.).

- The increase in consumption has resulted in increased volumes of goods imported to and exported from the U.S. since the second quarter of 2020. Imports rebounded from the initial downturn, increasing by 33% between May 2020 and November 2021. The value of exports has rebounded as well, increasing by 38% between May 2020 and November 2021.

- There has been a capacity crunch in the supply chain as a result of volumes of goods increasing while COVID's effects on operations and labor availability have persisted, contributing to the supply chain disruptions observed through 2020 and 2021

E-commerce growth trends, factors, and outlook:

- E-commerce sales in the U.S. spiked during 2020 (increasing nearly 33% during the first two quarters of 2020), when many brick-and-mortar retail stores across the country were closed. The value of e-commerce sales has continued to rise, even as the share of e-commerce sales dipped in 2021, suggesting sales have increased both online and in stores.

- Not all e-commerce deliveries involve a move from a warehouse to a customer's doorstep. There are several logistics models supporting the movement of goods ordered online through the supply chain to a consumer. These different models use various combinations of warehouse facilities, retail stores, and alternate pick-up locations and are connected by various types of vehicles.

- E-commerce is generally expected to continue growing, both in volume of sales, and as a share of total retail sales in the United States. If and when a "saturation point" is reached is uncertain.

- For the Portland metropolitan region, growth in e-commerce could contribute to an increase in commercial vehicle trips, demand for curbside loading in urban neighborhoods and commercial centers, and fuel demand for fulfillment center development in the metropolitan core (quick access to consumers is worth a real estate and development price premium to some companies) and in the exurban fringes.

- There are considerations that public agencies nationally have begun making to address real or potential traffic generation, parking and curb management, emissions, land use, and economic implications associated with e-commerce and the last-mile delivery moves attributable to e-commerce. These issues will be analyzed and described in more detail, along with examples of actions or strategies that have been effective in addressing those issues, in Task 5.

- While most of the trend data available for this analysis is national in scope, this study will analyze transportation system performance data and include more industry engagement that may affirm, qualify, and/or demonstrate effects of these trends in the Portland region.

A.1. Introduction

The COVID-19 pandemic has had far-reaching effects, and those effects have been observed in nearly every aspect of our social interactions, how and where we work and perform our jobs, how we shop and what we purchase, and how those goods are distributed and delivered. During the COVID-19 era, e-commerce, which refers to the purchase of goods using the internet, has rapidly matured from a means used by businesses to order goods and materials from other businesses and a popular way for the tech-savvy consumers to shop for apparel and household products, to be mainstreamed into the regular shopping routines of tens of millions of American households.

The rapid growth of e-commerce demand during the COVID-19 era, combined with labor shortages, equipment availability, and last-mile delivery challenges, has presented manufacturers, retailers, and transportation companies with the tremendous task of building capacity to meet rising demand that does not appear to be abating anytime soon.

This memorandum presents a summary of key data points and statistics that demonstrate the effects that the COVID-19 pandemic has had on the national economy and the economy of the Portland Metropolitan region, and the growth in e-commerce demand nationally since the onset of the pandemic. The memo describes some of the logistics challenges presented by the operating environment during the pandemic, and summarizes the complex logistics chains associated with staging product, fulfilling customer orders, and getting those orders into consumers' hands. The memo also includes an outlook on future e-commerce demand.

The organization of the memo is as follows:

- **Section A.2** highlights the economic effects of the COVID-19 pandemic on employment, consumer spending habits, international imports and exports to and from the U.S., and key global logistics challenges.
- **Section A.3** features data on e-commerce demand trends, descriptions of e-commerce logistics models, and an outlook on future e-commerce demand.

In Task 5, this study will evaluate some of the key challenges associated with supporting e-commerce growth, particularly on the transportation system and in land use, and will describe examples of strategies that public sector agencies have implemented to address those challenges.

A.2. Economic Effects of the COVID-19 Pandemic

The COVID-19 pandemic has impacted the U.S. and global economies in several ways since the initial onset of the pandemic in the first and second quarters of 2020, and continuing through 2021. The following pages present highlights of the effects the pandemic has had on employment nationally and in the Portland Metropolitan region, national consumer spending trends, and international trade and supply chains.

Employment

As the pandemic began to spread through the United States in early 2020, many companies closed in-person operations, either by company policy or as directed by government authorities. For many persons employed in high-wage professional services jobs, work was able to continue remotely while working from home and maintaining "social distance" from coworkers, clients and customers, and others. For many employed in service industry sectors, alternative work locations were not an option. Workers in healthcare, transportation, utilities, and several other sectors deemed "essential," continued to work in-person at their respective job sites. Many others, particularly in sectors such as hospitality and tourism, personal services, restaurants, among others, were terminated, laid off, worked reduced hours, or were otherwise impacted by stay-at-home orders and other pandemic-driven directives.

Tracking employment by wage cohorts, a story of two different pandemic experiences—one experience for higher-wage works, and a very different experience for lower-wage workers—emerges. According to data gathered and presented on the website tracktherecovery.org, employment among workers earning above the median income has returned to, and in many parts of the country has exceeded, pre-pandemic employment. Among below-median wage workers, employment remains far below pre-pandemic levels.

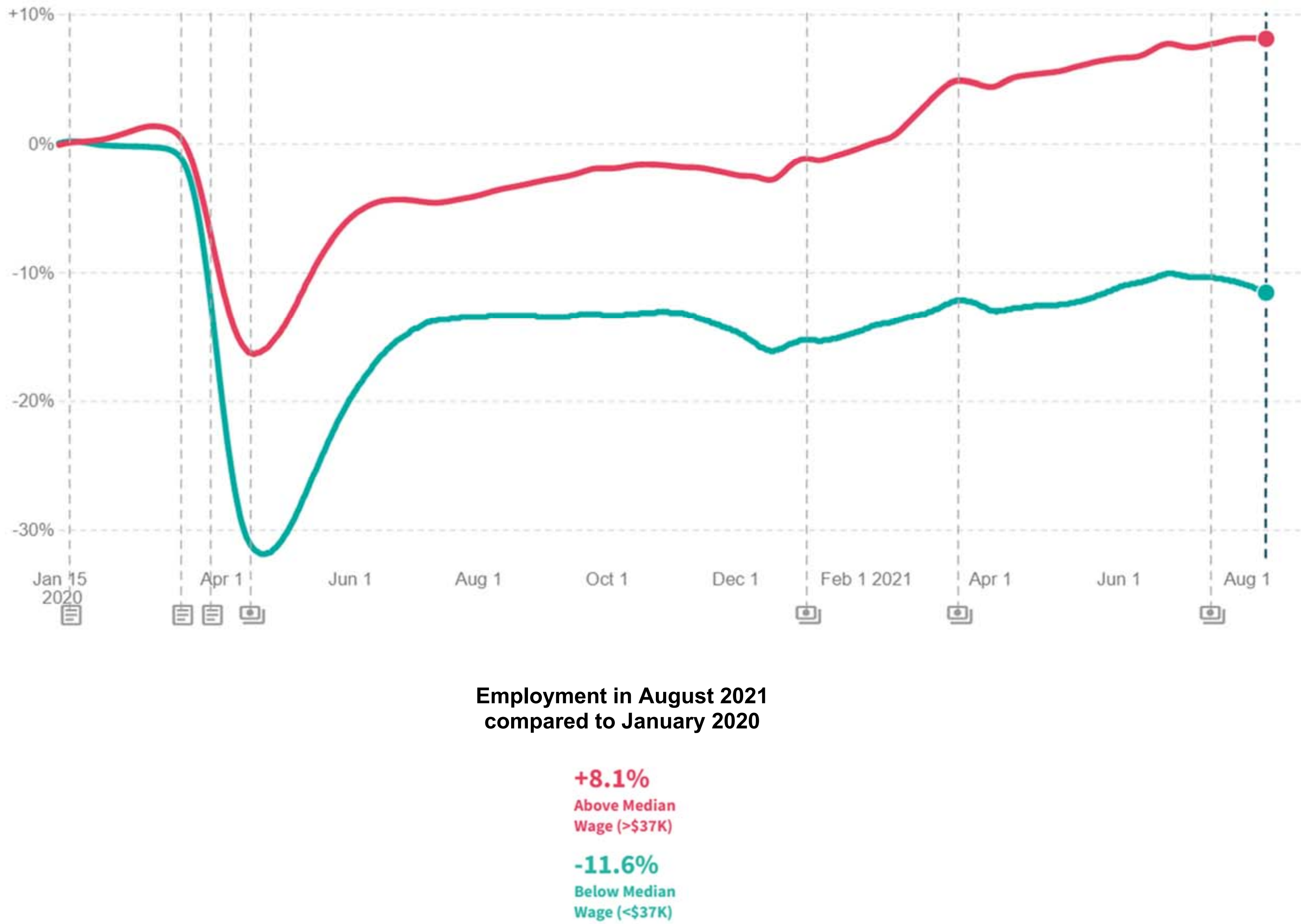
Figure A.1 illustrates this difference in employment trend by wage cohort nationally. Among workers earning above-median income nationally, employment fell 16% between January 2020 and April 2020. Since April 2020, employment among above-median workers recovered. By August 2021, above-median employment had increased more than 8% compared to before the pandemic began (January 2020). Below-median employment dropped by 32% between January and April of 2020. While there has been employment growth since April 2020, the August 2021 employment among below-median workers remained nearly 12% below pre-pandemic employment.

Figure A.2 illustrates the same data, but specific to the Portland–Vancouver–Hillsboro Metropolitan Statistical Area. The descent of high-wage (-27%) and low-wage (-42%) employment during the Spring of 2020 exceeds the nation as a whole, and the return of high-wage (+1.2% in August 2021 compared to January 2020) and low-wage (-29.8% in August 2021 compared to January 2020) suggest that the employment effects of the pandemic were more severe in the Portland Metropolitan area compared to the nation as a whole. That experience, however, is not unique to Portland. Large metropolitan areas appear to be underperforming the national average, both in terms of the initial effects of COVID on low and high wage employment in early 2020 and the recovery of employment in both wage cohorts through 2021, as Figure A.3 shows.

Employment has increased in 2021 in sectors of the economy that support e-commerce order fulfillment and delivery. In particular, substantial growth (33% and 40%, respectively, in the Portland-Vancouver region) has been observed among couriers and messengers and warehouse and storage workers, two key roles in the e-commerce supply and delivery chain. Figure A.4 shows the change in employment in sectors associated with e-commerce. The data source is the Oregon Employment Department, and the analysis was prepared by Sorin Garber Associates.[1]

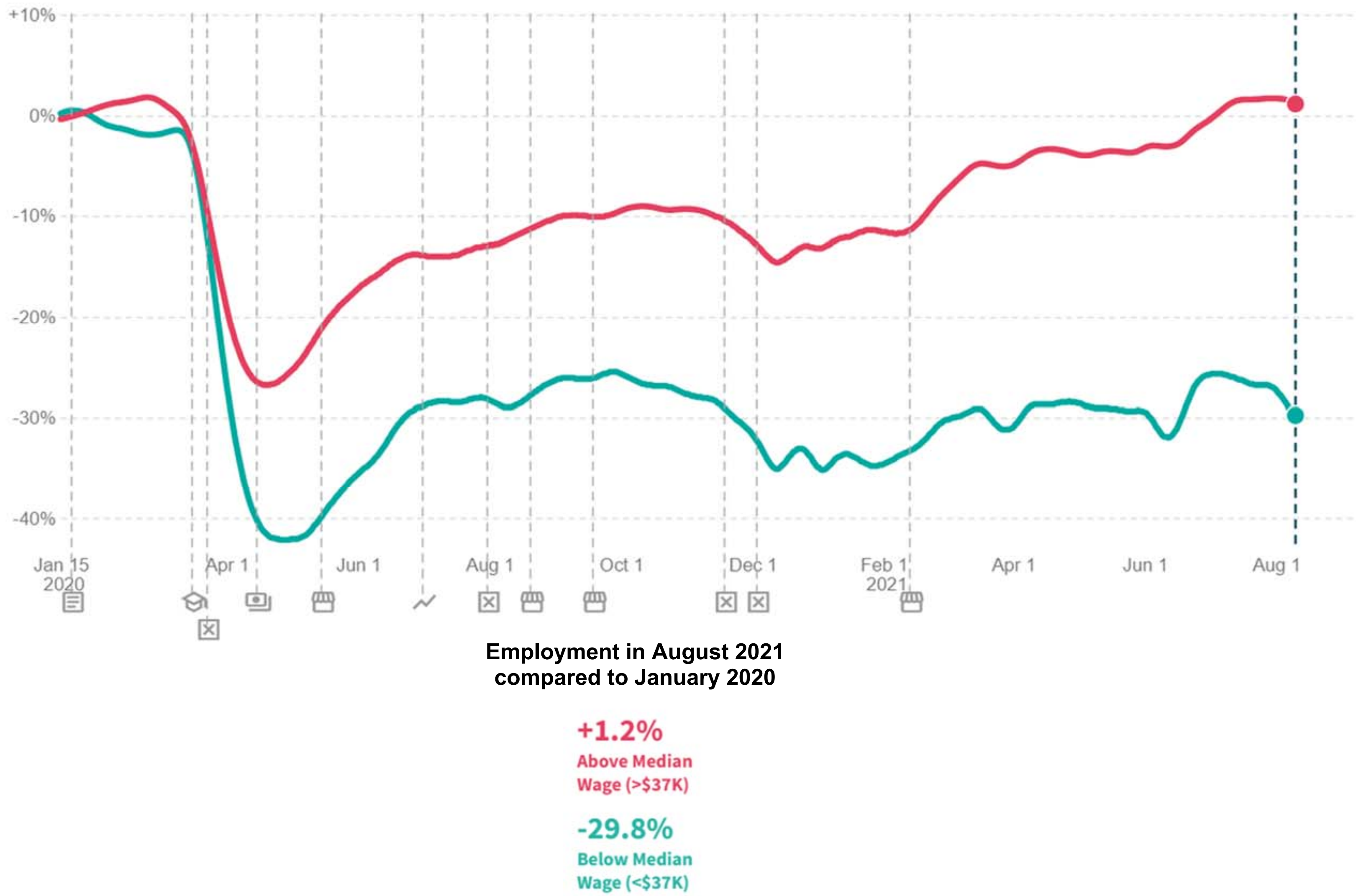
[1] "Are Home Deliveries Increasing during the Pandemic? Update 7," Sorin Garber Associates, Dec. 17, 2021.

Figure A.1. Above-Median Wage and Below-Median Wage Employment, United States, January 2020-August 2021



Source: tracktherecovery.org

Figure A.2. Above-Median Wage and Below-Median Wage Employment, Portland Metropolitan Area, January 2020-August 2021



Source: tracktherecovery.org

Figure A.3. Employment Among High- and Low-Wage Earners in Large Metropolitan Areas, Percent Change from January 2020-August 2021

Metropolitan Area	High-Wage	Metropolitan Area	Low-Wage
Norfolk	11.8%	United States Total	-11.6%
San Antonio	10.4%	Jacksonville	-14.1%
United States Total	8.1%	Raleigh	-14.5%
Charlotte	6.6%	Charlotte	-14.7%
Nashville	6.6%	Philadelphia	-14.7%
Jacksonville	6.2%	Cleveland	-15.7%
Detroit	5.9%	Columbus	-16.8%
Raleigh	5.1%	Indianapolis	-17.4%
Baltimore	4.4%	San Antonio	-18.0%
Sacramento	3.5%	Houston	-18.5%
Indianapolis	3.3%	Detroit	-18.9%
Kansas City	3.3%	Dallas-Fort Worth	-19.6%
Columbus	3.0%	Tampa	-19.9%
Tampa	2.0%	Boston	-20.0%
Portland	**1.2%**	Nashville	-20.3%
Las Vegas	1.0%	Sacramento	-22.0%
Minneapolis	0.7%	Kansas City	-22.0%
San Diego	-0.1%	Phoenix	-23.1%
Atlanta	-0.1%	Miami	-23.5%
Denver	-0.6%	Minneapolis	-23.8%
Phoenix	-0.7%	Denver	-23.8%
Cleveland	-1.7%	San Jose	-23.8%
Boston	-2.5%	Las Vegas	-23.9%
Miami	-2.5%	San Diego	-24.3%
Los Angeles	-3.6%	Chicago	-24.8%
Seattle	-3.7%	Norfolk	-25.4%
San Jose	-4.0%	Honolulu	-25.6%
Chicago	-4.1%	Austin	-26.0%
Dallas-Fort Worth	-4.2%	Los Angeles	-27.9%
Philadelphia	-4.5%	New York	-28.5%
Washington	-5.1%	Atlanta	-29.7%
Houston	-6.2%	**Portland**	**-29.8%**
Austin	-7.5%	Washington	-31.9%
Honolulu	-8.3%	Baltimore	-34.1%
New York	-8.9%	Seattle	-34.1%
San Francisco-Oakland	-12.4%	San Francisco-Oakland	-39.6%

Source: tracktherecovery.org

Figure A.4. Changes in Selected Employment Categories State of Oregon and Portland Metropolitan Area, 2019, 2020 and 2021*

	Oregon-Statewide			Portland / Vancouver Region		
	2019	2020	2021*	2019	2020	2021*
Private Sector Employment	1,655,800	1,544,000	1,574,211	1,075,500	997,800	1,013,967
Truck Drivers	18,958	18,542	18,956	11,100	10,800	11,111
Couriers and Messengers	10,558	13,242	14,267	7,600	9,500	10,133
Warehouse & Storage Workers	13,717	18,767	19,378	9,000	12,900	12,567
Retail	210,083	200,517	207,389	118,100	111,400	114,567

*January through September 2021 data.
Data Source: Oregon Employment Department; Graphic Source: Sorin Garber Associates, Dec. 17, 2021.

Consumer Spending Trends

Retained employment at higher income levels, combined with extended unemployment and stimulus programs, have supported growth in consumer spending since the middle of 2020. Further, households at higher income levels, especially in which workers have been working from home during the pandemic, have repurposed some of their household expenditures.

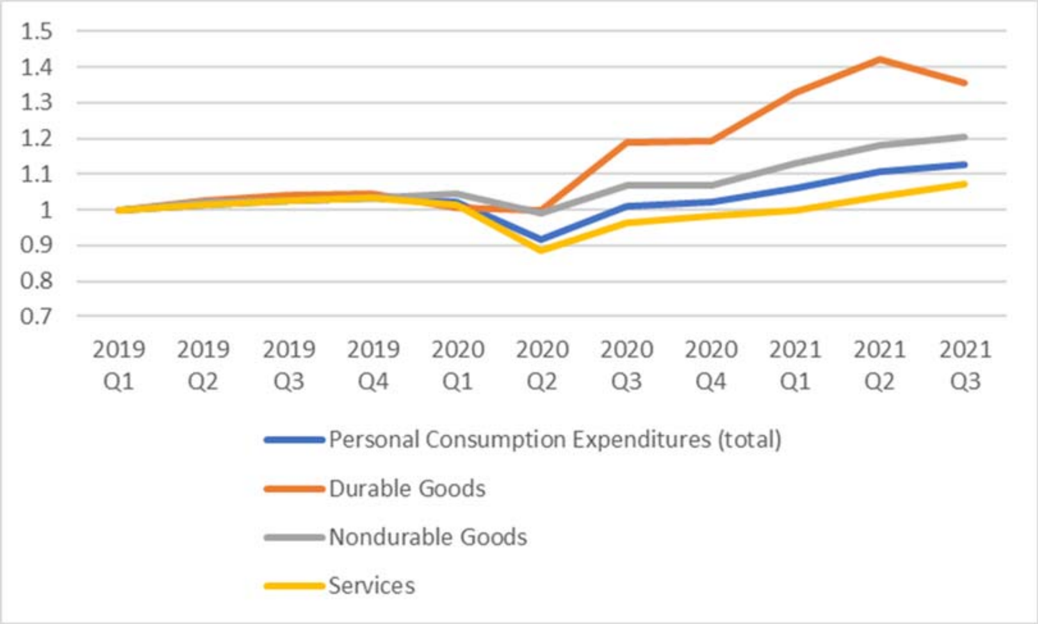
Figure A.5 illustrates the change in consumer spending on goods, on services, and overall, between the first quarter of 2019 and the third quarter of 2021. These data represent spending throughout the United States. The Bureau of Economic Analysis reports personal consumption expenditures by categories of goods and services. In total, personal consumption expenditures decreased during the second quarter of 2020, but increased thereafter, ending up approximately 13% higher in the 3rd quarter of 2021 than at the beginning of 2019. The personal consumption expenditures consist of spending on:

- *Durable goods*, such as motor vehicles, furnishings, and recreational goods. Spending on durable goods increased substantially after the initial downturn in 2020. By the 3rd quarter of 2021, spending on durable goods had increased 35% compared to the beginning of 2019. In particular, spending on recreational goods has increased more than 41% compared to 2019.

- *Nondurable goods*, such as food, clothing, and gasoline. Spending on nondurable goods also increased quite a bit after the initial downturn in 2020. By the 3rd quarter of 2021, spending on nondurable goods had increased about 20% compared to the beginning of 2019.

- *Services*, such as household services, transportation services, food services and accommodation, etc. Spending on services decreased by a greater proportion in 2020 than spending on goods, and has been the slowest to recover. By the 3rd quarter of 2021, spending on services had increased about 7% compared to the beginning of 2019.

Figure A.5. Personal Consumption Expenditures by Category, 2019-2021, Indexed to Q1 2019 Values (Seasonally Adjusted at Annual Rates)



Data Source: National Income and Product Accounts, Table 2.3.5, Bureau of Economic Analysis (accessed 1/13/2022).

The accelerated increase in consumer spending on durable and nondurable goods during the COVID-19 era is attributable, in part, to reduced spending on other goods and services. With office workers avoiding the expenses of commuting to work, and reduced spending on vacations, dining out, and other services, many households are using disposable income to improve their homes, purchase fitness equipment (in lieu of gym memberships), or to purchase more food for the home (in lieu of dining out). Business-to-business sales of cleaning equipment and supplies, among other goods, increased substantially in 2020 as well, as business establishments that remained open procured supplies and equipment to keep workers and visitors safe from exposure to the virus within their establishments.

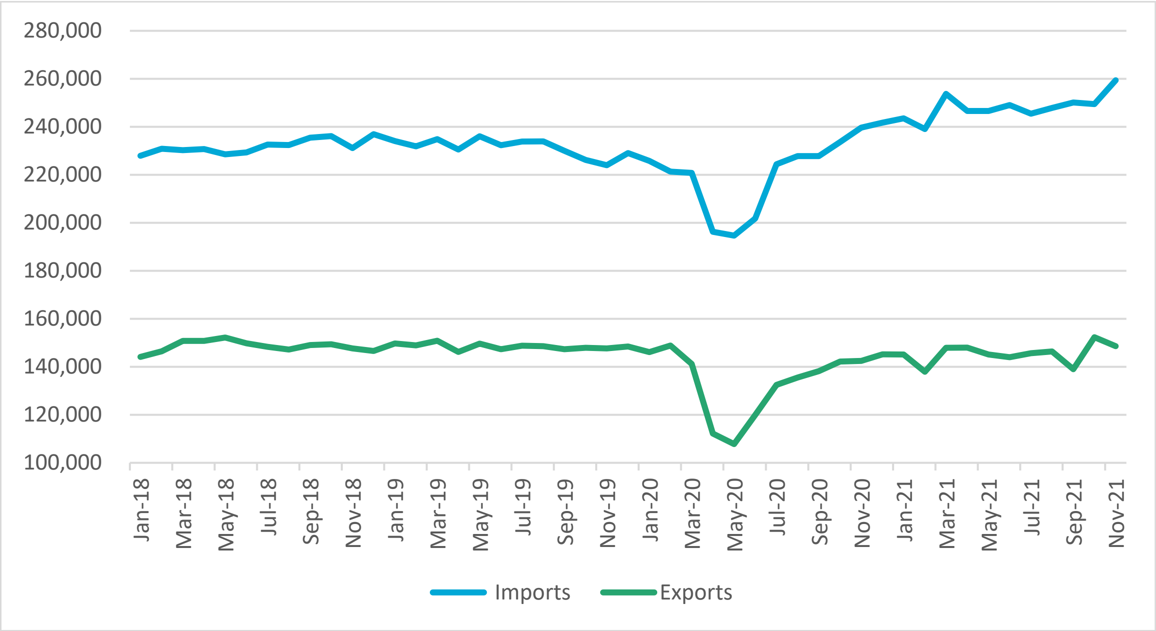
Import-Export Trend

Increased spending on goods is resulting in increased imports and exports through U.S. international trade gateways. The value of imports, measured in chained 2012 dollars and seasonally adjusted, increased 11% between the beginning of 2019 and November 2021, as Figure A.6 shows. This includes a precipitous drop during the Spring of 2020. Imports rebounded from the initial downturn, increasing by 33% between May 2020 and November 2021. Figure 7 shows the composition of imports by category of goods. Among the reported categories, automotive vehicles increased by the greatest margin (208%) between May 2020 and November 2021. However, due to the larger proportion of value in the consumer goods category, the 41% increase in value in that category has been a key driver in overall growth in import value.

There has been considerably less growth in the value of exports over the same analysis period, as Figure A.7 shows. Between January of 2019 and November 2021, the value of U.S. exports decreased by about 1%. Since the downturn in early 2020, the value of exports has rebounded, increasing by 38% between May 2020 and November 2021. Like exports, the value of imports increased by the greatest margin in the automotive vehicles category (259%), though that category is a small proportion of overall exports. Consumer goods exported from the U.S. increased 85% between May 2020 and November 2021.

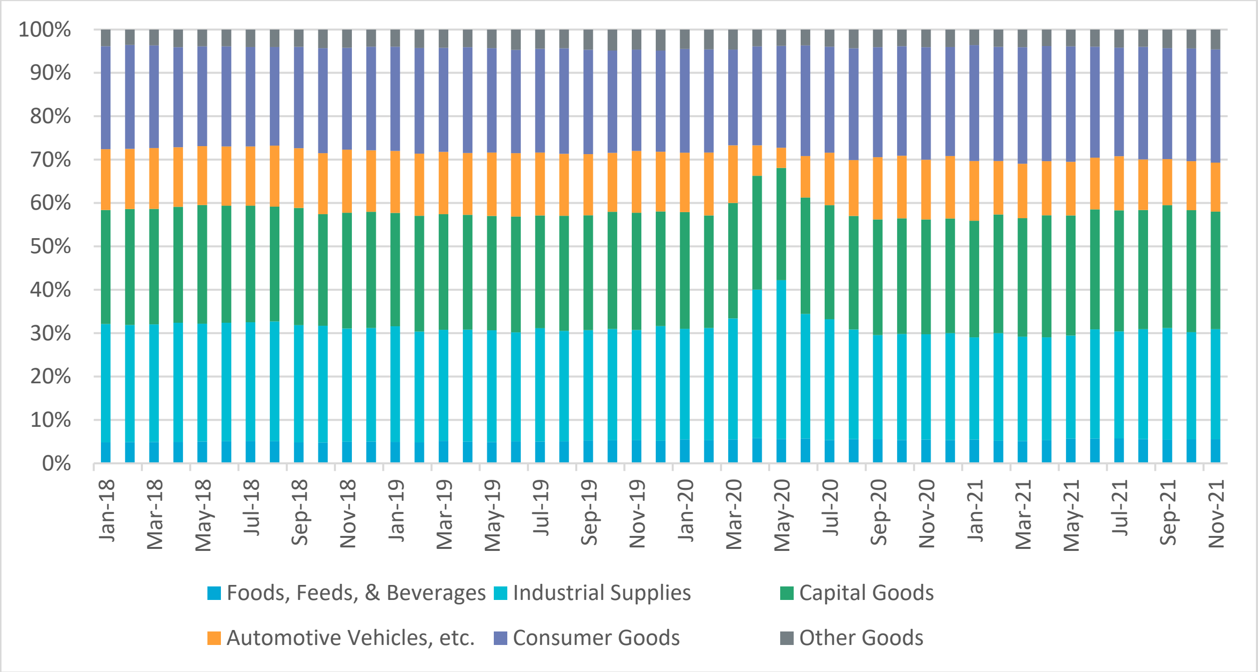
Industrial supplies, which composes the largest proportion of exports by category (37%) increased by 18% over the same period. The distribution of export value by category of goods is shown in Figure A.8.

Figure A.6. Value of U.S. Imports and Exports (millions of chained 2012 dollars), Seasonally Adjusted, January 2018-November 2021



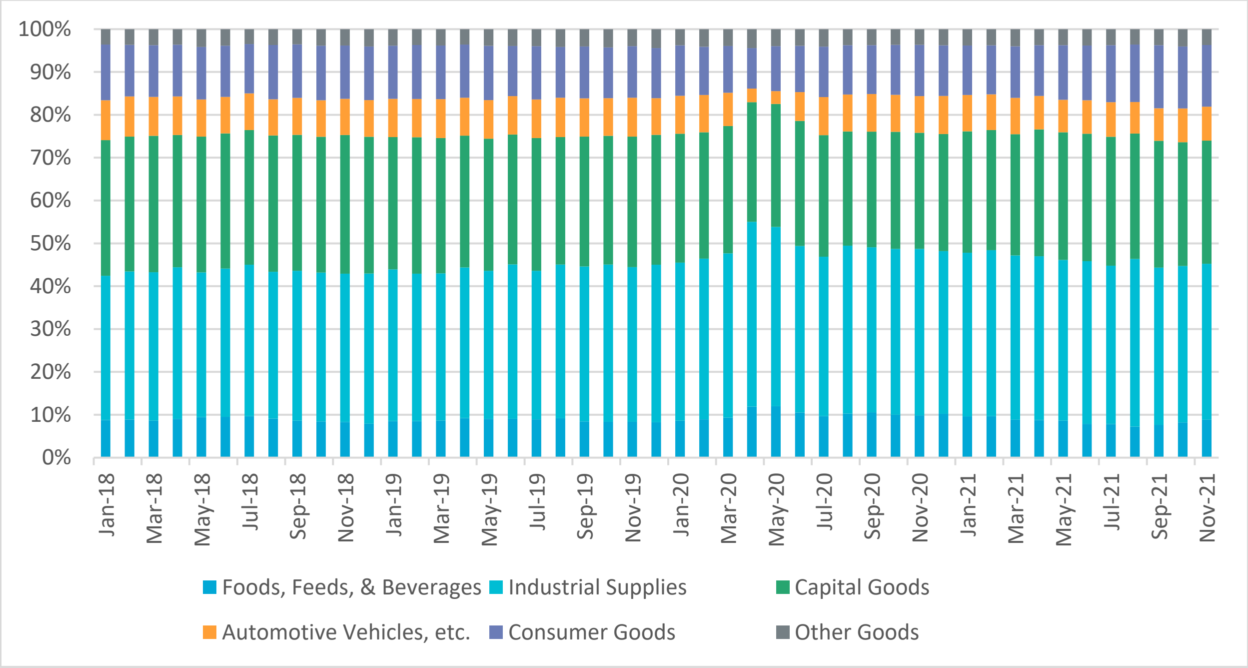
Source: U.S. Census; U.S. International Trade in Goods and Services (FT900).

Figure A.7. Proportion of Import Value by Category of Goods, January 2018-November 2021



Source: U.S. Census; U.S. International Trade in Goods and Services (FT900).

Figure A.8. Proportion of Export Value by Category of Goods, January 2018-November 2021



Source: U.S. Census; U.S. International Trade in Goods and Services (FT900).

Supply Chain Disruptions and Sourcing Decision-making

Growth in demand for consumer products and other goods, combined with the challenges of producing, transporting, and processing shipments of those goods in a COVID-19 environment, has presented many challenges to logistics companies, carriers, and shippers. These challenges have led many companies to reevaluate their sourcing decisions in order to mitigate the risk of disruption.

The initial effects of the pandemic were impacting supply chains as early as late 2019, when the virus was spreading through parts of China. For decades, manufacturing of many classes of goods has grown substantially in China, due to relatively inexpensive labor, few regulations and taxes, and being home to the world's largest workforce. By 2019, Chinese manufacturing accounted for 29% of global manufacturing.[2] The pandemic disrupted that production and the operations of logistics systems and ports in China. Because China is a supplier to so much of the world's consumer markets, disruptions in that country affect supply chains that stretch across the globe.

As the pandemic spread throughout the world in early 2020, new challenges arose. Mandated "lockdowns" in many countries, and social distancing measures in the U.S. led to widespread shutdowns or slow-downs affecting every industry, including manufacturing, warehousing, and transportation. As consumer demand increased during the pandemic, meeting the challenges of manufacturing, transporting, distributing, and delivering goods with depleted workforces and limited capacity was a daunting task.

Prior to the onset of the pandemic, an ocean container could travel from China to the West Coast of the United States in approximately two weeks. During 2020 and into 2021, the two week transit time was followed by up to two weeks at anchorage awaiting an available berth at the ports. The marine terminal crunch appeared to be most acute at the ports of Los Angeles and Long Beach, but capacity was a challenge at many ports throughout the U.S. Vessels returning to Asia were met with crowded ports and long anchorage times there as well. Figure A.9 shows the number of ships anchored outside of the ports of Los Angeles and Long Beach in January 2021.

The turnaround time for an Asia-to-America-and-back journey therefore extended from four weeks to seven weeks, eight weeks, or more in some cases. [3] In effect, the capacity of the ocean liner industry was limited due to the delays, at a time when demand was rebounding and soaring. This, along with the uneven growth between imports and exports through 2020 and 2021, led to record-high shipping container costs (topping $15,000 from China to the West Coast in Fall of 2020 and $20,000 in the Fall of 2021).[4] Figure A.10 shows the global container shipping rates from July 2019-December 2021.

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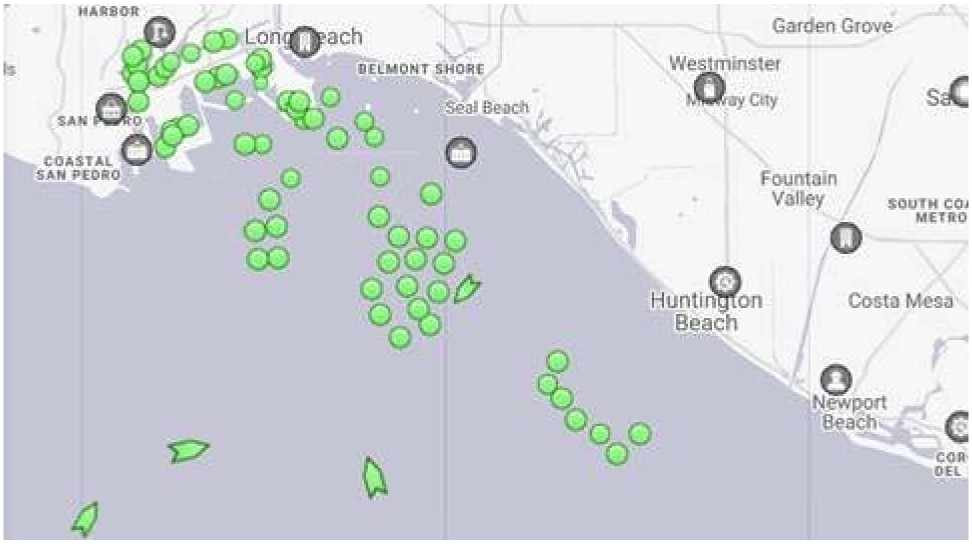
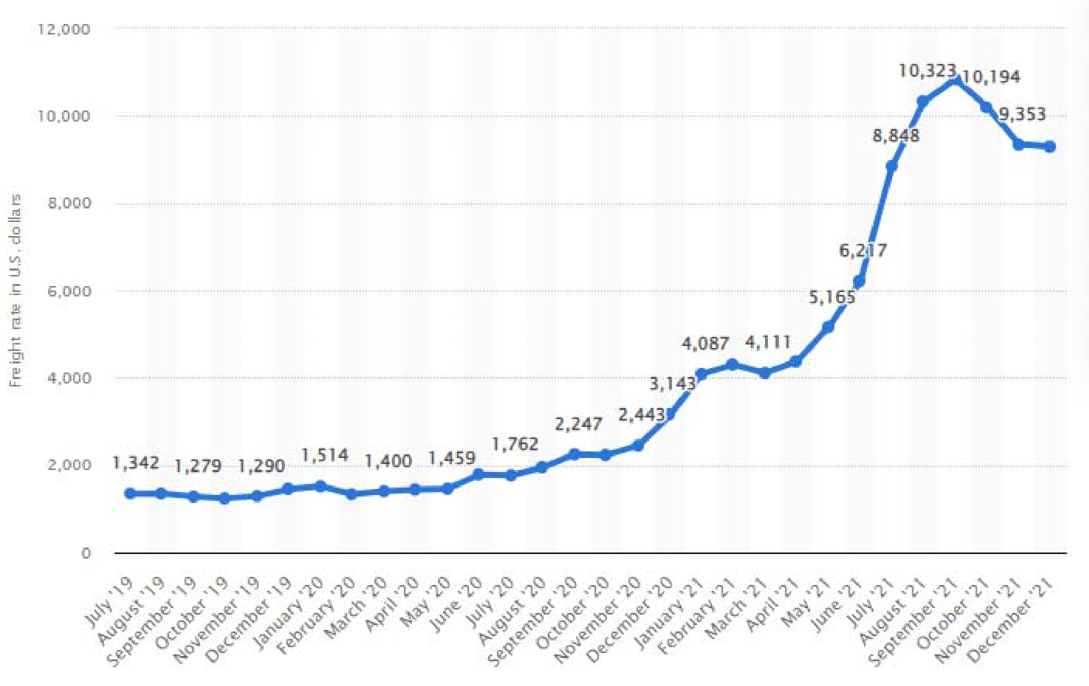
[2] https://www.statista.com/chart/20858/top-10-countries-by-share-of-global-manufacturing-output/
[3] https://www.bloomberg.com/graphics/2021-congestion-at-americas-busiest-port-strains-global-supply-chain/
[4] https://www.washingtonpost.com/business/interactive/2021/supply-chain-issues/

Figure A.9. Ships at Anchorage off the Coast of Southern California, January 28, 2021



Source: marinetraffic.com

Figure A.10. Global Container Freight Rate Index, July 2019-December 2021



Source: Statista.com

The global supply chain disruptions have led many logisticians to consider the merits of diversifying production locations by seeking additional production capacity in other Asian countries, and/or bringing more production back to the United States (a.k.a., "onshoring") or to Mexico or Central America (a.k.a., "nearshoring") in order to reduce exposure to disruption risks. Such decisions may take years to implement. Production capacity would have to be expanded in the new production locations, and transportation capacity may need to be reallocated in order to improve service to/from those locations. And in some cases, it may be simpler to build up inventory reserves than to relocate production facilities in order to mitigate supply risks.[5] These decisions also impact the cost of production and transportation (and therefore, the cost consumers pay in the marketplace), and the economies (including output, employment, wages and earnings) of the locations where production is expanded or reduced.

If and when the pandemic becomes a distant memory, quarter-over-quarter cost and profit could once more be the most important driving factor, and that could pressure production to relocate offshore in China or other low-cost locations once again. Apart from the pandemic, other issues such as rising labor costs in China, transit times, global politics and trade relationship issues, and other considerations may also come to bear.[6] It is therefore uncertain as to whether considerations of diversifying production and mitigating risk in the wake of the COVID-19 disruptions are short-term topics of interesting discussion, or long-term trends that could re-shape global supply chains.

[5] https://www.mckinsey.com/business-functions/operations/our-insights/how-covid-19-is-reshaping-supply-chains

[6] https://link.springer.com/article/10.1057/s42214-020-00075-5

A.3. E-Commerce and Retail Sales Trends

E-commerce is a term that is typically used in reference to commercial transactions made using the Internet. Initially slow to gain traction in the 1990s, advancements in technology and transportation logistics set the stage for rapid growth in e-commerce sales. Over the past 30 years, the Internet became more accessible and achieved substantial gains in connection and data transfer speeds and information storage and distribution. Thus, the Internet became capable of storing much more information and connecting people in new and different ways. In addition, the following logistics enhancements supported the growth of e-commerce distribution:

- Ships grew larger, making it cheaper to ship goods from overseas;
- Ports expanded to handle the increased volumes;
- Truck fleets added capacity and sophisticated routing systems to make deliveries more quickly and inexpensively;
- Information technology systems were developed to improve inventory management, track the movement of products through the supply chain, and to fulfill and track customer orders;
- Networks of fulfillment centers have been built to place inventories proximate to consumer markets, facilitating two-day or same-day delivery.

COVID-19 pandemic practices such social distancing and working from home contributed to a huge leap in e-commerce sales and in the volumes of products and shipments moving through the transportation system to deliver those goods. E-commerce's key value proposition of convenience (for the consumer) attacks a key advantage of traditional, store front retail.

Approximately 10 years ago, in late 2011, e-commerce sales in the United States totaled approximately $50.2 billion. This represented about 4.9% of total retail sales in the U.S. By the 1st quarter of 2020, on the eve of the COVID-19 pandemic's spread through the U.S., e-commerce sales totaled $154.6 billion, and represented 11.4% of total retail sales. As Figures A.11 and A.12 show, e-commerce sales spiked by 32% (to $203.8 billion, and nearly 16% of total retail sales) in the second quarter of 2020, when the pandemic was spreading across the U.S., and federal, state, and local authorities urged people to distance themselves from others if possible.

E-commerce offered a convenient and safe way to purchase goods and services during a time when many stores, offices, and other business establishments were closed or operating with very limited capacity. As some of the early stay-at-home orders and recommendations lapsed later in 2020, and many brick-and-mortar retail stores reopened and/or resumed normal operating hours and capacity. E-commerce sales dipped slightly, however, they have continued to increase through 2021. E-commerce's share of total retail, however, has decreased through 2021, suggesting that while e-commerce sales have increased, so too have brick-and-mortar retail sales. American consumers are spending more in total, both online and in stores. In the 3rd quarter of 2021 (the most recent data available at the time of publication of this memorandum), e-commerce sales in the U.S. totaled $214.6 billion, representing 13.0% of total retail sales.

Figure A.11. U.S. E-Commerce Retail Sales by Quarter, Q3 2011-Q3 2021

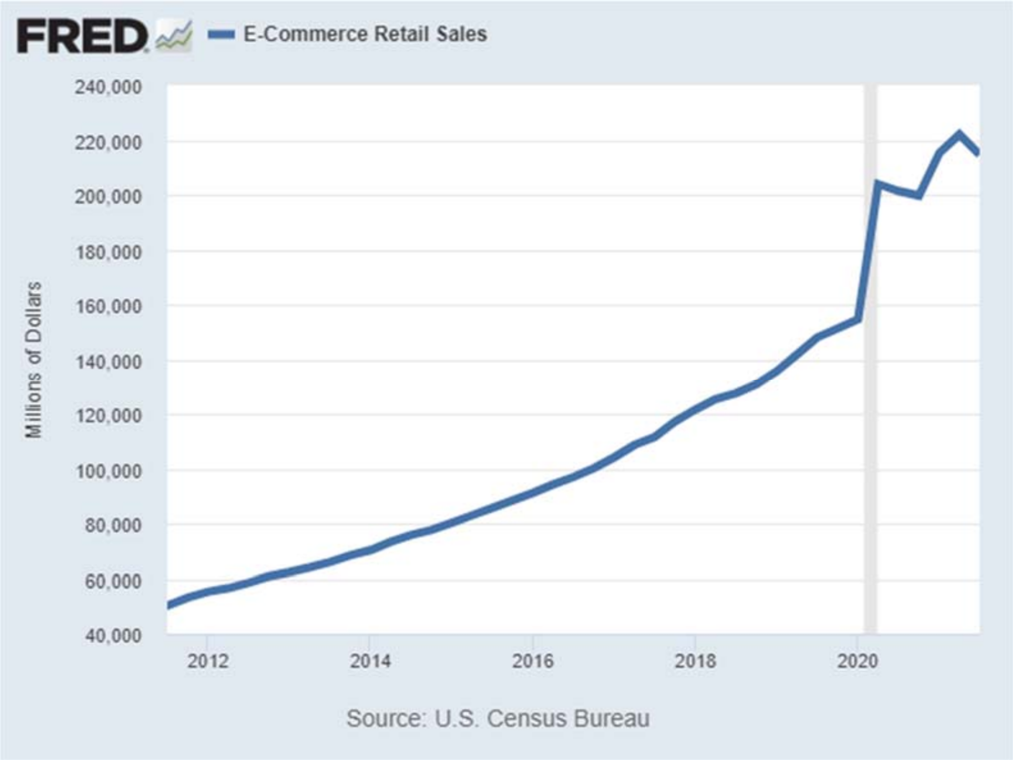
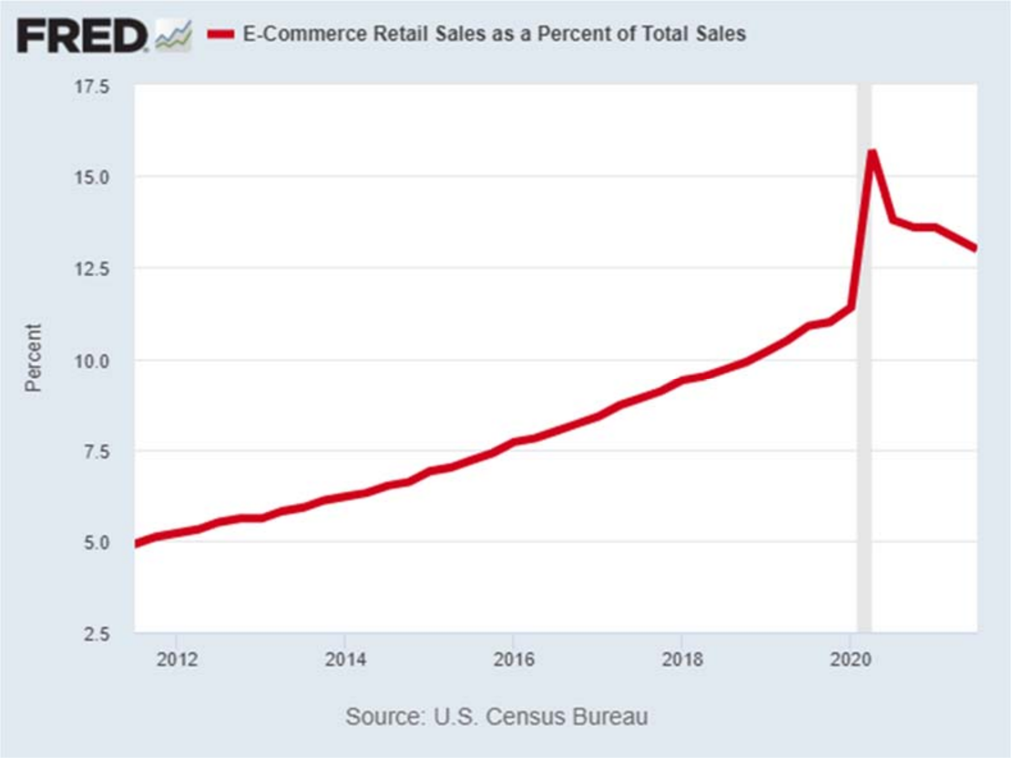


Figure A.12. E-Commerce as a Percent of Total U.S. Retail Sales by Quarter, Q3 2011-Q3 2021



The combination of increasing consumer demand and retail sales, with supply chain stresses and capacity constraints (discussed in the previous section of this memorandum) led to challenges for many retailers to maintain sufficient levels of inventory to meet their consumers' demands. Decades of keeping inventory levels (and costs) low and meeting customer demand "just in time" left supply chains especially vulnerable to the quick changes in consumer demands that came during the pandemic era. Indeed, at various times through 2020 and 2021, some products were unavailable on store shelves and/or e-commerce retail sites, and "shortages" of various goods were reported during this period.[7]

Figure A.13 shows the inventories to sales ratio in the United States over the past 10 years. After an initial spike in inventory-to-sales ratio in early 2020, which is likely attributable in part to closed retail stores, and receipt of orders placed prior to the effects of the pandemic on daily life, inventories have not kept pace with sales since.

Figure A.13. Inventory-to-Sales Ratio, U.S. Businesses, November 2015-November 2021

[7] https://www.wsj.com/articles/why-arent-there-enough-paper-towels-11598020793; https://www.mckinsey.com/mgi/overview/in-the-news/shortages-of-everyday-products-have-become-the-new-normal-why-they-wont-end-soon; https://www.nytimes.com/2021/06/01/business/coronavirus-global-shortages.html;

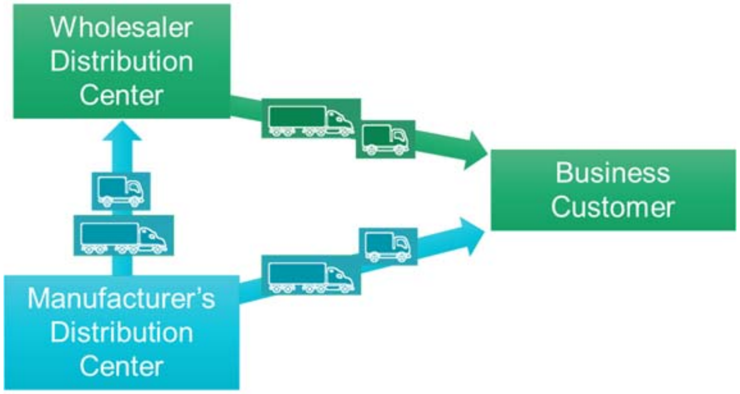
Delivery Logistics

How goods sold through e-commerce channels are transported and delivered depends in large part upon the type of e-commerce transaction. E-commerce transactions include:

- Business-to-business, or "B2B" transactions, such as a supplier of raw materials offering its products for sale to manufacturers via the Internet;
- Business-to-consumer, or "B2C" transactions, such as a retailer selling merchandise to consumers online (e.g., amazon.com, target.com, etc.);
- Consumer-to-consumer, or "C2C" transactions, such as a resident of Portland selling used home gym equipment on Craigslist.org, Facebook Marketplace, or other similar websites;
- Other combinations of business, consumer, and government transactions made using the Internet.

B2B transactions often result in large quantities of materials or goods being transported by various modes of transportation, but ultimately being delivered to the customer's location via a full truckload or less-than-truckload. B2B shipments that are smaller in size or quantity may be delivered by a parcel delivery company such as FedEx or UPS, or by the U.S. Postal Service (USPS). In these transactions, e-commerce is allowing the business customer to browse inventory and make the purchase transaction, but is not fundamentally changing the transportation and delivery modes and services used to fulfill these orders. Figure A.14 illustrates the logistics steps connecting the product manufacturer to the business customer.

Figure A.14. B2B E-Commerce Logistics Diagram

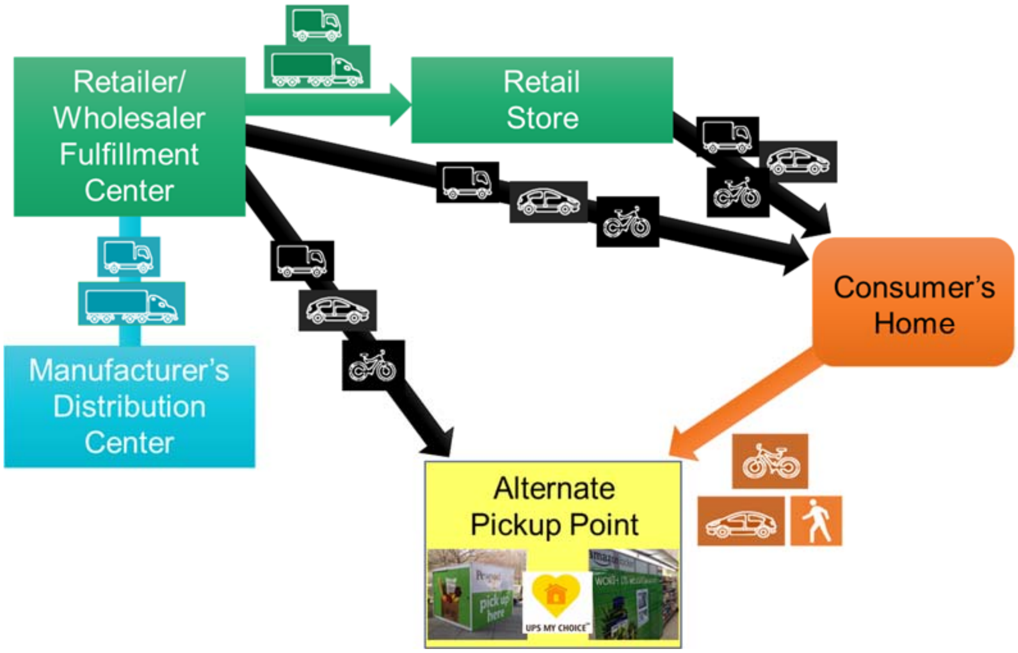


B2C and C2C transactions have changed the ways in which consumers interact with retailers, and how goods end up in consumers' hands. The following are some of the standard B2C and C2C delivery models that have emerged:

- **B2C Parcel Delivery (B2CPD).** Most consumer-based e-commerce transactions involve a consumer browsing the Internet, making a purchase, and having the purchased product(s) delivered to the consumer's home or other place of their choosing. This B2CPD model of e-commerce involves the packaging of a shipment at an e-commerce retailer (or third party) fulfillment center, and the pickup, transport, and delivery of that shipment to the customer's door. In some cases, the orders are packaged and shipped from a retail store near the consumer's location. The transportation and delivery of the consumer's order is typically handled by one of the major parcel carriers. A 2020 study performed in New Jersey found that 97% of e-commerce parcel deliveries in that region are delivered by four major carriers—USPS, UPS, Amazon, and FedEx.[8] Compared to "traditional" brick-and-mortar retail store shopping, this model of B2C e-commerce replaces what would have otherwise been a consumer's trip to a retail store with a parcel delivery trip.

Figure A.15 illustrates the logistics steps that bring goods from manufacturers and retailers to the consumer. The black arrows indicate delivery trips to a consumer's home or alternate place of the consumer's choosing (such as work, an Amazon locker, a nearby place of business that partners with delivery carriers, etc.). The consumer may make a trip by car, on foot, by bicycle to pick up the shipment from the alternate pickup point.

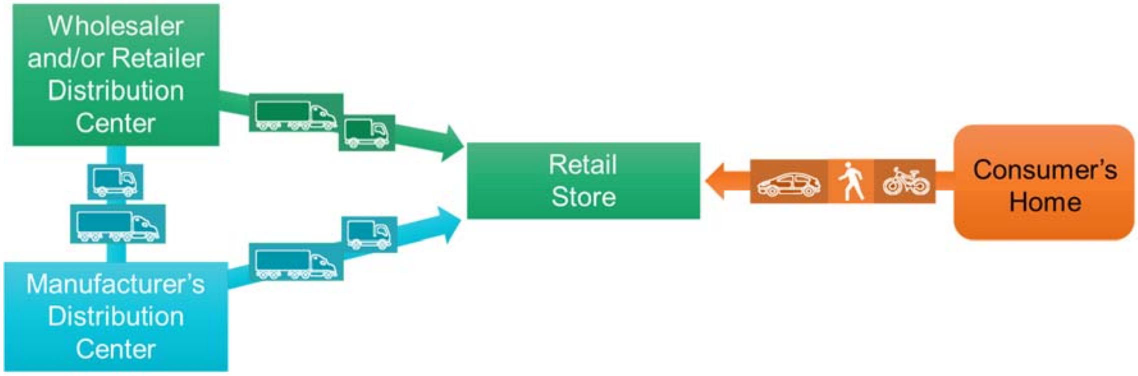
Figure A.15. B2CPD Logistics Diagram



- **B2C Pick-Up (B2CPU).** In recent years, B2C e-commerce transactions have also included options for consumers to order goods online and come to the store to pick them up. Some retailers have reallocated floor space within the store to make space for order fulfillment and to hold orders awaiting customer pick-up.[9] The COVID-19 pandemic introduced consumers to another pick-up option, allowing products to be ordered online and picked up "curbside" or in the parking lot. This allows the consumer to receive their orders without having to enter the store. The B2CPU model of e-commerce is more like traditional brick-and-mortar retail in that it requires the consumer to travel to the store. Figure A.16 shows the logistics diagram for B2CPU orders.

[8] E-Commerce Deliveries Commodity Profile, NJTPA 2050 Freight Industry Level Forecasts Study.
[9] https://www.digitalcommerce360.com/2021/06/03/best-buys-stores-drive-fast-fulfillment-for-online-orders/

Figure A.16. B2CPU Logistics Diagram



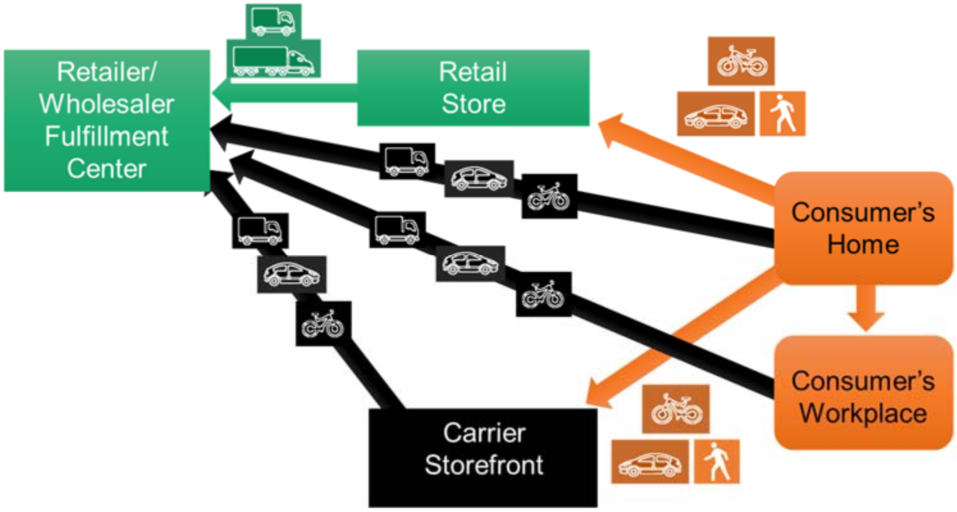
- **B2C Restaurant and Grocery (B2CRG).** Although grocery delivery services, such as Fresh Direct and Peapod, and restaurant delivery service giants GrubHub and Uber Eats, pre-date the COVID-19 pandemic (and certainly, many restaurants have offered their own delivery services for decades), the popularity of restaurant and grocery delivery services increased tremendously during the pandemic. Online grocery orders are fulfilled from either a local warehouse or nearby supermarket store, and delivered via box truck, van, or a third party delivery service (such as Uber) via automobile or cargo bicycle, to the consumer's home. The restaurant delivery services allow consumers to browse nearby restaurants, place an order, and track the delivery. The restaurant receives the order, prepares the food, and hands the packaged order to the delivery driver or cyclist (a.k.a., "deliverista"), who delivers the order to the consumer. These deliveries replace what may have been a consumer's trip to a supermarket or a restaurant. Figure A.17 shows the logistics chain connecting restaurants and grocery stores to consumers.

Figure A.17. B2CRG Logistics Diagram

- **B2C Reverse Logistics (B2CRL).** Reverse logistics refers to the movement of goods that consumers order, receive, and then return to the seller. The items could be returned due to poor fit (in the case of clothing and accessories), damage, unmet expectations, or a change of heart. The National Retail Federation estimates that approximately 21% of all consumer goods ordered online are returned.[10] In efforts to keep customer convenience and satisfaction high, many e-commerce retailers have allowed free returns, with multiple drop-off options (including shipping labels for parcel carrier pickup, allowing drop-offs at retail stores, etc.). Figure A.18 shows the logistics chain for reverse logistics moves.

[10] https://nrf.com/media-center/press-releases/retail-returns-increased-761-billion-2021-result-overall-sales-growth#:~:text=According%20to%20NRF%2C%20online%20sales,(10.6%20percent)%20deemed%20fraudulent.

Figure A.18. B2CRL Logistics Diagram



C2C e-commerce transactions could involve the seller shipping the product to the buyer via parcel delivery companies, akin to the B2CPD model, or by the buyer traveling to the seller's residence or other location to see and purchase the product.

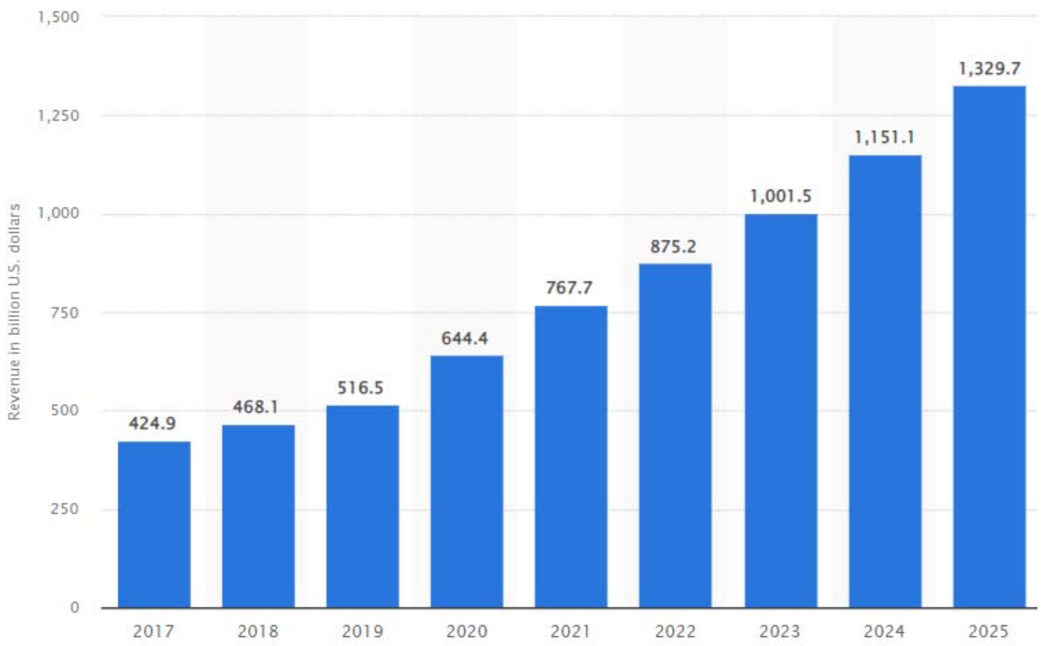
Demand Outlook

Forecasting future e-commerce demand is a challenging prospect, as the answers depend not only upon economic and demographic projections that are often used to forecast passenger and freight travel demand generally, but also upon the rate of growth in the public's comfort and use of online shopping and ordering services (and the arrival of Generation Z and future generations as consumers in the marketplace). In addition, the long-term implications of the COVID-19 pandemic on work-from-home versus office-based work, potential changes in the use of household income for various expenditures, and other aspects of purchasing behavior that have been undoubtedly altered by the pandemic, but for which the long-term prospects are unclear (i.e., will these changes persist or revert back to a pre-COVID "normal?"), will substantially impact the rate of increase in e-commerce sales, and the penetration of e-commerce as a percent of total retail sales going forward.

Statista published a report in January 2022 that included a short-term e-commerce revenue forecast. Focusing on the anticipated rate of growth, that forecast expects B2C e-commerce revenue in the U.S. to increase by 14% to 15% per year through 2025, as Figure A.19 shows. If that growth rate were to be realized, e-commerce sales in 2025 could be more than double the 2020 sales volume.[11] This is a much more aggressive forecast than the forecast published by the same organization in March 2021, which anticipated a 30% growth in B2C e-commerce revenue over the 2020-2025 period.

[11] https://www.statista.com/statistics/272391/us-retail-e-commerce-sales-forecast/

Figure A.19. Statista's E-Commerce Forecast Through 2025 (published January 3, 2022)



Source: Statista.com

A longer-range forecast was prepared for the North Jersey Transportation Planning Authority in 2020 using an assumption that after the pandemic-fueled surge in sales, the rate of growth in e-commerce sales would revert to pre-COVID growth rates. Using that formula, the NJTPA study estimated that the share of total retail sales associated with e-commerce would increase from 11% in 2019 to about 47% by 2050. Accounting for population growth and other demographic drivers, that would result in an increase in the number of e-commerce parcels delivered in that region between 2020 and 2050 of 447%.[12]

The NJTPA study also estimated the number of vehicle trips on that region's highway network associated with delivering e-commerce parcels. The study estimated that approximately 1,900 delivery vehicle trips are generated by e-commerce deliveries each day in the North Jersey region, and that number could increase to more than 8,000 per day by 2050. This analysis only accounted for the trips associated with performing deliveries, and did not estimate a net effect, such as the number of personal automobile (or other) trips to stores, or other trips that may be avoided because of e-commerce.[13]

Challenges and Issues

The growth of e-commerce has significant implications for planners at the federal, state, regional and local levels. E-commerce works best when the public sector makes investments in projects that help accommodate the growth in e-commerce volumes, alongside the private investment. Many of these investments have already been planned and delivered in the form of port expansions, highway developments, rail improvements, customs enhancements, distribution center developments, industrial real estate market growth, and so forth. Many of those enhancements are facilitating the movement of goods through international ports of entry and to warehouses, distribution, and fulfillment centers. However, there are considerations that the public sector has begun making to address real or potential

[12] Final Report, Appendix C, 2050 Freight Industry Level Forecasts Study, North Jersey Transportation Planning Authority.
[13] Ibid.

traffic generation, parking and curb management, emissions, land use, and economic implications associated with e-commerce and the last-mile delivery moves attributable to e-commerce. These issues will be analyzed and described in more detail, along with examples of actions or strategies that have been effective in addressing those issues, in Task 5.

Regional Freight Delay and Commodities Movement Study

Appendix B: Existing Information and Research on the Potential Impacts of E-commerce and Online Delivery Growth

submitted to

Metro Regional Government

submitted by

Cambridge Systematics, Inc.
38 East 32nd Street, 7th Floor
New York, NY 10016

with

DKS Associates

Table of Contents

Key Findings and Considerations

This memorandum presents a summary of key data points and statistics that suggest the state of growth in e-commerce within the Portland Metro region and the potential impacts of e-commerce and delivery services.

Key national trends and observations:

- E-commerce demand is growing nationally. After a "spike" of rapid growth in the second quarter of 2020 (32%), growth in e-commerce demand has continued, but the rate of growth has slowed considerably.

- E-commerce represents approximately 15% of total retail sales. This is well above pre-pandemic levels (approximately 12% in late 2019). E-commerce as a share of total retail sales spiked in 2020 but decreased as stores reopened in late 2020 and 2021. The past two quarters have witnessed a slight rebound in e-commerce's share of total retail sales.

Key state and regional trends and observations:

- Statewide (Oregon), growth in personal consumption expenditures between 2019 and 2021 exceeded the national average. Consumer spending on food and beverages, furniture and home furnishings, and miscellaneous retail items increased at a greater rate in Oregon than in the nation as a whole. Spending on motor vehicles and parts, health and personal care, sporting goods/hobbies/books/etc., and general merchandise did not increase in Oregon as much as nationally. Oregonians spending more on consumer goods than the national average suggests that e-commerce growth (as an increasingly popular retail channel) may be increasing at or above the national average rate of growth as well.

- Ocean container traffic moving through the Port of Portland increased 137% between August 2021 and August 2022. Much of this growth may be attributable to congestion at other west coast ports and increased charter service to the Port. However, increased consumer spending in stores and online in this region and nationally is likely a major contributor to increased international trade and congestion at many of the nation's international gateways.

- Key economic sub-sectors related to e-commerce experienced substantial increases in employment between 2019 and 2022, particularly couriers and messengers (53% increase) and warehousing and storage (65% increase), during a time when total private sector employment in the Portland-Vancouver metropolitan area decreased by 2% or 18,000 jobs. These two sub-sectors are a small share of the region's total employment, but are representing a larger share now (3.7%) than in 2019 (2.6%). Wages in these sectors have also increased during this time to over $400 million in 2022, representing 2.5% of wages paid in the region.

- E-commerce requires more industrial real estate space than traditional brick-and-mortar retail, and thus, the boom of e-commerce during the COVID-19 pandemic brought a surge in demand for industrial real estate in the Portland-Vancouver region. Vacancy rates have decreased from 5% in 2020 to 3.5% in late 2022. Lease rates are at record levels, and more than 10 million square feet of space are under construction. An Amazon fulfillment center in the Salem area accounts for 3.8 million square feet of that space under construction.

What remains unknown/opportunities for further research:

- The number of e-commerce shipments delivered or the value of sales made in the Portland region is unknown at this time. There are some data sources that estimate these types of statistics, but they are expensive to acquire.

- E-commerce deliveries are not included in the data and long-range forecast packages most often used for public sector freight transportation planning. This may change over time as e-commerce continues to grow and data and analysis approaches are enhanced.

- The net effects of e-commerce on travel demand, vehicle-miles traveled, and emissions have been the subject of many research efforts in recent years, but conclusions are difficult to draw based upon the outcomes of these efforts. There are many variables, including demographics, shopping behaviors, automobile ownership, transit utilization, logistics networks and distribution center locations, and personal auto and delivery fleet characteristics that would influence the net effects of e-commerce on VMT, delay, and emissions. More research and analysis, particularly within this region, would be needed in order to determine the contributions e-commerce may make to better or worse transportation system performance and environmental and community impacts of transportation.

B.1. Introduction

E-commerce, or the sales of retail goods via the internet, has become a mainstream channel for consumers across the nation to shop for various consumer goods—including home furnishings, appliances, clothing and accessories, and food, among others. The COVID-19 pandemic rapidly accelerated the volume of e-commerce sales made in the United States. With that, a substantial increase of employment in key industrial sector that support these operations – including transportation and warehouse. Also, an increased warehouse capacity and new development of fulfillment and other distribution centers close to the urban center has been observed between 2020 and 2022.

In a previous memorandum completed as part of the Regional Freight Delay and Commodities Movement Study, the effects that the COVID-19 pandemic has had on the national economy, global supply chain logistics, and e-commerce demand were reviewed. This memorandum pulls together data points that suggest there have been impacts on the economy, land development, and transportation systems within the Portland region specifically.

Data on e-commerce sales and the number of parcels delivered within the region are outside the reach of the budget of this study, and the net transportation system effects (i.e., whether the addition of delivery vehicle trips replaces household trips to brick-and-mortar retail stores) are still debated. However, data showing national trends in e-commerce sales, and state-level consumer spending and retail sales suggest that e-commerce purchasing is growing. Further, port container volumes at the Port of Portland, increased employment in key industry sub-sectors linked to e-commerce, and industrial real estate occupancy and development suggest that growth in e-commerce demand and augmentation of the logistics systems needed to fulfill orders and deliver parcels, are having impacts in the Portland region.

This memorandum presents a summary of key data points and statistics that demonstrate that the growth in e-commerce demand is likely having impacts on employment and wages, the industrial real estate market.

The organization of the memo is as follows:

- **Section 1** updates to national data sources on the growth in e-commerce sales
- **Section 2** data and other information that suggest e-commerce is having effects on the Portland region, including trends in consumer spending and retail sales in Oregon, container volumes moving through the Port of Portland, employment and wages in courier and messenger and warehousing sub-sectors in the Portland-Vancouver metropolitan area, and recent trends in industrial real estate development in the Portland-Vancouver metropolitan area.
- **Section 3** outlines research and analysis needs to better understand recent and projected future growth in e-commerce demand in the Portland region, and the net effects of e-commerce on transportation system performance (i.e., vehicle-miles traveled and delay) and emissions.

B.2. E-Commerce and Retail Sales Trend Updates

National Trends

In a memorandum titled *COVID Impacts on E-Commerce and Deliveries,* produced under the Regional Freight Delay and Commodities Movement Study in March 2022, trends in e-commerce demand and economic drivers of that demand were presented and analyzed. In the nearly one year since that publication, e-commerce demand has continued to increase, albeit at a lower rate of growth than the rate observed prior to the COVID-19 pandemic.

Approximately ten years ago, in late 2011, e-commerce sales in the United States totaled approximately $50.2 billion. This represented about 4.9% of total retail sales in the U.S. By the 1st quarter of 2020, on the eve of the COVID-19 pandemic's spread through the U.S., e-commerce sales totaled $154.6 billion, and represented 11.4% of total retail sales. As Figures B.1 and B.3 show, e-commerce sales spiked by 32% (to $203.8 billion, and nearly 16% of total retail sales) in the second quarter of 2020, when the pandemic was spreading across the U.S., and stay-at-home order and social distancing was the federal, state, and local authorities' recommendations.

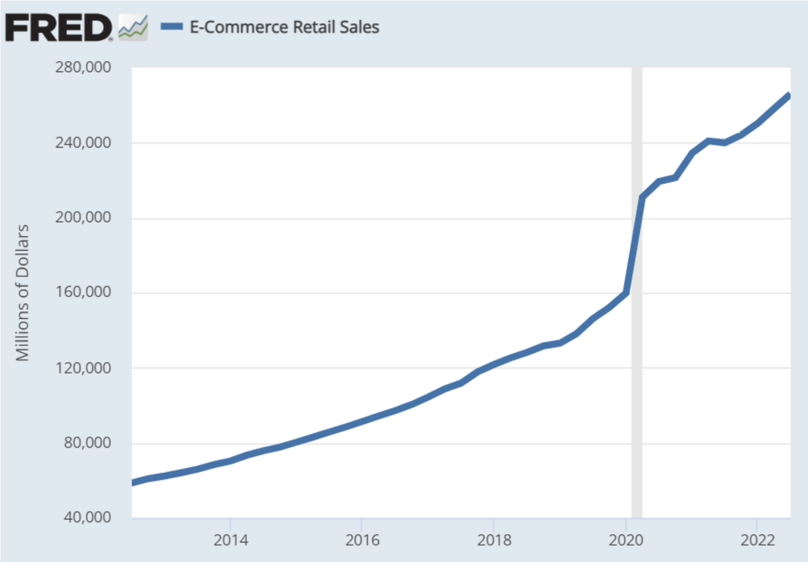
Since the spike in demand in the second quarter of 2020, e-commerce sales have continued to increase each quarter through 2022, at an average rate of 2.9% per quarter, a lower rate than the 3.6% per quarter average between 2011 and the first quarter of 2020. This slowed rate of growth can be attributed to several factors, including a logical deceleration after the 2020 spike, supply shortages, price inflation of consumer goods, and changes in consumer spending in anticipation of an economic slowdown in the near future.[1]

In the 3rd quarter of 2021 (the data point published in the 2022 technical memorandum), e-commerce sales in the U.S. totaled $240 billion[2], representing 13.0% of total retail sales. One year later, in the 3rd quarter of 2022 (the most recent data available at the time of this memorandum's publication), e-commerce retail sales in the U.S. totaled $265.9 billion, representing 14.8% of total retail sales. E-commerce sales increased approximately 11% between the 3rd quarters of 2021 and 2022, while total retail sales increased about 9% over the same period.

[1] https://www.wsj.com/articles/consumer-spending-personal-income-inflation-november-2022-11671750930; https://www.bea.gov/data/consumer-spending/main ; https://www.nytimes.com/2022/12/23/business/economy/consumer-spending-inflation-november.html

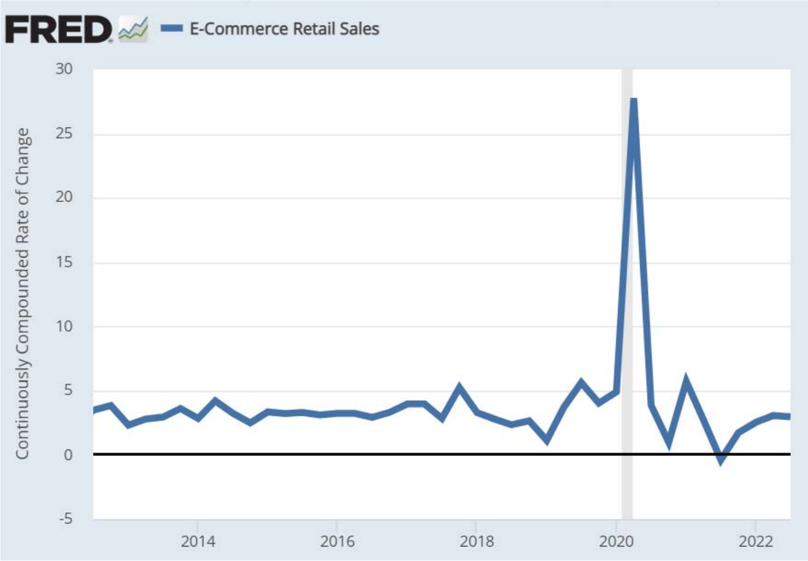
[2] AAccording to the U.S. Census Bureau, this is an adjusted total. At the time of the 2022 memo's publication, the Census reported $214.6 billion in e-commerce sales during the 3rd quarter of 2021.

Figure B.1 U.S. E-Commerce Retail Sales by Quarter, Q3 2013-Q3 2022



Source: U.S. Census Bureau, E-Commerce Retail Sales [ECOMSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECOMSA.

Figure B.2 Compounded Rate of Change in E-Commerce Retail Sales by Quarter, Q3 2013-Q3 2022



Source: U.S. Census Bureau, E-Commerce Retail Sales [ECOMSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECOMSA.

Figure B.3 E-Commerce as a Percent of Total U.S. Retail Sales by Quarter, Q3 2013-Q3 2022

Source: U.S. Census Bureau, E-Commerce Retail Sales as a Percent of Total Sales [ECOMPCTSA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/ECOMPCTSA.

State and Metro Regional Trends

Data on e-commerce sales and deliveries specific to the Portland metropolitan area are not available for this study. However, several other data sources suggest that the e-commerce demand growth observed at the national level is occurring in the region as well, including:

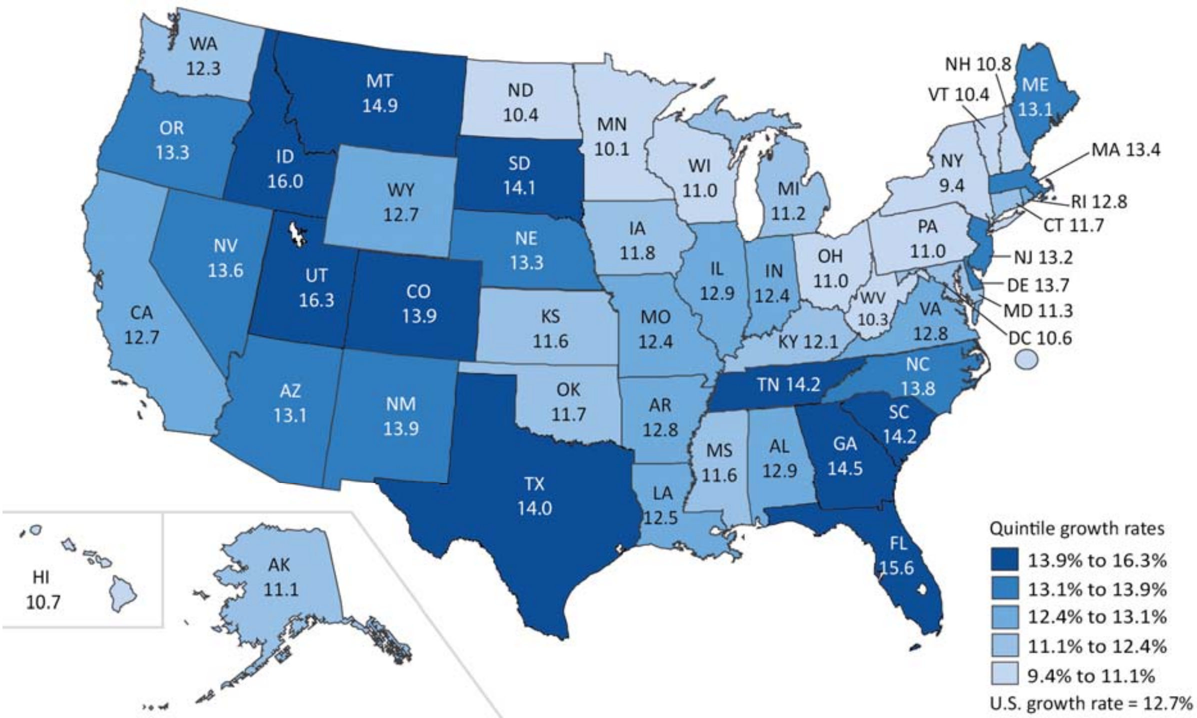
- **Personal consumption expenditures** reported at the state level;
- **Brick-and-mortar retail sales** reported at the state level;
- Trends in **port container volumes**;
- **Employment and wages** in industry sub-sectors related to e-commerce reported at the metropolitan area level; and
- **Warehousing and distribution center development** reported at the metropolitan area level.

Personal Consumption Expenditures

E-commerce is a subset of retail sales and consumer spending. Personal consumption expenditures, as defined and reported by the U.S. Bureau of Economic Analysis (BEA), include the value of goods and services purchased by, or on behalf of, persons residing in the United States. The BEA reports that personal consumption expenditures in the state of Oregon increased from $180.3 billion in 2019 to $202.9 billion in 2021, or 13.3%. This growth includes a decrease of 0.7% between 2019 and 2020. In 2021, Oregonians spent $47,779 in personal expenditures per capita. This includes $8,924 on housing and utilities, $7,956 on health care, $4,104 on food and beverages for off-premises consumption, $1,030 for gasoline and other energy goods, and $25,765 for all other consumption expenditures. The categories of consumer spending experiencing the greatest rates of growth from 2019-2021 are gasoline and energy (45%), motor vehicles and parts (34%), other durable goods[3] (33%), and clothing and footwear (32%).[4]

Personal consumption expenditures saw a statewide increase (13.3%) in Oregon between 2019 and 2021[5],slightly greater than the national average of 12.7%, placing Oregon in the second-highest quintile for the nation. Generally, states in the southeast and interior west, with faster-growing populations and economies, out-performed slower-growing northeastern and upper midwestern states, as Figure B.4 shows.[6]

Figure B.4 Personal Consumption Expenditures by State, Percent Change, 2019-2021[7]



Source: U.S. Bureau of Economic Analysis

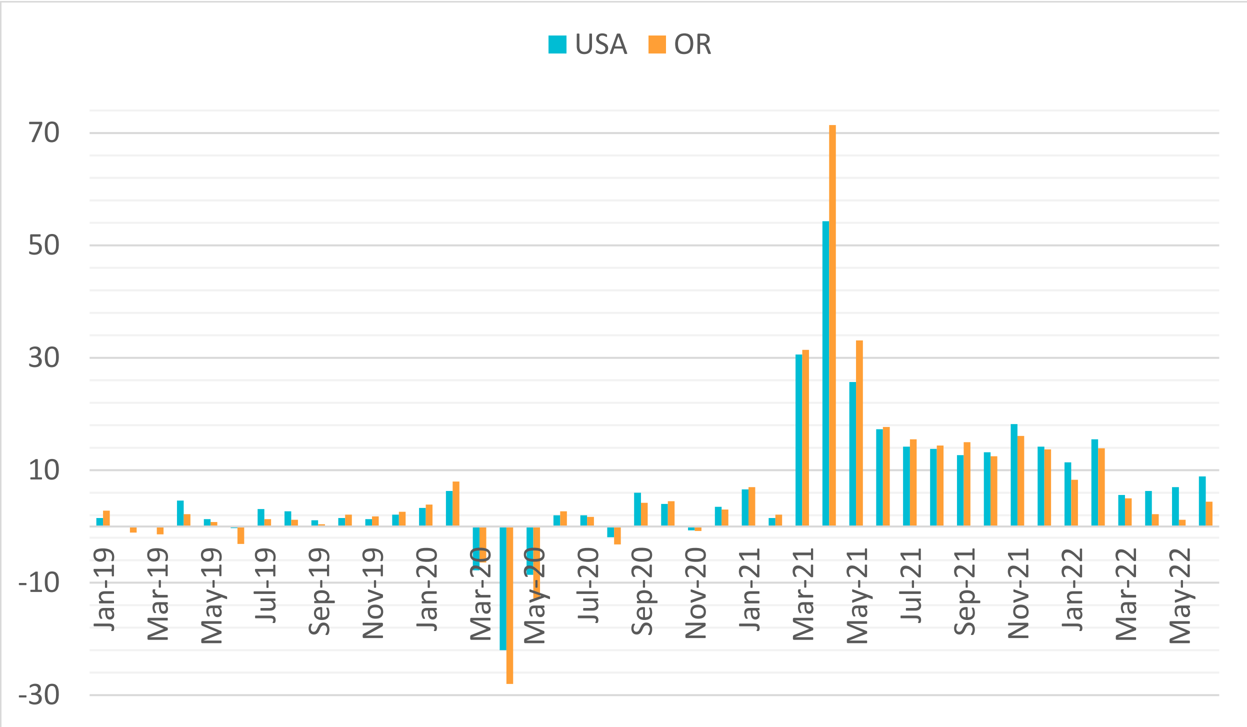
Retail Sales Trend

According to the U.S. Census Bureau's Monthly State Retail Sales Report, retail sales plunged nearly 30% in Oregon in May 2020 compared to May 2019 among brick-and-mortar retailers. Total retail sales, have increased nationally and in Oregon since 2020. Census data shows an increase of 7.5% nationally and 5.9% in Oregon between September 2021 and September 2022. Figure B.5 illustrates the percent

[3] "Other durable goods" includes durable consumer products excluding those defined as motor vehicles and parts, furnishings and durable household equipment, and/or recreational goods and vehicles. Examples of "other durable goods" include luggage, personal electronics, carpets and rugs, and other goods meant for long-term use.
[4] https://www.bea.gov/sites/default/files/2022-10/pce1022_0_0.pdf.
[5] This is the most recent comparison available as of January 25, 2023.
[6] https://www.bea.gov/sites/default/files/2022-10/pce1022_0_0.pdf.
[7] https://www.bea.gov/data/consumer-spending/state.

change in retail sales year-over-year for each month between January 2019 and June 2022 nationally and in Oregon.

Figure B.5 Year-Over-Year Percent Change in Retail Sales by Month, January 2019-June 2022, U.S. Average and Oregon



Source: U.S. Census Bureau, Monthly Retail Sales by State Report, September 2022 Release.

Oregon's growth in total retail sales accelerated in 2021 before slowing in 2022 for almost every retail sub-sector, with the exceptions of Food and Beverage and Building Materials and Garden Supply. These trends are summarized in Table B.1. In 2020, the greatest year-over-year percent increases in retail sales in Oregon were observed in the Food and Beverages (22.3%), Building Materials and Garden Supply (21.3%), and Miscellaneous Store Retailers (13.8%). In 2021, the greatest year-over-year sales increases were observed in Gasoline Stations (37.7%), Miscellaneous Store Retailers (28.6%), and Sporting Goods/Hobbies/Books/etc. (24.9%). In 2022, the greatest year-over-year sales increases were observed in Gasoline Stations (17.3%), Miscellaneous Store Retailers (14.3%), and Building Material sand Garden Supply (9.6%). [8]

The observed growth in sales in the building materials and garden supplies, food and beverages, and sporting goods/hobbies/books/etc. appear to support periodical evidence that consumers bought durable and nondurable goods during the pandemic that replaced many service expenditures. [9] For example, many office workers avoided the expenses of commuting to work and reduced their spending on vacations, dining out, and other services. Many households used those savings to improve their homes, purchase fitness equipment (in lieu of gym memberships), or to purchase more food for the home (in lieu of dining out).[10]

[8] https://www.census.gov/retail/state_retail_sales.html
[9] https://www.researchdive.com/4973/Analyst-Review/fitness-equipment-market; https://www.ers.usda.gov/publications/pub-details/?pubid=105532 ; https://www.npr.org/2020/09/11/909264580/why-home-improvement-has-surged-and-how-its-changing-america
[10] Ibid.

Compared to national averages, Oregonians increased their purchases of food and beverages, furniture and home furnishings, and miscellaneous retail items at a greater rate in 2020 than their peers in the other states combined. Spending on motor vehicles and parts, health and personal care, sporting goods/hobbies/books/etc., and general merchandise did not increase in Oregon as much as nationally.

Table B.1 Year-Over-Year Percent Change in Retail Sales by Sub-Sector, Oregon and National, September 2020-2022

	Oregon			National		
	Sep-20	Sep-21	Sep-22	Sep-20	Sep-21	Sep-22
Total Retail	4.2%	15.0%	5.9%	6.0%	12.7%	7.5%
Motor Vehicles and Parts Dealers	3.7%	9.4%	7.5%	10.2%	8.6%	5.5%
Furniture and Home Furnishing Stores	9.9%	6.8%	5.0%	7.3%	10.5%	-0.4%
Electronics and Appliance Stores	-13.0%	0.0%	-9.6%	-10.8%	18.3%	-8.5%
Building Materials and Garden Supply	21.3%	5.8%	9.6%	22.0%	6.2%	9.7%
Food and Beverage Stores	22.3%	1.6%	1.9%	9.1%	7.2%	7.2%
Health and Personal Care Stores	2.7%	14.7%	6.5%	8.4%	8.0%	4.4%
Gasoline Stations	-3.8%	37.7%	17.3%	-13.5%	40.4%	18.8%
Clothing and Clothing Accessories Stores	-3.4%	15.9%	6.6%	-5.9%	22.5%	6.1%
Sporting Goods, Hobbies, Books, etc.	10.4%	24.9%	3.8%	21.7%	12.8%	5.0%
General Merchandise Stores	-10.2%	22.9%	-0.6%	5.2%	9.6%	5.6%
Miscellaneous Store Retailers	13.8%	28.6%	14.3%	4.7%	28.0%	11.8%

Source: Monthly State Retail Sales, U.S. Census Bureau, September 2022.

Port Traffic Trends

Increased consumer spending and retail sales (in-store and online) have contributed to increased volumes of container traffic at international maritime gateways and rail facilities around the nation, including the Port of Portland. Other reasons for the growth in container traffic include rising consumer demands in this region and elsewhere in the country and port and rail congestion afflicting other international trade gateways.

The number of containers transported via the Port of Portland increased substantially (136.6%) between August 2021 and August 2022, as Figure B.6 shows. Figure B.7 shows the volumes of containers imported and exported through the Port of Portland between January 2020 and August 2022. This number peaked in September 2021 at approximately 8,000. Though, the monthly volume moved through 2022 remained well above the averages for 2020 and 2021.

Figure B.6 Port of Portland Year-over-Year Volume, August 2022

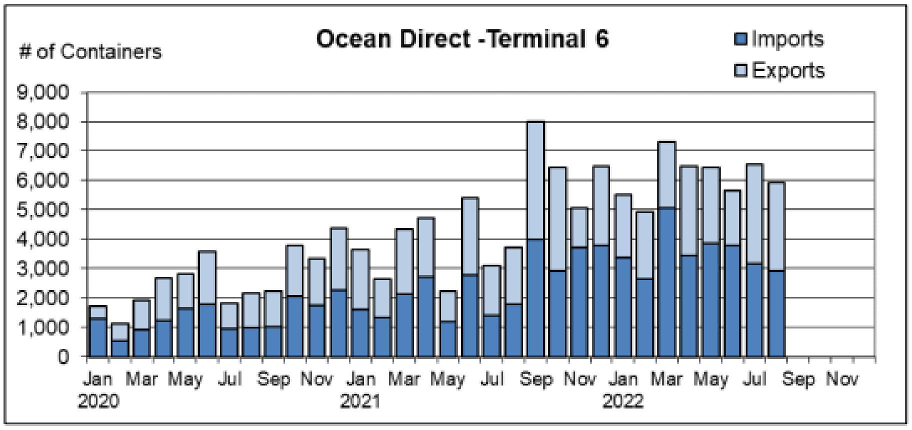
MARINE – TRADE & EQUITABLE DEVELOPMENT REPORT

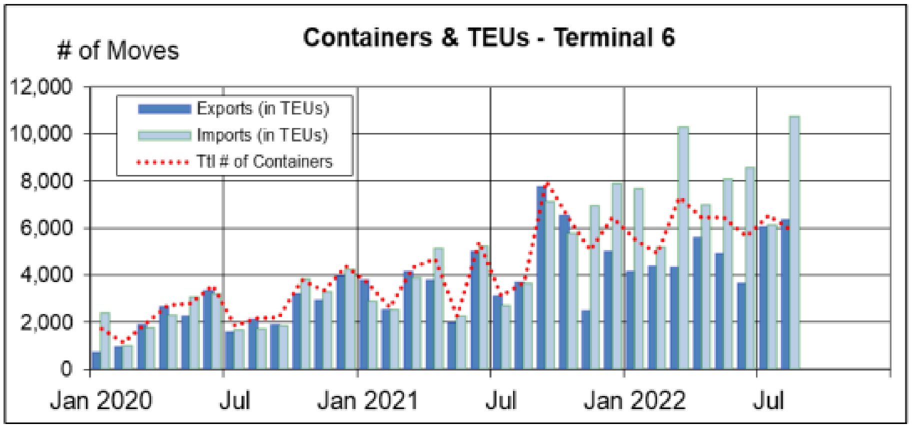
The figures in the table below show change relative to the prior year.

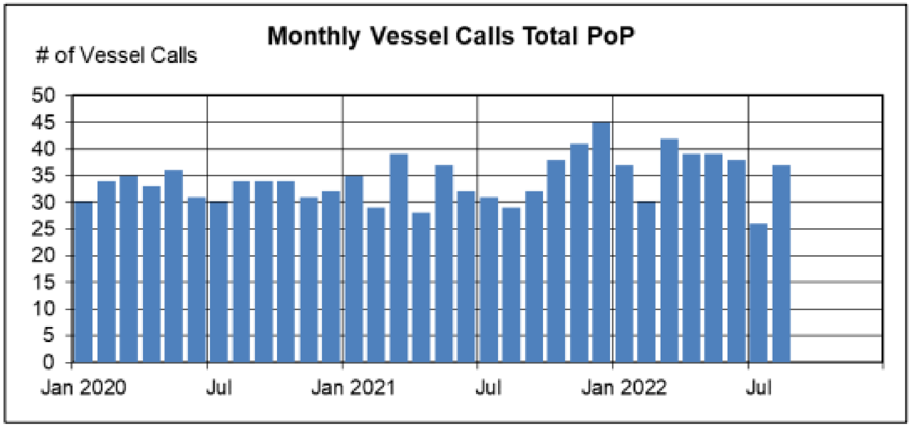
	August 2022	Fiscal Year-to-Date
Total Tonnage	24.9%	-0.1%
Ocean Containers	136.6%	124.4%
Railyard Containers	12.2%	23.8%
Autos	26.6%	12.9%
Mineral Bulk	16.4%	-10.4%
Grain	--	--

Source: Executive Director's Report to the Port of Portland Commission, September 2022

Figure B.7 Container Volumes and Vessel Calls at the Port of Portland, January 2020-August 2022







Source: Executive Director's Report to the Port of Portland Commission, September 2022

Employment and Wages in Key Economic Sub-Sectors

Employment has increased since the onset of the pandemic in sectors of the economy that support e-commerce order fulfillment and delivery in the Portland-Vancouver, OR-WA Metropolitan Statistical Area. The data source is the Oregon Employment Department, and the industry sub-sectors of interest were identified in a study prepared by Sorin Garber Associates.[11] The statistics have been updated with the most recently-available data from 2022.

Table B.2 and Figure B.8 show the change in employment in sectors associated with e-commerce supply and last-mile operations. In particular, substantial growth (53% and 65%, respectively, in the Portland-Vancouver region) has been observed among couriers and messengers, and warehouse and storage workers, two key roles in this sector. These e-commerce-related sub-sectors experienced growth when the region's total private sector employment decreased by 18,000 jobs or 2%.

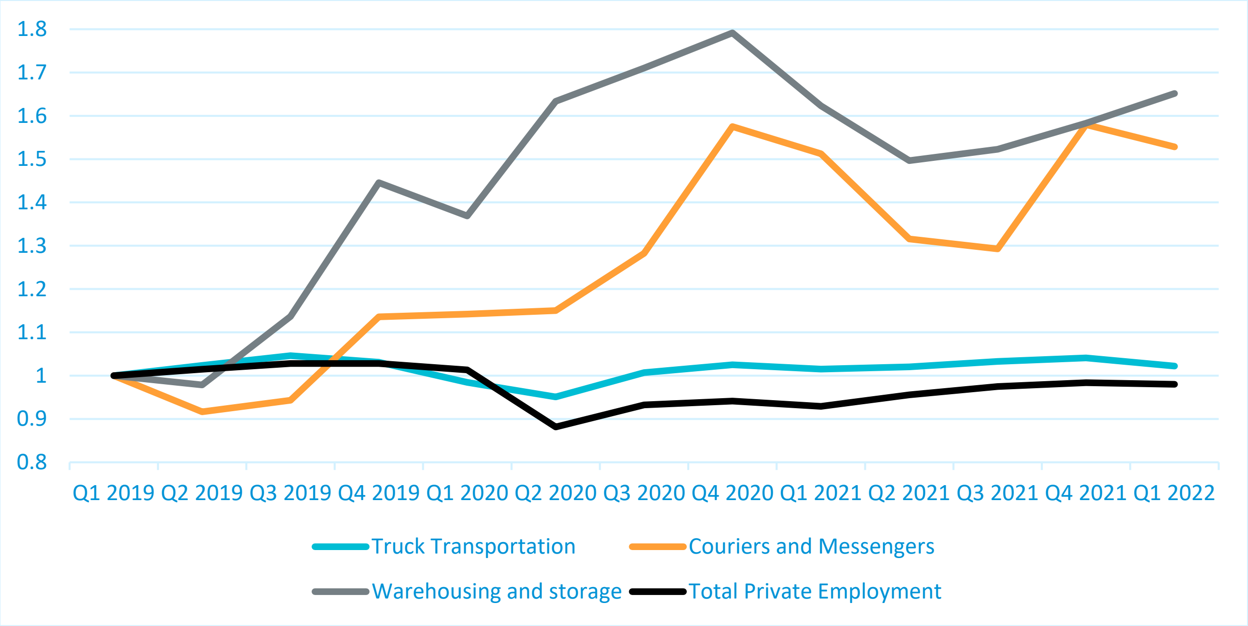
Table B.2 Employment in Key E-Commerce-Related Sub-Sectors, 2019-2022

Economic Sub-Sector	Q1 2019 Employment	Q1 2022 Employment	Change	Percent Change
Truck Transportation	8,992	9,192	200	2.2%
Couriers and Messengers	7,043	10,763	3,720	52.8%
Warehousing and Storage	7,749	12,799	5,050	65.2%
Total Private Employment	906,575	888,565	-18,010	-2.0%

Source: Oregon Employment Department

Figure B.8 Employment in Key Sectors, indexed to 2019 Q1

Quarterly, 2019 Q1 through 2022 Q1



Source: Cambridge Systematics, using data from Oregon Employment Department

[11] "Are Home Deliveries Increasing during the Pandemic? Update 7," Sorin Garber Associates, Dec. 17, 2021.

Table B.3 shows the sum of jobs in the truck transportation, couriers and messengers, and warehousing and storage sub-sectors, as a percent of the region's total private sector employment. The table also shows wages in these three sub-sectors as a percent of total regional private sector wages. The e-commerce-related sub-sectors have achieved a greater share of the region's employment, increasing from 2.6% of private sector employment in 2019 to 3.7% by 2022, with a peak of 4.0% in late 2020. Wages in these sub-sectors have also increased as a proportion of total private sector wages, growing from 1.8% in 2019 to 2.5% in 2022, with a late 2020 peak of 2.8%. As e-commerce demand continues to increase, so are jobs and wages paid in these sub-sectors, and the role that e-commerce plays in the region's economy is also likely to increase.

Table B.3 E-Commerce-Related Sub-Sectors as a Percent of Total Employment and Wages in the Region, 2019-2022

		Q1 2019	Q4 2020	Q1 2022
Employment	Number	23,784	34,194	32,754
	Percent of Region's Total	2.6%	4.0%	3.7%
Wages	Number	$266.9 million	$444.0 million	$416.3 million
	Percent of Region's Total	1.8%	2.8%	2.5%

Source: Oregon Employment Department

Warehousing and Distribution Center Development

The value of that proximity to customers makes the higher costs of acquiring and developing land in major metropolitan areas worthwhile for many companies that sell and distribute goods via e-commerce channels, where customers expect quick fulfillment and delivery of orders. E-commerce delivery operational needs including additional space for the storage, sorting and packing of individual customer orders; and the processing of large number of e-commerce related returns (return rates fluctuate between 16% to more than 20%)[12] contribute to a requirement of more warehousing and distribution center space per volume of goods than traditional brick-and-mortar retail. A 2021 report by ProLogis estimated that e-commerce requires three times the logistics space as brick-and-mortar retail due to the need to accommodate order fulfillment and processing returns.

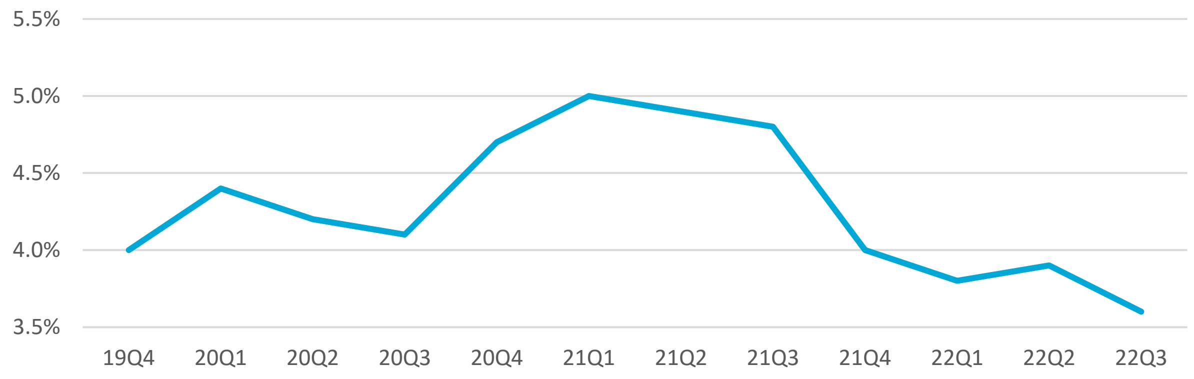
As e-commerce sales have increased nationwide, demand for industrial real estate has also increased. Within the Portland-Vancouver Market area, as defined by commercial and industrial real estate company Colliers in their market area (Portland-Vancouver metropolitan and Salem areas) reports vacancy within the industrial real estate sector increased early in the pandemic to 5% in early 2021, but has since decreased to near 3.5% by late 2022. Space under construction, measured in square feet, has increased from about 4 million square feet in the middle of 2020 to nearly 10 million square feet in mid-2022. A large portion of the inventory under construction is an Amazon facility totaling more than 3.8 million square feet, expected to open in early 2023 in Woodburn.

This increased demand and the rush to develop more industrial space have contributed to rising lease rates. Lease rates in the market area reached a record high of 85 cents per square foot in late 2022.

These trends are illustrated in Figures B.9 through B.11. A list of properties under construction is provided in Table B.4

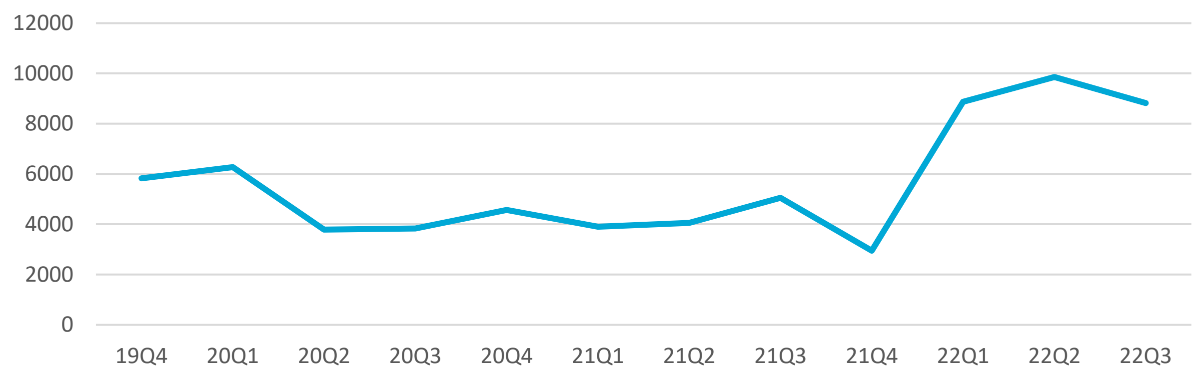
[12] https://nrf.com/media-center/press-releases/2022-retail-returns-rate-remains-flat-816-billion

Figure B.9 Industrial Space Vacancy Rate, Portland-Vancouver Market Area, Q4 2019-Q3 2022



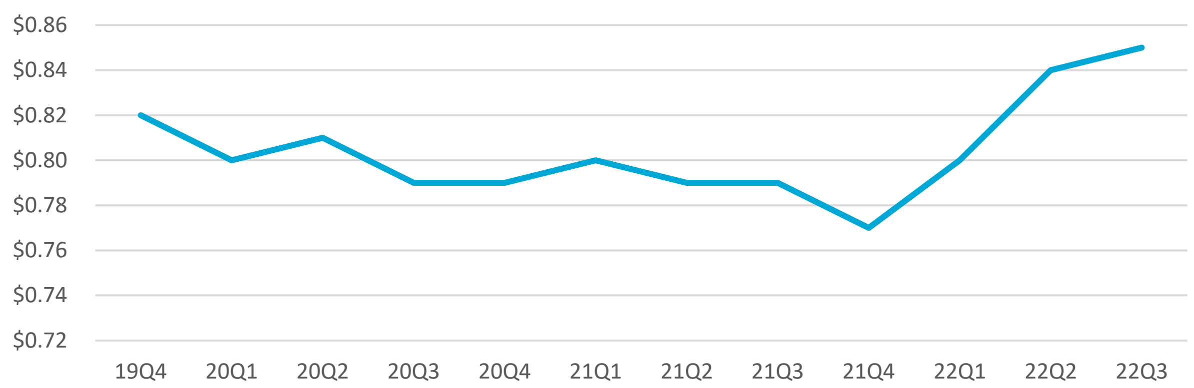
Source: Colliers Portland Industrial Reports, 2019-2022

Figure B.10 Industrial Space Under Construction by Quarter, Portland-Vancouver Market Area, Q4 2019-Q3 2022 (thousands of square feet)



Source: Colliers Portland Industrial Reports, 2019-2022

Figure B.11 Asking Lease Rates (triple net), Portland-Vancouver Market Area, Q4 2019-Q3 2022



Source: Colliers Portland Industrial Reports, 2019-2022

Table B.4 Properties Under Construction as of Q4 2022

Property	Submarket	Developer/Owner	Size (SF)	Delivery
Project Basie – Amazon Fulfillment Center	Salem	Trammel Crow/Amazon	3,850,000	Q1 2023
Prologis Meadows, Building E	North/Northeast	Prologis, L.P.	281,345	Q1 2023
PacTrust Corporate Park	Clark County	PacTrust	293,262	Q1 2023
Mill Creek Corporate Center, Bldg 5	Salem	PacTrust	86,400	Q1 2023
10680 289th	Westside	BBS Properties LLC	13,264	Q1 2023
LaCamas Tech Center, Bldg 2	Clark County	Rotschy Inc.	24,624	Q1 2023
Lu Pacific Industrial Park	I-5 South	Lu Pacific Properties LLC	131,594	Q1 2023
Mill Creek Corporate Center, Bldg 6	Salem	PacTrust	75,600	Q2 2023
138 Logistics Center, Bldgs A & B	North/Northeast	Phelan Development Company	489,700	Q2 2023
2480 SE 13th Ave	Southeast	American Metals Corporation	85,105	Q2 2023
4035 Grant St	Clark County	Port of Camas Washougal	50,000	Q2 2023
6301 NE 159th Ave – Bauer Cases	Clark County	Bauer Cases	85,000	Q2 2023
Grahams Ferry Industrial Center	I-5 South	Ares Commercial Real Estate	148,279	Q2 2023
18350 SW 126th Pl	I-5 South	-	18,000	Q3 2023
Burnt Creek Industrial	Clark County	Panattoni	681,780	Q3 2023
Sherwood Commerce Center, Bldgs A/B/C	I-5 South	Schnitzer Properties	445,007	Q4 2023
10500 SW Manhasset Dr	I-5 South	Fred Hines	44,647	Q4 2024

Source: Colliers Portland Industrial Report, Q4 2022

B.3. Opportunities for Further Research and Analysis

Some of the effects of e-commerce still need to be fully understood. To develop a better understanding and quantification the e-commerce impact, further research, development and/or enhancement of data and analysis tools, and better private sector engagement is required. The following are three key areas of opportunities for research? :

- **E-commerce parcels delivered in the region.** There are several data vendors, including Axciom, BDEX, FreightWaves, and Nielsen IQ (formerly Rakuten Intelligence, acquired by Nielsen in 2022) providing market research data on e-commerce purchases and/or shipments delivered. Each source has varying limitations due to sample sizes, data attributes collected, and/or cost. Nielsen IQ is perhaps the most often used for public sector freight planning purposes due to its robust sample and estimates of total e-commerce shipments in a given area. Nielsen IQ collects data on online orders from users of specific shopping and shipment tracking apps. Their research team expands the relatively robust sample to estimate total parcels in an area of interest, based upon market research and demographic factors. The data can be provided to the zip code level (delivery location), over any desired historic time period. Information about the products ordered and carriers making the deliveries (e.g., U.S. Postal Service, UPS, FedEx, Amazon, etc.) are generally available. These data do not, however, indicate the origin of the delivery trip, so to use these data to estimate the transportation is limited without tapping other data or information sources. This data is available for a fee, and was too expensive to acquire within the budget of this study, and the limitations of the other data sources make them unattractive for use in this study.

- **Forecasting future e-commerce parcels.** Retail market researchers may publish near-term forecasts or annual outlooks. However, forecasts that align with the forecasting horizons used in long-range transportation planning, state freight plans, etc., are not produced by the vendors. S&P Global, the vendor of Transearch, a popular freight commodity flow forecasting data product, has made strides to account for the growth of e-commerce demand in its forecasts. However, those flows are interplant—or warehouse-to-warehouse, and do not include estimates of last-mile delivery trips. As e-commerce demand continues to increase over time, and data and analysis approaches to estimate its effects improve, data vendors such as S&P Global, or U.S. DOT, the sponsor of the Freight Analysis Framework database, may seek to enhance their methodologies to account for, and identify, the contributions of e-commerce to freight flows and delivery trips.

- **Net effects of e-commerce deliveries on in-store shopping.** Much research has been carried out to discover whether e-commerce replaces, complements, or modifies consumers' in-store shopping behaviors. In other words, does e-commerce replace trips to the store or would/are those trips to the store still happening as they would otherwise? Some of this research suggests that there is a complementary relationship between e-commerce and in-store purchasing, and that the more consumers buy online, the more they buy in stores as well.[13] Whether a household makes fewer, more, or the same number of trips to a retail store as they purchase goods online, may depend upon the specific shopping habits of that household. For instance, a consumer may purchase clothing online that they would have otherwise bought at a big box retail store. However, that consumer may still go to purchase other items at the big box retail store. With the emergence of "BOPIS" (buy online, pick-up in-store) models that gained traction during the COVID-19 pandemic, the line between e-commerce and brick-and-mortar retail is, in some cases, becoming blurred.

- **Net effects of e-commerce deliveries on transportation system performance and the environment.** The consumer's online shopping behaviors may have significant impacts upon the

[13] Lee RJ, Sener IN, Mokhtarian PL, Handy SL, Relationships between the online and in-store shopping frequency of Davis, California residents. Transportation Research Part A: Policy and Practice, 2017; Farag S, Schwanen T, Dijst M, Faber J. Shopping online and/or in-store? Transportation Research Part A: Policy and Practice, 2007.

net effects on the transportation system and the environment. The same consumer described above may have ordered five clothing items as discrete, separate orders. Each order will be packaged individually and delivered on five different days. The transportation system impact of that purchasing behavior would suggest a greater trip generation and emissions impact than had the consumer traveled to a store to buy five items at once.

In addition, the built environment of a city or neighborhood can be a factor in determining the net vehicle-miles traveled (VMT) and emissions effects of e-commerce. A recent (2022) study by the Center for Sustainable Transportation estimated, using a model, that growth in online shopping is likely to reduce VMT and emissions in the Dallas, TX metropolitan area, where automobile ownership is high and alternative transportation usership is low, but that online shopping could have a negative impact (increasing VMT and emissions) in New York City, where automobile ownership is low and many consumers use transit, walking, or other modes to shop in stores.[14]

In sum, despite recent research on this topic, there are many variables, including demographics, shopping behaviors, automobile ownership, transit utilization, logistics networks and distribution center locations, and personal auto and delivery fleet characteristics that would influence the net effects of e-commerce on VMT, delay, and emissions. More research and analysis, would be needed in order to determine the contributions e-commerce may make to better or worse transportation system performance and the environmental and community impacts of transportation within this region

[14] National Impacts of E-commerce Growth: Development of a Spatial Demand Based Tool (August 2022). University of California, Davis, available from: https://escholarship.org/uc/item/46x4f1dr (accessed January 24, 2023).

Regional Freight Delay and Commodities Movement Study

Appendix C: Emerging Logistics Solutions for Efficient Delivery of E-commerce and Other Online Services

submitted to

Metro Regional Government

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Table of Contents

Key Findings and Considerations

According to retailer surveys conducted by FarEye in 2022, the last-mile move from the final sorting center to the customer represents 53% of the total logistics cost for e-commerce shipments. Fuel and labor costs, remote customer locations, and unsuccessful delivery attempts are key drivers of the high cost associated with the last mile.

This memorandum presents several examples of strategies that companies in the private sector are implementing in order to improve the efficiency of last-mile deliveries of e-commerce orders, and strategies that public agencies are adopting in order to mitigate or anticipate the effects of continued growth in e-commerce shopping and the resulting delivery trips.

Retailers and carriers (the companies charged with performing last-mile deliveries) are exploring a variety of operational, data, and technological strategies aimed at reducing the cost of last-mile deliveries. Key private-sector cost-reduction strategies described in this memorandum include:

- Managing demand by:
    - Incentivizing consumers to select no-rush shipping options, thus allowing items to be packaged, shipped, and delivered more efficiently; and
    - Encouraging customers who shop online to select in-store or curbside pickup options, thus avoiding the last-mile delivery altogether.
- Optimizing delivery trip routes and tours using a combination of machine learning and artificial intelligence, which can incorporate historic data to predict traffic and incidents, and incorporate the needs of specific customers and driver behaviors. Companies such as FedEx, UPS, and Amazon (among others) are exploring these technologies in order to improve the efficiency and reduce the cost of last-mile deliveries.

Public-sector agencies are typically concerned with addressing the impacts last-mile delivery trips have on transportation system operations, curbside parking availability, economic development considerations associated with distribution center development, and other community effects. The public-sector strategies described in this memorandum include curb management strategies such as right-sizing and managing curbside loading zones, and land use considerations involving industrial land use and potential conversions of vacant storefronts (or “dark stores”) into e-commerce fulfillment centers.

The City of Portland promotes the consideration of delivery needs in designating and managing its Truck Loading Zones (TLZ), including the use of flexible, or combination, spaces which allow loading and customer parking at different times of the day, based upon demand.

The New York City and Southern California metropolitan regions provide good examples of how to assess regional freight land use and warehousing needs in a metropolitan area.

There are not any confirmed dark store conversions identified in this study’s research in the Portland region, however, there are some issues that municipalities ought to consider if such conversions are proposed or desired. These include whether warehousing and storage is a permitted use in the area where the site is located, whether zoning changes are needed within industrial or commercial zones to cover the intended use, and whether the conversion of a retail storefront to fulfillment center use would have adverse impacts on foot traffic for adjacent retail spaces, tax revenues, etc.

C.1. Introduction

As presented in Appendix B, growth in consumer demand for goods purchased via e-commerce has had several impacts nationally and within the Portland Region. E-commerce growth is likely contributing to growth in employment in economic sectors such as warehousing and storage and couriers and messengers. It is also likely driving growth in demand for industrial real estate in the region.

E-commerce, and the delivery trips it generates, are increasing the logistics costs for retailers and freight carriers, and generating more demand for curbside loading and unloading zones. These curbside impacts are of especially great interest at a time when expansions of bicycle and pedestrian infrastructure, outdoor sidewalk and parking-space dining, and other uses are also vying for space at or near curbs.

This memorandum presents a summary of strategies that are being implemented or tested by actors in both the private and public sectors to address the impacts e-commerce is having on their respective priorities. The organization of the memo is as follows:

- **Section C.2** describes two key strategies undertaken by private sector actors to reduce the cost of last-mile deliveries, including managing demand for last-mile deliveries and optimizing routing using artificial intelligence and machine learning;

- **Section C.3** describes two groups of strategies undertaken by public sector actors to reduce the impacts of last-mile deliveries on communities. These include:

    - Curb management strategies, such as right-sizing loading zones, establishing flexible curb zones, and trials with loading zone reservation systems; and

    - Land use strategies, such as assessing industrial land use needs and considering adaptive reuse of vacant retail stores into e-commerce fulfillment facilities.

C.2. Logistics Strategies – Private Sector

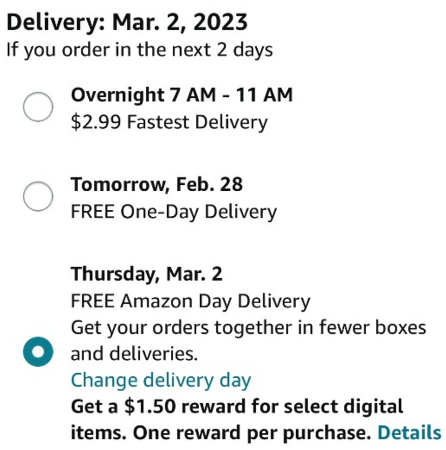
Last-mile deliveries represent a substantial share of the overall logistics costs associated with transporting consumer products from their points of origin to consumers' doorsteps. A 2022 retailers' survey by conducted by FarEye found that the last-mile move from the final sorting center to the customer represents 53% of the total logistics cost for e-commerce shipments.[1] Fuel and labor costs, remote customer locations, and unsuccessful delivery attempts are key drivers of the high cost associated with the last mile. Over the past several years, many retailers have outsourced deliveries to parcel delivery companies and gig workers in an effort to reduce costs and effectively meet rapid delivery timeframes. This outsourcing means that retailers have less visibility into and control over the delivery, and that delivery mishaps, while not the direct fault of the retailer, can give customers a poor experience that they may hold against the retailer.

Among the many strategies that retailers and parcel delivery companies are taking to make deliveries cheaper and more efficient are two that appear to be major themes for 2023—managing demand for deliveries by shifting consumers' shopping behaviors, and using artificial intelligence (AI) technology to optimize delivery tours.

C.2.1 Managing Demand

One strategy retailers have adopted in order to reduce delivery costs is to promote changes in consumers' demand for deliveries to their doorsteps. For more than seven years, Amazon has offered incentives to consumers, in the form of digital media credits and other perks, to consolidate orders to be delivered on one day of the week. At checkout, consumers are offered the option of having items delivered as soon as possible, which may involve separate shipments delivered on different days for orders containing more than one item. Alternatively, consumers may choose a "No-Rush Shipping" option to have all items delivered on the same day of the week, perhaps in fewer boxes, in exchange for a small reward, redeemable for specific Amazon reward. Figure C.1 shows an example of an available reward for choosing no-rush shipping.

Figure C.1 No-Rush Shipping Option, Amazon.com



Source: Amazon.com

[1] "Retailers lose visibility as they outsource last-mile delivery, FarEye says," Supply Chain Quarterly, January 26, 2023, available from: https://www.supplychainquarterly.com/articles/7599-retailers-lose-visibility-as-they-outsource-last-mile-delivery-fareye-says (accessed February 24, 2023).

Amazon is not the only retailer that offers incentives to slow down deliveries. Macy's, Target, and other retailers have adopted similar strategies. While the rate of participation and realized cost savings associated with no-rush shipping options are not published, a research study produced by MIT in 2019 estimated that this strategy could save retailers between 3% and 32% of their logistics costs, depending upon the level of consumer participation.[2]

Incentives do not have to be limited to monetary rewards. During the COVID-19 pandemic, Amazon encouraged consumers to delay delivery of non-essential items to "assist others" who may need the delivery of essential items sooner. Some researchers have suggested sharing the expected sustainability benefits of consolidated deliveries with consumers as a way to convince more of them to select the more sustainable delivery option.[3]

Another demand management strategy that has been offered by an increasing number of retailers, particularly those with brick-and-mortar and online presence, is the offering of "buy online, pick-up in store" or BOPIS, and "buy online, pick-up at curb" or BOPAC. The orders may be sent from a fulfillment center to the retail store for pickup, or fulfilled in-store using items that are in the store's inventory. These options gained popularity during the COVID-19 pandemic, as consumers were able to shop online from the safety of their own homes, and appear in a store or curbside for only a few moments to pick up their orders. In 2020, BOPIS/BOPAC sales increased nearly 107% from the previous year (representing about 10% of all e-commerce sales), and projections anticipate 15% growth for each of the next several years. Consumers cite convenience and time savings as top reasons for using this retail model.[4]

C.2.2 Tour Optimization using Artificial Intelligence

Many carriers, or companies that deliver e-commerce shipments to consumers' doorsteps, are developing and applying technological solutions in order to improve the efficiency and reduce the cost of performing last-mile deliveries. For many years, carriers have used various software packages to help them plan delivery routes and tours to minimize trip miles and/or planned travel times. However, conditions on the ground can lead to travel times that vary from static planned estimates. If a specific tour can take 50% longer to complete on a "bad day" of congestion, the carrier may have to budget a buffer of an extra 50% when assigning resources (drivers, vehicles, etc.) to routes. This buffer is an inefficiency. For example, carriers may have to budget more time and/or hire additional drivers so that deliveries are made on schedule on days when delays are significant, however, this may be too much labor capacity on average days.

Using artificial intelligence (AI) for the purpose of managing drivers' tours and routes is an emerging trend in the logistics industry. Some companies are using or experimenting with AI that can better optimize delivery route options. Standard routing systems and applications use mathematics to analyze all potential routes and select a best route based upon shortest estimated travel time and/or distance. Commercial routing applications, such as Google, bring in historic and real-time operations data to adjust route estimations. AI pushes the envelope further by predicting the best route over time, using a

[2] Waters, Michael, "Why retailers like Amazon and Target are embracing no-rush delivery," Modern Retail, December 4, 2020, available from: https://www.modernretail.co/retailers/why-retailers-like-amazon-and-target-are-embracing-no-rush-delivery/; (accessed January 25, 2023).

[3] Thomas, Rodney A.; Monique L. Ueltschy Murfield; Lisa M. Ellram, "Leveraging sustainable supply chain information to alter last-mile delivery consumption: A social exchange perspective," Sustainable Production and Consumption, vol. 34, November 2022, pp 285-299, available from: https://www.sciencedirect.com/science/article/abs/pii/S2352550922002548 (accessed January 25, 2023).

[4] Owens, Beth, "BOPIS: What it is and why it's so popular with consumers," Ryder Ecommerce, February 16, 2022, available from: https://whiplash.com/blog/buy-online-pickup-in-store/, (accessed January 25, 2023); Rosencrance, Linda, "Top 7 ways to improve last-mile delivery," Tech Target, June 9, 2021, available from: https://www.techtarget.com/searcherp/feature/Top-7-ways-to-improve-last-mile-delivery, (accessed January 25, 2023).

combination of traffic information, load and customer information, and driver behaviors. AI also "learns" from observations over time, and can adjust predictions accordingly.[5] Some providers of AI-supported route optimization software claim that the AI can also incorporate drivers' needs for rest stops, refueling, and other activities into the routing and navigation calculations, and adjust estimated delivery times accordingly. The estimated delivery times can be shared with the customer in real time.[6]

In addition, AI-enabled information systems are linking delivery performance with inventory management systems in order to manage distribution center operations, i.e., managing loading dock capacity for inbound and outbound shipments, determining the rates certain products go from arrival at the distribution center to out for delivery, etc.[7] The "big three" private delivery companies—UPS, FedEx, and Amazon—are using, or are experimenting with, AI-enabled route optimization and navigation systems. The delivery robots briefly piloted by FedEx and Amazon also used AI and machine learning to optimize routes and to help the robots identify and avoid hazards and obstacles. While both FedEx's Roxo and Amazon's Scout robot programs have been discontinued, AI appears to be in the future of delivery planning and operations for human-performed and autonomous deliveries.

C.3. Logistics Strategies – Public Sector

Strategies employed by the public sector aim to avoid or mitigate the effects of last mile deliveries on the safe and efficient operation of transportation systems, the environment, and/or communities. Examples described in this section include several strategies to manage curb utilization, thus making the delivery of e-commerce shipments and other goods safer, and land use strategies and considerations that address some of the environmental, equity, and traffic effects of distribution center development.

C.3.1 Curb Management Strategies

In high-density urban neighborhoods and "main street" commercial districts, one of the most challenging street design and management issues is providing access to the curbside for all users of the street. Curbs are often where on-street parking is located. Transit stops, fire hydrants, commercial vehicle loading zones, and bicycle lanes desire space at the curb. Curb extensions for pedestrian safety change the shape of the curb at intersections. The COVID-19 pandemic brought restaurant dining to the curbside in many communities as well. In the City of Portland, businesses may acquire permits to continue using some sidewalk and on-street parking areas for business operations.[8]

Managing the design and operation of the curb to ensure that all of these users are safely accommodated can be difficult. If and when conflicts arise between multiple users attempting to access the curb, conditions may deteriorate, leading to unsafe conditions and/or fines. For example, automobile motorists may experience difficulty finding on-street parking where they want to go and instead choose to park in a loading zone, bike lane, or crosswalk. Commercial vehicles may have difficulty finding a place to unload a shipment of food to a restaurant or shop, and may double-park, adding time and potential parking tickets to the cost of performing a delivery. Both examples lead to unsafe conditions for other street users. Parking enforcement alone is not an effective strategy for preventing these unsafe conditions from emerging.

Common strategies used to address these issues of concern include "right-sizing" commercial vehicle loading zones, flexible zones, and piloting curb reservation systems that allow truck drivers to reserve

[5] https://nexocode.com/blog/posts/ai-in-last-mile-delivery-optimization-vehicle-routing-problem/
[6] https://www.dispatchtrack.com/blog/ai-powered-routing?hs_amp=true
[7] https://www.infosys.com/insights/ai-automation/documents/moving-goalposts.pdf
[8] Hasenstab, Alex, "Portland street dining will continue under permanent permit system," Oregon Public Broadcasting, March 16, 2022, available from: https://www.opb.org/article/2022/03/16/portland-street-dining-permits-permanent-system-bureau-of-transporatation/ (accessed February 14, 2023).

space at a curbside loading zone in order to pick up and/or deliver goods. Each of these strategies is described below.

Right-Sizing Loading Zones

"Right-sizing" commercial vehicle loading zones includes strategies to ensure that loading zones exist where they are needed, and that they can accommodate the types of vehicles that visit the area. Loading zones sized to accommodate a tractor-trailer may not be necessary in commercial districts or other areas that receive most of their deliveries from smaller box trucks or commercial vans.

New York City has developed a Neighborhood Loading Zone (NLZ) program, which aims to reduce the amount of delay and safety issues that stem from double parking. The NLZ program provides dedicated space for vehicles to load and unload goods and passengers. The New York City Department of Transportation (NYCDOT) is required by a city ordinance enacted in 2021 to install at least 500 loading zones each year, particularly in communities where the residential density is greater than 75 people per acre.[9] A large portion of the city meets that density threshold. The legislation was intended to mitigate the traffic and safety hazards that come from double parking and to better accommodate the boom in deliveries performed in commercial and, increasingly, in residential areas as well.

Figure C.2 Neighborhood Loading Zone in New York City

Source: NYCDOT

The NLZs restrict parking on designated on-street parking areas during the hours of 7AM until 7PM on weekdays to commercial delivery vehicles performing residential or commercial delivery, passenger vehicles making quick pickup/drop off of passengers or goods (groceries, etc.), taxis or other for-hire vehicles performing passenger pickup/drop-off. Figure C.2 shows an example of NLZ signage. NYCDOT managers the NLZ program and works in coordination with local community boards to get feedback on desired NLZ locations.[10] NYCDOT has not kept up with the pace of implementation required in the city

[9]The New York City Administrative Code, § 19-170.1 Truck loading zones and commercial parking meter areas, available from: https://codelibrary.amlegal.com/codes/newyorkcity/latest/NYCadmin/0-0-0-136361 (accessed February 14, 2023).
[10] "Neighborhood Loading Zone (NLZ) Program Expansion," NYCDOT, available from: https://nycdotprojects.info/project/neighborhood-loading-zone-nlz-program-expansion (accessed February 14, 2023).

ordinance, but the program has been expanding to communities throughout the city, and the agency expects to have 800 NLZs in operation by 2026.[11]

A pilot study conducted in Manhattan found that the average NLZ accommodated 600 vehicles per month, dwelling for an average of 26 minutes at a time. Observed double-parking decreased by 70%.[12]

The City of Portland's Performance-Based Parking Manual sets forth several objectives and strategies that the City of Portland intends to take in order to ensure that truck loading zones (TLZ) are available where they are needed. According to the manual:

> *"Currently [2018] there are 44 separate signage designations for TLZs, no default standard advising where on a blockface to locate a TLZ, and a lack of usage data for existing TLZs. The lack of default guidance to implement TLZs has led to an inefficient use of public right-of-way with multiple conflicts between users in the limited curbside environment."*[13]

The Performance-Based Parking Manual also sets forth six recommended elements for implementing TLZs in the city. These include: establishing standardized loading zone signage; establishing a preferred location for loading zones on a city block (e.g., near-side or far-side of an intersection); maintaining existing 30-minute time limits for loading and unloading in TLZs; prioritizing the placement of TLZs on certain street types (e.g., retail/commercial, boulevard, and flexible streets, as defined in the Comprehensive Plan); and initiating a review process to ensure designated TLZs continue to serve business and community needs over time.[14] The Performance-Based Parking Manual also recommends using combined, or flexible zones, which are described in more detail below.

Flexible Zones

While not a new idea, applying flexible zones for curbside uses can be made more functional with technology and dedicated proactive management. As their name suggests, flexible curb zones are designed to manage the curb according to the different demands at different times of the day.

Examples of variable use curb situations and their accompanying variability at different times of day include a bucket of tools that each location pulls from to design the curb management appropriate to the location. This may include charging a fee for loading or parking (the fee could be a demand-based fee), establishing a reservation system for spaces on the curb, providing signage that clearly identifies the curbside uses and when they are permitted, and more. Business Improvement Districts and similar organizations are ideally suited to work with the local government to implement smart curbs that change their regulations based on local needs and trends at different times of day.

Figure C.3 shows an example of a flexible zone in the suburban community of Daybreak in Jordan, Utah. The space pictured is used to accommodate trucks and vans performing deliveries to restaurants and shops in the community's commercial center during the morning hours. By midday, food trucks and other vendors set up in this space to sell to area residents, workers, and visitors during lunch and dinner mealtimes. The time-of-day change in use for this plaza, or for curbside parking spaces, allows for the safe delivery of goods at the times they're most needed (in this case, mornings) and other uses at other times of the day.

[11] "Loading Zones," NYCDOT, available from https://www.nyc.gov/html/dot/html/motorist/loading-zones.shtml (accessed February 14, 2023).
[12] "Connecting TSMO and Freight," USDOT, 2022, available from: https://ops.fhwa.dot.gov/publications/fhwahop22p091/fhwahop22p091.pptx (accessed February 14, 2023).
[13] City of Portland, "Performance-Based Parking Manual, 2018, available from: https://www.portland.gov/sites/default/files/2020-04/portland-parking-management-manual-digital-version-april-2018_v3_reduced.pdf (accessed February 8, 2023).
[14] Ibid.

Figure C.3 Flexible Zone in Daybreak, Utah

Source: NCHRP Report 844

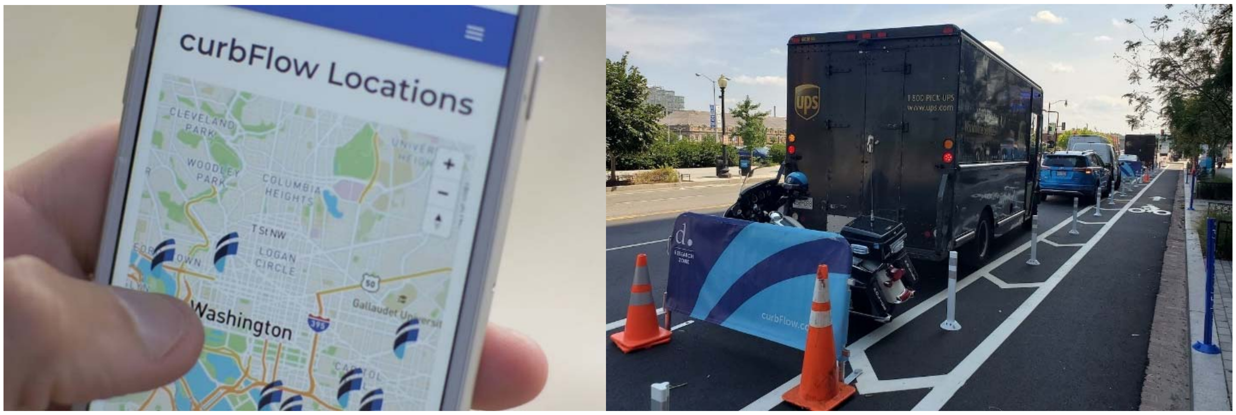
The City of Portland's Performance-Based Parking Manual, first presented in the section describing Right-Sizing Loading Zones, also contains a recommendation for the City to maximize the use of "combination zones" that serve as both Truck Loading Zones (TLZ) and visitor parking areas for customers and visitors in order to provide TLZ access while maximizing parking capacity for other users as well. Combination zones, as envisioned in the manual, allow spaces to serve as TLZs during designated periods and to be used as timed zones for visitor or residential uses at other times of the day.[15]

Reservation Systems

Some cities have piloted reservation systems, allowing motor carriers to reserve a curbside space in advance, to ensure there is a space for their driver to park and perform a delivery. A famous example of a loading zone reservation system is Washington, DC, which began a 12-week pilot program at 9 locations in 2019. The Washington, DC pilot allowed delivery drivers, including those using private vehicles (e.g., Uber eats, etc.) to reserve curb space using curbFlow, a website. The program allowed users to reserve a space up to 30 minutes in advance and remain as long as they were actively loading or unloading. Over 6,350 drivers from more than 900 companies registered to use the service and commercial drivers made more than 15,000 reservations. Researchers and District Department of Transportation (DOT) staff gathered data on performance and found that the reservation program reduced instances of double-parking by 64%. They also learned much more about the types of vehicles and average duration of loading zone occupancy.[16] Figure C.4 shows the curbFlow website as viewed on a mobile device, where drivers could find and reserve spaces, and the temporary loading zone configuration at one of the pilot locations in Washington.

[15] City of Portland, "Performance-Based Parking Manual."
[16] Pyzyk, Katie, "CurbFlow pilot reduced double parking in DC by 64%," Smart Cities Dive, November 14, 2019, available from: https://www.smartcitiesdive.com/news/curbflow-pilot-reduced-double-parking-in-dc-by-64/567268/ (accessed January 25, 2023).

Figure C.4 Washington, DC curbFlow Pilot Program, 2019



Source: curbFlow

Challenges identified during the Washington, DC pilot include, some hesitance from motor carriers to use the website, unauthorized use of reserved spaces by other vehicles, and technical challenges with the website. The website vendor, curbFlow, engaged with Columbus, Ohio to pilot reservation system using the website and a mobile app in 2020. The performance results were similar to the Washington, DC pilot—approximately 19,000 reservations over a 6-month period, and a reported 65% reduction in double-parking.[17]

Aspen, Colorado piloted “smart” loading zones, in which delivery carriers could reserve specific times. The key takeaway from the Aspen program appears to be the data gathered regarding the days and times when reservations were made in the largest and smallest numbers. Aspen officials learned that the peak demand for loading zones were on Tuesdays and Fridays, and that demand was lowest on Wednesdays (60% lower). These data could prompt the city to designate more loading zones to be available on Tuesdays and Fridays and scale those back to offer more on-street automobile parking on Wednesdays.[18]

Pittsburgh, working with vendor Automotus, started a smart loading zone pilot in 2021, which allows users to reserve loading zone spaces and pay for parking through a mobile app. The pilot program is credited with reducing double parking in pilot locations by 40% in its first year. The city has extended the pilot program through December 2024.[19]

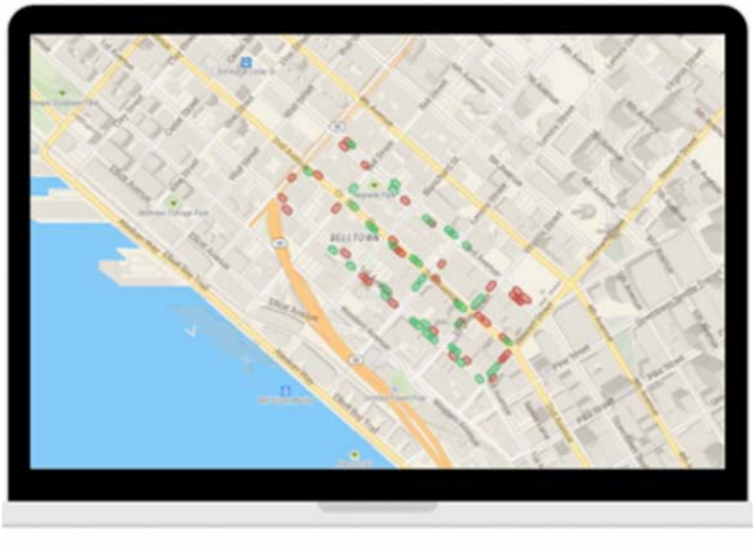
Some critics of reservation systems point out the enforcement challenges and also argue that there could be inefficiencies if reservations hold spaces for longer than needed to perform the delivery, making them unavailable to other users.[20]

Another smart parking strategy, which could be used in lieu of or in combination with reservation systems, is the use of vehicle detection technology to determine where loading zones are available in real time. This information could be shared with drivers through mobile apps and websites, and help direct drivers to available spaces, thus reducing delay and emissions, and double-parking. Such a program has been piloted in Seattle. In 2021, the Urban Freight Lab at the University of Washington released the OpenPark

[17] Stone, Tom, “City of Columbus shows success of real-time curb-management pilot,” Traffic Technology Today, June 30, 2020, available from: https://www.traffictechnologytoday.com/news/smart-parking/city-of-columbus-shows-success-of-real-time-curb-management-pilot.html (accessed (February 6, 2023).
[18] Descant, Skip, “Curb-Management Pilots Smooth the Flow of Traffic, Deliveries,” Government Technology, January 7, 2021, available from: https://www.govtech.com/fs/curb-management-pilots-smooth-the-flow-of-traffic-deliveries.html (accessed March 8, 2023).
[19] https://pittsburghpa.gov/domi/smart-loading-zones
[20] Schaefer, Matty, “The Case Against Loading Zone Reservations, Modern Mobility, August 5, 2021, available from: https://curb.substack.com/p/the-case-against-loading-zone-reservations (accessed February 15, 2023).

app, which shares real-time loading zone availability information.[21] Figure C.5 shows a snapshot of loading zone availability (available spaces shown in green) in Seattle.

Figure C.5 Snapshot of OpenPark App, Showing Available Loading Zone Spaces (Green)



Source: The Urban Freight Lab, University of Washington

C.3.2 Land Use

Warehousing/Distribution Center Development Sites

As cited in Appendix B Technical Memorandum, the distribution center space required to support e-commerce retail (including distribution and order fulfillment activities) is three times the distribution center space required to support traditional retail. As e-commerce demand has grown in recent years, especially since the onset of the COVID-19 pandemic in 2020, demand for industrial real estate in the Portland metropolitan area, and elsewhere around the country, has increased substantially.

In order to provide quick fulfillment and delivery of customer orders, sites for e-commerce fulfillment centers are often sought within or very close to major population centers. While urban industrial sites were often passed up in favor of cheaper greenfield sites in exurban areas or outside the region altogether in the 1990s and 2000s, e-commerce is changing the economic calculations of industrial developers and retail company facility owners/tenants. The higher costs of land acquisition and parcel assembly, demolition of obsolete older industrial buildings, brownfields remediation, and other costs are becoming worthwhile for some e-commerce retailers in some metropolitan areas. The higher costs of building multistory buildings on smaller urban footprints have been justified in places like Seattle and New York City, where real estate prices are high, and last-mile transportation is expensive and unreliable. In the Portland metropolitan area, Amazon, the largest e-commerce retail company, has six fulfillment and sorting centers presently in operation, including three within the City of Portland.

As Appendix B showed, the growth in e-commerce is contributing to a hot industrial real estate market in the Portland metropolitan area. While not all buildings under construction are intended to serve e-

[21] "New Parking App Provides Real-Time Curb Visibility," The Urban Freight Lab, University of Washington, April 13, 2021, available from: https://depts.washington.edu/sctlctr/news-events/announcements/new-parking-app (accessed March 2, 2023).

commerce, the growth of e-commerce is putting pressure on the marketplace, reducing vacancies and raising rents, which are contributing factors behind an increase in industrial space currently under construction in the region.

Public agencies may wish to develop and implement a strategy to assess the land use inventory and the various needs for industrial space. Such an assessment could aim to answer questions such as:

- Is e-commerce competing with other industrial space users and pricing them out of the market?;
- Does the Portland region have a sufficient supply of land zoned for industrial use to meet current and future needs?
- Is industrial land in the appropriate places, in terms of where operators want to be, where community and environmental effects are minimized, and where workers can safely and efficiently get to those job opportunities?
- What trends may impact future industrial land use needs and locations of future developments?

Examples of such assessments include:

- The Regional Freight Land Use Study, performed by the New York Metropolitan Transportation Council (NYMTC), the Metropolitan Planning Organization in the New York City area. NYMTC conducted an industrial real estate market assessment, reviewed key trends and issues that drive industrial real estate development and needs, and developed a typology describing several categories of "freight land uses," grouped by common attributes, as shown in Figure C.6. The typology described the defining characteristics of each category, examples of where such uses exist within the NYMTC region, and the different ways in which various trends are impacting, or could potentially impact, each category of freight land use.[22]
- The Southern California Association of Governments (SCAG) developed a study that performed an inventory of warehousing facilities in the region, reviewed trends impacting demand, and future needs for warehousing space in the region. The study enhanced and applied a model used to predict the square footage of warehousing and distribution center space. The model translates changes in expected freight volumes (measured in twenty-foot equivalent units of containers) to square footage. This model helps SCAG and government agencies in that region to understand how growth in the region's economy and trade can generate different warehousing capacity needs.[23]

[22] "Regional Freight Land Use Study," New York Metropolitan Transportation Council, available from: https://www.nymtc.org/en-us/Regional-Planning-Activities/Freight-Planning/Regional-Freight-Land-Use-Study (accessed March 13, 2023).

[23] "Industrial Warehousing in the SCAG Region," Southern California Council of Governments, 2018, available from: https://scag.ca.gov/post/industrial-warehousing-study (accessed March 13, 2023).

Figure C.6 Freight Land Use Categories Defined in NYMTC Regional Freight Land Use Study

Freight Land Use Types	Descriptions	Typical Use(s) in Municipal Zoning	
Freight-Handling Centers	Seaports, cargo airports, carload and intermodal freight rail yards, tandem yards, container storage, and other facilities where freight is handled for import, export, transfer/transload, etc.	Transportation and Utilities	
Large, Greenfield Distrubtion Centers	Concentrations of new, state-of-the-art distribution centers developed on previously unoccupied and relatively inexpensive land. Located in suburban areas with proximity to major highway corridors for access to urban core and major freight hubs (e.g., ports, intermodal facilities).	Industrial, warehousing, manufacturing	
Modernizing Distribution Clusters	Concentrations of legacy warehouses and industrial facilities in urban areas that are being redesigned to serve a large local market, typically for e-commerce. Modernized facilities may include multi-story buildings, advanced technology, efficient loading/unloading bays, multimodal connectivity, and other features.	Industrial, warehousing, manufacturing	
Agricultural Areas	Areas where agriculture generates shipments of freight (inbound fertilizers and equipment; outbound crops, livestock, and/or other agricultural products)	Agricultural	
Legacy Industrial/Manufacturing Clusters	Concentrations of older, smaller warehouses and industrial facilities. Limited loading space and expansion potential. Located in urban or urban-adjacent areas.	Industrial, commercial/retail/office	
Endangered Freight Land Use Areas	Historic or legacy industrial neighborhoods in urban areas that are experiencing higher rents, higher operating costs, and conflicts with adjacent uses due to increasing demand for residential, commercial, or other non-industrial uses.	Industrial, transitioning to residential, mixed use, etc.	
Freight-Receiving Land Uses	Residential communities, institutions (schools, hospitals, etc.), commercial (retail, office, etc.), and mixed-use districts are land uses that receive shipments of freight. Some commercial properties are being repurposed to generate freight shipments (e.g., vacant retail stores that are being repurposed as e-commerce distribution centers).	Residential, commercial (office, retail, etc.), institutional, mixed use	

Source: NYMTC, Regional Freight Land Use Study, 2022.

"Dark Store" Conversions

Vacant retail, often referred to as "dark stores," and shopping malls that have closed or have high rates of vacancy, are sometimes candidates for e-commerce fulfillment (or "micro-fulfillment") use. This is a relatively recent phenomenon, which appears to be gaining some momentum nationally, although the top markets for such conversions have been in the Midwest to date.[24] It is unclear if there have been any notable conversions of large retail stores to fulfillment center use in the Portland metropolitan region. While retail-to-fulfillment conversions appear to be a win-win for retail property managers and e-commerce retailers, there are several issues for local municipalities and the public at large to consider, and changes in zoning and/or development regulations may be needed in some communities if these uses are desired.

From the e-commerce retailer's perspective, the local shopping center or big box retail store is a good staging point for last-mile deliveries to those customers.[25] From the retail property manager's perspective, e-commerce fulfillment represents a prospective tenant at a time when in-store retail is in decline. Figure C.7 shows an example of a dark store conversion in Virginia. A former K-Mart store, which sat vacant for several years, was converted to an Amazon fulfillment center, which opened in 2022.

Figure C.7 Former K-Mart Store Converted to Amazon Fulfillment Center in Waynesboro, Virginia

Key challenges include zoning and development regulations in the municipalities where such retail properties are located. Converting retail space for warehousing and distribution (including

[24] " Mall Stores Becoming Warehouses as E-Commerce Surges," Realty News Report, August 19, 2020, available from: https://realtynewsreport.com/stores-becoming-warehouses/; accessed (February 6, 2023).

[25] "Just Don't Call It A Warehouse: Repurposing Unused Retail Spaces To Support E-Commerce," Reimagining Real Estate, Bisnow, December 10, 2011, available from: https://www.goulstonstorrs.com/publications/just-dont-call-it-a-warehouse-repurposing-unused-retail-spaces-to-support-e-commerce/ (accessed February 6, 2023).

order fulfillment) use may constitute a change of the use, even if the tenant is still operating a retail store on the site.[26]

The activity happening on site is the storage, fulfillment, and shipment of goods, which tends to align with industrial and warehousing land use codes. However, arguments could be made that these facilities are the next generation of retail and ought to be grouped with commercial land use codes instead. Most municipalities do not have a land use code that clearly captures dark stores converted to fulfillment centers. However, amendments to either the industrial/warehousing, or commercial/retail codes could be made to accommodate and/or address public concerns and priorities. In cases where the retail store is/was part of master-planned development (such as a large retail mall), a revision of the master plan may be needed. Such amendments to zoning codes or master plans could address or specify:

- Maximum floor area to be used for fulfillment/warehousing/distribution;
- Parking and loading area requirements for trucks, delivery vehicles, and employee parking;
- Windows and other features that promote an “active” frontage;
- Minimum thresholds for in-person retail sales (with the goal of retaining some foot traffic)[27]

Other public considerations include:

- The potential change in tax revenue (lost sales tax from the retail use versus potential revenue streams associated with fulfillment center employment and/or sales tax revenues from employee expenditures at neighboring businesses);
- Potential net effects of the loss of trips associated with the traditional retail use (truck deliveries to supply the store, employee trips, and shoppers’ personal auto/walking/transit trips) and trips added, associated with the distribution activity (truck deliveries to supply the fulfillment center and outbound trips of delivery vehicles); and
- Potential effects that the conversion from retail to fulfillment center may have on foot traffic and the viability of neighboring retail uses.[28]

[26] Faiella, Adam J., “Going Dark: Land Use Implications of Converting Retail Space to “Dark Stores” for Fulfilling Online Orders,” Sills, Cummins, and Gross, P.C., April 21, 2020, available from: https://www.sillscummis.com/going-dark-land-use-implications-of-converting-retail-space-to-dark-stores-for-fulfilling-online-orders/ (accessed February 6, 2023).

[27]Richards, Tim, AICP, Esq., Store or Warehouse? Zoning for Micro-Fulfillment Centers,” Clarion Associates, May 3, 2021, available from: https://www.clarionassociates.com/whats-new/store-or-warehouse-zoning-for-micro-fulfillment-centers/ (accessed February 6, 2023); “Land Use Considerations for Converting Vacant Retail Space for Distribution Spaces,” Hinckley Allen Real Estate, available from: https://www.hinckleyallen.com/publications/land-use-considerations-for-converting-vacant-retail-space-for-distribution-spaces/ (accessed February 6, 2023).

[28] Ibid.

Regional Freight Delay and Commodities Movement Study

Appendix D: COVID-19's Impacts on E-commerce and Other Delivery Services in the Portland Region

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Key Findings and Considerations

Task 5.3 is the third and final component of Task 5, which collectively provides an overview of the current state of e-commerce deliveries, the effects of the COVID-19 pandemic on e-commerce and other deliveries, and examples of strategies being implemented by public and private actors to improve the efficiency of last-mile deliveries. This task provides an overview of the effects the COVID-19 pandemic had on e-commerce and other deliveries in the Portland Region, relying primarily on a series of interviews with several key freight stakeholders in the region. Key findings and considerations include:

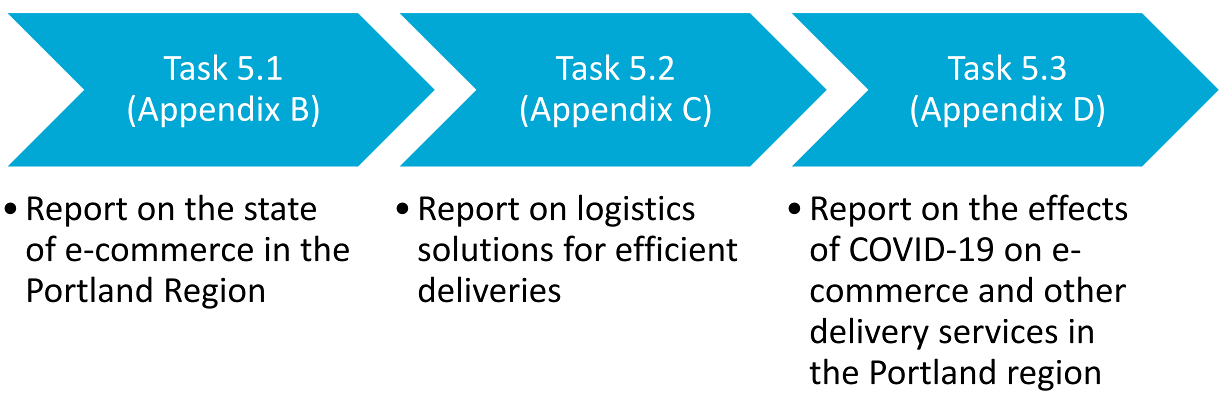
- Data on e-commerce deliveries (number of parcels delivered, number of delivery tours, etc.) are not obtainable for use in this study. The gathering of data points presented in Task 5.1 and the input of interviewees engaged in Task 5.3 help to shed light on trends and their impacts in the region.
- The COVID-19 pandemic redistributed demand for deliveries, as business-to-business and office deliveries declined, and residential e-commerce deliveries increased to replace and exceed them;
- Parcel delivery companies like FedEx have had to adjust their logistics chains to accommodate this shift in demand.
- Less-than-truckload (LTL) carriers, which move larger shipments such as appliances and furniture, have observed increased demand for their services to residential consumers since the onset of the pandemic.
- One LTL carrier notes, anecdotally, that traffic congestion in the Portland region has largely returned to pre-pandemic levels and that there are many challenges delivering goods to Downtown Portland and other mixed-use urban areas.
- The growth of e-commerce since the onset of the pandemic has contributed to demand for large-footprint distribution centers, and some have been (or are being) built. However, the opportunities to build such facilities in the region are limited due to land availability and persistent demand for space among Portland's legacy companies that manufacture and distribute goods in smaller spaces.

D.1 Introduction

Task 5 of the Regional Freight Delay and Commodities Movement Study consists of three sub-tasks that collectively aim to inform policy decision-making with insights into e-commerce and delivery trends and impacts, including the effects the COVID-19 pandemic has had on the volume of e-commerce deliveries and the impacts of those deliveries in the Portland region. Although data on the number of e-commerce deliveries performed in the region are beyond the scope and budget of the study, and methodologies to estimate net transportation system performance effects are nascent, review and analysis of regional, statewide, and national data points, combined with interviews with key freight stakeholders, provide valuable insights on this topic.

As Figure D.1 shows, Task 5.1, submitted previously, reviewed national data on e-commerce sales, statewide data on consumer spending, and metropolitan regional data on employment and wages and industrial real estate development to qualitatively describe the "state" of e-commerce activity in the Portland Region. Task 5.2 described examples of logistics solutions implementable by public- and private-sector stakeholders to address the impacts of last-mile deliveries on the cost of moving goods and the effects that deliveries have on street parking and transportation system operations. Task 5.3 adds to the previously completed work insights from freight stakeholders in the Portland Region that help to fill gaps in the available data and describe how the COVID-19 pandemic impacted e-commerce and other last-mile deliveries in this region.

Figure D.1 Elements of Task 5 in the Freight Delay and Commodities Movement Study



The organization of this appendix is as follows:

- **Section D.2** re-caps the market effects of COVID-19 on consumer spending behaviors and where deliveries take place.
- **Section D.3** describes the effects of COVID-19 on last-mile deliveries in the Portland Region.

D.2 Market Effects of COVID-19

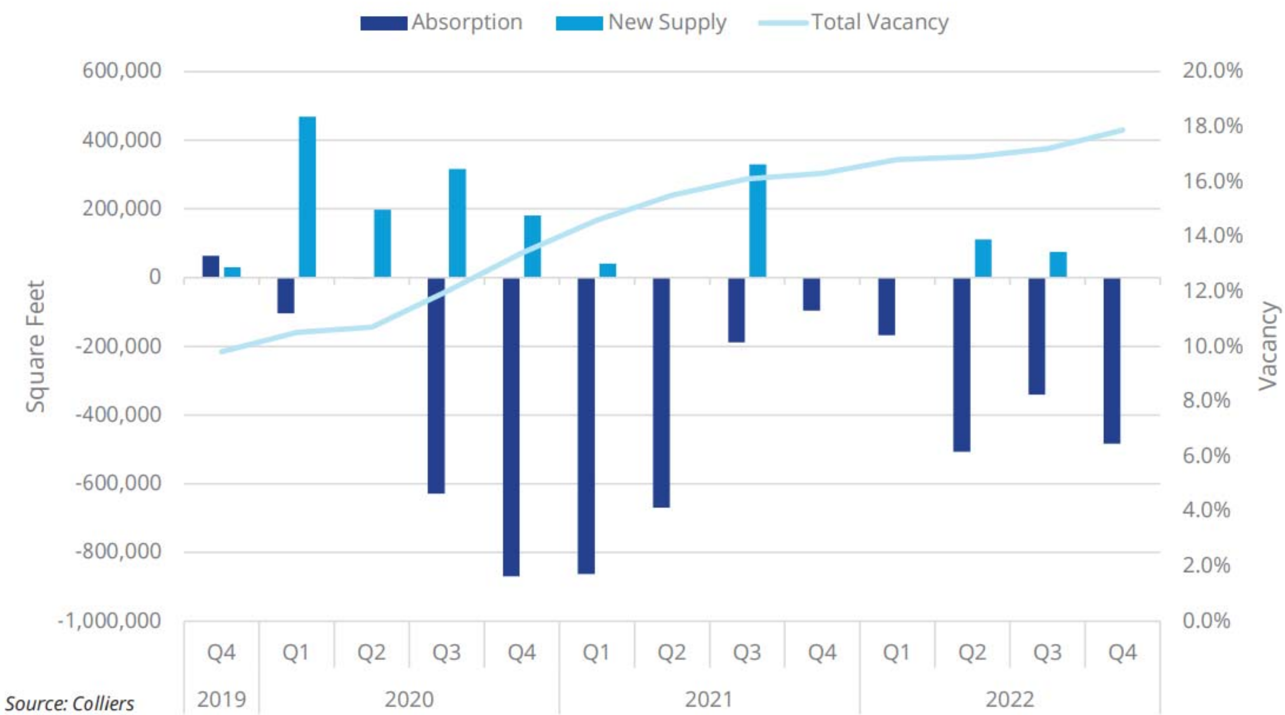
As described in Appendix B, personal consumption expenditures increased substantially during the COVID-19 pandemic, particularly between late 2020 and mid-2021. In Oregon, personal consumption expenditures increased by 13.3% between 2019 and 2021, which is slightly greater than the increase nationally (12.7%) during the same period.

During the “physical distancing” phase of the pandemic, from March 2020 into 2021, many Americans needed to buy office furniture and other supplies to allow them to work comfortably from home. Many Americans replaced gym memberships by purchasing exercise equipment to allow them to work out from home. With the time and cost of commuting suspended, some embarked on home improvement projects. And with many brick-and-mortar stores closed, operating on limited schedules, and with many consumers choosing not to go shop in-person, many of these purchases were made online. Nationally, e-commerce sales increased more than 37% between the first quarter of 2020 and the third quarter of 2021. While data on e-commerce purchases and deliveries made within the Portland region specifically were unobtainable for this study, the growth in consumer spending at the state level, increases in distribution center development, and employment in warehousing, couriers and delivery sectors of the economy within the Portland region, appear to suggest that e-commerce deliveries to households in the Portland region increased as well.

D.2.1 Office Market Trend

In the Portland region, the office vacancy rate reached 18% in the fourth quarter of 2022, as shown in Figure D.2. That is an increase from 16.3% in the fourth quarter of 2021 and 9.9% in the fourth quarter of 2019, on the eve of the pandemic. Vacancies are especially high in Portland’s Central Business District (CBD). In the fourth quarter of 2022, vacancy downtown was 25.5% compared to 18.1% in the same quarter of 2019. This vacancy trend suggests that a slow return to in-person office work is leading to companies downsizing their office footprints and/or seeking cheaper space outside the CBD. The implications for this trend with regard to e-commerce deliveries include continued reduction and/or a delayed return of office deliveries, including documents and office supplies, and a likely long-term continuation of “office workers” working from home and having office equipment and furnishings delivered to their homes. As the parcel and less-than-truckload case studies in the following section describe, this trend is having implications for how delivery companies manage their operations.

Figure D.2 Portland Region Office Real Estate Trend



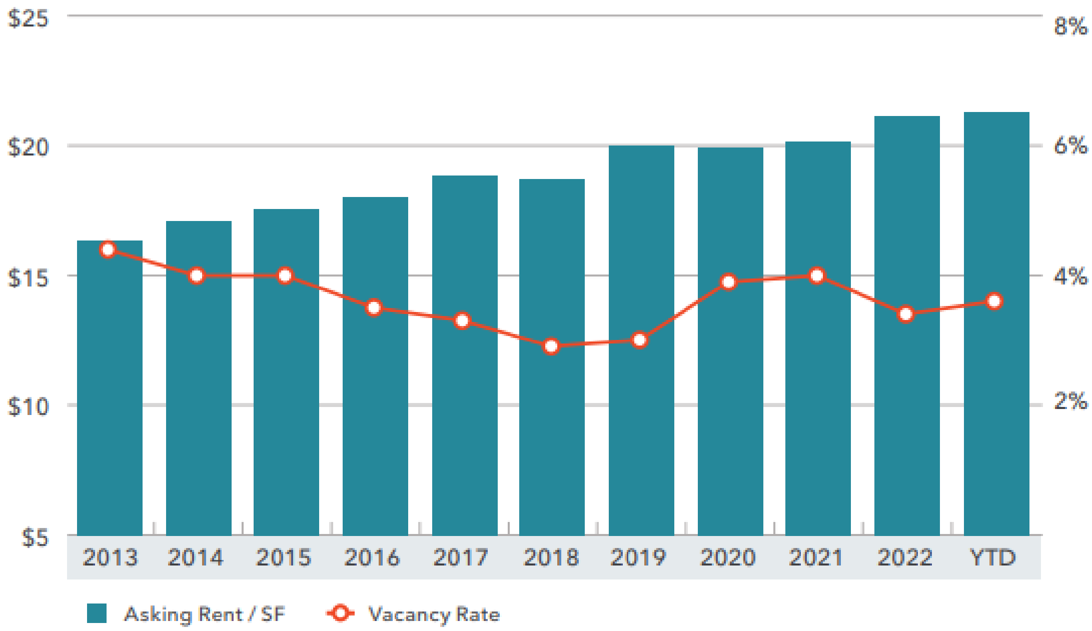
Source: “Portland Office Report, Q4 2022” Colliers International, 2023.

D.2.2 Retail Market Trend

The retail real estate market in Portland appears to be on a slow trend toward recovery from a 2020-2021 spike in vacancy, as Figure D.3 shows. Though vacancies crept upward between Quarter Four 2022 and Quarter One 2023 (from 3.4% to 3.6%) vacancies are below the 2021 peak of 4%. Retail vacancies in the Portland region are below the national average of 4.4%.[1] These observations suggest that brick-and-mortar retail in the region is resilient and that the pandemic-era boost in e-commerce sales has not led to an immediate demise of in-store retail.

[1] “Retail vacancy rates in the United States from 2019 to 2nd quarter 2022,” Statista, available from: https://www.statista.com/statistics/194102/us-retail-vacancy-rate-forecasts-from-2010/#:~:text=In%20the%20United%20States%2C%20vacancy,the%20second%20quarter%20of%202022 (accessed April 27, 2023).

Figure D.3 Average Asking Rent per Square Foot and Vacancy Rate, Portland Area Retail



Source: "Market Trends: Portland Retail, 1Q 2023," Kidder Mathews, 2023.

D.3 Effects of COVID-19 on Last-Mile Deliveries in the Portland Region

To fill the gaps in available data, the project team conducted interviews with a small number of stakeholders engaged in various aspects of e-commerce logistics, including a parcel carrier, large trucking company, and an industrial real estate broker all based in the Portland region. These interviews include observations regarding the change in demand for e-commerce deliveries, adaptations made to logistics networks, challenges associated with delivering shipments to customers, and industrial real estate market dynamics in the Portland region.

D.3.1 Parcel Delivery Example: FedEx

E-commerce orders are delivered as parcels, the vast majority of which are delivered by one of the top four parcel carriers—United States Postal Service, UPS, FedEx, and Amazon (listed in no particular order here). In the case of FedEx, “Priority 1” business customers have long been a top priority. These business customers may be sending documents or other time-sensitive shipments that need time-certain delivery to their destinations. Priority 1 business customers are a top priority to FedEx due to the consistent volume of business with those customers, and the customers’ willingness to pay a premium for reliable and expedited delivery.

The transport and delivery of e-commerce shipments has been a growing part of FedEx’s business for years. However, the COVID-19 pandemic fueled a rapid shift in FedEx’s customer and demand profile. Priority 1 business shipments declined, while residential deliveries of e-commerce orders increased substantially. This had implications for how FedEx moves shipments in its system. First, Priority 1 shipments primarily move by air from Portland to Memphis in the evening, which is FedEx’s national sorting center for air shipments. Many of those shipments come back to Portland by air the following day for delivery. FedEx has been shifting more of those local shipments directly into the local delivery system, bypassing the need to transport them to Memphis. E-commerce parcels, in contrast, are mostly moving in FedEx’s 2-day shipping service, which includes a larger number of moves via FedEx Ground services. While priority business customers may be shipping 10-20 parcels at a time, e-commerce customers may be shipping or receiving one or two.

This shift has placed greater emphasis on FedEx’s capacity to perform local pick-up and delivery activities and to move shipments through their ground transportation network. FedEx has invested in new vehicle routing applications, expanded weekend deliveries, and has blended pick-up routes and delivery routes so that all drivers are performing pick-ups and deliveries on their routes, increasing the efficiency of those activities.

D.3.2 Less-than-truckload Example: Old Dominion

Old Dominion Freight Line is a less-than-truckload (LTL) motor carrier with a national service footprint and a service center (or terminal) located in North Portland. LTL shipments are larger than those moved by parcel carriers but smaller than shipments by the truckload fleets that dominate the trucking industry: parcel shipments average about 5 pounds, LTL shipments about 1,300 pounds, and truckloads well over 10,000 pounds. Trucking is most efficient when trucks are full; maintaining full loads with small shipments requires consolidation through terminal networks. LTL “city” drivers fill their trucks by serving many local customers shipping to many places. They return to terminals, where shipments headed to the same destinations are consolidated into full loads. These loads are taken by linehaul or “road” drivers to terminals in the destination cities, where they are deconsolidated for delivery to customers in the local area. There are several LTL carriers that have operations in the Portland region, including UPS Freight, FedEx Freight, and Old Dominion, among others.

Even prior to the onset of the pandemic, E-commerce had created a new direct-to-consumer retail channel that is driven by small orders and shipments with accelerating delivery requirements that are difficult for full truckload services to consolidate. Store-based retailers have thus fragmented portions of their supply chain to LTL carriers, and manufacturers are using LTL carriers to move small product shipments to fulfillment centers and direct-to-consumers who order online. Shipments containing home furnishings, appliances, and other large, heavy, or bulky items are largely moved and delivered by LTL carriers like Old Dominion.

The COVID-19 pandemic accelerated the growth in LTL shipments of goods responding to e-commerce orders. This acceleration required Old Dominion to make more delivery tours to residential areas. Overall, traffic volume in 2020 and 2021 was below pre-pandemic levels, which made delivery tours more efficient and from the customers’ perspective, the reliability of on-time performance was improved. Table D.1 shows observed changes in traffic volume by corridor from 2019-2021, showing a decline in daily traffic volume by 13% on the corridors evaluated, including a 23% decrease during the AM peak period and a 12% decrease during the PM peak period.

Table D.1 Percent Change in Arterial Volumes by Time Period on Select Arterials

Segment	Weekday All day 2019 to 2021 Change	Weekday 2019 to 2021 Change			Weekend 2019 to 2021 Change		
		AM Period	Midday Period	PM Period	AM Period	Midday Period	PM Period
NE Martin Luther King Blvd. @ NE Ainsworth St.	-14%	-17%	-7%	-16%	1%	-4%	-7%
N. Interstate @ N Ainsworth St.	-14%	-28%	-18%	14%	-30%	-13%	-20%
SW Barbur Blvd. @ SW Capitol Hwy.	-23%	-36%	-9%	-27%	22%	4%	14%
NE Halsey Blvd. @ NE 148th Ave.	-16%	-30%	-11%	-12%	-21%	-7%	2%
NE Sandy Blvd. @ NE 148th Ave.	-14%	-26%	-6%	-17%	-14%	4%	-9%
SE Stark St. @ NE 148th Ave.	-14%	-23%	-16%	-12%	27%	0%	8%
NW Marine Dr. @ NW Frontage Rd.	-6%	-16%	-2%	-9%	22%	12%	16%
NE 82nd Ave. @ NE Halsey St.	-17%	-25%	-12%	-18%	-17%	-6%	-6%
SE 82nd Avenue @ SE Foster Rd	-13%	-25%	-13%	-3%	-18%	-5%	-6%
SE 122nd Avenue @ SE Foster Rd	-9%	-21%	-8%	-5%	-30%	-19%	-1%
99W @ SW 124th Ave.	-12%	-26%	-4%	-12%	-8%	-1%	3%
NW Cornell Rd. @ 185th Ave.	-18%	-34%	-11%	-13%	1%	-5%	-3%
SW TV Hwy. @ SW 185th Ave.	-10%	-8%	-9%	-10%	-11%	6%	-4%
SW Farmington Rd. @ SW 185th Ave.	-13%	-22%	-6%	-9%	-21%	-7%	2%
SW TV Hwy. @ SE Brookwood Ave.	-14%	-22%	-12%	-16%	-11%	-3%	-1%
N Columbia Blvd. @ N Portland Rd.	-16%	-32%	-6%	-20%	-19%	-15%	-3%
SE Powell Blvd. @ E end of Ross Island Br.	-18%	-28%	-13%	-19%	1%	-4%	-1%

Segment	Weekday All day 2019 to 2021 Change	Weekday 2019 to 2021 Change			Weekend 2019 to 2021 Change		
		AM Period	Midday Period	PM Period	AM Period	Midday Period	PM Period
W Powell Blvd. @ NE Hogan Dr.	-9%	-14%	-4%	-5%	-6%	-11%	-2%
OR 212 @ SE 98th	-9%	-12%	-14%	-10%	-4%	-3%	3%
OR 212 @ SE 172nd	-6%	-11%	9%	-13%	-18%	-7%	-2%
Average	**-13%**	**-23%**	**-9%**	**-12%**	**-8%**	**-4%**	**-1%**

Source: Rose, Eliot, “Emerging Transportation Trends tasks 3-5: technical memo,” June 7, 2022.

Anecdotally, a representative from Old Dominion has observed that traffic congestion had decreased substantially during this period. However, the representative believes that congestion has since increased, and has returned to, or perhaps is in excess of pre-pandemic levels. In addition, the times of day congestion that this stakeholder has observed suggests that the peak periods may be shifting, and that occurrences of midday and weekend congestion are increasing.

LTL carriers like Old Dominion have expressed concerns that expansions of dedicated bicycle lanes, parklets, and other curbside programming are having impacts on their ability to access the curb and perform deliveries in Downtown Portland and other urban, mixed-use districts. This concern suggests that a more comprehensive curb utilization and commercial loading zone program, such as the examples cited in Appendix C, may be worthy of further exploration in this region.

D.3.3 Industrial Real Estate Example: Windermere Real Estate

Appendix B presented data showing that the industrial real estate market in the Portland region is experiencing low vacancies and record-high rents. This tightness in the market has incentivized the development of more industrial buildings throughout the region. While not all of the industrial real estate square footage is dedicated to facilitating the fulfillment and distribution of e-commerce shipments, retailers’ desire to position product close to large consumer markets is contributing to the increased demand for space in the region.

A discussion with Tom Dechenne of Windermere Real Estate shed further light on trends that are driving growth in demand for industrial space in the Portland region. While e-commerce fulfillment and retail distribution centers are receiving a lot of attention due in part to the large footprint each of those facilities has, the Portland region’s industrial real estate market by and large is driven by demand for smaller-scale warehousing, distribution, and manufacturing space. Those facilities are the “legacy” market in the Portland region, and demand for those spaces remains.

Until recently, the average industrial tenant was using 13,000-15,000 square feet of space for distribution. This space is in addition to any space that may be used for office or manufacturing purposes. In the past 5-10 years, several larger distribution centers in excess of 200,000 square feet used for distribution by a single tenant have been developed in the region. In addition, some buildings are being built in the 50,000-100,000 square foot range to accommodate multiple tenants. These smaller-footprint users are described as “the bread and butter” of the Portland region’s industrial real estate market.

Several larger distribution centers have been developed and others are under construction now. South of the Portland area, Amazon’s Project Basie will contain more than 3 million square feet of space. The availability of large parcels such as Broadmoor Golf Course and Hayden Meadows have provided opportunities to build larger-footprint buildings as well. However, these opportunities are otherwise scarce due to limited availability of large and suitable parcels, high land acquisition and development costs, and despite rising rents, the return on investment may not be realized. For these reasons, the interviewed stakeholder believes that multi-story distribution centers, like one developed by ProLogis in Seattle, or assemblage of several industrial parcels for the purpose of redevelopment into larger, modern distribution facilities, appear unlikely in the near term, as lease rates in the Portland area are not yet at a level that would yield a sufficient return.

As e-commerce shopping continues to grow, occasional opportunities to build large distribution facilities may materialize, but manufacturing and smaller-scale distribution are likely to remain the “bread and butter” of the industrial real estate market in the Portland region for the foreseeable future.

D.4 Conclusions and Opportunities for Further Research

The research and analysis performed under Task 5 of the scope of the Regional Freight Delay and Commodities Movement Study revealed that the data and tools traditionally available to transportation planners do not provide much insight into the net effects of e-commerce and the COVID-19 on travel demand, traffic volumes (e.g., link-level volumes on the region’s highway network), and associated environmental, economic, and community impacts. E-commerce has changed how many people in the Portland region shop, and the COVID-19 pandemic changed when and where people in the region work, shop in stores, and recreate. Data points on consumer spending, national e-commerce sales, and economic data sources suggest that e-commerce deliveries are increasing in number but quantifying that increase and determining its effects remains a challenge.

Future studies could tap consumer market research databases to better estimate the volume of parcels and other shipments that consumers purchase online. More research and consensus must be developed in order to determine the effects that e-commerce and the changes in where and when people work and shop since the onset of COVID-19 have had on the number of trips households make to retail stores and other business establishments, and whether the effects of delivery tours performed by parcel delivery companies and less-than-truckload trucking companies are offset by a reduction in automobile trips to stores.

Regional Freight Delay and Commodities Movement Study

Appendix E: Regional Freight Policy Questions and Findings

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Key Findings and Considerations

Task 6.1 of the Regional Freight Delay and Commodities Movement Study presents findings and conclusions developed during the course of the study that respond to the Regional Freight Policy Questions that were developed in Task 3, in coordination with Metro staff, the Project Management Team (PMT) and Stakeholder Advisory Committee (SAC). This task includes a presentation of key findings related to the Regional Freight Policy Questions and a description of the economic context for the regional freight policy questions.

Key findings related to the regional freight policy questions are shown in Figure E.1. A more detailed discussion of these questions and findings is provided in Section 2 of this memorandum.

Figure E.1 Regional Freight Policy Questions and Key Relevant Findings

Regional Freight Policy Questions:	Key Relevant Findings:
What are emerging trends in the freight sector that have certain types of impacts on the transportation system?	• Supply chain uncertainty and risk mitigation • Continued technological advancement • Continued growth in e-commerce demand
When and how should the public sector play a role in addressing the growth impacts that e-commerce and goods delivery is having?	• When e-commerce impacts public infrastructure or policy. Potential actions include: • Transportation system and curb management strategies • Land use policies to manage and guide development • Improve data and understanding of trends and impacts
Are there new ways to address goods movement performance and what is relevant to know about freight and goods movement?	• Key measures related to performance include: • Travel time and reliability • Safety (truck-involved and at-grade crossing crashes and severity) • Risk and resilience (natural disaster risk, flood data, wildfire risk) • Equity (impacts and opportunities, best practices re: data and methods being developed)
What are ways in which the freight sector can reduce greenhouse gas emissions?	• Alternative fuels and electrification • Mode shift and alternative last-mile delivery solutions • More efficient routing and delivery

Having reviewed the preliminary findings of the Regional Freight Delay and Commodities Movement Study in consultation with Metro, two key issues regarding the regional economic context of regional freight policymaking in response to, and in anticipation of, freight trends and impacts have been revealed:

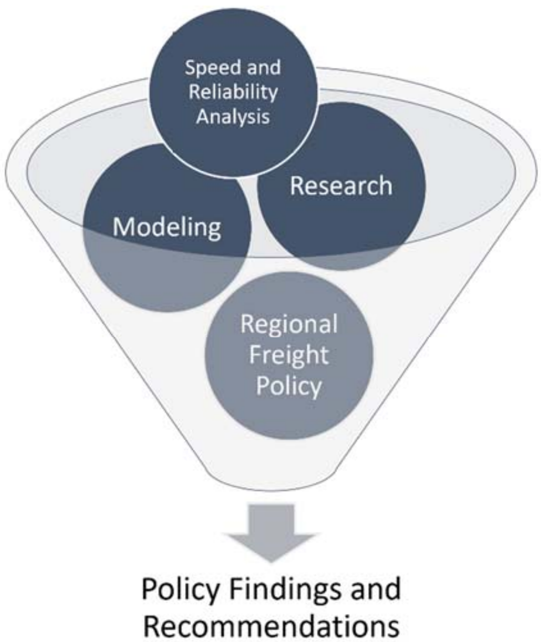
1. The region's manufacturing and distribution sectors, combined with an expected continued growth in consumer e-commerce demand, are likely to continue placing pressure on the Portland region's industrial real estate market. There are several opportunities and strategies that could help to address these needs.

2. The effects of the COVID-19 pandemic on commercial and office real estate, especially in Portland's Central City, are lasting, and there are opportunities to adapt the Central City to a future that is less reliant upon office occupancy and more focused on residential and mixed-use. There are important considerations for how such a transition would affect the movement of goods, and how deliveries may be accommodated.

E.1 Introduction

The Regional Freight Delay and Commodities Movement Study has included a significant effort to develop insight into current and recent trends regarding the volumes and types of goods moved in the region, and the effects of highway system performance, e-commerce deliveries, and the COVID-19 pandemic on goods movement and the impacts goods movement has on the region's economy and quality of life. As Figure E.2 shows, these insights were developed through and extensive analysis of speed and travel time reliability analysis on freight corridors, travel demand modeling of commodity flows on the region's highway network, research into e-commerce trends, impacts, and best practices to address such impacts, and a review of the Regional Freight Policy developed and refined in Metro's Regional Freight Strategy.[1]

Figure E.2 Information Contributing to the Policy Findings



Section E.2 of this memorandum describes key findings related to the four regional freight policy questions developed earlier in this study (Task 3).

Section E.3 of this memorandum describes two key issues regarding the regional economic context of regional freight policymaking in response to, and in anticipation of, freight trends and impacts.

Section 4 presents a brief list of conclusions and recommended next steps.

[1] "Regional Freight Strategy," Oregon Metro, September 19, 2019, available from: https://www.oregonmetro.gov/regional-freight-plan (accessed August 8, 2023).

E.2 Regional Freight Policy Questions

In an effort to maintain a connection between the Regional Freight Delay and Commodities Movement Study's scope of work and the regional freight policies detailed in the Regional Freight Strategy, the study team, in coordination with the Project Management Team and Stakeholder Advisory Committee, developed a list of key Regional Freight Policy Questions that the study's analysis and research should help to answer. The four Regional Freight Policy Questions include:

1. What are emerging trends in the freight sector that have certain types of impacts on the transportation system?
2. When and how should the public sector play a role in addressing the growth impacts that e-commerce and goods delivery are having?
3. Are there new ways to address goods movement performance and what is relevant to know about freight and goods movement?
4. What are ways in which the freight sector can reduce greenhouse gas emissions?

The remainder of Section 2 describes key findings that respond to each of the four Regional Freight Policy Questions.

E.2.1 Question 1: What are emerging trends in the freight sector that have certain types of impacts on the transportation system?

This study has considered several key emerging trends in the freight sector that have real or potential impacts on the transportation system in the Portland Region. Most of these trends also have implications for the region's economy. These trends and implications are listed in Table E.1.

Table E.1 Emerging Freight Trends and Impacts

Trend	Description	Global "Big Picture" Impact(s)	Regional Impact(s)
Uncertainty and Emphasis on Risk Mitigation	» Disruptions such as COVID-19 had far-reaching supply chain impacts. » Many companies would like to mitigate risk	» Some companies are seeking to diversify production locations » Some companies are "re-shoring" production and materials sourcing to reduce risks	» Economic: Potential opportunities for new manufacturing jobs » Transportation: Origins and destinations (and hence modes and routes) of freight flows may change

Technological advancement	» Technological advancement in goods movement and supply chain management aims to improve efficiencies and reduce costs. Such advancements include:
	  » Artificial intelligence to manage inventories and routing
	  » Automation of warehousing, terminal operations, and eventually vehicles
	  » 3D printing or "distributed manufacturing" can re-shore some production and/or support a small-scale "cottage" manufacturing industry
		» The technological advancements listed to the left could reduce transportation costs and facilitate more diverse and resilient supply chains	» Economic: Potential opportunities to facilitate cost reductions in the Portland region relative to others (economic competitiveness)
			» Transportation: Improved efficiency, reduced truck delay

Growth in e-commerce demand	» E-commerce sales in the U.S. increased significantly during the COVID-19 pandemic. Although many stores re-opened after the height of the pandemic, many Americans prefer to shop for certain goods online. E-commerce is expected to represent a larger share of U.S. retail sales in the future.	» Transition from "just in time" to "time definite" delivery; » Increase in foreign imports to the U.S. » Development of networks of fulfillment and delivery centers to position product, fulfill orders, and facilitate quick delivery in metro areas	» Economic: Increased jobs in warehousing and courier/messenger sectors, loss in retail sector » Economic: Increased pressure on an already-tight industrial real estate market in the region » Transportation: Net effects of e-commerce (added delivery trips and avoided consumer trips to the store) are not well understood » Transportation: Challenges completing deliveries in many Portland neighborhoods and other urban/mixed-use centers

E.2.2 Question 2: When and how should the public sector play a role in addressing the growth impacts that e-commerce and goods delivery are having?

As presented in Appendix B, growth in consumer demand for goods purchased via e-commerce has had several impacts nationally and within the Portland Region. E-commerce growth is likely contributing to growth in employment in economic sectors such as warehousing and storage and couriers and messengers. It is also likely driving growth in demand for industrial real estate in the region.

E-commerce, and the delivery trips it generates, are increasing the logistics costs for retailers and freight carriers; and generating more demand for curbside loading and unloading zones. These curbside impacts are of especially great interest at a time when expansions of bicycle and pedestrian infrastructure, outdoor sidewalk and parking-space dining, and other uses are also vying for space at or near curbs.

Appendix C presented a summary of strategies that are being implemented or tested by actors in both the private and public sectors to address the impacts e-commerce is having on their respective priorities.

Relevant to this policy question, the public sector should play a role in addressing the growth impacts that e-commerce and goods delivery are having:

- **When?** When those impacts are affecting transportation infrastructure performance and/or public policy goals; and

- **How?** Through strategies to manage curb access and utilization, land use policies that accommodate deliveries and facilitate or direct fulfillment center development to preferred locations, and policies that support workforce and economic development.

On the **"when"** side of this question, there remains much research and analysis to be done in order to determine the net effects e-commerce and deliveries have on the performance of the Portland region's transportation system. For example, how many e-commerce orders that are delivered to a given household actually replace a trip to a retail store, and how frequently households receive e-commerce deliveries versus taking a trip to a store are the subjects of ongoing research by a number of organizations across the country. However, the analysis presented in Appendix B points to other data and trends that suggest that e-commerce sales are continuing to increase, and a logical conclusion is that the number of delivery trips required to deliver a rising number of shipments is also increasing. Industry interviews, summarized in the Task 5.3 Technical Memorandum, suggest that access to the curb, particularly in urban and mixed-use districts throughout the region, has become more difficult in recent years.

On the **"how"** side of the question, Appendix C described several best practices that have been tested and/or applied in order to address some of the key issues and impacts associated with growth in e-commerce and last-mile deliveries.

Table E.2 lists some of these key issues and impacts, some strategies demonstrating "how" they can be addressed, and notes regarding "when" certain actions can be programmed.

Table E.2 How and When to Address E-Commerce Issues and Impacts

Issue/Impact	How to Address the Issue	When Should Actions be Taken?
Curb access, double-parking, etc.	Context-sensitive curb management and parking strategies, including right-sizing loading zones, flexible curb zones, and reservation systems (see Task 5.2 technical memorandum)	If and when evidence of insufficient curb access is present or likely to occur. Review of best practices is an immediate/ongoing action; Piloting and/or implementing strategies is a potential near-term (within 5 years) action.
Land use: Warehouse and fulfillment center development	Conduct an inventory of land use appropriate for warehouse and fulfillment center development and assess capacity versus need. Monitor development and redevelopment trends in industrial districts. Might changes to land use policies be needed to promote or discourage certain development types?	Conducting an inventory of land use is an immediate action that can be taken. Monitoring development and redevelopment trends can begin immediately and continue indefinitely.
Land use: "Dark store" conversions	Review land use regulations to determine if dark store conversions are feasible. Conduct outreach to determine if and where such conversions may be desirable or undesirable. Adjust land use regulations as necessary.	Review, analysis, and outreach can be an immediate action, with any necessary regulation adjustments to follow.
Augment the public's understanding of e-commerce trends and impacts	Purchase available data, perform analysis and integrate with existing modeling tools in order to estimate the transportation system effects of e-commerce and last-mile deliveries Incorporate findings into planning documents and public/stakeholder engagement activities	Acquiring data and developing more advanced analysis tools could begin in the near term. Within 0-5 years, more research on net effects of e-commerce on transportation performance and emissions should be available.

E.2.3 Question 3: Are there new ways to address goods movement performance and what is relevant to know about freight and goods movement?

There are several key measures of freight and goods movement performance that stakeholders in the public and private sectors tend to agree are important, and where data to measure them either exist or are in various stages of being developed. Four key measures considered in this section include:

- Travel time and travel time reliability;
- Safety, defined as the number and severity of truck-involved or at-grade rail crossing crashes;
- Risk due to disasters or other disruptions; and
- Equity, admittedly more emphasized in public sector conversations and planning at this time.

E.2.3.1 Travel time and travel time reliability

Among the key performance indicators for freight and goods movement are measures of the delay and the cost of that delay to the users of the freight system. The travel time between any given origin and destination (aka “speed”) is an indicator of predictable delay. Travel time reliability indicates unpredictable delay. Both types of delay incur costs to the users of the freight system (i.e., truck drivers and/or trucking companies). Highway segments or interchanges where delay is concentrated are often referred to as bottlenecks, which are major generators of elevated costs to freight system users. These congestion costs contribute to the overall cost of transporting goods and can impact the prices consumers pay for certain products, and the economic competitiveness of a region or state relative to other areas where transportation costs may be lower.

While predictable and unpredictable delay contribute to higher costs, they do so for different reasons. Predictable, or recurring, delay occurs all or most days. When rush hour traffic occurs every weekday between certain times of the day, commuters and truck drivers alike plan their trips to account for that predictable delay. The cost—including driver wages, fuel use, and other expenses—is anticipated. Unpredictable, or non-recurring, delay may happen less frequently. It could occur due to a crash, poor weather, or another event that impacts traffic intermittently. This unpredictable delay incurs a cost, but not on every trip. Truck drivers and trucking companies must consider the probability of such a delay and plan a “buffer” of time and cost to account for the possibility that such a delay occurs. Therefore, the trucking companies’ customers may have to pay a price that is based upon a significant delay, even if that delay does not happen on each trip.

Measuring travel time and travel time reliability was performed as part of the Task 4 efforts in this study using the National Performance Measures Research Data Set (NPMRDS), which estimates vehicle speeds using probe data on 19 of the 23 Regional Mobility Corridors in the Portland region. Further analysis could be done to estimate the costs associated with current and potential future delays, using hourly truck operating cost factors applied to the estimated hours of delay or unreliability, following methodologies detailed in national research[2] and other best practices. That information could inform policies aimed at addressing congestion, help economic development or workforce policymakers weigh the region's economic competitiveness in certain industry sectors.

E.2.3.2 Safety

Nationally, there were over 5,700 fatalities in crashes involving large trucks in 2021. That was an 18% increase from 2020 and a 49% increase since 2012. The increased number of crashes may be attributable to a combination of causes, including, but not limited to, increased traffic volumes and increased congestion in urban areas (note that urban areas accounted for about 55% of large truck-involved crashes in 2021).

Analysis of safety related to goods movement should also consider crashes that occur at at-grade highway-rail crossings. Over the past decade, freight trains have become longer, resulting in longer durations of closure at many crossings. In addition, the volume of automobile and other road traffic has also increased over the past decade. This means that the delays and congestion resulting from trains passing through crossings is increasing in many areas. This may be resulting in more dangerous behavior on the part of drivers trying to "beat" the crossing gates, and/or instances of pedestrians attempting to climb over or through stalled trains.

The increasing number and severity of crashes and grade crossing-related delays are troubling trends, and helpful performance measures to track the safety of the freight transportation system would be useful for assessing the effectiveness of physical improvements, Vision Zero policies and strategies as they relate to goods movement, and other projects and policies that address safety. Key performance measures could include:

- Number and severity of large truck-involved crashes by corridor, corridor segment, or area, using crash data from ODOT's Crash Analysis Reporting Unit, and/or the WSDOT Crash Data Portal.[3]
  - Further analysis could focus on crashes involving large trucks and cyclists or pedestrians to identify areas where active transportation users are more exposed to the risk of collisions with trucks. This could inform bicycle and pedestrian infrastructure design, truck routing and site access considerations, etc.
- Number and severity of at-grade crossing crashes by corridor and crossing using data available from the Federal Railroad Administration (FRA) Office of Safety Analysis.[4] Note, the FRA grade crossing data will transition to a new website and will offer new data analysis tools effective early 2024.

E.2.3.3 Risk and Resiliency

Because many supply chains have national or global reach, disruptions anywhere along the chain, from localized congestion on one of the Regional Freight Mobility Corridors to a blocked global trade route like the

[2] NCHRP Report 925: Estimating the Value of Truck Travel Time Reliability, Transportation Research Board, 2019, available from: https://www.trb.org/NCHRP/Blurbs/180007.aspx (accessed August 3, 2023).

[3] Oregon Department of Transportation Crash Analysis Reporting Unit, available from: https://www.oregon.gov/odot/data/pages/crash.aspx (accessed August 2, 2023); Washington State Department of Transportation Crash Data Portal, available from: https://remoteapps.wsdot.wa.gov/highwaysafety/collision/data/portal/public/ (accessed August 2, 2023).

[4] https://safetydata.fra.dot.gov/OfficeofSafety/default.aspx (note, this site will no longer be active after May 1, 2024).

Suez Canal, can have impacts upon where, how, and at what cost goods move. The ability of industry to plan for and mitigate the impacts of these disruptions is critical for supply chain resiliency and ultimately for the on-time, efficient delivery of raw materials and finished products. When these disruptions cannot successfully be mitigated, businesses and consumers are faced with materials shortage and production shutdowns. Effects of the COVID-19 pandemic on overseas production and international trade gateways were described in the Task 3.2 technical memorandum, as an example of a recent disruption with effects that rippled throughout the entire economy and supply chain.

Supply chain disruptions can be categorized in many ways and include:

- **Physical:** natural and manmade impediments to use of transportation infrastructure. Floods, wildfires, and increasingly, extreme heat, can have significant impacts on roads, highways, bridges, and rail lines in the Portland region and surrounding areas.
- **Economic:** changes in the state, national or global economy impacting freight flows in the Portland region.
- **Institutional:** changes in policy that facilitate or hinder efficient freight movement.

Resiliency refers to the ability of a system to absorb or withstand an event, operate or maintain continuously, and recover or adapt following a disruption. In the context of the Portland region, a resilient system involves infrastructure design and maintenance; connectivity within and between modal networks to provide alternatives; and institutional capacity for communication and coordination across jurisdictions or between public and private sectors.

Measures of risk and resiliency may include:

- Measuring resiliency against physical disruptions, including natural disasters. Data sources include:
  - Federal Emergency Management Agency (FEMA) National Risk Index, which measures the risk of certain types of natural disasters at the county level, using historical information. This can provide a high-level assessment of risk at a level of geography (county level) that is fairly coarse for a metropolitan region;[5]
  - FEMA National Flood Hazard Layer (NFHL) shows localized areas of flood risk and can be used for link-level analysis of corridors and networks.[6] This database could be used to track mileage of Regional Freight Mobility Corridors that exist within areas of high risk, and/or track projects that harden or otherwise mitigate the risk of flooding in high-risk areas.
  - Oregon Wildfire Risk Explorer, developed by the Oregon Department of Forestry, Oregon State University, and U.S. Forest Service, maps the risk of wildfires throughout the State of Oregon.[7] This tool uses data from the 2018 Quantitative Wildfire Risk Assessment, and it appears (as of August 2023) that an update may be forthcoming. This tool may be used to assess risk of wildfires along freight corridors in the region, and to track projects that harden or otherwise

5 https://hazards.fema.gov/nri/

6 https://www.fema.gov/flood-maps/national-flood-hazard-layer

7 https://tools.oregonexplorer.info/OE_HtmlViewer/index.html?viewer=wildfire

mitigate the risk of wildfire disruptions and damage to the infrastructure. The Washington State Department of Natural Resources has mapping tools and other information focused more upon active fires and burn risk due to current and recent fire events than assessing risk based upon historical information.[8]

- Measuring resiliency against economic and/or institutional disruptions is a task that could be best supported by scenario analysis and/or developing a freight scenario planning tool. Such tools allow a user to select alternative economic forecasts and/or apply one or more "what-if" scenarios that are tailored to key economic or institutional priorities or risks in a region. The tool then generates alternative freight forecasts and trip tables that could be processed using the regional travel demand model to illustrate the effects of each scenario on the volume of trucks and performance on the regional network. The North Jersey Transportation Planning Authority (NJTPA) and several state DOTs have developed these tools in recent years.[9]

E.2.3.4 Equity

Transportation equity seeks fairness in mobility and accessibility to meet the needs of all community members.[10] A core tenet of transportation equity is ensuring that the benefits and burdens of the transportation system are equitably distributed. Advancing transportation equity within a freight context is challenging. The benefits of freight are diffuse as they are broadly distributed across geography and stakeholders. Meanwhile, the burdens of freight tend to be localized and disproportionately borne by communities adjacent to freight assets, such as highways, rail lines and terminals, marine terminals, and warehouses. Goods movement has historically contributed to—and continues to exacerbate—uneven distribution of benefits and burdens on disadvantaged communities. International trade requires large shipping vessels, airplanes, trucks, trains, and other vehicles, as well as large industrial and warehousing facilities. Both the vehicles and facilities create air, noise, and other pollutants, and increase health and safety concerns—burdens of which are partially or completely borne by local populations, often in lower-income and communities of color.

Measuring freight equity is challenging, and best practices are few and far between as of 2023. For example, the Bipartisan Infrastructure Law (BIL) required that state DOTs consider equity in their state freight plans, but the federal government has provided little technical guidance. In the 2021-2023 round of state freight plans, only 39% of the plans conducted a quantitative or qualitative analysis of freight equity. Most used proximity analyses to determine the proportion or concentration of equity focus areas (i.e., communities of concern) near the multimodal freight network. While useful, these approaches did not incorporate methods to estimate impacts to target communities, such as measuring or estimating freight-related congestion or emissions. Measuring these impacts is an important next step for state freight plans, but adoption of more robust methodological approaches will likely require more guidance at the federal level, a set of "first mover" states or MPOs to adopt robust equity analyses methodologies, or both.

Further, few states or MPOs have established performance measures to support freight equity goals and objectives. Without quantitative measures, states and MPOs will struggle to take a proactive approach to

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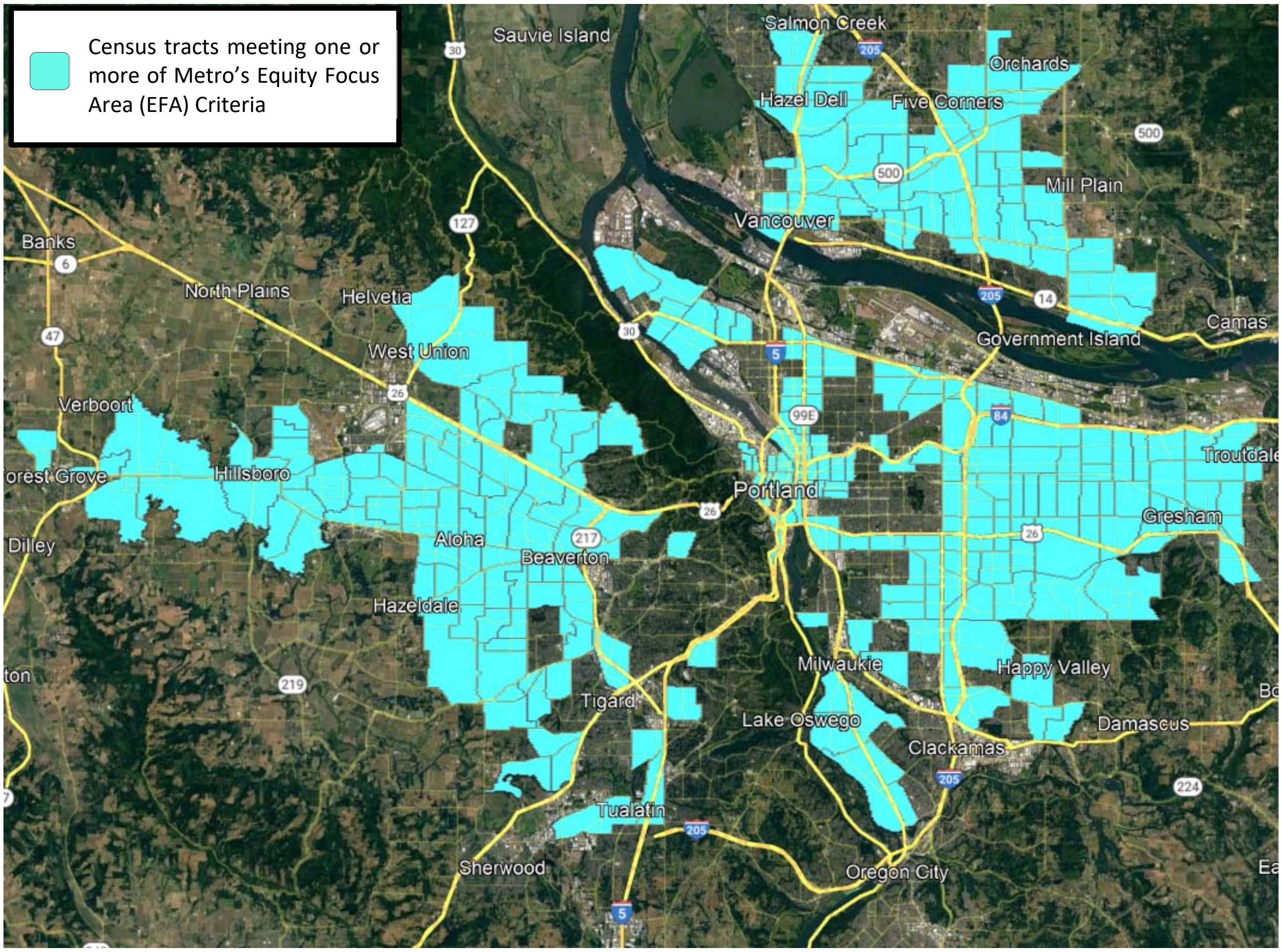
[8] https://www.dnr.wa.gov/Wildfires

[9] https://www.njtpa.org/2050FreightForecasts.aspx

[10] U.S. Department of Transportation Federal Highway Administration (FHWA), "Transportation Planning and Capacity Building, Transportation Equity," available from: https://www.planning.dot.gov/planning/topic_transportationequity.aspx (accessed July 15, 2023).

freight equity as they cannot fully assess the efficacy of interventions and detect trends in how their freight-related investments and decision-making impact equity concerns.

Figure E.3 Metro's Equity Focus Areas, 2020



Source: Cambridge Systematics, using geodata from Metro

E.2.4 Question 4: What are ways in which the freight sector can reduce greenhouse gas emissions?

Goods movement, by any mode, relies overwhelmingly upon fossil fuels, and burning those fuels releases greenhouse gases. In 2021, transportation contributed 29% of the greenhouse gas emissions in the United States. Medium- and heavy-duty trucks contributed 23% of transportation sector emissions, or about 7% of total emissions in the United States.[11] There are several strategies that are being advanced—or that could be advanced—to facilitate a transition to alternative, or "green" energy sources, alternative modes, and/or to reduce emissions through improved efficiency.

[11] "Fast Facts on Transportation Greenhouse Gas Emissions," U.S. Environmental Protection Agency, available from: https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions (accessed August 10, 2023).

E.2.4.1 Alternative Fuels and Electrification

Transitioning medium- and heavy-duty vehicle fleets from diesel to electric or other zero-emission vehicle (ZEV) technology would have a substantial impact upon the greenhouse gas emissions attributable to goods movement. Some vehicle manufacturers have developed, tested, and are manufacturing medium- and heavy-duty vehicles that are powered using electric batteries. Municipal vehicle fleets, such as school buses, waste collection trucks, etc., are among the fleets being targeted for transition at the moment. The fact that those fleets are mostly under public control (or public contract), and travel relatively short distances in a localized area mean that so long as the home garage is equipped with charging infrastructure, those vehicles can have their batteries replenished while they are not in use.

For heavy-duty trucks, many of which travel long distances, the challenges are a bit more complex.

- There is little electric fast-charging infrastructure available along highway corridors that trucks travel along, and most utilities do not have the capacity to provide the power needed to charge large volumes of heavy-duty vehicles. In order to transition heavy-duty fleets that travel long distances, fast-charging stations would have to be nearly as common as diesel fueling stations along major highway corridors.

- There are few manufacturers building electric trucks, the production lead times are long, and the costs are substantial. Further, state and federal incentives are insufficient, from the perspective of the industry, and do not offset the higher costs of acquiring, operating, and maintaining heavy-duty electric vehicles.[12]

- Related to cost, it is unlikely that smaller trucking companies and owner-operators could purchase electric vehicles as readily as large fleets could, thus introducing industry equity considerations.

- The weight of a battery cuts into the payload a truck can carry, even with the 2,000-pound allowance provided by the Fixing America's Surface Transportation (FAST) Act; and brings safety and roadway wear-and-tear impact considerations to the fore.

[12] https://www.oregon.gov/deq/aq/Documents/zevMHDIncentiveRep.pdf

Figure E.4 Electric Island, Heavy-Duty Electric Charging Station in Swan Island, Portland

Source: Daimler Trucks North America

These challenges are why heavy-duty freight vehicles are likely to transition to electric at a much slower rate than personal automobiles in the U.S. Some motor carriers suggest that hydrogen fuel cells may be a more practical solution from the industry's perspective.[13] However, there are challenges to overcome before hydrogen fuel cell trucks are produced in large-scale, and the development of fueling station capacity would be necessary to support long-distance trips.

Also important to note, while electrification would help to significantly reduce the greenhouse gas emissions attributable to goods movement, trucks produce particulate matter emissions from brake dust and tire wear that can have impacts on human health, particularly in communities adjacent to routes with high volumes of truck traffic.

E.2.4.2 Mode shift and alternative last-mile delivery solutions

One method for reducing greenhouse gas emissions associated with freight could be to shift more trips from trucks to more fuel-efficient modes, such as rail (for long distances) or cargo cycles (for last-mile deliveries in urban contexts). Although rail has a lower cost per ton-mile than trucking for many commodities, the first- and last-mile must be made by truck for most moves, and the cost of transloading product between road and rail equipment can be prohibitive for short trips. Longer trips, approximately 400 miles or more, are where the lower cost per-ton-mile overcomes those other costs, and where rail becomes price-competitive with trucking.[14] According to the Freight Analysis Framework from the U.S. DOT, approximately 22% of the freight moving in the Portland region is traveling distances of 500 miles or more.

[13] https://www.catf.us/2023/03/why-the-future-of-long-haul-heavy-trucking-probably-includes-a-lot-of-hydrogen/ ; https://www.nrel.gov/news/program/2022/fast-flow-future-heavy-duty-hydrogen-trucks.html

[14] This is a "rule of thumb," and the actual range at which rail and truck moves equalize in cost may differ significantly depending upon the commodity, rail and truck equipment needed to move that commodity, operational considerations between specific origins and destinations, contracts between shippers and carriers, and other factors. https://ops.fhwa.dot.gov/publications/fhwahop15034/ch2.htm

The major railroads (aka, Class I railroads) have been adopting strategies to reduce operating costs and improve their revenue-to-expense ratios over the past decade or more. Often referred to as "Precision Schedule Railroading," or "PSR," these strategies have led to reductions in staffing levels, reduced service on less-busy routes, lengthened dwell times in some yards, longer train lengths, and questions regarding safety and maintenance. Adoption of PSR strategies has coincided with a reduction in rail's mode share nationally. In 2011, rail moved 35% of freight tons in the U.S. By 2021, rail moved 27% of freight tons in the U.S.[15] While PSR may have satisfied the railroads' shareholders, the long-term viability of freight rail in the U.S., and rail's ability to offer a level of service competitive with trucking, will require some shifts in priorities toward offering attractive services to shippers.

For very short trips, such as last-mile deliveries in urban areas, alternative modes of transportation include cargo bicycles and delivery robots.

- **Cargo bicycles.** In recent years, companies using electric cargo bicycles to perform short-distance delivery trips have emerged in many major cities. B-line Sustainable Urban Delivery is one such company based in Portland. B-line has partnered with the Portland Bureau of Transportation (PBOT) to promote more sustainable urban freight and delivery practices in order to reduce carbon emissions. [16]

Figure E.5 B-Line Cargo Bicycle in Portland

Source: Portland Bureau of Transportation, image captured from a video titled "2040 Freight Featured Perspective: B-Line Sustainable Urban Delivery, 2022.

- **Delivery robots.** Using autonomous robots to deliver parcels and other small shipments has been piloted by several companies since Starship Technologies began deploying them in 2014. Since then, Starship Technologies has expanded them to more than 100 test locations, many of which are on college campuses. In 2019, Amazon piloted "Scout," a similar autonomous delivery robot, though the Scout program was largely rolled back in late 2022 due to operational issues and cost considerations.[17] The delivery robots represent an opportunity to deliver small shipments using a

[15] "Freight Rail: Information on Precision-Scheduled Railroading," Government Accountability Office (GAO), December 2022, available from: https://www.gao.gov/assets/gao-23-105420.pdf (accessed August 3, 2023).

[16] https://www.portland.gov/transportation/news/2022/1/26/bicycle-delivery-company-featured-first-video-series-showcase-unique

[17] https://www.freightwaves.com/news/amazon-scraps-scout-home-delivery-robot

small electric-powered vehicle. This saves fuel, reduces emissions, and can avoid parking/loading conflicts that trucks and vans encounter in urban and mixed-use districts.

Figure E.6 Starship Technologies Delivery Robots

Source: Starship Technologies

E.2.4.3 More efficient routing and delivery

As detailed in the Task 5.2 technical memorandum, many carriers, or companies that perform last-mile deliveries, are developing and applying technological solutions in order to improve efficiency and reduce costs. Using artificial intelligence (AI) for the purpose of managing drivers' tours and routes is an emerging trend in the logistics industry. Some companies are using or experimenting with AI that can better optimize delivery route options, and to respond to disruptions or other sources of delay in real time. These applications can help the carrier to reduce the time needed to complete a delivery tour and reduce labor and fuel costs. They can also help to reduce the emissions associated with last-mile delivery.

E.3 Regional Economic Context for the Regional Freight Policy Questions

Having reviewed the preliminary findings of the Regional Freight Delay and Commodities Movement Study in consultation with Metro, two key issues regarding the regional economic context of regional freight policymaking in response to, and in anticipation of, freight trends and impacts have been revealed:

1. The region's manufacturing and distribution sectors, combined with an expected continued growth in consumer e-commerce demand, are likely to continue placing pressure on the Portland region's industrial real estate market. There are several opportunities and strategies that could help to address these needs.

2. The effects of the COVID-19 pandemic on commercial and office real estate, especially in Portland's Central City, are lasting, and there are opportunities to adapt the Central City to a future that is less reliant upon office occupancy and more focused on residential and mixed-use. There are important considerations for how such a transition would affect the movement of goods, and how deliveries may be accommodated.

Table E.3 provides an overview of the key trends and the impacts and/or opportunities associated with each of these issues, and some potential actions that Metro and/or other agencies may consider addressing or anticipate the impacts and opportunities. These are discussed in greater detail throughout the remainder of Section 3 of this technical memorandum.

Table E.3 Overview of Economic Context Issues, Impacts, and Actions

Economic Context Issue	Key Trend(s)	Impacts/Opportunities	Potential Actions
Land Use Trends and Implications	Growth in e-commerce and legacy industry are contributing to continued growth in demand for industrial real estate	Costs are increasing Redeveloping older industrial parcels is possible, but the industry may need help in some instances Adaptive re-use may yield additional capacity Pressure may mount to expand UGB for industrial use	Assess industrial land needs based upon volume of goods/cargo instead of employment alone Review land use/development regulations to preserve industrial land for industrial use Consider remediation and access issues that may be limiting development potential on some sites Review land use/development regulations to consider "dark store" and other conversion/re-use opportunities
Post-COVID Central City with Less	Office vacancies remain high 3 years after the	Portland's Central City is especially impacted by high vacancies in the office market	The City of Portland is easing barriers to conversion of office space to residential use.

Emphasis on Office	onset of COVID. More companies may downsize or vacate office space as leases come up for renewal.	Conversion or redevelopment of some existing office buildings to residential may occur	PBOT may need to consider how a widespread changeover from office to residential impacts loading zone and other delivery-related needs. Widespread changeover may also have impacts on the types of retail and other services that locate in Central City. There could be freight/loading needs that need to be considered.

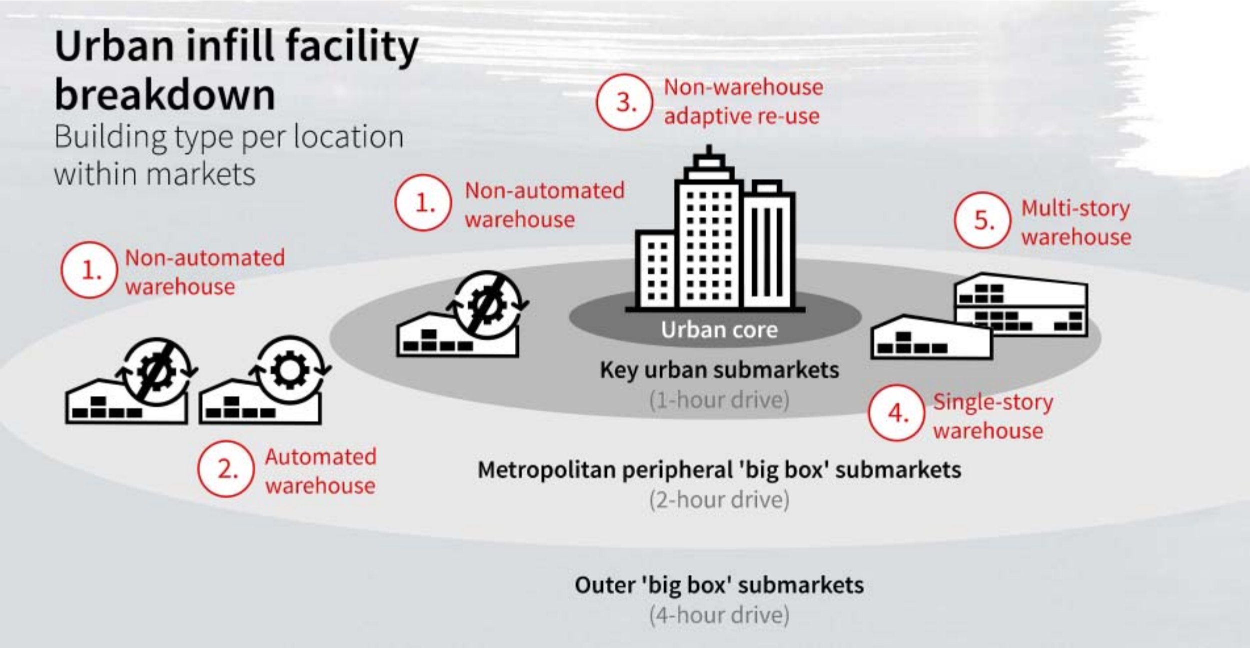
E.3.1 Land Use Trends and Implications

As described in detail in the Task 5.1 technical memo, the industrial real estate market in the Portland metropolitan region has been "hot" in recent years. Demand for new or expanded space among the region's legacy manufacturing and distribution companies is competing with growing demand for space to accommodate e-commerce order fulfillment and parcel distribution. This trend is resulting in low vacancy rates, higher rents, and more construction and/or redevelopment of industrial space throughout the region. Further, these trends are not unique to the Portland region, as demand for industrial space is being impacted by e-commerce demand and evolving supply chains across the country.

Meeting the demands for industrial space in the region is not a one-size-fits-all solution, and recent logistics trends suggest that there is considerable demand for space within and near the urban cores of metropolitan areas. In recent years, supply chains have been moving toward multi-stage networks, with goods kept at and directed from several points, and with facilities of different sizes and functions put in place along the chain. The proliferation of warehouse and distribution centers among manufacturers and retailers is manifesting as greater numbers of facilities both at the high end and at the low end of the size spectrum. Large and increasingly automated distribution centers (DCs) are situated at the outskirts of a region to serve multiple submarkets with big and diverse volumes of inventory held at the ready. The regional DCs feed smaller DCs and cross-docks situated closer to and inside the submarkets.

FigureE.7 from JLL illustrates this new system. Large-scale, automated regional DCs exist in the periphery of a metropolitan region, or in areas between two or more metropolitan areas within a few hours' drive of one another. As the system moves in toward the urban core, the blend of facilities widens, with combinations of traditional warehouses, repurposing of established structures, and the introduction of the new, multi-story facilities. This is a dynamic and evolving system, because the disruption of traditional retail patterns and the repercussions for manufacturers are still being played out and will be for years to come. Recently, Amazon, the biggest player in the e-commerce retail space, appears to be pulling back from investments in larger regional DC facilities, as their system may need time to absorb the increased inventory that has been developed over the past few years.

Figure E.7 Urban Warehousing Submarkets



Source: JLL

Within and surrounding the Portland metropolitan region, Amazon's recent developments have followed a similar model. The recently completed Project Basie is a five-story, 3.8 million square foot facility in Woodburn in Marion County.[18] This facility supplies warehouses, sorting facilities, and delivery centers within the Portland metropolitan area and beyond. Amazon has developed or moved into over two million square feet of space within the greater Portland Urban Growth Boundary (UGB) area including, but not limited to, a sorting center in Hillsboro (PDX5), two buildings in the Hayden Meadows area, PDX 9 in the Troutdale area, DPD4 in Tualatin, and UOR2 and a multi-story UOR1 in the Northwest Industrial area of Portland. These facilities are much smaller, ranging in size from 100,000 to about 800,000 square feet each.

As previously noted, e-commerce distribution is only one of the drivers of activity in the industrial real estate market in the Portland region. The region has a legacy of manufacturing and other goods distribution activities, including semiconductor and other high-tech manufacturing. Recent trends in the semiconductor industry, including international trade relationships and the Creating Helpful Incentives to Produce Semiconductors (CHIPS) and Science Act, in particular, appear to favor the expansion manufacturing capacity in the United States. Because of this sector's presence in the Portland region, and state support for firms pursuing CHIPS Act funds[19], the region is well-positioned to capture some of that potential growth.

E.3.1.1 How Can the Portland Region Accommodate Growing Demand for Industrial Space?

Metro conducts periodic inventories of land supply and utilization within the Urban Growth Boundary (UGB) and considers municipalities' requests to expand the UGB to meet specific regional goals. The most recently completed UGB report, published in 2018, found that there were 8,600 net buildable acres of industrial land

[18] https://www.koin.com/news/business/plans-underway-for-new-amazon-facility-in-woodburn/

[19] https://www.oregon.gov/biz/programs/semiconductor_chips/pages/default.aspx

inside the Metro UGB. The 2018 report also noted that there had been no requests from municipalities to expand the UGB area for industrial purposes, as all requests made that year were to accommodate residential development. The assessment of industrial land supply and needs was determined based upon existing and forecasted future employment in "industrial jobs." The employment density for industrial properties can vary by wide margins. For example, Lam Research employs 4,000 people at its 600,000-square-foot manufacturing facility in Tualatin, while Amazon's Project Basie is expected to employ less than 1,000 in more than 3 million square feet of distribution center space. Looking into the future, further advancements in the automation of both manufacturing and warehousing and distribution activities are likely to have impacts on employment density of industrial properties as well.

As the development and absorption of industrial space suggests, the demand for space is outpacing the growth in employment in industrial sectors. Metro could account for this phenomenon by shifting to a methodology that estimates the need for industrial space based upon the volume of goods moved through the facilities, potentially with breakdowns by broad categories of industrial space (e.g., high-value manufacturing, low-value manufacturing, e-commerce fulfillment, warehousing, etc.). The Southern California Association of Governments (SCAG) developed an Warehouse Space Forecasting Model that estimates warehousing demand based upon the volume of goods moving, and forecasted to move, in the region.[20] This is an example of a methodological approach that Metro could take and/or expand upon in order to estimate industrial space needs based upon goods movement trends and forecasts.

To assess whether the supply of industrial land can meet current and future demand, Metro ought to consider:

- The supply of undeveloped industrial land that exists within the UGB and what the development potential of that land is;

- The potential for parcel assemblage and redevelopment of older, less marketable industrial buildings into larger, newer buildings that meet modern industrial needs. Compared to greenfield sites outside the UGB, sites in established industrial clusters typically have good transportation system access and utility connections. Industrial redevelopment examples include:

    - FedEx's redevelopment of its own facility in Maspeth, Queens, NY into a larger, modern distribution facility;

    - Real estate developer ProLogis's acquisition of adjacent parcels in a legacy industrial cluster in Chicago for the purpose of building a speculative distribution center; and

    - A realty company's acquisition of a shuddered factory in Oakland for proposed redevelopment into a speculative distribution center.[21]

- Consider opportunities to facilitate development on sites that require some investment in order to realize their full potential. This may include brownfields that require substantial and expensive environmental remediation, accommodation of on-site truck parking, and/or addressing site access

[20] https://scag.ca.gov/sites/main/files/file-attachments/task4_understandingfacilityoperations.pdf

[21] https://southsideweekly.com/a-planned-amazon-warehouse-in-bridgeport-is-the-latest-site-in-the-fight-against-an-inequitable-distribution-of-warehouses-on-the-citys-south-and-southwest-sides/; https://www.costar.com/article/1329283780/developer-with-close-ties-to-amazon-pitches-industrial-redevelopment-plan-for-east-bay-site

issues for trucks and/or rail. As the value of industrial real estate continues to increase, there may be more willingness among private sector actors to fund or contribute to the costs of addressing such needs.

In addition to assessing land development and redevelopment potential, Metro could consider various policy initiatives that support desired industrial development outcomes. Such initiatives could include:

- Limiting rezoning of land from industrial to other uses that are not compatible with industrial use, in order to preserve the region's supply of industrial land.

- Reviewing and, if necessary, revising land use regulations to ensure that industrial land is used primarily for industrial purposes, and that accessory uses, such as office, do not predominate. While many if not most manufacturing and warehousing buildings include some office or flex space, the primary use should be the use(s) that facilitate the production and/or distribution of goods.

- Reviewing, and if necessary, revising land use regulations to accommodate the transformation of vacant retail stores, often referred to as "dark stores," into last-mile delivery centers for e-commerce, if and where desired. Dark store conversions are rare, though there are some examples in the Midwest, Texas, and other parts of the country. However, they represent an interesting opportunity to reactivate vacant commercial space and provide logistics companies with space for goods distribution within metropolitan areas. There are a number of potential land use regulation conflicts, however, including determining whether such uses are permitted in commercial zones, parking and loading area needs and requirements, accounting for any window coverage and "active" frontage requirements that may exist in local zoning, etc.

Figure E.8 Conversion of a former Kmart "Dark Store" to an Amazon Delivery Center in Waynesboro, Virginia

Source: Christopher Lamm, author's personal collection, 2022

As Metro considers a new assessment of the UGB, it is important to consider the capacity of the region's industrial lands to provide for modern manufacturing, warehousing, and distribution needs. These needs include modern building specifications, proximity and access to customers and consumers, utility and transportation access. This assessment may include identifying capacity for new development on Greenfields within the UGB, potential assemblage and redevelopment of legacy industrial parcels, and the remediation of brownfields.

E.3.2 Moving and Delivering Goods in a Post-COVID-19 Central City

The COVID-19 pandemic has had lasting effects on where and when people work, especially people who have higher-income office jobs and the flexibility to work remotely. Nationally, the office real estate market is facing record-high vacancy rates (approximately 19%)[22] and a slowdown in new development proposals. In the Portland metropolitan area, 20.3% of the office space was available for lease, as of the second quarter of 2023. In Portland's Central City, office vacancy is near 30%.[23]

Vacancy only tells part of the story. Because a company is leasing space, that does not mean its employees are using it. For example, Kastle Systems, a company that tracks card swipes through its security systems in many office buildings, estimates that while New York City's vacancy rate is 16%, only about 49% of the office space in the city is being used.

Because many office leases have terms of 10 years or more, the effects of remote work are going to show up in lease and absorption statistics for several years to come. Some companies that have been locked into long-term leases in Portland's Central City have sought to break or renegotiate those leases to save spending on underutilized office space. Some companies that have leased office space have either closed office locations, downsized their office footprint, and/or sought to sublease some space. As the work-from-home and hybrid work schedules appear to be here to stay, more companies will likely eliminate or scale down their office footprints as their lease terms end over the next few years.

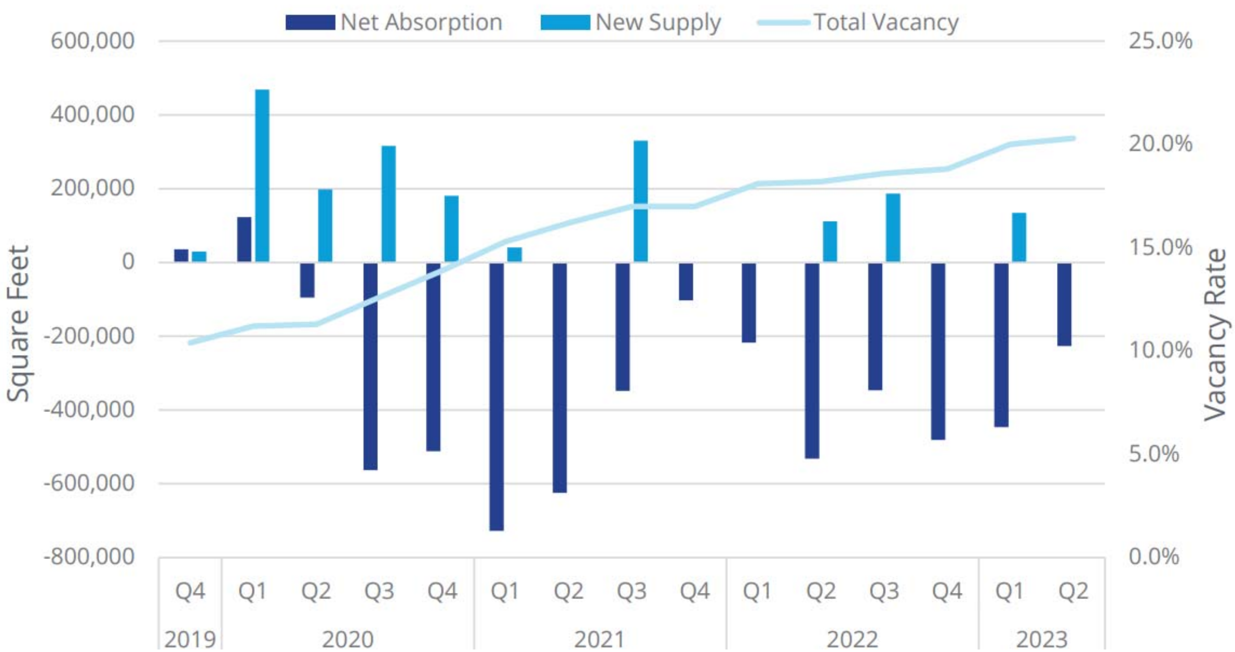
For the Portland region, and especially Portland's Central City, this means office vacancy rates may continue to climb, and that space absorption[24] may continue to be negative for several years to come. Figure E.9 shows vacancy and absorption in the Portland region between Quarter 4, 2019 and Quarter 2, 2023. Figure E.10 shows a breakdown of availability by class of office space and by submarket within the region. Note that the "Downtown" Portland area has the highest rates of availability in the region.

[22] https://rejournals.com/jll-reports-a-new-high-in-the-u-s-office-vacancy-rate-18-9/

[23] https://www.colliers.com/en/research/portland/2023-q2-portland-metro-office-market-report

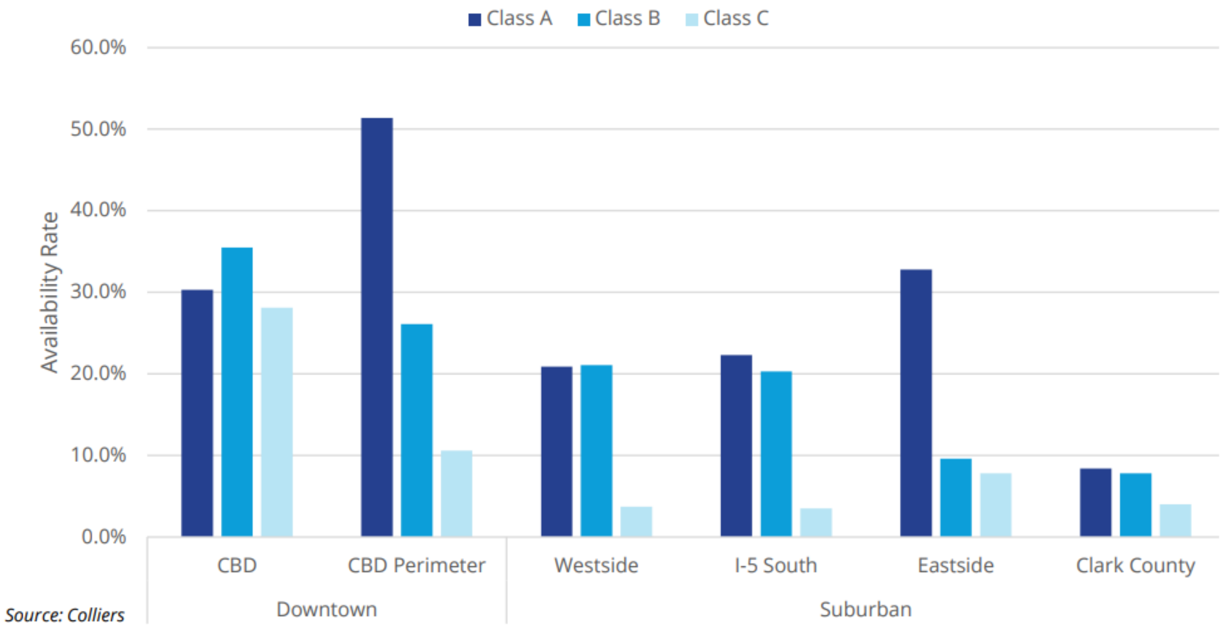
[24] Net absorption is a measure of the space that becomes occupied or is vacated during a quarter. Figure shows that the net absorption in the Portland metropolitan region has been negative for every quarter between Quarter 2 2020 and Quarter 2 2023. This means that in each quarter, more space is being vacated than moved into.

Figure E.9 Office Vacancy and Absorption in the Portland Region, Q4 2019-Q2 2023



Source: “Portland Office Report, Q2 2023” Colliers International, 2023[25]

Figure E.10 Office Space Availability by Submarket in the Portland Region



Source: “Portland Office Report, Q2 2023” Colliers International, 2023

25 https://www.colliers.com/en/research/portland/2023-q2-portland-metro-office-market-report

In some cities, such as New York and Houston, some office buildings are being converted to residential use in order to meet seemingly insatiable demand for multifamily housing in those cities.[26] Some management companies have given up trying to lease large amounts of space to corporate tenants and instead are focusing on co-working or “hot desk” space that individuals may rent to have a comfortable place to work that is close to, but not in, their homes.

In Portland, the City Council adopted measures in March 2023 to facilitate an easier process for converting office space into housing units by providing limited exemptions from system development charges related seismic retrofits and by changing seismic design requirements.[27]

If the future of Portland’s Central City is more focused on being a center for housing, retail, and entertainment, with less emphasis on office space, there may be some implications for how goods move into, and are delivered in, that district. Office buildings receive inbound shipments of office supplies, office equipment and furniture, and generate outbound shipments of solid waste. When converted from office to residential, a building would generate some truck and commercial van traffic during the renovation/retrofit period, as vehicles would bring construction supplies, equipment, and personnel to the site to perform the renovations. Once the residential units become available, moving trucks would bring new tenants’ belongings to the site, and daily deliveries of e-commerce orders, trucks and vans belonging to contractors who perform day-to-day maintenance and repair, and outbound shipments of solid waste would be generated.

To facilitate such transitions, the Portland Bureau of Transportation (PBOT) may consider how its policies and initiatives regarding curb access and on-street parking and loading may be impacted by the change in use and resulting changes in delivery needs. This may include the identification of new or modified on-street loading zones. The city’s planners may need to consider development requirements that promote off-street loading and building lobby retrofits to accommodate package holding rooms. If the character of the Central City changes substantially, there may be impacts on the composition of retail tenants as well. There may be greater demand for grocery stores, dry cleaning and laundry, and other businesses to support a larger residential population. The delivery needs of these businesses may necessitate further consideration of commercial vehicle parking and loading.

[26] https://www.investopedia.com/office-vacancies-rise-7480033

[27] Portland City Council adopts two ordinances to assist in office-to-residential conversions | Portland.gov

E.4 Conclusions and Next Steps

The review of the regional freight policy questions and their regional economic context has led to the development of the findings and recommended actions described in this memorandum. These findings and recommendations, along with the findings of the other technical documents developed during the study, will be presented in the study's Final Report and presented to the Project Management Team and Stakeholder Advisory Committee.

Metro should consider enhancing the Actions contained within the Regional Freight Strategy[28] to include new actions or revised language to account for the issues and needs identified in this study. Potential actions described in sections 2 and 3 of this technical memorandum could be developed into new, or incorporated into existing, actions in the Regional Freight Strategy.

Further, Metro should provide technical guidance to the region's planning and transportation agencies and stakeholders concerning the performance of the region's freight transportation system, potential for the region's land use supply to meet current and future industrial development needs, and best practices in curb management.

In addition, further research and development to advance the state-of-the-practice and to establish relevant and standard methodologies and measures, could potentially equip Metro to provide technical guidance and/or track performance in order to:

- Better understand the net effects of e-commerce delivery trips on regional highway network performance, including congestion, reliability, and emissions effects.
- Assess the equity effects of freight and deliveries, and to track performance related to equity.

[28] https://www.oregonmetro.gov/sites/default/files/2019/09/20/Regional-Freight-Strategy-FINAL-091919.pdf (pp. 87-102).

Regional Freight Delay and Commodities Movement Study

Appendix F: Criteria and Locations for Improved Freight Access

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Table of Contents

Key Findings and Conclusions

Task 6.2 of the Regional Freight Delay and Commodities Movement Study presents the results of a process implemented to identify criteria for improving freight access to industrial lands and terminals, and corridors/locations where improved access may be necessary, based upon analysis of the criteria. The access criteria include measures related to improving travel time and reliability, as well as addressing safety, equity, and economic development considerations. In consultation with Metro, the following access criteria were identified:

- Reduce delay and improve reliability;
- Address network gaps (missing links, dimensional or weight constraints, etc.);
- Reduce fatal and severe crashes;
- Address community impacts, especially in Equity Focus Areas; and
- Improve access to developable or re-developable industrial parcels within the Urban Growth Boundary (UGB).

Analyzing data and maps that contain information relevant to each of the criteria, the corridors listed in Table F.1 were identified as key areas where access improvements may be needed in order to improve the movement of goods and reduce negative externalities. The four rows highlighted in yellow, including the I-5 corridor from I-84 to Vancouver, the "Gateway to Troutdale corridor," I-205 between I-84 and OR 99E, and OR 8 between OR 217 and Hillsboro, stand out among the corridors listed for having some of the greatest congestion, unreliability, safety, and/or equity issues.

F.1 Locations Where Improved Access is Needed, Based Upon Criteria

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017-2021)	No. of Fatal Crashes (2017-2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
I-5 from I-405 to OR 217	**Top-Tier**		19	**2**	**3**	
I-5 from OR 217 to Wilsonville	**Top-Tier**		**26**	2	2	✓
I-5 from I-84 to Vancouver (including N. Going St. and OR 99E north of Columbia Blvd.	Top-Tier	✓	**30**	**14**	**8**	✓
I-84 from I-5 to I-205	Top-Tier		**20**	7	**11**	
SE Powell from Ross Island Br. to I-205	Top-Tier		**28**	7	5	
US 30 from I-405 to (and including) the St. Johns Br.	**N/A**		**10**	3	0	
Gateway to Troutdale corridor (I-84, Sandy Blvd. and Airport Way east of I-205)	Top-Tier		**48**	31	**13**	✓

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017-2021)	No. of Fatal Crashes (2017-2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
US 26 from I-405 to OR 217	**Top-Tier**		**27**	**0**	**1**	
OR 217 (US 26 to I-5)	Top-Tier		**23**	**0**	**6**	✓
I-205 from I-84 to OR 99E	Top-Tier		**42**	**10**	**13**	
I-205 from OR 99E to I-5	Second-Tier		**8**	**1**	**0**	✓
Marine Dr. – truck queuing at Terminal 6	**N/A**		**7**	**2**	**0**	✓
Murray Blvd. from US 26 to SW Allen Blvd.	**Top-Tier**		**10**	**3**	**4**	
OR 99W from OR 217 to SW 124th Ave	Second-Tier		**15**	**7**	**2**	✓
OR 8 from OR 217 to Hillsboro	**Top-Tier**		**40**	**11**	**16**	✓
OR 224 from OR 99E to SE 122nd Ave and OR 212 from I-205 to SE 122nd Ave	Second-Tier		**15**	**3**	**1**	✓

The description of issues and locations in this memorandum are intended to identify areas where further evaluation and potential projects may be identified and defined. Investigating these needs will be recommended among future actions recommended in the Final Report of this Study.

F.1 Introduction

This technical memorandum considers the effects of congestion, delay, and unreliability on the movement of goods in the Portland region, as well as safety, equity, and economic development considerations that could potentially be addressed through freight access improvements. The memorandum identifies and describes a set of criteria for identifying where freight access improvements may be needed. The memorandum also identifies a list of corridor segments that meet those criteria. Addressing the issues identified in these corridor segments could improve the efficiency of goods movement, reduce negative externalities, and support economic development in the region. The memorandum is organized as follows:

- Section F.2 lists and describes criteria for providing better access to industrial lands and intermodal terminals and improving travel time reliability.
- Section F.3 lists and describes locations in the Portland region where improved access to industrial lands and intermodal terminals, and/or improvements to travel time reliability are needed.
- Section F.4 notes how the findings of this memorandum will be incorporated into the Final Report for the study.

F.2 Criteria for Improving Access

"Improving access" to industrial lands and intermodal terminals in the Portland region is an objective that can be achieved by addressing a variety of issues related to the movement of goods in the region. In consultation with Metro, several criteria were developed to address not only delay and reliability issues, but also important issues such as safety, equity, and economic development and competitiveness. The five criteria for improving access to industrial sites and/or intermodal terminals include:

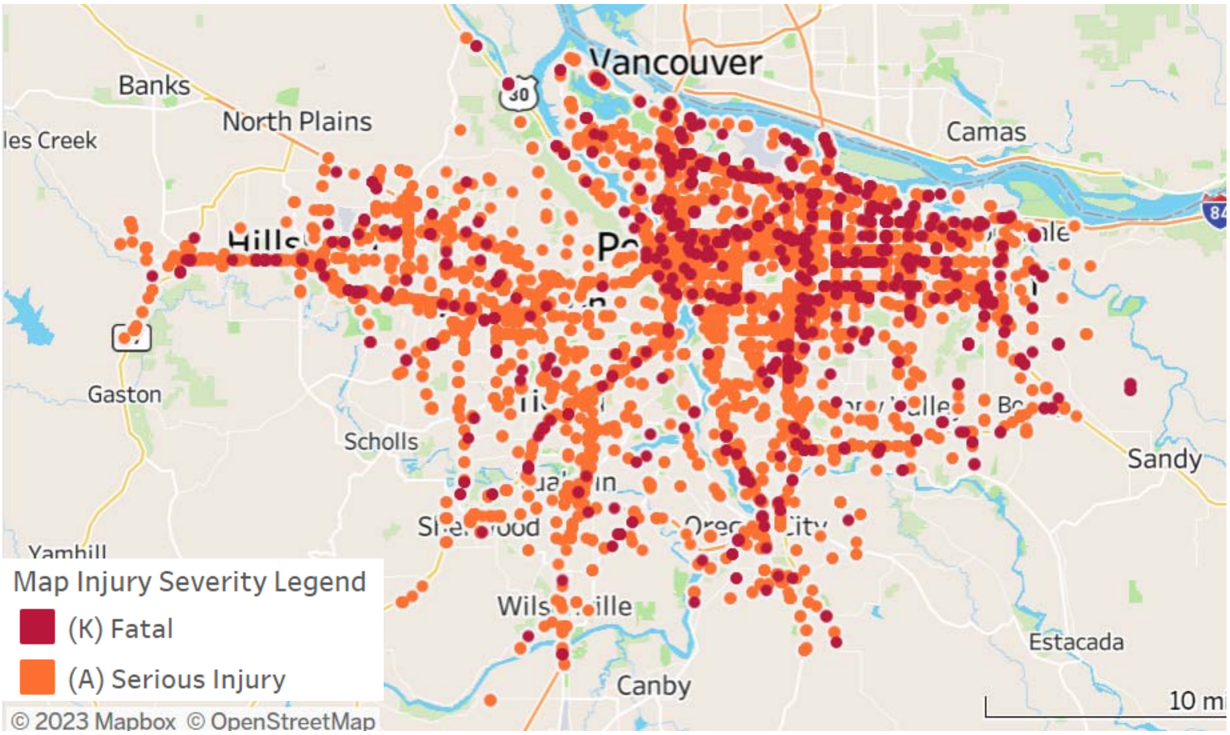
- **Reduce delay and improve reliability.** Delay and unreliability on the highway network impedes access to industrial lands and intermodal terminals by increasing the time it takes to move goods, increasing the cost of moving those goods, and increasing environmental and community effects of goods movement. Congestion and unreliability often results in truck drivers being dispatched at less-than-ideal times, in trucking companies charging customers higher rates to cover real or potential delays, and in some truck trips diverting off of preferred routes and into communities and neighborhoods. These consequences can lead to undesirable results, such as higher emissions, more noise and community impacts, and a higher cost of doing business for companies in the Portland region. Reducing delay and improving reliability can help shippers and carriers optimize their operations, control costs, and lead to desirable economic, environmental, and quality of life outcomes.

- **Addressing network gaps.** Network gaps is a term referring to locations where a road, ramp, bridge, or other connection is needed in order to more effectively link industrial sites and/or intermodal terminals with the regional freight network and/or other key transportation corridors. The existence of a gap may lead to circuitous routing, increasing truck vehicle-miles traveled, congestion, emissions, and/or other community impacts. Addressing network gaps can lead to more direct truck routing and avoid or mitigate some of the aforementioned effects.

- **Reduce truck-involved and non-truck-involved crashes.** Improving access includes addressing safety issues along access routes that trucks use. While truck-involved crashes are often the focus of freight studies, all crashes have an impact on the safety and reliability of the freight transportation system. Analysis has been performed to identify where some of the most severe crashes have occurred—those involving serious injuries and fatalities—over a five year period between 2017 and 2021, using the data available in the Oregon Crash Data Viewer.[1] Addressing the factors that contribute to crashes, including design and operational factors, can thus improve freight access by reducing fatalities, injuries, costs, and delays associated with crashes.

[1] "Crash Data Viewer," Oregon Department of Transportation, available from: https://www.oregon.gov/odot/Data/Pages/Crash-Data-Viewer.aspx (accessed November 20, 2023).

Figure F.1 Serious Injury and Fatal Crashes in the Portland Urbanized Area, 2017-2021

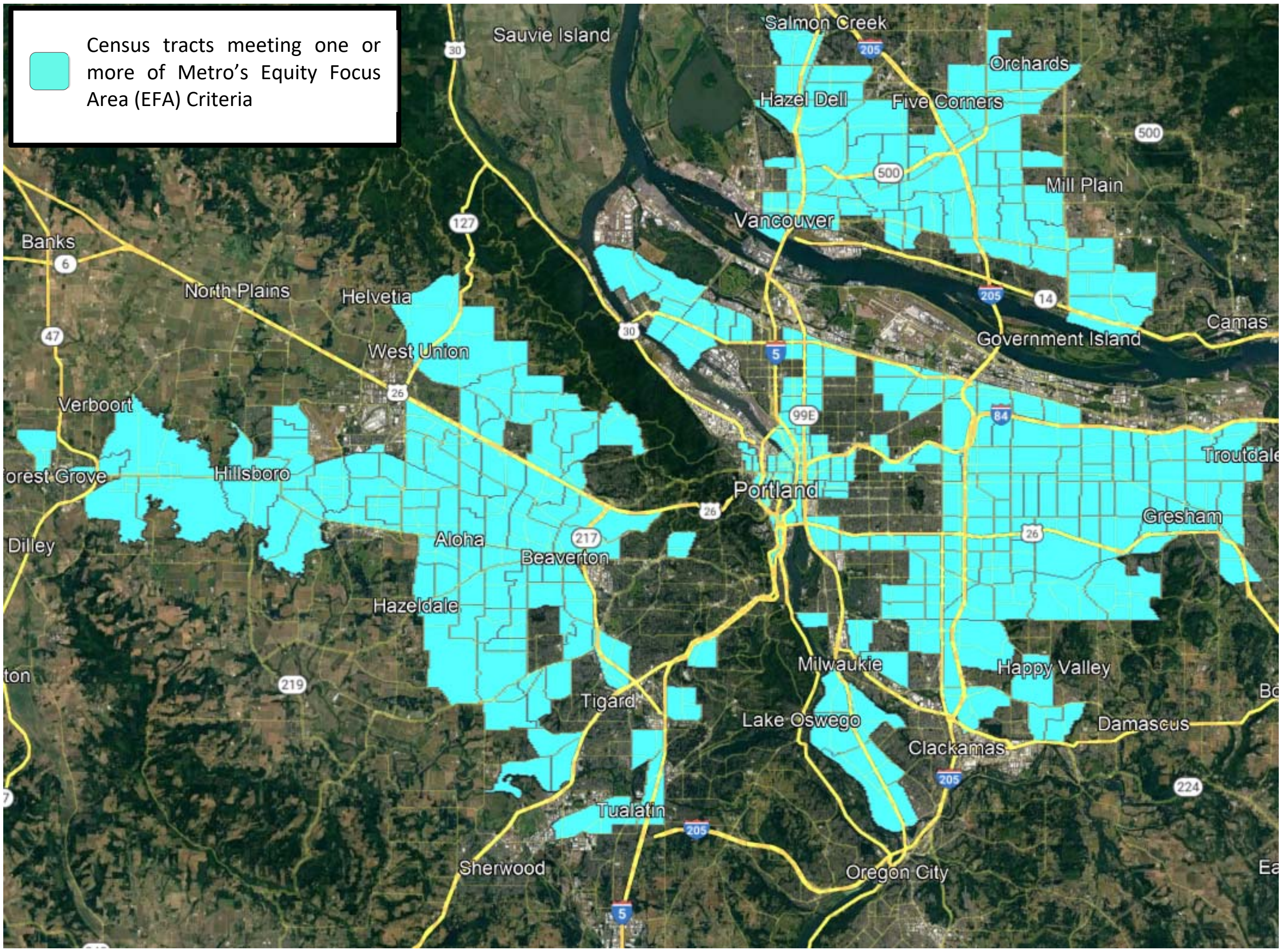


Source: Crash Data Viewer, ODOT

- **Address community impacts associated with truck movements, especially in Equity Focus Areas.** In some parts of the region, industrial sites, intermodal terminals, and/or the routes that trucks use to access such facilities are located in or adjacent to communities with vulnerable populations. The benefits of freight in the Portland region, including supporting economic growth and development and residents' quality of life, are typically regional in scale. However, the negative effects of freight-generating and freight-handling facilities, such as noise, particulate emissions, odors and light pollution, are typically borne by the community immediately adjacent to the facilities where freight is handled and the transportation network where freight moves. Strategies to avoid or mitigate these negative effects can help to ensure that vulnerable populations can share in the benefits of freight without being overburdened by the negative externalities. Analysis was performed to identify the number of Census tracts that each corridor passes through or adjacent to, which meet one or more of Metro's Equity Focus Area (EFA) criteria. Metro's EFA criteria include Census tracts that represent communities where the rate of Black, Indigenous, or People of Color (BIPOC), people with limited English proficiency (LEP), or people with low income (LI) is greater than the regional average. Additionally the density (persons per acre) of one or more of these populations must be double the regional average.[2]

[2] "Equity Focus Area (EFA) 2020," Metro, available from: https://rlisdiscovery.oregonmetro.gov/datasets/drcMetro::equity-focus-areas-efa-2020/about (accessed October 31, 2023).

Figure F.2 Metro-Defined Equity Focus Areas (EFA)



Source: Metro and Google Earth

- **Access developable (or re-developable) industrial parcels within the Urban Growth Boundary (UGB).** The needs of manufacturing, retail and e-commerce distribution, and intermodal transfer of shipments (e.g., seaport and rail terminals) are key drivers in demand for industrial land and buildings in the Portland region. The rise of e-commerce and demand for microchip manufacturing, in particular, have introduced more real or potential demand for modern distribution and manufacturing facilities. Consumer demands for next-day or same-day delivery of e-commerce orders necessitates having facilities located in, or very close to, major population centers. Opportunities may be emerging to assemble land parcels in mature industrial parks and clusters and to develop or redevelop modern manufacturing or distribution buildings. Some of these sites may need improved transportation access in order to realize their potential. Analysis was performed to identify where new industrial development or redevelopment is occurring within the Portland region, according to recent Colliers industrial real estate reports.[3]

[3] Portland Metro Industrial Market Reports, available from: https://www.colliers.com/en/research/portland/2023-q2-portland-metro-industrial-market-report (accessed October 13, 2023).

F.3 Locations Where Improved Access Is Needed

Reviewing key corridors and segments in the Portland region, in light of the access criteria described in Section 2, led to the identification of 15 locations where improved access may be needed. Table F.2 lists the locations and the criterion/criteria applicable to each. Addressing these access needs can help to reduce the travel time and cost associated with moving goods in the region, improve safety by reducing crashes, address the equity of freight externalities such as emissions and noise, and support economic development by improving access to developable or re-developable industrial sites within the Urban Growth Boundary.

For delay/reliability issues, "top-tier" corridors refer to locations where 7 or more hours of congestion are observed daily and/or travel time reliability during the morning and/or midday periods can result in travel times 3+ times as long relative to "normal" conditions. "Second-tier" delay or reliability occurs where 4-7 hours of congestion daily and/or reliability issues resulting in travel time that is 2-3 times greater than "normal" are observed during the morning and/or midday periods.

The remainder of Section 3 describes relevant conditions at each location. The four rows highlighted in yellow, including the I-5 corridor from I-84 to Vancouver, the "Gateway to Troutdale corridor," I-205 between I-84 and OR 99E, and OR 8 between OR 217 and Hillsboro, stand out as having some of the most substantial congestion, unreliability, safety, and/or equity issues.

Table F.2 Locations Where Improved Access is Needed, Based Upon Criteria

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017-2021)	No. of Fatal Crashes (2017-2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
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OR 217 (US 26 to I-5)	Top-Tier		**23**	**0**	**6**	✓
I-205 from I-84 to OR 99E	Top-Tier		**42**	**10**	**13**	
I-205 from OR 99E to I-5	Second-Tier		**8**	**1**	**0**	✓
Marine Dr. – truck queuing at Terminal 6	**N/A**		**7**	**2**	**0**	✓

	Delay / Reliability Issues: Second-Tier or Top-Tier	Network Gaps	No. of Serious Injury Crashes (2017-2021)	No. of Fatal Crashes (2017-2021)	No. of Equity Focus Area Census Tracts	Develop-able Site Access
Murray Blvd. from US 26 to SW Allen Blvd.	**Top-Tier**		**10**	**3**	**4**	
OR 99W from OR 217 to SW 124th Ave	Second-Tier		**15**	**7**	**2**	✓
OR 8 from OR 217 to Hillsboro	**Top-Tier**		**40**	**11**	**16**	✓
OR 224 from OR 99E to SE 122nd Ave and OR 212 from I-205 to SE 122nd Ave	Second-Tier		**15**	**3**	**1**	✓

I-5 from I-405 to OR-217 connects the central city of Portland with the southwest corner of the city and Lake Oswego. Northbound, between SW Dartmouth St and SW Capitol Highway, travel time reliability is a top-tier issue during the morning hours, as travel time can be more than 3 times longer during that period than "normal" times. There is a medium-tier reliability issue in the morning between SW Capitol Highway and SW Multnomah Blvd. I-5 between I-405 and OR 217 has been the site of 19 crashes involving serious injuries and two crashes involving fatalities during a five-year period from 2017 through 2021. There are three Census tracts adjacent to this highway segment that meet Metro's Equity Focus Area (EFA) criteria, including tracts 5701 and 5901 in South Portland and tract 6403 in West Portland Park, all of which meet Metro's low income thresholds to qualify as EFAs.

I-5 from OR-217 to Wilsonville. South of Oregon Route 217, there is a substantial reliability issue between I-205 and Boones Ferry Rd during midday hours, when travel time can be 4.7 times the "normal" travel time. Twenty-six serious injury crashes and two fatal crashes have occurred on this corridor segment between 2017 and 2021. There are two Census tracts meeting Metro's EFA criteria. Tract 30806 in Tigard meets the threshold for limited English proficiency, and Tract 32005 meets the thresholds for Black, Indigenous, People of Color (BIPOC) and low income. This segment provides highway access to a mature cluster of industrial buildings in and around Tualatin, and a growing cluster near Wilsonville.

I-5 from I-84 to Vancouver (including N. Going St. and OR 99E north of Columbia Blvd.). This corridor segment provides an important highway connection to/from Portland's industrial north, including the Port of Portland's marine terminals and the airport (PDX). In the southbound direction, between Marine Drive and I-84, there is delay for 5.3 to 9.1 hours per day, and travel time during the midday is up to 3.3 times the normal travel time, suggesting a top-tier congestion and unreliability issue on this corridor segment. Northbound, between I-84 and the Washington state line, there are fewer hours of congestion, but midday unreliability is far more pronounced, with travel taking 4.5 to 6.7 times the normal travel time. In the five year period between 2017 and 2021, 30 serious injury and 14 fatal crashes have occurred. This corridor passes through or adjacent to 8 Census tracts that meet one or more of Metro's EFA criteria. There are sites in this are of the region where industrial development and/or redevelopment could occur.

I-84 from I-5 to I-205. This portion of I-84 experiences between 3.9 and 7.7 hours of congested conditions daily in the westbound direction, which qualifies as a top-tier congested corridor. Reliability is a second-tier issue, as I-84 appears to be reliably congested during much of the day. There were 20 crashes involving serious injuries and 7 crashes involving fatalities on these two roadways between 2017 and 2021. There are 11 Census tracts meeting Metro's EFA criteria that these segments of I-84 pass through or adjacent to.

SE Powell from Ross Island Br. to I-205. This corridor experiences between 7.3 and 9.9 hours of congested conditions daily in both directions. Reliability is a second-tier issue, as SE Powell Blvd. is reliably congested during much of the day. There were 28 crashes involving serious injuries and 7 crashes involving fatalities on these two roadways between 2017 and 2021. There are 5 Census tracts meeting Metro's EFA criteria that these segments SE Powell pass through or adjacent to.

US 30 from I-405 to (and including) the St. Johns Bridge. This segment of US Route 30 provides access to and from Portland's industrial Northwest. Congestion and reliability are not major issues along this corridor segment, relative to other corridors evaluated throughout the region. There were 10 serious injury crashes and 3 fatal crashes in this corridor between 2017 and 2021. There are no Census tracts in this corridor that meet any of Metro's EFA criteria.

Gateway to Troutdale corridor (I-84, Sandy Blvd. and Airport Way east of I-205). This corridor consists of three facilities—I-84, Sandy Blvd., and Airport Way—heading east from I-205 to Troutdale. Airport Way experiences 7.7 hours of congestion westbound and 8.4 hours of congestion eastbound daily. There are second-tier reliability issues on this corridor during the midday hours, particularly on Airport Way, where travel times can exceed twice the normal travel time in the westbound direction. The sum total of serious injury crashes on all three road segments in this corridor was 48 between 2017 and 2021. There were 31 fatal crashes during the same period. There are 13 Census tracts in Portland's eastern neighborhoods that meet one or more of Metro's EFA criteria. There are some developable or potentially re-developable industrial parcels along or near this corridor, where improved access could potentially support such investments.

US 26 from I-405 to OR 217 is a key highway facility connecting Central City Portland to Beaverton and points west. Delay and reliability issues along this corridor are primarily observed in the eastbound direction. Between SW Canyon Rd and SW Vista Ave, eastbound traffic is congested between 8.4 and 12.3 hours daily. Between Route 217 and SW Canyon Rd., eastbound travel speeds are unreliable during the morning and midday periods, when travel time can be 3.6 times and 2.6 times the normal travel time, respectively. There were 27 crashes involving serious injuries in this corridor between 2017 and 2021, and no crashes involving fatalities. There is one Census tract that meets Metro's EFA criteria. Census tract 30200, which includes the interchange of US 26 and OR 217, meets Metro's EFA criteria for limited English proficiency.

OR 217 (US 26 to I-5). Oregon Route 217 provides a limited-access highway link between US 26 near Beaverton and I-5 in Tigard. There are several sites along this corridor where industrial development has recently occurred or is underway. Southbound traffic is congested between Walker Rd. and SW Denney Rd. for 4.7 to 7.2 hours per day, which places this segment in the top tier for daily speed performance issues. Reliability during the morning and midday periods are in the top tier southbound between Walker and Denney and northbound between SW 72nd Ave. and SW Hall Blvd. Between 2017 and 2021 there were 23 crashes involving serious injuries and no fatal crashes. There are six (6) Census tracts meeting one or more of Metro's EFA criteria along this corridor.

I-205 from I-84 to OR 99E provides a north-south alternative to I-5 east of central Portland. North of OR 99E in Oregon City, I-205 experiences second-tier levels of congestion northbound between Johnson Creek and SE Stark St. and between NE Glisan St. and I-84. Travel time reliability is a major issue northbound north of Glisan and between Sunnyside and Johnson Creek, and southbound near SE Powell, during the midday period. Other segments along this corridor observe second-tier levels of unreliability during the morning and/or midday periods. Between 2017 and 2021, 42 crashes involving serious injuries, and 10 crashes involving fatalities, have occurred on this corridor. There are 13 Census tracts that meet one or more of Metro's EFA criteria along this corridor.

I-205 from OR 99E to I-5. Between OR 99E in Oregon City and I-5 in Tualatin, northbound traffic between SW Stafford Rd. and OR 43 experiences second-tier travel time reliability issues during midday hours. Travel can take 2.2 to 2.7 times as long as during "normal" times. Between 2017 and 2021, 8 crashes involving serious injuries and 1 fatal crash occurred on this segment of I-205. There are no equity focus areas located along this corridor. There are some developable, or potentially developable, industrial sites along this corridor in the vicinity of Tualatin.

Marine Dr. – truck queuing at Terminal 6. North Marine Drive is the primary route trucks use to access Terminal 6 in the Port of Portland. During the supply chain disruptions of 2020-2021, occasional lengthy truck queues outside the terminal gate were observed. However, queueing has become less frequent as of 2023. Seven serious-injury crashes and two fatal crashes occurred in this corridor between 2017 and 2021. There are no equity focus areas along this corridor.

Murray Blvd. between US Route 26 and SW Allen Blvd. provides north-south truck access to retail districts, including Tualatin Valley Highway (OR 8), and the Nike World Headquarters campus. The portion of this corridor south of OR 8 experiences more than 7 hours of congestion daily. The same segment experiences significant travel time reliability issues in the morning period, as does the segment between US 26 and Walker. The segment between Walker and OR 8 experiences significant reliability issues during the midday period. Between 2017 and 2021, 10 serious injury crashes and 4 fatal crashes occurred along this corridor. Four equity focus area Census tracts are located along this corridor.

OR 99W from OR 217 to SW 124th Ave in Tualatin provides access to industrial clusters in the Tualatin and Sherwood areas. Congested conditions in this corridor are observed between 4-7 hours daily, and second-tier reliability issues exist in the morning and midday periods. This corridor was the scene of 15 serious injury crashes and 7 fatal crashes between 2017 and 2021. Two equity focus area Census tracts are located along this corridor.

OR 8 from OR 217 in Beaverton to Main Street in Hillsboro is a major east-west arterial corridor connecting Beaverton with Hillsboro. There are several major retail complexes located along this corridor. Congestion is a significant issue between Murray Blvd. and OR 217 for more than 7 hours daily. Travel time reliability is a second-tier issue along most of the corridor during morning and midday periods, however, significant travel time reliability issues, in which travel times can take more than 3 times "normal" travel time, are observed in the westbound direction between SE 209th Ave and Hillsboro. There were 40 severe injury crashes and 11 fatal crashes on this corridor between 2017 and 2021. There are 16 equity focus area tracts located along this corridor.

OR 224 from OR 99E in Milwaukie to SE 122nd Ave in Clackamas, and OR 212 from I-205 to SE 122nd Ave. This corridor provides access between Milwaukie and I-205, and between a cluster of distribution centers in Clackamas and I-205. Congestion and reliability are second-tier issues in this corridor during the morning and midday periods. There were 15 serious injury crashes and 3 fatal crashes in this corridor between 2017 and 2021. Three equity focus area Census tracts are located along this corridor.

F.4 Next Steps

The description of issues and locations in this memorandum are intended to identify areas where further evaluation and potential projects may be identified and defined. The Final Report of this study will likely include a recommendation that these needs be further investigated through a systemic or series of corridor-specific studies and evaluations. Such studies could identify operational and/or capital programs aimed at addressing congestion, travel time reliability, safety, community impact and equity, and/or economic development goals.

Regional Freight Delay and Commodities Movement Study

Appendix G: Commodity Truck Modeling and Results

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Table of Contents

G.1 Freight Demand Model Introduction

This purpose of the Freight Demand Modeling and Data Improvement Project was to replace the current trip-based truck model developed by Oregon Metro (Metro) that utilizes fixed commodity flows with a truck tour model designed to reflect decisions made by shippers, receivers, truck operators, terminal managers, and others. The model simulates movement of individual shipments throughout the supply chain, including both direct shipments and those that travel through transshipment facilities. Shipments are allocated to trucks of various classes, and the movements of all freight vehicles are simulated over the course of a typical weekday.

Key participants in the project included Metro, the Oregon Department of Transportation (ODOT), the Port of Portland, and local agencies throughout the region.

The objectives of the project were to:

- Develop tools to enable a more comprehensive analysis of infrastructure needs and policy choices pertaining to the movement of goods;
- Develop more detailed network assignments by truck type to support regional environmental analysis, as well as local traffic operations and engineering analysis;
- Develop freight forecasts that are responsive to changes in economic forecasts, changing growth rates among industrial sectors, and changing rates of economic exchange and commodity flows between sectors; and
- Replace the trip-based truck model with more realistic tour-based model.

G.1.1 Current Metro Models

Metro has deployed commodity-flow based truck models for almost 20 years. These models have utilized data based on the Freight Analysis Framework (FAF) and prepared under contract for Metro and the Ports of Portland and Vancouver. The current model is based on FAF3, which utilized data gathered in the 2007 Commodity Flow Survey (CFS), together with data from several other sources.

Commodities are grouped into 16 categories, and assigned to major “gateways” by long-haul mode and direction. Long-haul truck-borne commodities enter and exit at major highway cordons. The commodities are segmented by carrier type (private, common carrier, truckload, and LTL). A portion of the commodities in each group are routed through warehouse, distribution, and consolidation facilities based on a 2006 survey. They are distributed to individual Transportation Analysis Zones (TAZ’s) based on employment types associated with each group and then assigned to medium and heavy vehicles based on load factors. External-internal and internal-external truck flows are derived by designating a portion of the truck volumes at each external station as through trips, in accordance with the 2006 survey.

Daily heavy and medium truck trips are factored into time periods using data from a region-wide truck count database. The trips are factored to passenger-car-equivalents and assigned to the network using multi-class assignment techniques. The current truck model does not include local delivery vehicles or non-freight commercial vehicles, and there is no feedback of network travel costs into the model.

Metro's current trip-based passenger model, code-named "Kate", was estimated in 2016 and calibrated and validated in the spring of 2017. The main model inputs are households by size, income, and life cycle; and employment by sector. A series of demographic models is used to estimate household attributes not included in the inputs, such as the number of workers, number of school-age children, and number of household vehicles. Fixed trip generation rates are assigned to households based on specific attributes (e.g., persons, workers, and age of head of household) for eight trip purposes. Destination choice for home-based work trips is further segmented into three income classes. The mode choice model assigns seven travel modes - drive alone, drive-with-passenger, auto passenger, walk-to-transit, drive-to-transit, walk, and bike. The drive alone and drive-with-passenger modes are assigned to the network as SOV and HOV vehicles, respectively. Public transit sub-modes (bus, LRT, streetcar, commuter rail) are determined in the transit assignment path choice; but are not segmented in the demand model. There is full feedback and equilibration of the demand model (destination choice, mode choice, and assignment path choice) with auto network costs.

There is a separate airport model that estimates person-trips to Portland International Airport for all purposes and modes, a separate bicycle route choice model that interacts with mode choice, and a special events model that is used for certain types of transit studies.

G.1.2 Model User Needs

Early in the study, a series of stakeholder interviews were held with potential users of the freight model output to identify key freight-related issues and challenges, important impacts to measure for decision-making, expected use of a freight model or outputs, and the level of interest in freight model development from their perspective. The stakeholder groups were:

- Oregon Metro
- ODOT
- Port of Portland
- Local agencies
- Portland Freight Committee

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The key freight-related issues and challenges identified by the groups include the following:

- Multimodal analysis (rail, air, water, pipeline) in addition to truck;
- Local truck movements for pick-up and delivery (last mile connections and congestion);
- Impacts of distribution centers (new and existing) and industrial land development;
- Economic impacts of freight; and
- Operational impacts of local truck movements (reliability, road diets and impacts to bike/pedestrian movements).

The model addresses all of these issues, except pipeline transport, either directly or indirectly. Pipeline movements could be added to the mode choice models in future enhancements. Other issues, such as economic and operational impacts, will require additional tools which Metro may choose to develop.

The stakeholder groups also identified a set of impacts that will be important to measure:

- Shifts in imports and exports (representing global shifts in freight to the U.S.);
- Shifts in national commodity flow movements due to Portland improvement projects;
- Greenhouse gas (GHG) emissions;
- Roadway operational improvements;
- Rail capacity and speed improvements;
- Shifts in transloading at the Ports of Portland and Vancouver;
- Distribution of oil arriving by pipeline; and
- Economic benefits of freight movements.

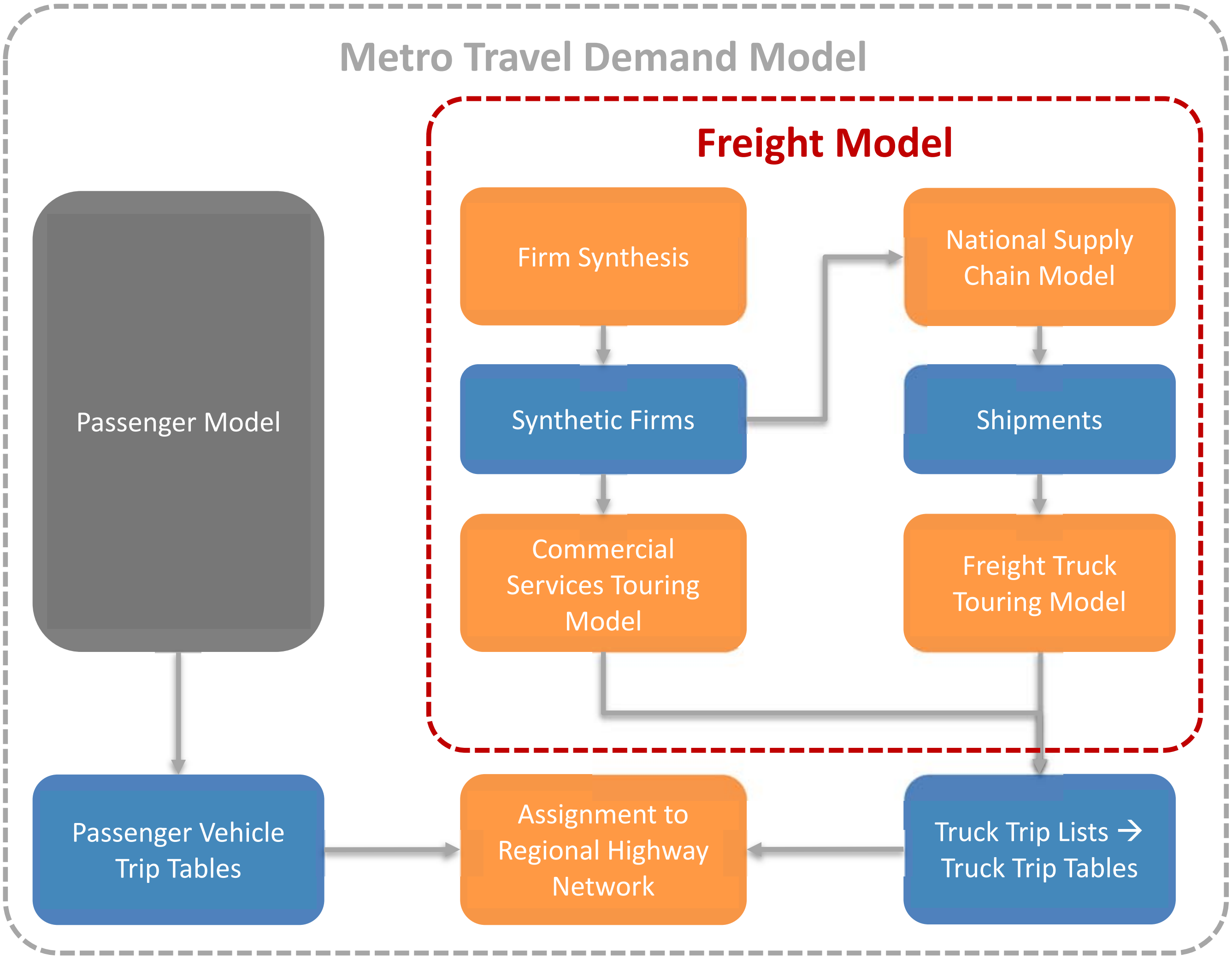
The model represents imports and exports, but does not explicitly model global freight movements, so the impacts of global changes could be represented by adjusting these inputs as a scenario analysis. Operational analysis would benefit from integrating truck movements produced by the model with an operational model, such as VISSIM, capable of evaluating localized operational improvements. Although pipelines are not included directly in the model, the distribution of oil to consumers arriving by pipeline to the port is represented by truck movements.

The stakeholder interviews were also used to identify how the model or its outputs might be used by the various groups. The responses focused on the ability to evaluate possible investments or policies to improve freight mobility and the need to communicate the freight movement story to decision-makers and the public.

G.1.3 Model Overview

Figure G.1 shows the integrated model system containing Metro's passenger travel demand models (gray boxes) that are used to estimate personal travel by auto and other modes. The freight and commercial vehicle travel demand models being developed in this SHRP 2 C20 project are shown in orange, with the output datasets shown in blue.

Figure G.1 Integrated Freight Model System



There are there primary modeling systems that comprise the Metro freight model:

- The **national supply chain model** simulates the transport of freight between supplier and buyer businesses in the United States, in this case focusing on movements that involve Portland. Its output, a list of commodity shipments by mode, is used in two ways. First, in the Metro model, a model component connected to the national supply chain model converts the annual shipment flows to daily vehicle trip tables that can be assigned to the regional highway network in Metro's model, along with trips tables from the passenger model. Secondly, as indicated by the blue arrow, the list of commodity shipments by mode is extracted from the supply chain model and used an input to the freight truck touring model.
- The **freight truck-touring model** simulates truck movements within the Portland region that deliver and pick up freight shipments at business establishments. The model is a tour-based model, and builds a set of truck tours including transfer points at which the shipment is handled before delivery/after pickup for shipments with a more complex supply chain (i.e., a warehouse, distribution center, or consolidation center) and the suppliers and buyer of shipments where those are within the model region. The shipment list from the national supply chain model is used as the demand input for the freight truck touring model and describes the magnitude and location of delivery and pick up activity in the region that must be connected by truck movements. The model will generate trip lists by vehicle type and time of day so that the outputs from this model can be combined with the outputs from the commercial services touring model and appropriate trip tables from Metro's passenger model for highway assignment.
- The **commercial services touring model** simulates the remainder of the travel of light, medium, and heavy trucks that is for commercial purposes, i.e., providing services and goods delivery to households and services to businesses. As with the freight truck touring model, the commercial services touring model is a tour-based model, but this time demand is derived from the characteristics of the business establishments and households in the region and as such is not affected by the national supply chain model. That is, while the freight truck touring model simulates truck tours based on commodity flows, the commercial services touring model generates and simulates truck and light-duty vehicle movements based on demand for services and goods from the region's industries.

For each of these model systems, we describe the analytical engine, the input and output databases, and the integration of the models into Metro's regional travel demand modeling system (trip-based model, Kate version).

The outputs from the both the freight truck touring model and the commercial services touring model are lists of truck trips and tours and are aggregated to represent trip tables. In this case, a trip list from each model with trip start and end location and trip timing information is aggregated into zone to zone trips by time period that can be assigned to the regional highway networks in the Metro travel model along with trips tables from the passenger model.

G.1.4 Model Development Process

G.1.4.1 Implementation Plan

To guide the model development process, an implementation plan was developed detailing the initial demonstration model transfer, software requirements, integration with the current Metro travel models, external linkages, and desired enhancements/customizations of the model. The questions considered in the plan included:

- Extent to which the freight model would be integrated with Metro's passenger travel demand modeling system;
- Maintenance of the model and its data elements, including possible coordination with external partners such as the Ports and ODOT;
- Integration of the truck touring model with a national supply chain model approach;
- Sensitivity to long-haul movements across the U.S. for shipments that travel to, from or through Portland;
- Resources available in the project to implement the supply chain model components;
- Resources needed to acquire and maintain necessary data inputs, both initially and in the future; and
- Software and hardware requirements, tailored to meet Metro's freight model performance objectives and staff capabilities.

G.1.4.2 Data Plan

A data plan was developed to identify data needs and how they would be met in fulfillment of project objectives, as developed through Metro staff discussion and the stakeholder interviews. The data plan was intended to identify currently available data and a flexible set of options to accommodate Metro's approach to model integration and data collection funding. The freight model required three types of data to support model development and application:

- Behavioral data for model estimation;
- Observed travel data outcomes for model calibration and validation; and
- Model input data describing transport networks and zone systems, warehousing and major distribution facilities, employment/establishments, households, supply chain relationships and national commodity flows.

The behavioral and observed travel data was required for the development of the working updated model. The model input data was needed for implementation of the working enhanced demonstration model.

G.1.4.3 Data Collection

The final data plan was implemented to collect and prepare the required data for model estimation, calibration, and validation. The behavioral data collection for model estimation comprised the following tasks:

- Design of truck travel diary survey questionnaire;
- Development of survey tools, including an online survey application (rSurvey) and a mobile survey application (rMove);
- Development of a survey sampling plan, including holding focus group meetings to obtain information to guide the plan development and introduce prospective survey participants to the project;
- Survey recruitment;
- Survey data collection, including the development and hosting of a project website, conducting a pilot survey, and conducting the full survey; and
- Processing and summarization of the survey data.

The observed travel data for model calibration and validation consisted of truck counts and commodity flow survey data. The truck count data was used for the development of the truck touring model, while the commodity flow data was used both as input data for the supply chain model and setting calibration targets for the supply chain model. The following steps were involved in the truck count data collection:

- Compilation of raw count data;
- Initial data checking;
- Count adjustment;
- Aggregation of counts to model time periods and vehicle classifications;
- Import of data to GIS;
- Import of data to model network; and
- Final data checking

The commodity flow data was derived from the Freight Analysis Framework by Metro. As specified in the data plan, the model input data consisted of the commodity flow data, industry input-output tables, zone systems, networks, employment data, and TAZ household data by Metro. These are discussed in Section 3.3.

G.1.4.4 Model Development Approach

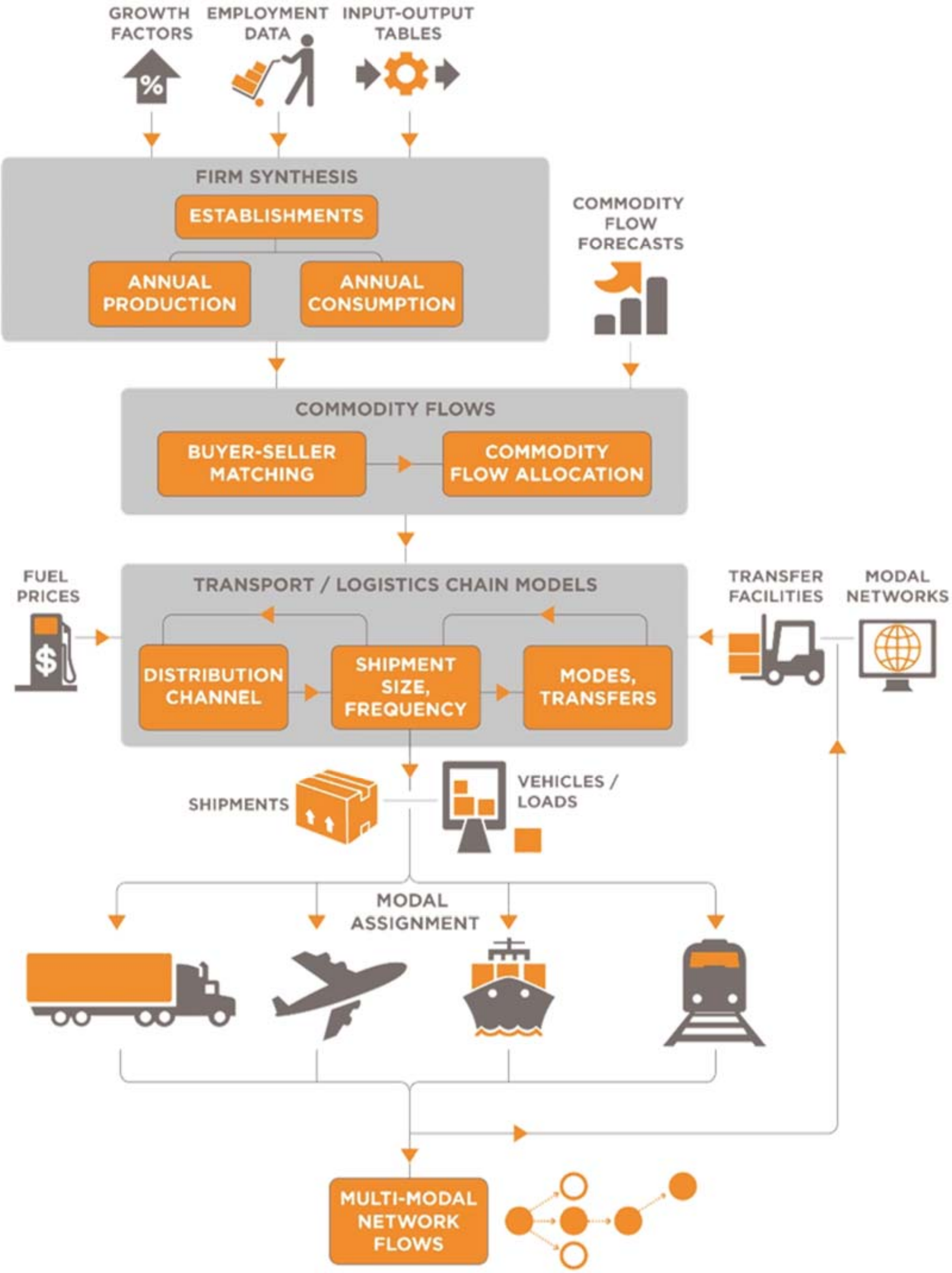
The Portland freight model is based on a combined supply chain and tour-based framework developed with Federal Highway Administration research funding by RSG and implemented in Chicago, Florida, Piedmont and Baltimore with rFreight^{TM} software. This framework is comprised of several steps that simulate the transport of freight between each supplier and buyer business in the United States, with additional imports and exports from international businesses.

Supply Chain Models

Figure G.2 shows these supply chain processes, with major input and output data identified. The steps are introduced in this section and further detail is provided in Section 4 on model development. The modeling system includes the selection of business locations, trading relationships between businesses, and the resulting commodity flows, distribution channel, shipment size, and mode and path choices for each shipment made annually:

1. **Firm Synthesis.** Synthesizes all firms in the United States and a sample of international firms
2. **Supplier Firm Selection.** Selects supplier firms for each buyer firm by type
3. **Goods Demand.** Predicts the annual demand in tonnage for shipments of each commodity type between each firm in the United States
4. **Firm Allocation.** Allocates firms in each county to traffic analysis zones within the Portland region
5. **Distribution Channels.** Predicts the level of complexity of the supply chain (e.g., whether it is shipped directly or whether it passes through one or more warehouses, intermodal centers, distribution centers, or consolidation centers)
6. **Shipment Size and Frequency.** Estimates discrete shipments delivered from the supplier to the buyer
7. **Modes and Transfers.** Predicts four primary modes (road, rail, air, and waterway) and transfer locations for shipments with complex supply chains

Figure G.2 National Supply Chain Model Structure



The model incorporates a multimodal transportation network that provides supply side information to the model including costs for different paths by different modes (or combinations of modes). While the model is focused on Oregon and Portland, it also encompasses freight flows between Oregon and the rest of the world. The rail, air and waterway freight movements are not assigned in the current work. The highway assignments are described below as part of the truck touring model process.

The supply chain models were transferred from the Baltimore/Maryland model and calibrated using the locally collected data sources. The primary purpose of the supply chain models in the Portland freight model is to produce individual shipments of goods into, out of, and through the Portland region. These models were calibrated to achieve reasonable external flows by mode. The model components of the supply chain were not calibrated individually, since the focus of the project is on the tour-based models in the Portland region.

The supply chain models rely on commodity flow forecasts, so adjustments to growth forecasts need to be translated into adjustments to commodity flow forecasts for scenario analysis or evaluation of different growth forecasts. A separate model component for procurement markets (that RSG has developed) could be deployed as an enhancement to allow a more structured scenario analysis of growth forecasts, but this is not part of the current work. This modeling framework does provide for the future inclusion of this procurement market game model and is currently an element of exploratory research at the FHWA.

Truck Touring Models

The supply chain model is integrated with a regional truck touring model, which is a sequence of models that takes shipments from their last transfer point to their final delivery point. The integrated modeling system connects the national supply chain models with the regional truck touring models. The final transfer point is the last point at which the shipment is handled before delivery (i.e., a warehouse, distribution center, or consolidation center for shipments with a more complex supply chain or the supplier for a direct shipment). It performs the same function in reverse for shipments at the pick-up end, where shipments are taken from the supplier to distances as far as the first transfer point. For shipments that include transfers, the tour-based truck model accounts for the arrangement of delivery and pick-up activity of shipments into truck tours.

A commercial services touring model is also developed to provide a comprehensive representation of all trucks. This model has the same structure and features of the regional truck touring model, but demand is generated from businesses and households in the region rather than from goods movement. These commercial services include utilities, business and personal services.

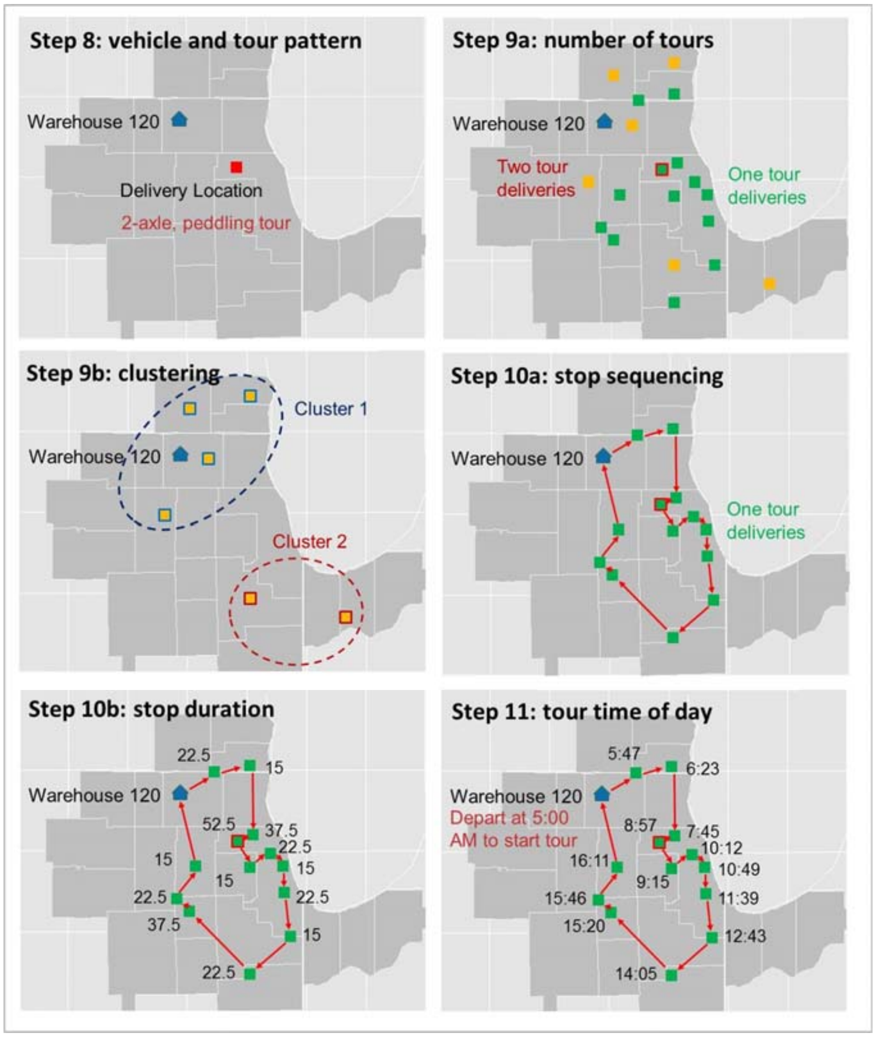
The regional freight truck and commercial vehicle touring models were transferred from the work done in Baltimore. These were calibrated and validated using locally collected data.

The model produces trip lists for all the freight delivery trucks and commercial vehicles in the region that can be assigned to a transportation network. The truck touring model components predict the elements of the pick-up and delivery system within the Portland region through several modeling components, as shown in **Error! Reference source not found.**:

1. **Vehicle and tour pattern choice**. Predicts the joint choice of whether a shipment is delivered on a direct- or a multi-stop tour and the size of the vehicle that makes the delivery.
2. **Number of tours and stops**. Predicts the number of multi-stop tours required to complete all deliveries and estimates the number of shipments that the same truck delivers.
3. **Stop sequence and duration**. Sequences the stops in a reasonably efficient sequence but not necessarily the shortest path. Predicts the amount of time taken at each stop based on the size and commodity of the shipment.
4. **Delivery time of day**. Predicts the departure time of the truck at the beginning of the tour and for each subsequent trip on the tour.

The Portland freight model is integrated with the passenger travel model for highway assignment and can become part of the Portland travel demand modeling system.

Figure G.3 Truck Tour Modeling Steps



G.2 Commodity Model Analysis: Electronics

The purpose of this document is to provide an analysis of electronics industry commodity flows for the Portland metropolitan region. Flows will report net inflows and outflows of the electronics commodity groups to estimate consumption and processing flows in the region. This analysis uses the electronics commodity group as a starting point for discussion and potential usage with the project team.

This report uses the FHWA's current published version of the Freight Analysis Framework data, FAF version 5.4.1. This is based on the 2017 Commodity Flow Survey with the most recent refinements to data analysis and forecast assumptions. The FAF data breakdown commodities into Standard Classification of Transported Goods (SCTG) groups, of which there are 41. The electronics industry covers SCTG code 35. The analysis will conduct similar analyses for 5 other similarly size metropolitan areas for comparative purposes.

G.2.1 Analysis of Results: Base Year 2017 Electronics Industry Production/Consumption/Transshipments

Chart 1 shows annual dollars per capita (year 2017) of electronics production for each region. Austin, Indianapolis, and Portland are important electronics industry production regions and contribute considerable economic benefits per capita. Austin reports the highest electronics production flows ($7,500 per capita); about one-third higher than in the Portland metropolitan area. The Indianapolis, IN region reports nearly the equivalent electronics production movements than Portland at $4,900 per capita annually.

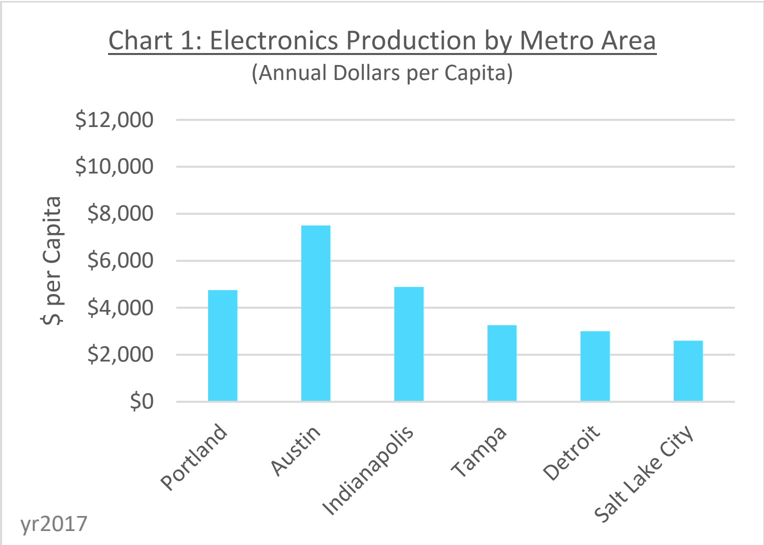


Chart 2 compares electronics consumption industry flows destined to each region. Austin, Indianapolis, and Portland continue to be important markets for this industry consumption. Auto manufacturing includes a lot of electronics, so Detroit's increased presence of electronics consumption flows makes sense here too.

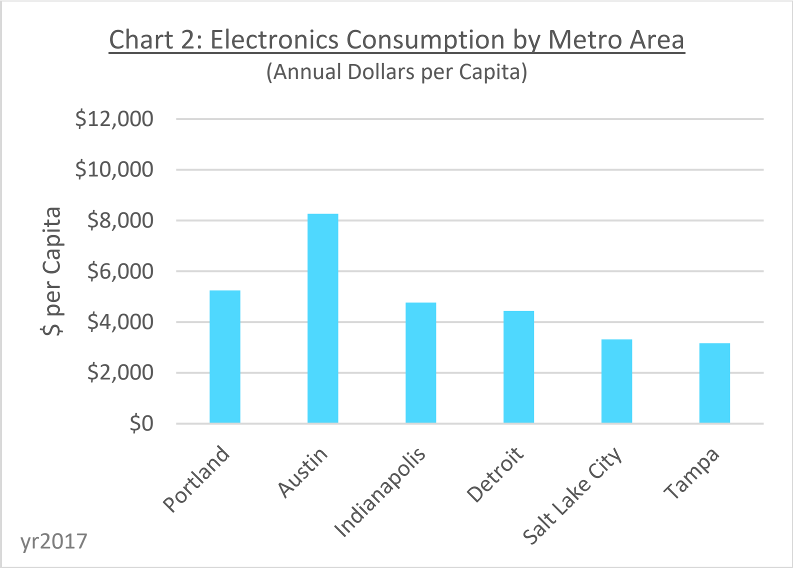
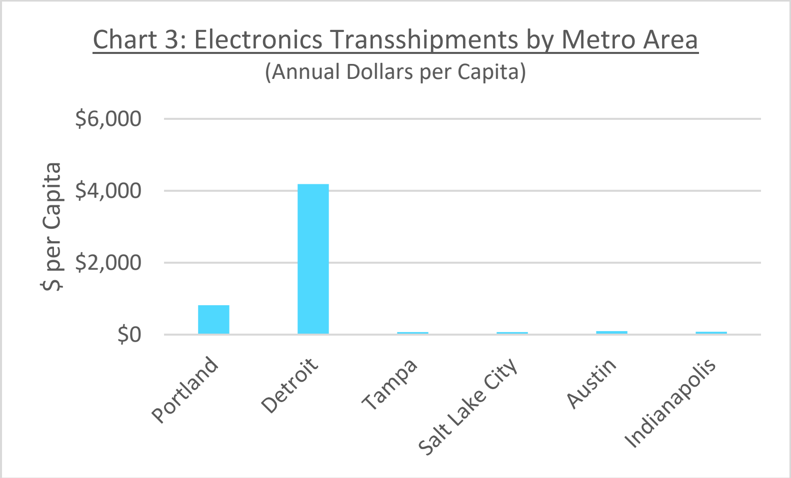


Chart 3 compares Electronics transshipment among the regions of interest. These flows are typically internationally imported to the US or are flows from the US that are exported to international destinations. These commodity flows do not necessarily remain within the region. Results indicate Detroit, MI processes the highest dollar per capita ($4,200) in electronics industry transshipments. This is due to its relative importance as a major international market. Portland registers the next highest value at approximately $813 per resident, annually. All other regions of interest here account for under $100 per capita.



G.2.2 Analysis of Results: Future Year 2030 and 2045 Portland Electronics Industry Trends

This section reports on the percentage change growth in absolute dollar values of electronics industry flows for years 2030 and 2045 for the Portland region. The intent of this analysis is to identify electronics commodity flow growth rates that Portland can expect to materialize soon.

Chart 4 reports future electronics production flows for the Portland region. These commodity flows are expecting strong growth relative to year 2017 levels: nearly a 30% increase between years 2030 and 2045.

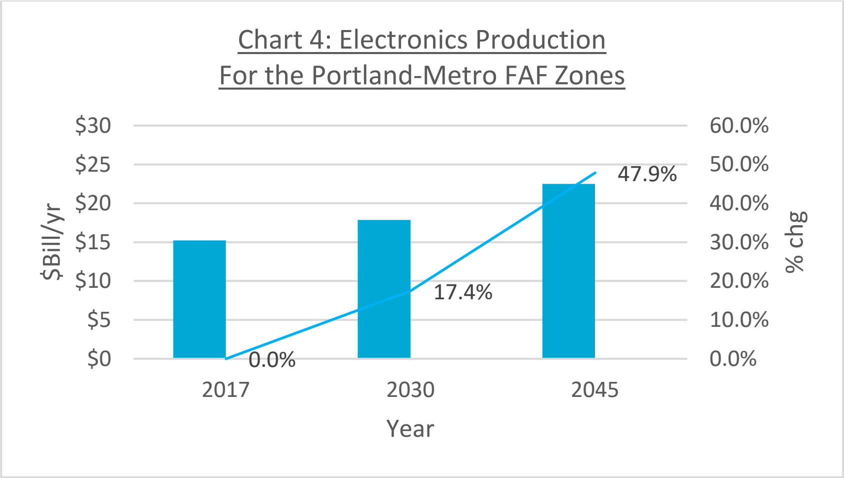


Chart 5 further illustrates strong growth patterns in Portland's electronics consumption flows. Electronics consumption grows over 20% in year 2030; and reports nearly a 65% increase in 2045 relative to year 2017.

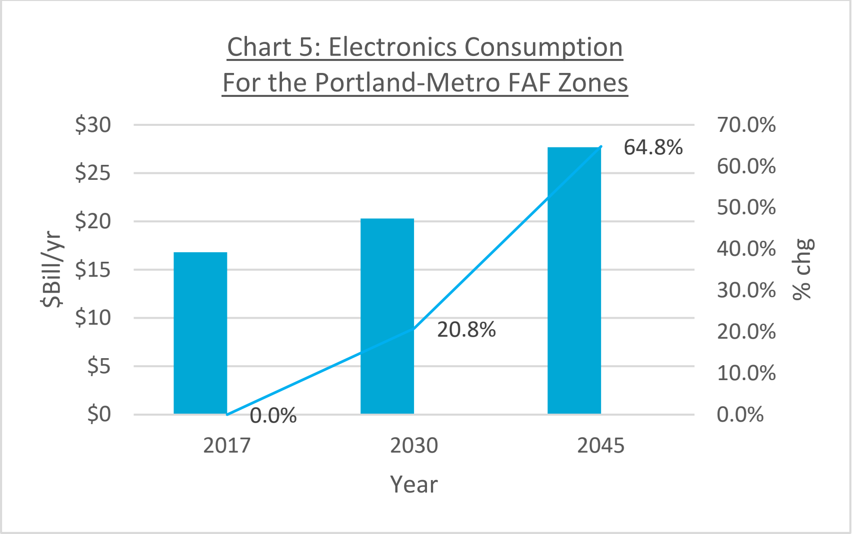
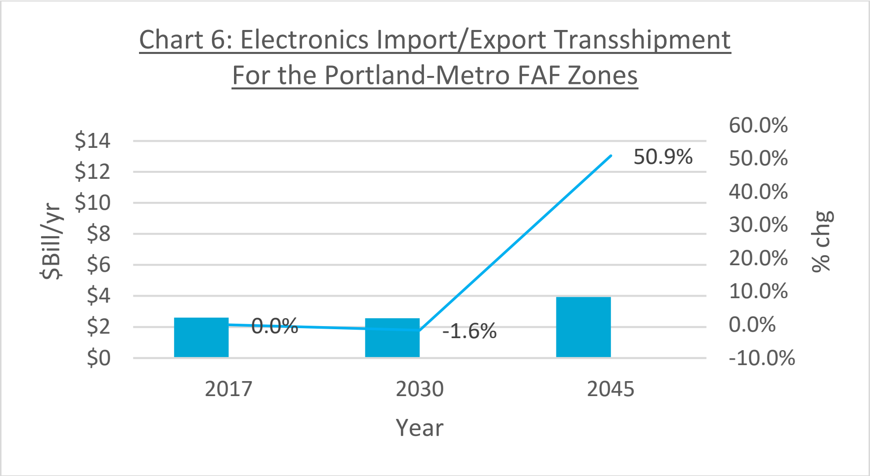


Chart 6 reports Portland area electronics transshipment flows (international imports and exports) increase by over 50% in year 2045; with interim year 2030 growth largely unchanged from 2017 levels.



G.2.3 Conclusions

This paper reports base and future year electronics industry flows as reported by the national 2017 FAF dataset. Summaries for the Portland region electronics production/consumption/ transshipments and for each of the additional metro areas are provided by year 2017. Additionally, electronics industry forecasts by movement type (production/consumption/transshipment) for the Portland region is summarized.

The data show significant electronics industry economic benefits to the Portland region. The impacts of these benefits are most notable in electronics consumption categories, reporting the third highest annual dollar value (by regions looked at in this analysis) at over $5,000 per Portland resident for year 2017. Future year trends indicate even stronger growth - near 65% growth by year 2045.

Portland benefits by being located near a major ship/rail/truck transshipment Port with a strong semi-conductor and electronics industry presence close-by. The significant growth expected in electronics industry flows that are to, from, within, and/or include transshipment in the Portland region will contribute to increased truck traffic and congestion on area roads. The importance of accurately accommodating and planning for these movements contribute to keeping competitive advantages Portland has relative to other regions.

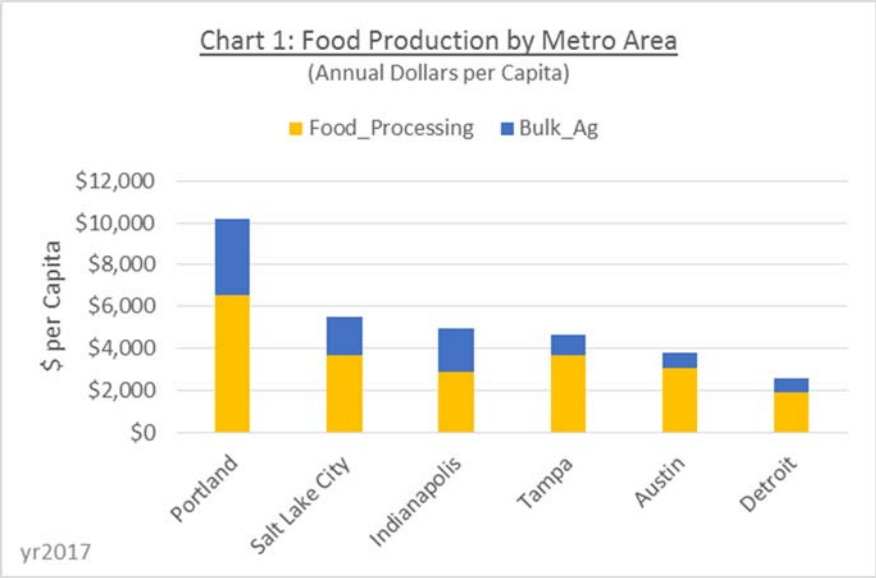
G.3 Commodity Model Analysis: Food

The purpose of this document is to provide a detailed analysis of food industry commodity flows. The analysis identifies food commodities by two groups - bulk agriculture and processed/finished food movements. Flows (by the two groups) will report net inflows and outflows of the food commodity groups to estimate food consumption and food processing flows in the region. This analysis uses the food commodity group as a starting point for discussion and potential usage with the project team.

This report uses the FHWA's current published version of the Freight Analysis Framework data, FAF version 5.4.1. This is based on the 2017 Commodity Flow Survey with the most recent refinements to data analysis and forecast assumptions. The FAF data breakdown commodities into Standard Classification of Transported Goods (SCTG) groups, of which there are 41. The food industry covers SCTGs 1-9. This work combined the 9 commodities into two groups: 1-4 (bulk and agricultural products) and 5-9 (processed food products). The analysis will conduct similar analyses for 5 other similarly size metropolitan areas for comparative purposes.

G.3.1 Analysis of Results: Base Year 2017 Food Industry Production/Consumption/Transshipments

Portland area food industry flows contribute considerable economic benefits per capita relative to comparison areas similar in size. Chart 1 shows annual dollars per capita (year 2017) of food production (by type) for each region. Food movements that begin in the Portland area are approximately double than those that begin in its closest competitor Salt Lake City, UT. This gap widens when compared to the 4 remaining regions, with Detroit reporting 25% of food production value per capita compared to the Portland region. Food processing (dark orange bars) in the Portland area accounts for the largest share, approximately two-thirds of all Food Production commodity flows.



Next, Chart 2 compares Food Consumption of bulk agricultural and processed foods that are destined to each region. These movements typically serve regional population food needs, as well as for further processing/finishing. Bulk agriculture (yellow bars) commodities help to account for Portland's large share in overall Food Consumption value relative to other regions. For example, Portland's food bulk agriculture is nearly 4 times the value per capita relative to the next highest valued Indianapolis, IN region.

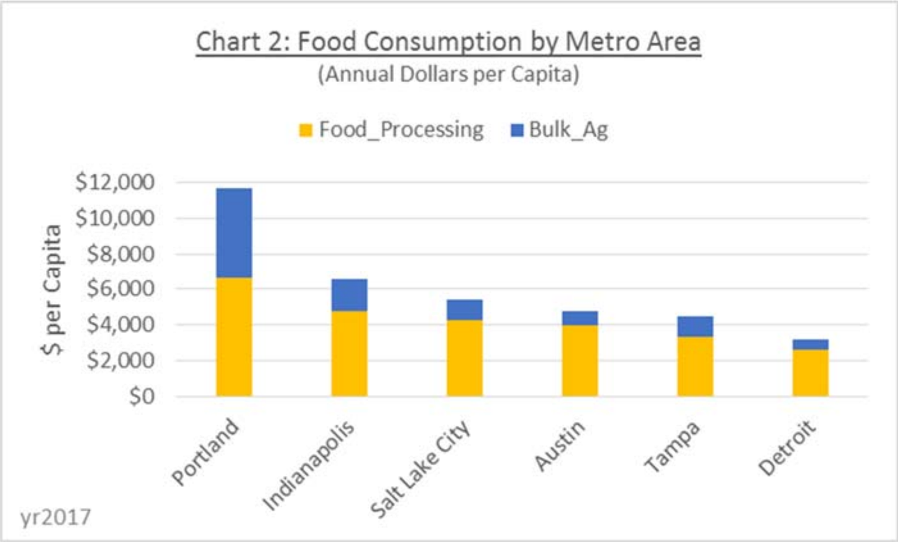
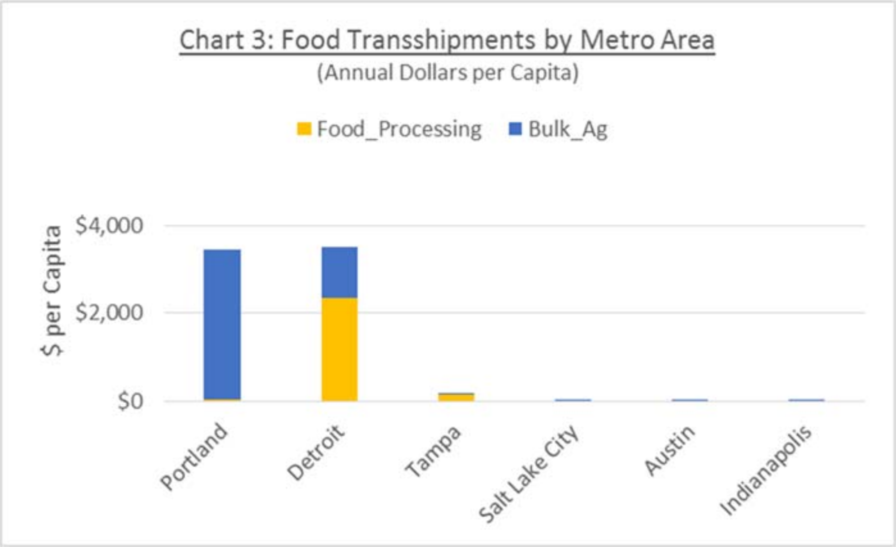


Chart 3 compares Food Transshipment among the regions of interest. These flows are typically internationally imported to the US or are flows from the US that are exported to international destinations. These commodity flows do not necessarily remain within the region. Results indicate Detroit, MI has the highest dollar per capita Food Industry transshipment values. This is due to its relative dominance within the Food Processing sector. Portland reports the next highest value at approximately $3,500 per capita, annually. Bulk agriculture transshipments (i.e., truck-rail, ship-truck multiple modes) account for nearly all Portland's transshipment value.



G.3.2 Analysis of Results: Future Year 2030 and 2045 Portland Food Industry Trends

This section reports on the percentage change growth in absolute dollar values of food industry flows for years 2030 and 2045 for the Portland region. The intent of this analysis is to identify food commodity flow growth rates that Portland can expect to materialize in the near future.

Chart 4 reports future growth of Food Production flows for the Portland region. These commodity flows are expect strong growth relative to year 2017 levels. Bulk agriculture sees a near 34% increase between years

2030 and 2045. Food Processing reports some of the largest growth trends among flows, recording near 30% growth in year 2030 and above 78% in year 2045 relative to year 2017.

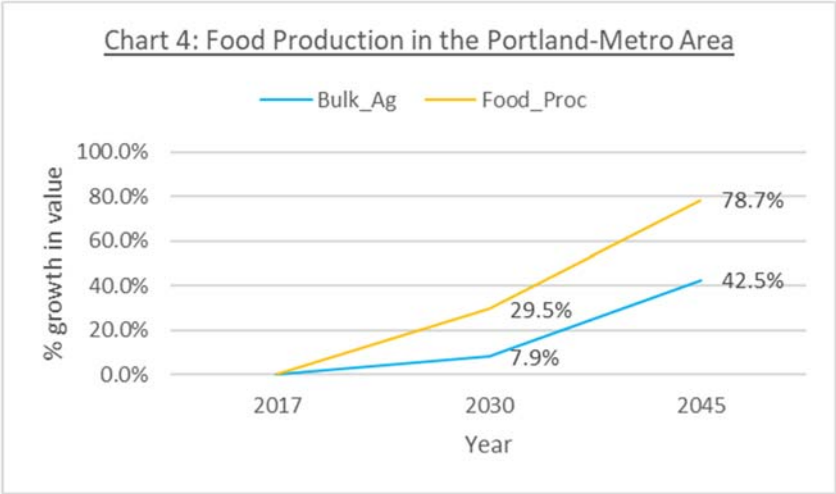


Chart 5 further illustrates strong growth patterns in Portland's Food Consumption flows. Bulk Agriculture growth is just under 10% growth in year 2030 and climbs to near 40% growth in 2045. Food Processing growth trends are even higher. Nearly 20% in year 2030 and over 50% increases in 2045 relative to year 2017.

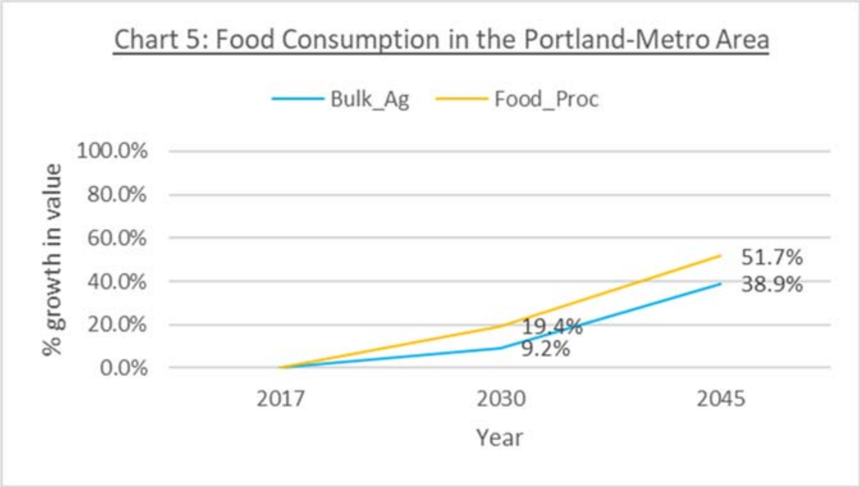
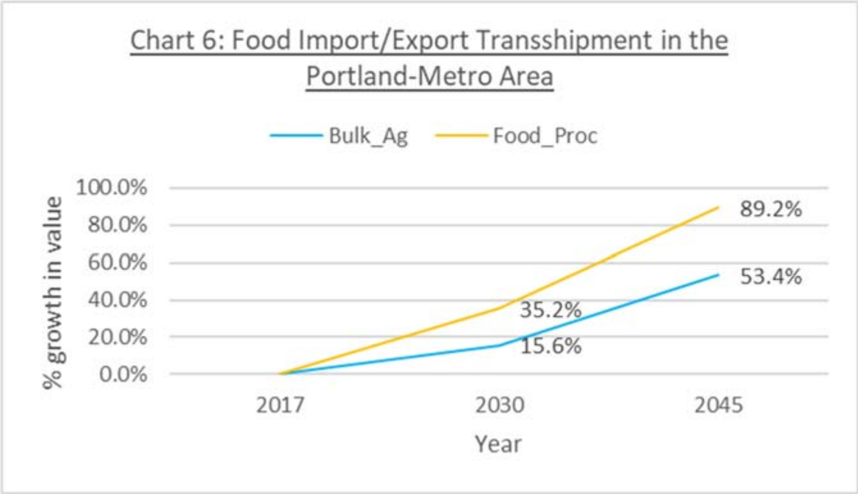


Chart 6 reports Portland area Food Transshipment flows (international imports and exports) grow at the highest rates relative to Food Production and Consumption flows. Bulk Agriculture transshipment flows increase by over 50% in year 2045, with interim year growth reported at over 15%. Food Processing category transshipments report near 50% growth between 2030 and 2045.



G.3.3 Conclusions

This paper reports base and future year food industry flows (split into bulk and food products groups) as reported by the national FAF dataset. Summaries for the Portland region food production/consumption/ transshipments and for each of the additional metro areas are provided by year 2017. Additionally, food industry forecasts by movement type (production/consumption/transshipment) for the Portland region is summarized.

The data show significant food industry economic benefits to the Portland region. The impacts of these benefits are most notable in food consumption and production categories, reporting the highest annual dollar value by region at over $20,000 per Portland resident for year 2017. Future year trends indicate even stronger growth. While Portland food transshipments (i.e., international imports and exports only) are smaller in dollars ($3,500 per capita) future trends make this the largest growth share (>50%) by category.

Portland benefits by being located near a major ship/rail/truck transshipment Port with a strong agricultural presence close-by. The significant growth expected in food industry flows that are to, from, within, and/or include transshipment in the Portland region will contribute to increased truck traffic and congestion on area roads. The importance of accurately accommodating and planning for these movements contribute to keeping competitive advantages Portland has relative to other regions.

G.4 Commodity Model Analysis: Motor Vehicles

The purpose of this document is to provide a detailed analysis of motor vehicle industry commodity movements. Flows will report net inflows and outflows of the motor vehicle industry commodity groups to estimate production, consumption and transshipment flows in the region. This analysis uses the motor vehicle commodity group as a starting point for discussion and potential usage with the project team.

This report uses the FHWA's current published version of the Freight Analysis Framework data, FAF version 5.4.1. This is based on the 2017 Commodity Flow Survey with the most recent refinements to data analysis and forecast assumptions. The FAF data breakdown commodities into Standard Classification of Transported Goods (SCTG) groups, of which there are 41. The motor vehicle industry covers SCTG code 36. This analysis will conduct similar analyses for 5 other similarly size metropolitan areas for comparative purposes.

G.4.1 Analysis of Results: Base Year 2017 Motor Vehicle Industry Production/Consumption/Transshipments

Detroit, MI (aka "Motor City") not surprisingly reports the highest motor vehicle production value per capita comparatively. Portland area motor vehicle industry flows contribute slightly fewer economic benefits per capita than Indianapolis, but are equivalent to Salt Lake City, UT in comparison. Chart 1 shows annual dollars per capita (year 2017) of motor vehicle production for each region. Motor vehicle industry movements (e.g. automobiles, auto parts and accessories) that begin in Portland are double than those that begin in Austin, TX or Tampa, FL.

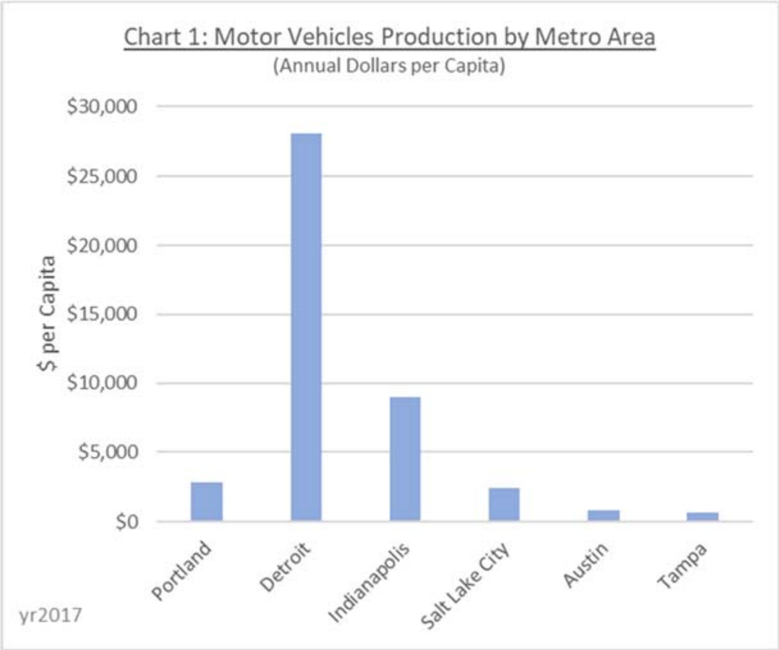


Chart 2 compares motor vehicle industry consumption flows destined to each region. These movements typically serve regional motor vehicle industry employment needs and further processing/finishing. Predictably the Detroit metropolitan area accounts for the largest share in overall motor vehicle consumption value relative to other regions. For example, Detroit's motor vehicle industry consumption value per capita is triple the value per capita ($25,000) relative to the next highest valued Indianapolis, IN region. Salt Lake City, Austin, and

Portland report the next largest motor vehicle consumption flows, respectively in year 2017. Portland's per capita value is reported at just under $3,000 annually.

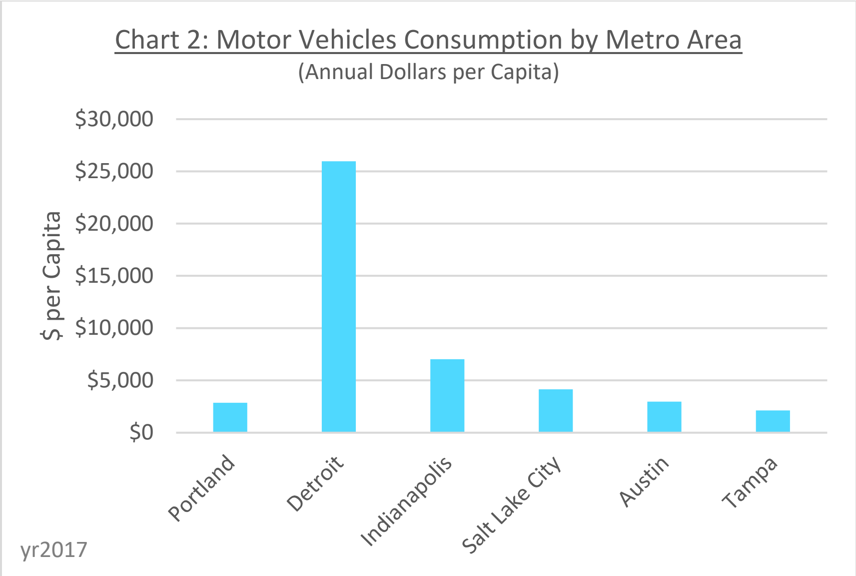
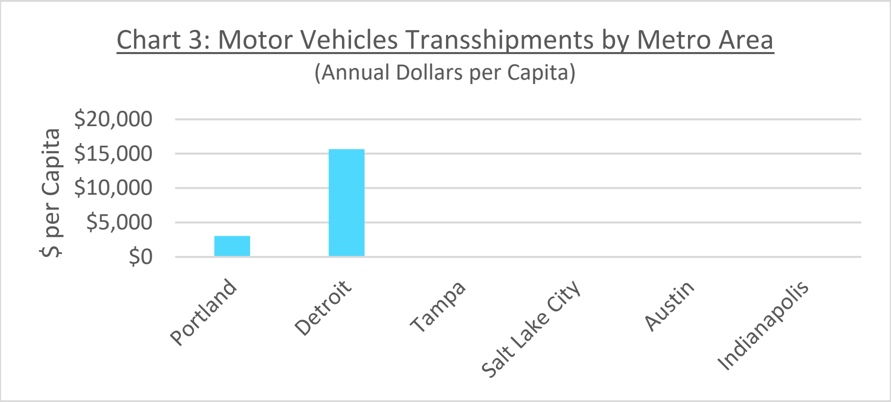


Chart 3 compares motor vehicle industry transshipments among the regions. These flows are typically internationally imported to the US; or are flows from the US that get exported to international destinations. These commodity flows do not necessarily remain within the region. With world headquarters for General Motors Corp., Ford Motor Co., DaimlerChrysler Corp., and Volkswagen of America Detroit, MI reports the highest dollar per capita annually motor vehicle transshipment value ($25,000 per capita). Portland reports the second highest value at approximately $3,000 per capita, annually.



G.4.2 Analysis of Results: Future Year 2030 and 2045 Portland Motor Vehicle Industry Trends

This section reports on the percentage change growth in absolute dollar values of motor vehicle industry flows for years 2030 and 2045 for the Portland region. The intent of this analysis is to identify commodity flow growth rates that Portland can expect to materialize in the future.

Chart 4 reports future growth of Motor Vehicle Production flows for the Portland region. Commodity flows expect strong growth trends: over 25% year 2017 levels in interim year 2030, and 66% by year 2045.

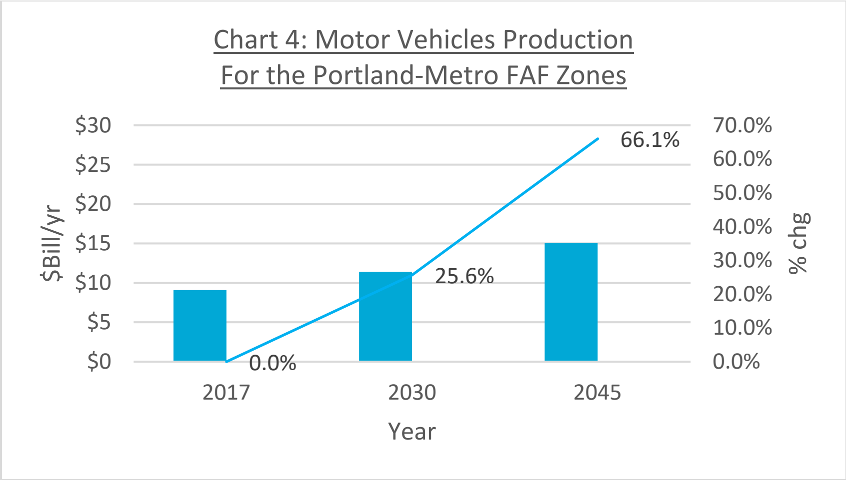


Chart 5 indicates strong growth patterns in Portland's motor vehicle consumption industry flows. Sector growth is approximately 30% by year 2030; and more than doubles to 68% of year 2017 levels by year 2045.

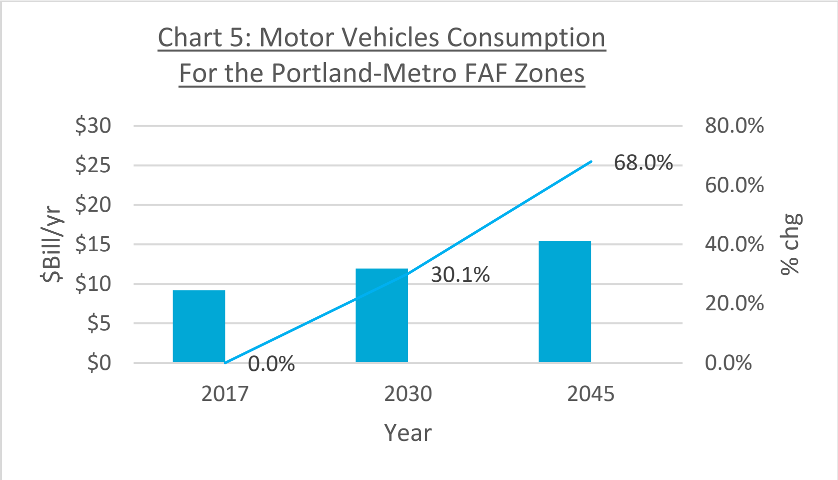
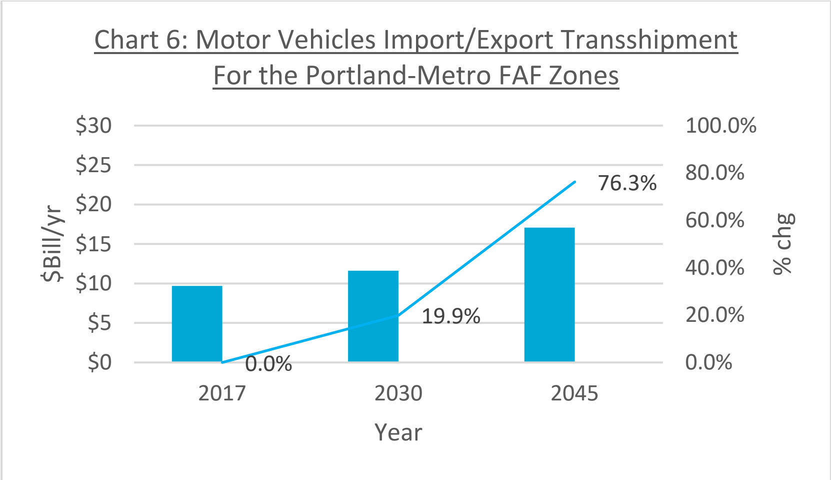


Chart 6 reports Portland area motor vehicle transshipment flows (international imports and exports) grow at the highest rates relative to their production and consumption industry flows. Transshipment motor vehicle flows increase by over 75% by year 2035, with interim year growth reported at over 19%.



G.4.3 Conclusions

This paper reports base and future year motor vehicle industry flows as reported by the national FAF dataset. Summaries for the Portland region motor vehicle production/consumption/transshipments for each of the additional metro areas are provided by year 2017. Additionally, motor vehicle industry forecasts by movement type (production/consumption/transshipment) for the Portland region is summarized.

The data show significant motor vehicle industry economic benefits to the Portland region. The impacts of these benefits are most notable in the motor vehicle transshipment category, reporting the highest annual dollar value by region at over $3,000 per Portland resident for year 2017. Future year trends indicate robust growth. These flows report the largest growth share by category at greater than 75%.

Long recognized as the heart of the American automotive industry, Detroit dominates much of the domestic motor vehicle industry commodity flows presented in this analysis. On a much smaller scale, Portland benefits by these flows as well. Located near a major ship/rail/truck transshipment the Port or Portland provides the region with a valuable economic asset in terms of supporting this sector's projected growth. These industry flows will contribute to increased truck traffic and congestion on Portland area roads. The importance of accurately accommodating and planning for these movements contribute to keeping competitive advantages inherent to Portland.

Regional Freight Delay and Commodities Movement Study

Appendix H: Congestion and Travel Time Reliability Analysis and Results

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Table of Contents

H.1 Purpose and Background

This memo summarizes work to develop a methodology and to calculate initial observed (rather than modeled) travel speed metrics for throughways and regional freight routes designated in the Regional Transportation Plan for the Portland metropolitan region. This work supports further testing and refinement of the draft Regional Mobility Policy (RMP) and research being conducted in support of the Regional Freight Delay and Commodities Movement Study (CMS) that is underway. Both efforts are part of the 2023 Regional Transportation Plan (RTP) update.

The Regional Mobility Policy is a policy in the RTP as well as the Oregon Highway Plan (OHP). It applies to transportation system planning and plan amendment processes within the Portland metropolitan area. The policy is used to identify transportation needs and solutions during updates to the RTP and local transportation system plans (TSPs), and to evaluate the potential impacts of local comprehensive plan amendments and zoning changes.

An update to the regional mobility policy has been underway since 2019, through a joint effort of Metro and the Oregon Department of Transportation (ODOT). In November and December 2022, JPACT and the Metro Council accepted the new draft policies and supported further development of the draft performance measures and targets during 2023 RTP system analysis in 2023. The draft regional mobility policy for the 2023 RTP identifies travel speed on throughways as one of three mobility performance measures. More information about the regional mobility policy update, including research that informed the draft travel speed targets for throughways can be found at:

- https://www.oregonmetro.gov/sites/default/files/2023/02/24/Draft-2023-RTP-Regional-mobility-policy-overview-Jan2023.pdf
- https://www.oregonmetro.gov/sites/default/files/2023/03/01/Regional-Mobility-Policy-Update-Reliability-Research-Process_0.pdf

In addition, the Regional Freight Delay and Commodities Movement Study is exploring how the global pandemic has caused disruptions to the movement of vital commodities, the supply chain, and retail shopping. The study identified regional mobility corridors that are carrying the highest volume and highest value of commodities, and how groups of certain types of commodities like food and electronics flow through the transportation system in the region. The study is exploring how e-commerce is impacting and benefiting the transportation system and regional economy, and how unreliability and mobility on the regional transportation system impacts commodity movement.

Both the draft regional mobility policy and the regional commodities movement study include travel speed-based performance metrics to identify transportation needs. Observed and modeled speed data will be used separately in each planning effort. This memo describes only observed data to document existing performance of the facilities evaluated.

H.1.1 Data and Methods Used in the Analysis

The methods and data described in this memo build on Metro's existing, ongoing work to calculate and report on National Highway System (NHS) and freight reliability performance metrics as required by the Moving Ahead for Progress in the 21st Century (MAP-21). All findings presented in this memo are based on 2019 data for the entire year, from January 1 to December 31, 2019.

Data

Speed data were drawn from the National Performance Management Research Data Set (NPMRDS, available only for the National Highway System [NHS]) and the commercial INRIX Speed dataset (access provided by ODOT). All data were accessed using the Regional Integrated Transportation Information System (RITIS) platform. While all speed data could be obtained from the commercial INRIX dataset, the NPMRDS was used where available due to its more clearly defined standards and methodology, and ongoing independent validation. Both data sources rely on cell phone location and vehicle navigation data to sample travel speeds.

NPMRDS and INRIX speed data are provided on the proprietary Traffic Message Channel (TMC) network. An initial step in this analysis included coding the RTP throughways and regional freight routes onto that network. In general, the analysis was limited to "mainline" (non-ramp) TMC links falling mostly inside the Metropolitan Planning Area (MPA).

Data were averaged over 15-minute intervals, following federal guidance for performance monitoring and reporting. NPMRDS contains only real-time data, with no missing value imputation. The INRIX data was filtered to keep only real-time speeds, again for consistency between data sources.

Methods

Methods were then developed to summarize 15-minute speed data into facility-based segments for each corridor.

The draft regional mobility policy proposes a target of no more than four hours per *week*day with average travel speeds under 35 miles per hour (controlled access freeways) or 20 miles per hour (non-freeways with traffic signals). An initial metric was created to capture that performance target. If average speeds fall below 35 mph for more than four hours in a day, it indicates the system is failing at that location and a transportation need exists. Additional time of day reliability measures were calculated to support CMS/freight performance needs.

RMP hours under speed threshold

As shown in Figure H.1, for each directional link, the average number of weekday hours that the observed speed fell under the minimum speed threshold was calculated.[1] Then, an average number of hours below the threshold for the entire segment was calculated by weighting each link by its length. An example segment-level result is provided in Figure H.2.

[1] excluding federal holidays

Figure H.1 Two I-84 segments (WB & EB) showing average hours per day under the speed threshold of 35mph for each TMC link

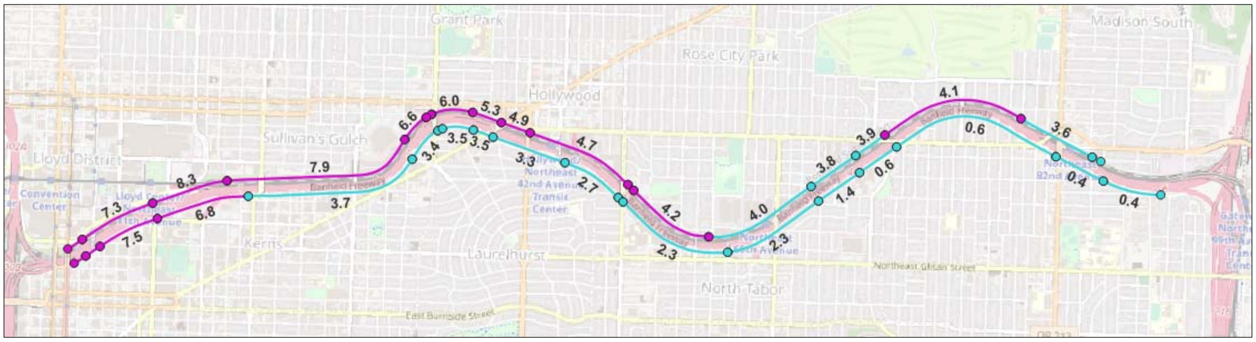
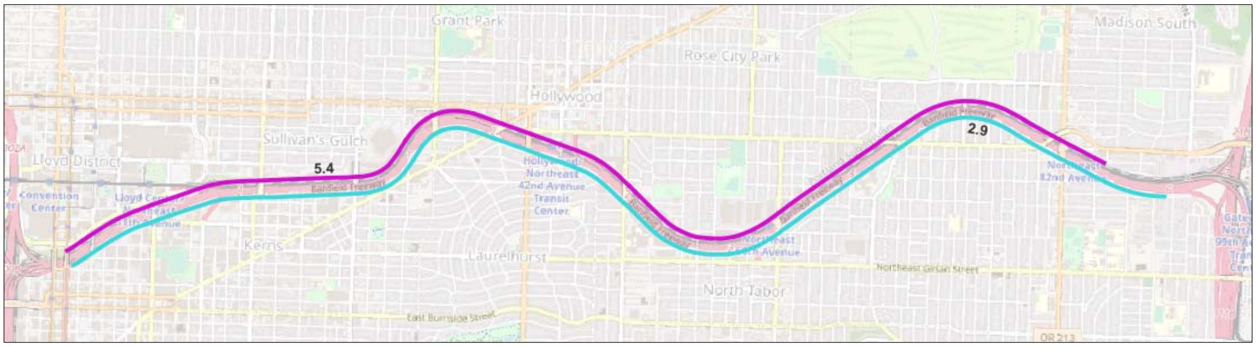


Figure H.2 Segment level hours per day in each direction for the same segments shown in Figure H.1



Seven out of forty-eight regional throughway segments listed in Table H.1 failed to meet the minimum speed threshold for 4 or more hours per weekday during 2019. Full results are in Sections H.3 and H.4.

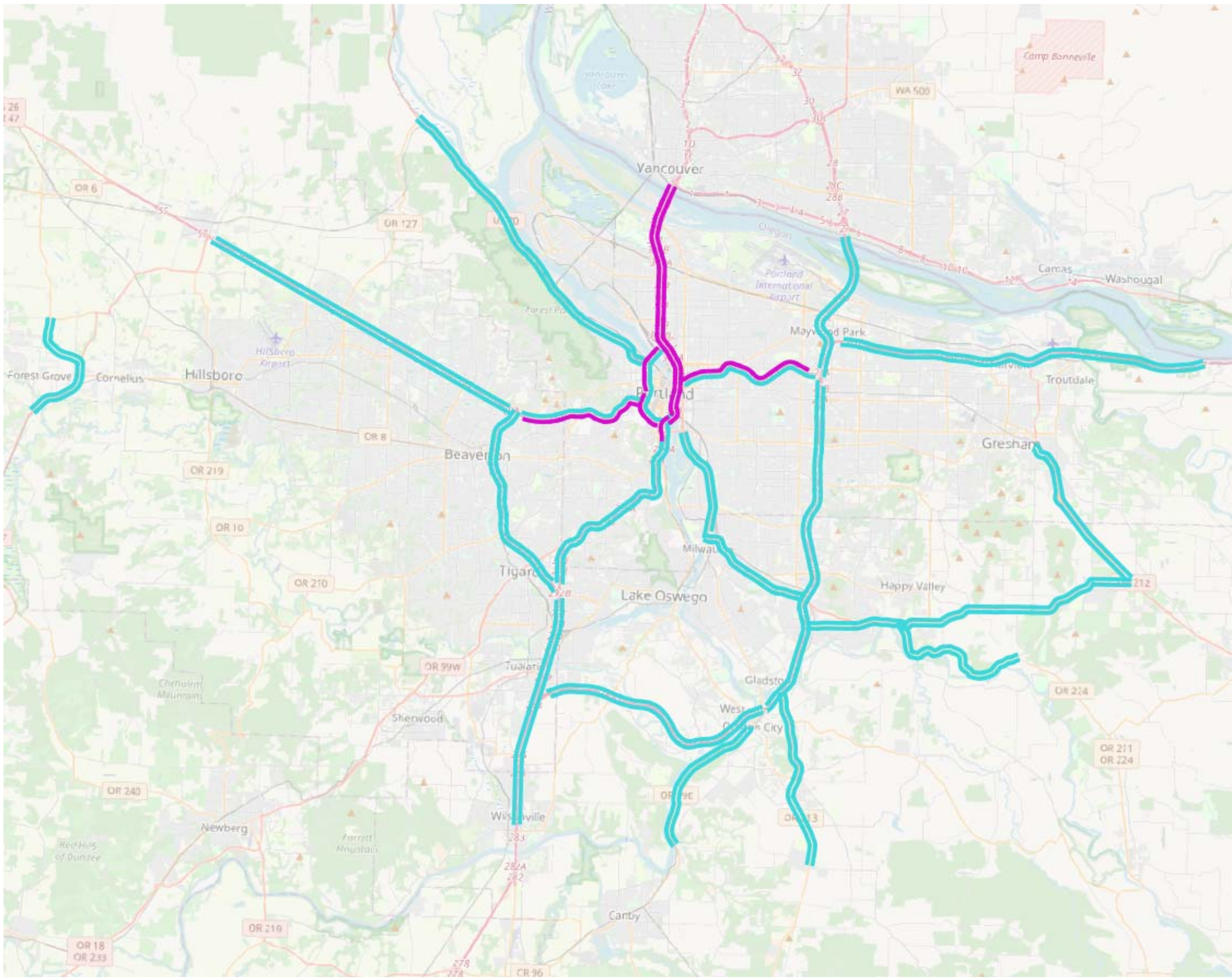
Table H.1 Regional throughway segments not meeting target (2019)

Segment	Dir	Miles[2]	Target speed (mph)	Hours below target speed
US 26 (I-405 to Highway 217)	E	4.2	35	8.9
I-5 (Fremont Bridge to Columbia River)	N	5.9	35	5.5
I-84 (I-5 to I-205)	W	4.6	35	5.4
I-5 (Fremont Br. to Marquam Br.)	N	2.2	35	5.4
I-5 (Fremont Br. to Marquam Br.)	S	3.1	35	4.8
I-5 (Fremont Bridge to Columbia River)	S	5.7	35	4.3
I-405 (Fremont Br. to Marquam Br.)	S	3.1	35	4.2

Figure H.3 maps out the locations (in purple) that are not meeting the target.

[2] Distance differs by direction due to TMC network segmentation and exclusion of on/off ramps.

Figure H.3 Speed performance of regional throughway system (2019, basemap data: OpenStreetMap)



H.2 CMS Travel Time Reliability Method and Summary

For all CMS corridor segments, we also calculated a modified version of the Truck Travel Time Reliability measure from NHS performance reporting:

- Divide travel speed data into five time bins[3]
    - o _am - 6 a.m. to 10 a.m. weekdays (Mon-Fri)
    - o _md - 10 a.m. to 4 p.m. weekdays (Mon-Fri)
    - o _pm - 4 p.m. to 8 p.m. weekdays (Mon-Fri)
    - o _we - 6 a.m. to 8 p.m. weekend days (Sat-Sun)
    - o _on - 8 p.m. and 6 a.m. for every day (Sun-Sat)

[3] Highway performance reporting for trucks is only on the Interstate highway system and uses truck-specific travel speeds when available. To maintain consistency, all vehicle speeds for all facilities were used, since truck-specific travel speeds are not available off the NHS system.

- For each of the five prescribed time periods, calculate 95th and 50th percentile speeds on each link[4]
- Take the ratio of the 50th (typical) to the 95th percentile speeds. The resulting number represents how many times faster typical travel is to congested travel on a link (e.g. a value of 2 means typical speeds are twice as fast as the congested speeds; or conversely, that congested travel times are 2 times that of typical times).
- Take the highest ratio (least reliable) over the five periods for each link
- Summarize over each mobility segment using a distance-weighted average ratio[5]

The 2018 RTP update established a maximum of 3.10 for the (un)reliability ratio on the regional Interstate highway system. Applying that ratio to CMS segments, 16 out of 102 directional segments failed to meet the criterion in 2019, as shown in Table . The full results are available in Section H.5.

Table H.2 Commodities Movement Study freight segments not meeting regional reliability target (2019)

Corridor	Segment	Dir	Miles[6]	Travel Time Reliability ratio
1	I-5 (Fremont Bridge to Columbia River)	N	5.88	5.24
4	I-5 (Fremont Br. to Marquam Br.)	N	2.22	4.74
3	I-5 (Highway 217 to Wilsonville Road)	S	7.73	4.50
1	N. Greeley Ave. - south of Going St. to N. Interstate Ave.	N	1.15	4.03
16	NW Front Ave. - NW 21st to NW 61st	N	2.45	3.88
4	I-405 (Fremont Br. to Marquam Br.)	N	3.22	3.83
16	NW Front Ave. - NW 21st to NW 61st	S	3.05	3.71
18	NE 47th/NE Cornfoot Road - Columbia Blvd. to NE Alderwood	N	1.97	3.67
1	N. Interstate Ave. - south of Going St. to N. Greeley Ave.	S	0.87	3.64
2	I-5 (I-405 to Highway 217)	N	7.72	3.62
1	I-5 (Fremont Bridge to Columbia River)	S	5.70	3.61
1	N. Greeley Ave. - south of Going St. to N. Interstate Ave.	S	1.13	3.52
1	N. Interstate Ave. - south of Going St. to N. Greeley Ave.	N	0.88	3.43
13	US 26 (I-405 to Highway 217)	E	4.16	3.36
17	St. Johns Bridge and N. Ivanhoe St. to N. St. Louis Ave.	S	0.94	3.30
12	Highway 217 (US 26 to I-5)	S	7.05	3.14

[4] The ratio of 50th (median) to 95th percentile speed corresponds identically to the federal procedure that uses 95th and 50th percentile travel *times*. Speeds are presented for consistency with the regional performance target units.

[5] Time period summaries are also provided to help identify when reliability is poor.

[6] Distance differs by direction due to TMC network segmentation and exclusion of on/off ramps.

H.3 Full Results for Regional Throughways

Table H.2 provides full results of the speed analysis for regional throughways. Results are also available as a sortable digital appendix (link).

Table H.2 Regional throughway segment speed analysis full results (2019)

Segment	Dir	Miles[7]	Target speed (mph)	Hours below target speed
I-5 (Fremont Bridge to Columbia River)	**N**	**5.88**	**35**	**5.49**
I-5 (Fremont Bridge to Columbia River)	**S**	**5.70**	**35**	**4.34**
I-5 (I-405 to Highway 217)	N	7.72	35	3.35
I-5 (I-405 to Highway 217)	S	6.96	35	0.45
I-5 (Highway 217 to Wilsonville Road)	N	7.76	35	0.97
I-5 (Highway 217 to Wilsonville Road)	S	7.73	35	2.40
I-405 (Fremont Br. to Marquam Br.)	N	3.22	35	3.22
I-405 (Fremont Br. to Marquam Br.)	**S**	**3.09**	**35**	**4.22**
I-5 (Fremont Br. to Marquam Br.)	**N**	**2.22**	**35**	**5.45**
I-5 (Fremont Br. to Marquam Br.)	**S**	**3.15**	**35**	**4.82**
I-84 (I-5 to I-205)	E	4.90	35	2.91
I-84 (I-5 to I-205)	**W**	**4.64**	**35**	**5.45**
I-84 (I-205 to NE Marine Dr. in Troutdale)	E	7.22	35	0.07
I-84 (I-205 to NE Marine Dr. in Troutdale)	W	7.10	35	0.87
I-205 (I-84 to Glen Jackson Bridge)	N	5.23	35	3.03
I-205 (I-84 to Glen Jackson Bridge)	S	4.96	35	1.72
I-205 (I-84 to Highway 99E)	N	11.50	35	2.64
I-205 (I-84 to Highway 99E)	S	11.60	35	1.63
I-205 (Highway 99E to I-5)	E	8.14	35	3.04
I-205 (Highway 99E to I-5)	W	8.27	35	0.59
Highway 217 (US 26 to I-5)	N	6.75	35	2.31
Highway 217 (US 26 to I-5)	S	7.05	35	3.24
US 26 (I-405 to Highway 217)	**E**	**4.16**	**35**	**8.93**
US 26 (I-405 to Highway 217)	W	4.24	35	0.61
US 26 (Highway 217 to NW Glencoe Road)	E	11.60	35	0.87
US 26 (Highway 217 to NW Glencoe Road)	W	11.37	35	0.54
US 30/ NW Yeon Ave. - I-405 to NW Cornelius Pass Road	N	11.09	20	0.31
US 30/ NW Yeon Ave. - I-405 to NW Cornelius Pass Road	S	11.74	20	0.48
SE McLoughlin Blvd (Highway 99E) - SE Powell Blvd. to Highway 224	N	3.54	20	0.79
SE McLoughlin Blvd (Highway 99E) - SE Powell Blvd. to Highway 224	S	3.81	20	0.70
Highway 224 (Highway 99E to I-205)	W	4.01	20	0.83
Highway 224 (Highway 99E to I-205)	E	4.01	20	1.00
Highway 224/212 - I-205 to SE 242nd	E	7.83	20	1.40
Highway 224/212 - I-205 to SE 242nd	W	7.83	20	1.23
Highway 212 in Damascus from SE 242nd Avenue to US 26 (Mount Hood Hwy.)	E	3.67	20	0.56
Highway 212 in Damascus from SE 242nd Avenue to US 26 (Mount Hood Hwy.)	W	3.67	20	0.72

[7] Distance differs by direction due to TMC network segmentation and exclusion of on/off ramps.

Segment	**Dir**	**Miles[7]**	**Target speed (mph)**	**Hours below target speed**
Highway 213 from I-205 to S. Leland Road	N	6.11	20	0.65
Highway 213 from I-205 to S. Leland Road	S	6.11	20	0.62
Highway 224 (Clackamas Highway) from Highway 212 to 232nd Drive	N	5.57	35	3.00
Highway 224 (Clackamas Highway) from Highway 212 to 232nd Drive	S	5.57	35	1.80
Highway 47 (OR 47) w/in MPA boundary	N	4.65	35	2.13
Highway 47 (OR 47) w/in MPA boundary	S	4.65	35	1.89
Highway 99E (OR 99E) from 6th Street in Oregon City to South End Road	N	5.19	20	0.23
Highway 99E (OR 99E) from 6th Street in Oregon City to South End Road	S	5.19	20	0.24
I-84 in Troutdale from SE 257th Drive (west of Sandy River) to MPA boundary east of Troutdale OR	E	5.22	35	0.07
I-84 in Troutdale from SE 257th Drive (west of Sandy River) to MPA boundary east of Troutdale OR	W	5.24	35	0.03
US 26 from SE Hogan Road (SE 242nd) in Gresham to Highway 212	N	5.63	20	0.64
US 26 from SE Hogan Road (SE 242nd) in Gresham to Highway 212	S	5.62	20	0.32

Bold font indicates segment that did not meet the target

H.4 Selected Freight Mobility Corridors from Commodities Movement Study – Speed Results

Table H.3 provides full results of the speed analysis for selected regional freight mobility corridor segments that were included in the Commodities Movement Study. Complete segment-level results are also provided in a digital appendix (link). This includes most of the regional throughways and additional links of specific importance to freight, such as intermodal connectors. Included are 21 out of 102 directional segments that did not meet the speed criterion.

Table H.3 Commodities Movement Study freight segment speed analysis results (2019)

Corridor	Segment	Dir	Miles[8]	Min speed (mph)	Hours below min speed
1	**I-5 (Fremont Bridge to Columbia River)**	**N**	**5.88**	**35**	**5.49**
1	**I-5 (Fremont Bridge to Columbia River)**	**S**	**5.70**	**35**	**4.34**
1	Martin Luther King Jr. Blvd. - north of Columbia Blvd. to Marine Drive	N	1.90	20	0.74
1	Martin Luther King Jr. Blvd. - north of Columbia Blvd. to Marine Drive	S	1.90	20	1.85
1	N. Greeley Ave. - south of Going St. to N. Interstate Ave.	N	1.15	30	2.44

[8] Distance differs by direction due to TMC network segmentation and exclusion of on/off ramps.

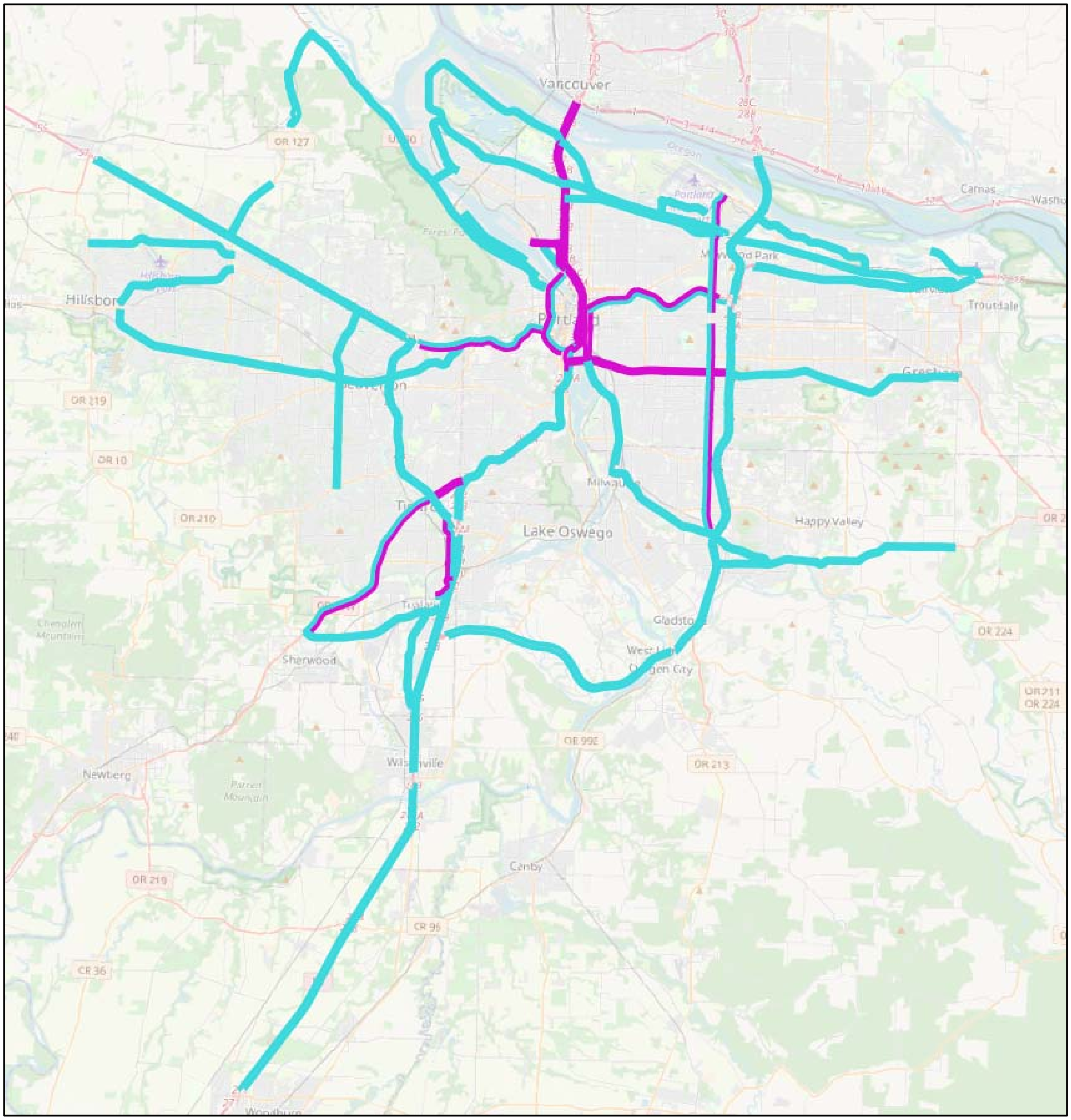
Corridor	Segment	Dir	Miles[8]	Min speed (mph)	Hours below min speed
1	N. Greeley Ave. - south of Going St. to N. Interstate Ave.	S	1.13	30	1.63
1	**N. Interstate Ave. - south of Going St. to N. Greeley Ave.**	**N**	**0.88**	**20**	**8.78**
1	**N. Interstate Ave. - south of Going St. to N. Greeley Ave.**	**S**	**0.87**	**20**	**6.67**
2	I-5 (I-405 to Highway 217)	N	7.72	35	3.35
2	I-5 (I-405 to Highway 217)	S	6.96	35	0.45
2	**OR99W/Barbur Blvd. (I-5 to Highway 217)**	**N**	**0.96**	**20**	**4.23**
2	**OR99W/Barbur Blvd. (I-5 to Highway 217)**	**S**	**0.96**	**20**	**7.98**
3	I-5 (Highway 217 to Wilsonville Road)	N	7.76	35	0.97
3	I-5 (Highway 217 to Wilsonville Road)	S	7.73	35	2.40
3	SW 72nd Ave./SW Upper Boones Ferry Road - Highway 217 to SW Boones Ferry Road	N	2.85	20	3.86
3	**SW 72nd Ave./SW Upper Boones Ferry Road - Highway 217 to SW Boones Ferry Road**	**S**	**2.85**	**20**	**4.53**
3	SW Boones Ferry Road - Tualatin-Sherwood Road to I-5 (in Wilsonville)	N	3.21	20	1.58
3	SW Boones Ferry Road - Tualatin-Sherwood Road to I-5 (in Wilsonville)	S	3.21	20	1.50
4	I-405 (Fremont Br. to Marquam Br.)	N	3.22	35	3.22
4	**I-405 (Fremont Br. to Marquam Br.)**	**S**	**3.09**	**35**	**4.22**
4	**I-5 (Fremont Br. to Marquam Br.)**	**N**	**2.22**	**35**	**5.45**
4	**I-5 (Fremont Br. to Marquam Br.)**	**S**	**3.15**	**35**	**4.82**
4	**Martin Luther King Jr. Blvd./Grand Ave. - I-84 to SE Powell Blvd.**	**N**	**1.58**	**20**	**13.86**
4	**Martin Luther King Jr. Blvd./Grand Ave. - I-84 to SE Powell Blvd.**	**S**	**1.58**	**20**	**5.47**
5	I-84 (I-5 to I-205)	E	4.90	35	2.91
5	**I-84 (I-5 to I-205)**	**W**	**4.64**	**35**	**5.45**
5	**SE Powell Blvd. - Ross Island Bridge to I-205**	**E**	**5.19**	**20**	**6.27**
5	**SE Powell Blvd. - Ross Island Bridge to I-205**	**W**	**5.19**	**20**	**6.58**
6	I-84 (I-205 to NE Marine Dr. in Troutdale)	E	7.22	35	0.07
6	I-84 (I-205 to NE Marine Dr. in Troutdale)	W	7.10	35	0.87
6	NE Airport Way - I-205 to NE 181st Ave.	E	4.13	20	1.55
6	NE Airport Way - I-205 to NE 181st Ave.	W	4.23	20	1.67
6	NE Marine Drive - NE 238th Ave. to I-84	E	1.80	20	0.10
6	NE Marine Drive - NE 238th Ave. to I-84	W	1.80	20	0.05
6	NE Sandy Blvd. - I-205 to NE 238th Ave.	E	7.17	20	2.26
6	NE Sandy Blvd. - I-205 to NE 238th Ave.	W	7.17	20	2.48
6	SE Powell Blvd. - I-205 to SE 242nd/Hogan Road	E	7.63	20	2.60
6	SE Powell Blvd. - I-205 to SE 242nd/Hogan Road	W	7.63	20	3.16
7	I-205 (I-84 to Glen Jackson Bridge)	N	5.23	35	3.03
7	I-205 (I-84 to Glen Jackson Bridge)	S	4.96	35	1.72
7	**NE 82nd Avenue (NE Airport Way to SE Stark St.)**	**N**	**4.34**	**20**	**4.17**
7	NE 82nd Avenue (NE Airport Way to SE Stark St.)	S	4.34	20	3.65
8	I-205 (I-84 to Highway 99E)	N	11.50	35	2.64
8	I-205 (I-84 to Highway 99E)	S	11.60	35	1.63
8	**SE 82nd Avenue (SE Stark St. to Highway 224)**	**N**	**6.55**	**20**	**4.67**
8	SE 82nd Avenue (SE Stark St. to Highway 224)	S	6.55	20	3.63
10	I-205 (Highway 99E to I-5)	E	8.14	35	3.04
10	I-205 (Highway 99E to I-5)	W	8.27	35	0.59

Corridor	Segment	Dir	Miles[8]	Min speed (mph)	Hours below min speed
11	**Highway 99W - Highway 217 to Tualatin Sherwood Road**	**N**	**6.28**	**20**	**4.07**
11	Highway 99W - Highway 217 to Tualatin Sherwood Road	S	6.28	20	3.14
11	Tualatin Sherwood Road - SW Boones Ferry Road to Highway 99W	E	4.49	20	1.35
11	Tualatin Sherwood Road - SW Boones Ferry Road to Highway 99W	W	4.49	20	2.38
12	Highway 217 (US 26 to I-5)	N	6.75	35	2.31
12	Highway 217 (US 26 to I-5)	S	7.05	35	3.24
12	Murray Blvd. US 26 to SW Scholls Ferry Road	N	5.84	20	3.23
12	Murray Blvd. US 26 to SW Scholls Ferry Road	S	5.84	20	3.44
13	Canyon Road/OR 8 (US 26 to Highway 217)	E	2.57	20	0.99
13	Canyon Road/OR 8 (US 26 to Highway 217)	W	2.57	20	1.19
13	**US 26 (I-405 to Highway 217)**	**E**	**4.16**	**35**	**8.93**
13	US 26 (I-405 to Highway 217)	W	4.24	35	0.61
14	Highway 8 Highway 217 to SW Baseline (Hillsboro)	N	9.43	20	3.44
14	Highway 8 Highway 217 to SW Baseline (Hillsboro)	S	9.43	20	3.40
14	NE Cornell Road - Cornelius Pass Road to SW Baseline (Hillsboro)	N	4.06	20	1.88
14	NE Cornell Road - Cornelius Pass Road to SW Baseline (Hillsboro)	S	4.06	20	2.69
14	NE Evergreen Road - Cornelius Pass Road to NW Glencoe Road	E	4.84	20	0.29
14	NE Evergreen Road - Cornelius Pass Road to NW Glencoe Road	W	4.83	20	0.44
14	NW Cornelius Pass Road - US 26 to NW Germantown Road	N	2.11	20	1.25
14	NW Cornelius Pass Road - US 26 to NW Germantown Road	S	2.03	20	1.00
14	US 26 (Highway 217 to NW Glencoe Road)	E	11.60	35	0.87
14	US 26 (Highway 217 to NW Glencoe Road)	W	11.37	35	0.54
16	NW Cornelius Pass Road - US 30 to NW Skyline Road	N	3.53	20	0.20
16	NW Cornelius Pass Road - US 30 to NW Skyline Road	S	3.53	20	0.06
16	NW Front Ave. - NW 21st to NW 61st	N	2.45	20	3.13
16	NW Front Ave. - NW 21st to NW 61st	S	3.05	20	2.16
16	US 30/ NW Yeon Ave. - I-405 to NW Cornelius Pass Road	N	11.09	20	0.31
16	US 30/ NW Yeon Ave. - I-405 to NW Cornelius Pass Road	S	11.74	20	0.48
17	**N Going St. - I-5 to Swan Island**	**E**	**0.99**	**20**	**4.87**
17	**N Going St. - I-5 to Swan Island**	**W**	**0.99**	**20**	**6.19**
17	N Lombard St. - N St. Louis Ave. to N. Terminal Road (Terminal 4)	N	2.01	20	2.08
17	N Lombard St. - N St. Louis Ave. to N. Terminal Road (Terminal 4)	S	2.01	20	2.90
17	N. Columbia Blvd/N Lombard St - I-5 to N Rivergate Blvd. (Terminal 5)	W	7.08	30	2.83
17	N. Columbia Blvd/N Lombard St - I-5 to N Rivergate Blvd. (Terminal 5)	E	7.08	30	3.28
17	N. Marine Drive - I-5 to N. Lombard St. @ Terminal 5 (Terminal 5 and 6)	E	4.50	30	3.45

Corridor	Segment	Dir	Miles[8]	Min speed (mph)	Hours below min speed
17	N. Marine Drive - I-5 to N. Lombard St. @ Terminal 5 (Terminal 5 and 6)	W	4.50	30	1.60
17	St. Johns Bridge and N. Ivanhoe St. to N. St. Louis Ave.	N	0.94	20	2.04
17	St. Johns Bridge and N. Ivanhoe St. to N. St. Louis Ave.	S	0.94	20	2.34
18	NE 47th/NE Cornfoot Road - Columbia Blvd. to NE Alderwood	N	1.97	20	0.78
18	NE 47th/NE Cornfoot Road - Columbia Blvd. to NE Alderwood	S	1.97	20	0.56
18	NE Columbia Blvd. - I-5 to I-205	N	5.28	20	2.09
18	NE Columbia Blvd. - I-5 to I-205	S	5.22	20	2.20
18	NE Lombard St. (Highway 30B) - Martin Luther King Jr. Blvd. to NE 82nd Ave.	E	4.97	20	1.29
18	NE Lombard St. (Highway 30B) - Martin Luther King Jr. Blvd. to NE 82nd Ave.	W	4.97	20	0.99
21	SE McLoughlin Blvd (Highway 99E) - SE Powell Blvd. to Highway 224	N	3.54	20	0.79
21	SE McLoughlin Blvd (Highway 99E) - SE Powell Blvd. to Highway 224	S	3.81	20	0.70
22	Highway 224 (Highway 99E to I-205)	W	4.01	20	0.83
22	Highway 224 (Highway 99E to I-205)	E	4.01	20	1.00
22	SE International Way/Lake Road - SE 37th to Highway 224	E	0.77	20	NA
22	SE International Way/Lake Road - SE 37th to Highway 224	W	0.77	20	NA
23	Highway 224/212 - I-205 to SE 242nd	E	7.83	20	1.40
23	Highway 224/212 - I-205 to SE 242nd	W	7.83	20	1.23
23	Sunrise Highway (Hwy 224) - I-205 to SE 122nd	W	1.94	20	0.41
23	Sunrise Highway (Hwy 224) - I-205 to SE 122nd	E	1.94	20	0.61
99	I-5 (Wilsonville at Willamette River to Woodburn at Highway 211)	N	11.39	35	0.28
99	I-5 (Wilsonville at Willamette River to Woodburn at Highway 211)	S	11.32	35	0.20

Bold font indicates segment that did not meet the target

Figure H.4 Selected regional freight mobility corridor segments not meeting regional speed performance target (2019, basemap data: OpenStreetMap)



H.5 Selected Freight Mobility Corridors from Commodities Movement Study – Reliability Results

Table H.4 provides full results for the travel speed reliability analysis. Complete segment-level results by time of day are provided in a digital appendix (link).

Table H.4 Commodities Movement Study freight segment reliability analysis results (2019)

Corridor	Segment	Dir	Miles[9]	Travel Time Reliability ratio
1	**I-5 (Fremont Bridge to Columbia River)**	**N**	**5.88**	**5.24**
1	**I-5 (Fremont Bridge to Columbia River)**	**S**	**5.70**	**3.61**
1	Martin Luther King Jr. Blvd. - north of Columbia Blvd. to Marine Drive	N	1.90	2.09
1	Martin Luther King Jr. Blvd. - north of Columbia Blvd. to Marine Drive	S	1.90	2.11
1	**N. Greeley Ave. - south of Going St. to N. Interstate Ave.**	**N**	**1.15**	**4.03**
1	**N. Greeley Ave. - south of Going St. to N. Interstate Ave.**	**S**	**1.13**	**3.52**
1	**N. Interstate Ave. - south of Going St. to N. Greeley Ave.**	**N**	**0.88**	**3.43**
1	**N. Interstate Ave. - south of Going St. to N. Greeley Ave.**	**S**	**0.87**	**3.64**
2	**I-5 (I-405 to Highway 217)**	**N**	**7.72**	**3.62**
2	I-5 (I-405 to Highway 217)	S	6.96	1.27
2	OR99W/Barbur Blvd. (I-5 to Highway 217)	N	0.96	1.78
2	OR99W/Barbur Blvd. (I-5 to Highway 217)	S	0.96	1.93
3	I-5 (Highway 217 to Wilsonville Road)	N	7.76	2.34
3	**I-5 (Highway 217 to Wilsonville Road)**	**S**	**7.73**	**4.50**
3	SW 72nd Ave./SW Upper Boones Ferry Road - Highway 217 to SW Boones Ferry Road	N	2.85	1.49
3	SW 72nd Ave./SW Upper Boones Ferry Road - Highway 217 to SW Boones Ferry Road	S	2.85	1.71
3	SW Boones Ferry Road - Tualatin-Sherwood Road to I-5 (in Wilsonville)	N	3.21	1.45
3	SW Boones Ferry Road - Tualatin-Sherwood Road to I-5 (in Wilsonville)	S	3.21	1.71
4	**I-405 (Fremont Br. to Marquam Br.)**	**N**	**3.22**	**3.83**
4	I-405 (Fremont Br. to Marquam Br.)	S	3.09	3.03
4	**I-5 (Fremont Br. to Marquam Br.)**	**N**	**2.22**	**4.74**
4	I-5 (Fremont Br. to Marquam Br.)	S	3.15	2.91
4	Martin Luther King Jr. Blvd./Grand Ave. - I-84 to SE Powell Blvd.	N	1.58	2.68
4	Martin Luther King Jr. Blvd./Grand Ave. - I-84 to SE Powell Blvd.	S	1.58	2.83
5	I-84 (I-5 to I-205)	E	4.90	1.83
5	I-84 (I-5 to I-205)	W	4.64	3.08
5	SE Powell Blvd. - Ross Island Bridge to I-205	E	5.19	2.11
5	SE Powell Blvd. - Ross Island Bridge to I-205	W	5.19	2.13
6	I-84 (I-205 to NE Marine Dr. in Troutdale)	E	7.22	1.10
6	I-84 (I-205 to NE Marine Dr. in Troutdale)	W	7.10	2.27
6	NE Airport Way - I-205 to NE 181st Ave.	E	4.13	1.32
6	NE Airport Way - I-205 to NE 181st Ave.	W	4.23	1.66

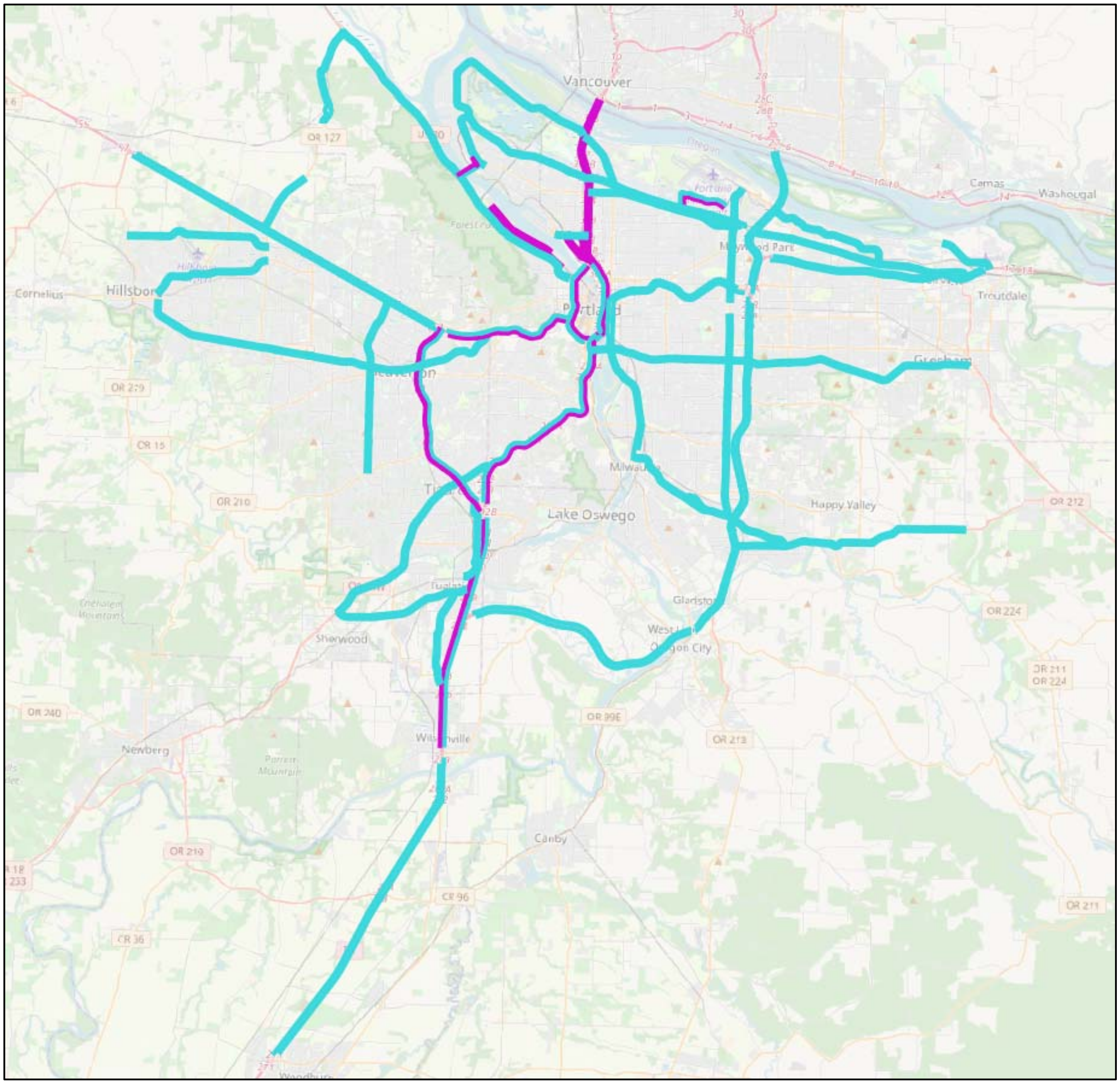
[9] Distance differs by direction due to TMC network segmentation and exclusion of on/off ramps.

Corridor	Segment	Dir	Miles[9]	Travel Time Reliability ratio
6	NE Marine Drive - NE 238th Ave. to I-84	E	1.80	1.27
6	NE Marine Drive - NE 238th Ave. to I-84	W	1.80	1.16
6	NE Sandy Blvd. - I-205 to NE 238th Ave.	E	7.17	2.31
6	NE Sandy Blvd. - I-205 to NE 238th Ave.	W	7.17	2.33
6	SE Powell Blvd. - I-205 to SE 242nd/Hogan Road	E	7.63	2.14
6	SE Powell Blvd. - I-205 to SE 242nd/Hogan Road	W	7.63	2.34
7	I-205 (I-84 to Glen Jackson Bridge)	N	5.23	2.49
7	I-205 (I-84 to Glen Jackson Bridge)	S	4.96	3.05
7	NE 82nd Avenue (NE Airport Way to SE Stark St.)	N	4.34	2.39
7	NE 82nd Avenue (NE Airport Way to SE Stark St.)	S	4.34	2.26
8	I-205 (I-84 to Highway 99E)	N	11.50	2.79
8	I-205 (I-84 to Highway 99E)	S	11.60	3.01
8	SE 82nd Avenue (SE Stark St. to Highway 224)	N	6.55	2.53
8	SE 82nd Avenue (SE Stark St. to Highway 224)	S	6.55	2.59
10	I-205 (Highway 99E to I-5)	E	8.14	2.78
10	I-205 (Highway 99E to I-5)	W	8.27	1.50
11	Highway 99W - Highway 217 to Tualatin Sherwood Road	N	6.28	2.17
11	Highway 99W - Highway 217 to Tualatin Sherwood Road	S	6.28	2.27
11	Tualatin Sherwood Road - SW Boones Ferry Road to Highway 99W	E	4.49	1.46
11	Tualatin Sherwood Road - SW Boones Ferry Road to Highway 99W	W	4.49	1.64
12	Highway 217 (US 26 to I-5)	N	6.75	2.28
12	**Highway 217 (US 26 to I-5)**	**S**	**7.05**	**3.14**
12	Murray Blvd. US 26 to SW Scholls Ferry Road	N	5.84	2.17
12	Murray Blvd. US 26 to SW Scholls Ferry Road	S	5.84	2.23
13	Canyon Road/OR 8 (US 26 to Highway 217)	E	2.57	1.87
13	Canyon Road/OR 8 (US 26 to Highway 217)	W	2.57	1.79
13	**US 26 (I-405 to Highway 217)**	**E**	**4.16**	**3.36**
13	US 26 (I-405 to Highway 217)	W	4.24	1.38
14	Highway 8 Highway 217 to SW Baseline (Hillsboro)	N	9.43	2.27
14	Highway 8 Highway 217 to SW Baseline (Hillsboro)	S	9.43	2.05
14	NE Cornell Road - Cornelius Pass Road to SW Baseline (Hillsboro)	N	4.06	2.10
14	NE Cornell Road - Cornelius Pass Road to SW Baseline (Hillsboro)	S	4.06	2.01
14	NE Evergreen Road - Cornelius Pass Road to NW Glencoe Road	E	4.84	1.37
14	NE Evergreen Road - Cornelius Pass Road to NW Glencoe Road	W	4.83	1.34
14	NW Cornelius Pass Road - US 26 to NW Germantown Road	N	2.11	2.27
14	NW Cornelius Pass Road - US 26 to NW Germantown Road	S	2.03	2.02
14	US 26 (Highway 217 to NW Glencoe Road)	E	11.60	1.92
14	US 26 (Highway 217 to NW Glencoe Road)	W	11.37	1.46
16	NW Cornelius Pass Road - US 30 to NW Skyline Road	N	3.53	1.24
16	NW Cornelius Pass Road - US 30 to NW Skyline Road	S	3.53	1.27
16	**NW Front Ave. - NW 21st to NW 61st**	**N**	**2.45**	**3.88**
16	**NW Front Ave. - NW 21st to NW 61st**	**S**	**3.05**	**3.71**
16	US 30/ NW Yeon Ave. - I-405 to NW Cornelius Pass Road	N	11.09	1.66
16	US 30/ NW Yeon Ave. - I-405 to NW Cornelius Pass Road	S	11.74	1.92
17	N Going St. - I-5 to Swan Island	E	0.99	2.60

Corridor	Segment	Dir	Miles[9]	Travel Time Reliability ratio
17	N Going St. - I-5 to Swan Island	W	0.99	2.38
17	N Lombard St. - N St. Louis Ave. to N. Terminal Road (Terminal 4)	N	2.01	2.96
17	N Lombard St. - N St. Louis Ave. to N. Terminal Road (Terminal 4)	S	2.01	2.58
17	N. Columbia Blvd/N Lombard St - I-5 to N Rivergate Blvd. (Terminal 5)	W	7.08	1.87
17	N. Columbia Blvd/N Lombard St - I-5 to N Rivergate Blvd. (Terminal 5)	E	7.08	1.80
17	N. Marine Drive - I-5 to N. Lombard St. @ Terminal 5 (Terminal 5 and 6)	E	4.50	1.98
17	N. Marine Drive - I-5 to N. Lombard St. @ Terminal 5 (Terminal 5 and 6)	W	4.50	1.57
17	St. Johns Bridge and N. Ivanhoe St. to N. St. Louis Ave.	N	0.94	2.21
17	**St. Johns Bridge and N. Ivanhoe St. to N. St. Louis Ave.**	**S**	**0.94**	**3.30**
18	**NE 47th/NE Cornfoot Road - Columbia Blvd. to NE Alderwood**	**N**	**1.97**	**3.67**
18	NE 47th/NE Cornfoot Road - Columbia Blvd. to NE Alderwood	S	1.97	2.53
18	NE Columbia Blvd. - I-5 to I-205	N	5.28	1.87
18	NE Columbia Blvd. - I-5 to I-205	S	5.22	2.17
18	NE Lombard St. (Highway 30B) - Martin Luther King Jr. Blvd. to NE 82nd Ave.	E	4.97	1.70
18	NE Lombard St. (Highway 30B) - Martin Luther King Jr. Blvd. to NE 82nd Ave.	W	4.97	1.66
21	SE McLoughlin Blvd (Highway 99E) - SE Powell Blvd. to Highway 224	N	3.54	2.37
21	SE McLoughlin Blvd (Highway 99E) - SE Powell Blvd. to Highway 224	S	3.81	1.70
22	Highway 224 (Highway 99E to I-205)	W	4.01	1.87
22	Highway 224 (Highway 99E to I-205)	E	4.01	2.06
22	SE International Way/Lake Road - SE 37th to Highway 224	E	0.77	NA
22	SE International Way/Lake Road - SE 37th to Highway 224	W	0.77	NA
23	Highway 224/212 - I-205 to SE 242nd	E	7.83	2.31
23	Highway 224/212 - I-205 to SE 242nd	W	7.83	1.86
23	Sunrise Highway (Hwy 224) - I-205 to SE 122nd	W	1.94	2.00
23	Sunrise Highway (Hwy 224) - I-205 to SE 122nd	E	1.94	2.34
99	I-5 (Wilsonville at Willamette River to Woodburn at Highway 211)	N	11.39	1.77
99	I-5 (Wilsonville at Willamette River to Woodburn at Highway 211)	S	11.32	1.18

Bold font indicates segment that did not meet the regional target

Figure H.5 Selected Freight Mobility Corridor segments not meeting regional reliability target (2019, basemap data: OpenStreetMap)



If you picnic at Blue Lake or take your kids to the Oregon Zoo, enjoy symphonies at the Schnitz or auto shows at the convention center, put out your trash or drive your car – we've already crossed paths.

So, hello. We're Metro – nice to meet you.

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