Massachusetts Freight Plan

Technical Memorandum #2

Existing Conditions and Trends

prepared for:

Massachusetts Department of Transportation

prepared by:

Cambridge Systematics, Inc.

with

Regina Villa Associates

Portscape, Inc

funded by:

Federal Highway Administration

March 2017

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date

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This memorandum identifies existing conditions and trends in Massachusetts' overall population, employment, productivity (i.e., Gross Domestic Product [GDP]), and commodity flows, both over time and compared to neighbor states. In addition, it discusses regional employment clusters and key industries, supported by the findings of interviews with freight system users conducted in October and November, 2016. Finally, it summarizes the key elements of the Massachusetts freight system, including discussion of modes, mode-specific issues and impacts of MassDOT's mode-specific policy decisions.

1.0 Economy

The data used in this section were collected from the following sources:

- **Population estimates** from 2000-2015 were provided by the US Census Bureau Annual Estimates of the Resident Population. The Census Bureau provides these estimates at a municipal level for Massachusetts.
- **Population projections** from the Donahue Institute at the University of Massachusetts, Boston have been used to supplement the Census Bureau estimates at the municipal and statewide levels.
- **Employment estimates for the US and neighbor states** were provided by the US Census Bureau's County Business Patterns program from 2006-2014. For 2015, data were provided by each state's employment and/or labor office.
- **Employment estimates for Massachusetts,** drawn from the Federal Bureau of Labor Statistics, were provided by the Executive Office of Labor and Workforce Development (EOLWD).
- **Gross Domestic Product** for Massachusetts, surrounding states, and the US overall was provided by the Bureau of Economic Analysis (BEA) Regional Economic Accounts.

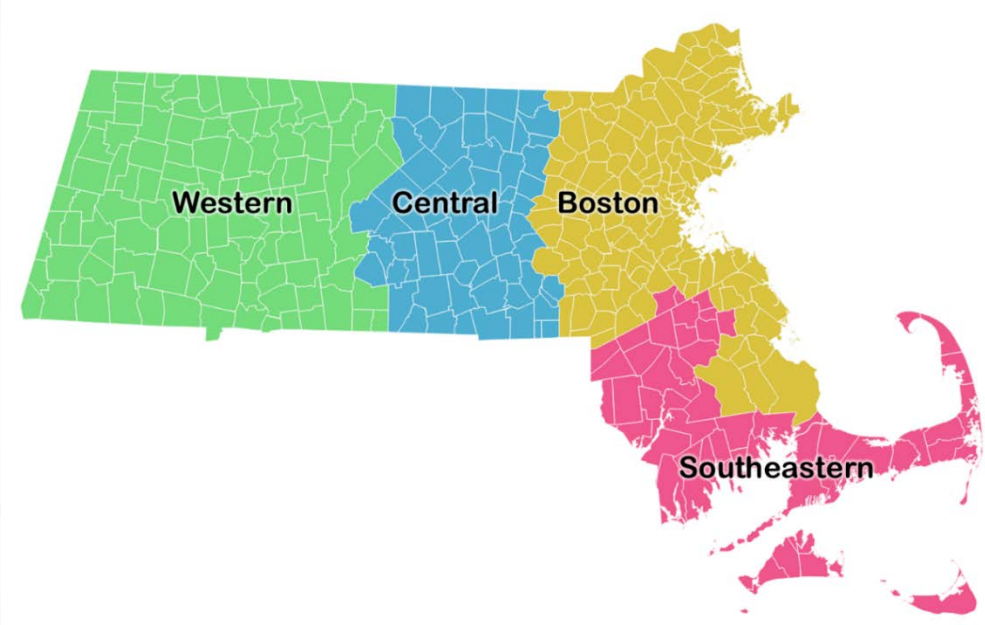
This analysis was conducted over Massachusetts and bordering states: New Hampshire, Vermont, New York, Connecticut, and Rhode Island. Within the Commonwealth, the EOLWD has established 16 "workforce development areas" (WDAs). To simplify the analysis, these WDAs were combined into four economic regions of Massachusetts as follows:

- **Boston:** Boston, Greater Lowell, Lower Merrimack Valley, Metro North, Metro South/West, North Shore, and South Shore;
- **Central:** North Central Massachusetts and Central Massachusetts;
- **Southeastern:** Bristol, Greater Brockton, Greater New Bedford, and Cape and Islands; and
- **Western:** Berkshire, Franklin/Hampshire, and Hampden.

Other schemes for establishing regions within Massachusetts use a similar approach and similar region names. This should be noted when comparing the data in this memorandum to data gathered elsewhere. These regions also cross the borders of some local business coalitions and interest groups – the 495/MetroWest Corridor

Partnership, for example, includes communities in the Boston and Central regions. The regions are illustrated in Figure 1.1.

FIGURE 1.1: ECONOMIC REGIONS OF MASSACHUSETTS



Source: Massachusetts Executive Office of Labor and Workforce Development

It should be noted that the "South Shore" WDA extends from the Boston city line to Cape Cod and includes communities such as Milton and Quincy that are clearly in the Boston metro area. As employment forecasts are provided only on a WDA basis, the decision was made to assign "South Shore" to the Boston region.

1.1. Population

Population trends can indicate economic health and demand for goods and services over time, and are therefore instructive in understanding the freight load on the Massachusetts transportation system. Historic and projected population for the Commonwealth and its regions is shown in Table 1.1.

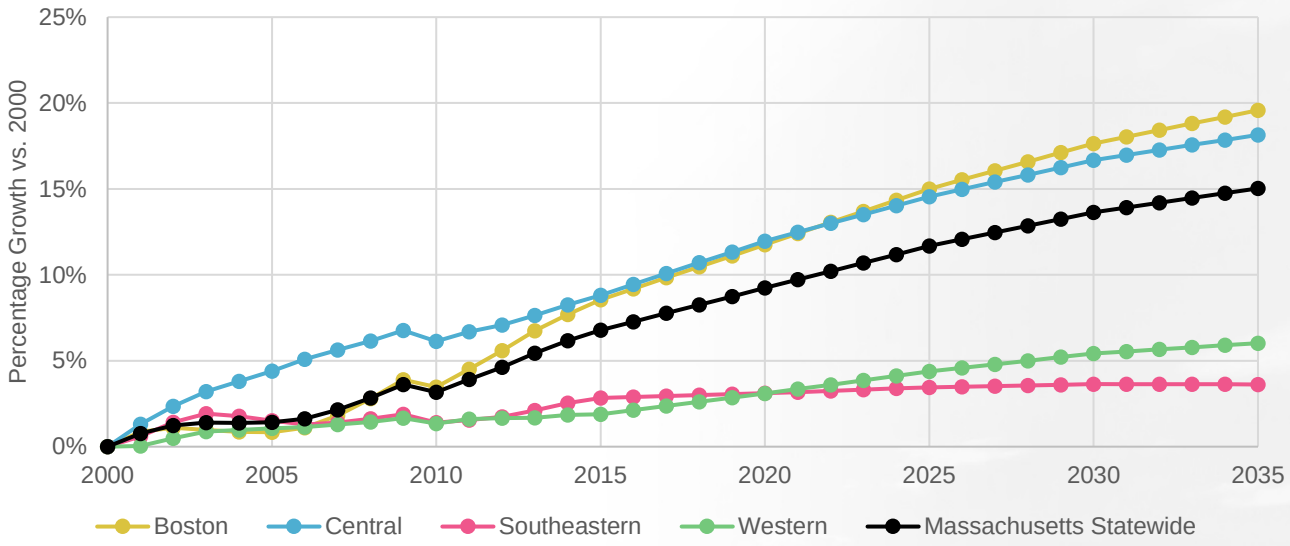
TABLE 1.1: POPULATION FOR MASSACHUSETTS AND REGIONS

Region	2000 Population	2015 Population	2030 Population (estimate)
Massachusetts	6,363,015	6,794,422	7,231,126
Boston	3,716,737	4,034,547	4,372,499
Central	776,174	844,607	905,617
Southeastern	1,039,432	1,068,936	1,077,318
Western	830,672	846,332	875,692

Source: US Census Bureau, Donahue Institute (UMass)

Figure 1.2 shows percentage growth in each region relative to 2000. The Boston and Central regions are projected to grow faster than Southeastern and Western Massachusetts, though all regions are expected to continue to grow.

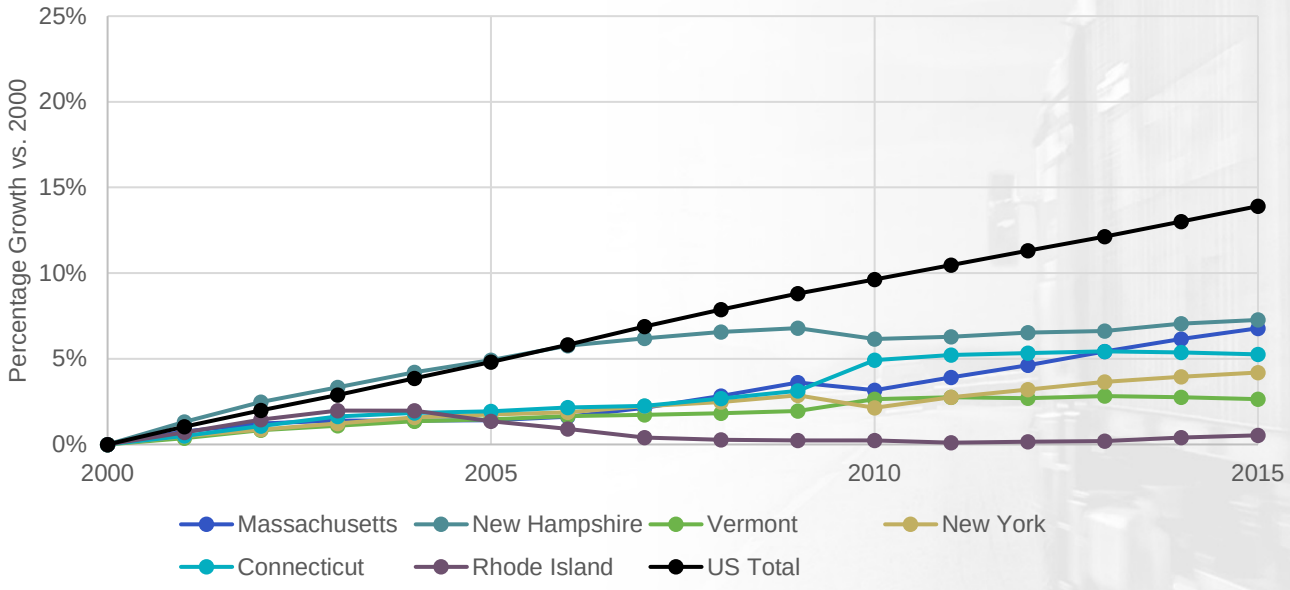
FIGURE 1.2: POPULATION GROWTH OF MASSACHUSETTS AND REGIONS



Source: US Census Bureau, Donahue Institute (UMass)

The growth rate of Massachusetts falls below the national average but above most bordering states, as shown in Figure 1.3.

FIGURE 1.3: POPULATION GROWTH OF MASSACHUSETTS AND BORDERING STATES



Source: US Census Bureau

1.2. Employment

Employment trends are a measure of both general economic health and of the relative prominence of industries in regions and states. Total employment for Massachusetts and regions in 2004 and 2014 is provided in Table 1.2.

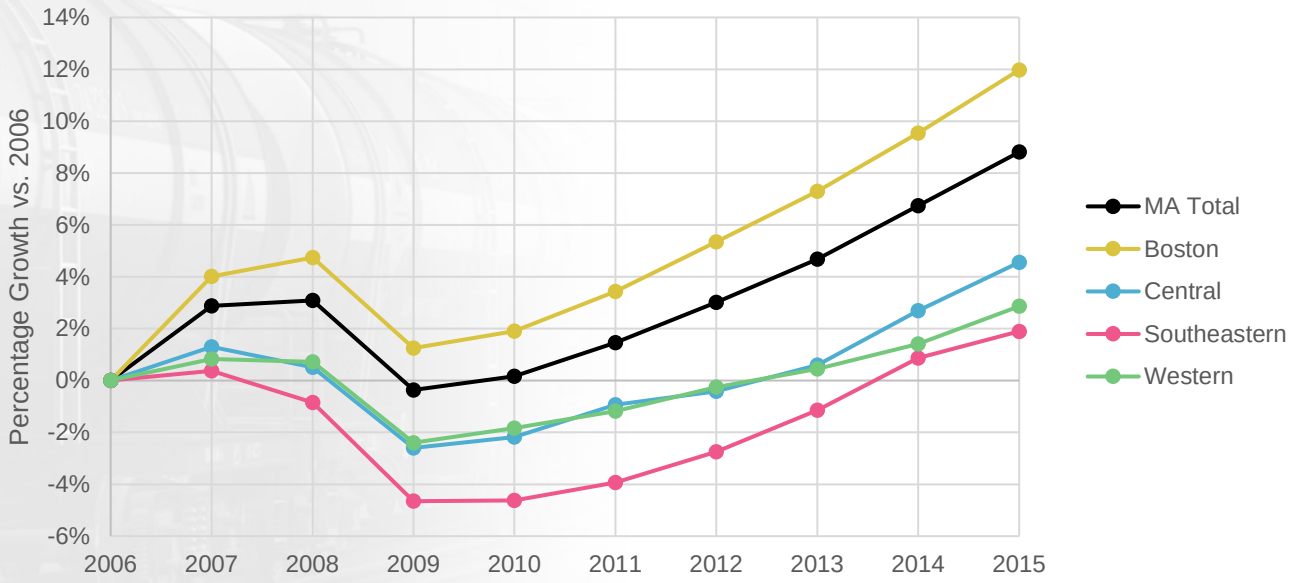
TABLE 1.2: EMPLOYMENT FOR MASSACHUSETTS AND REGIONS

Region	2004 Employment	2014 Employment
Massachusetts	3,106,403	3,315,700
Boston	2,011,565	2,203,551
Central	322,764	331,368
Southeastern	423,821	427,526
Western	348,253	353,155

Source: Massachusetts Executive Office of Labor and Workforce Development

Figure 1.4 shows percentage growth in each region relative to 2006 (to be consistent with the border state dataset and to more accurately reference a “pre-recession” baseline). As of 2015, all regions have seen a rebound in employment to pre-recession levels. Though only the Boston region has grown by more than 5 percent relative to 2004, it far exceeds the others.

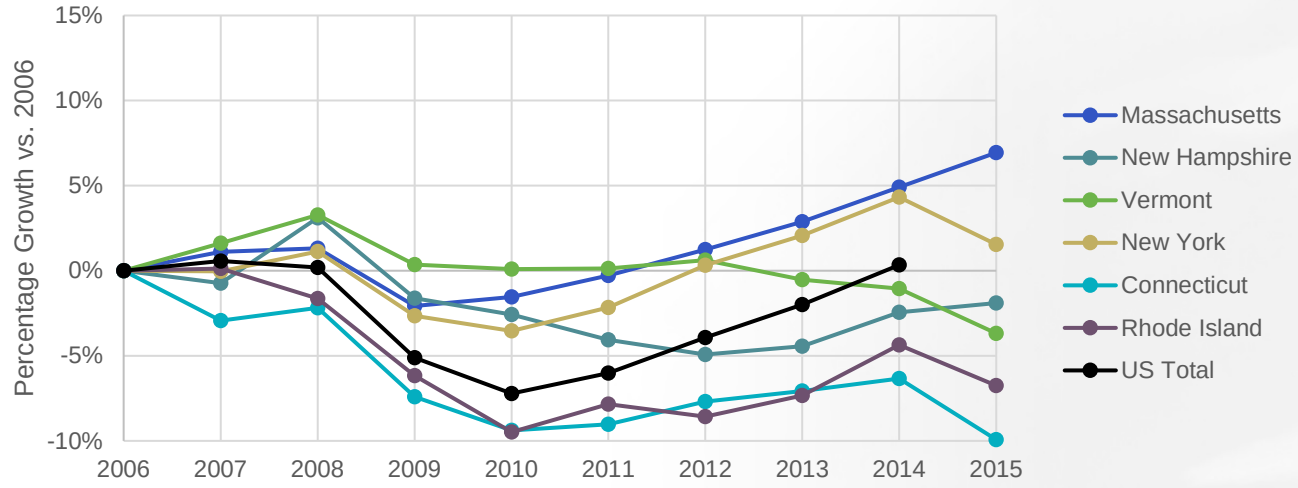
FIGURE 1.4: EMPLOYMENT GROWTH OF MASSACHUSETTS ECONOMIC REGIONS



Source: Massachusetts Executive Office of Labor and Workforce Development

The employment growth rate of all Massachusetts regions meets or outpaces the national average. The Commonwealth’s overall employment growth exceeds all neighboring states, as shown in Figure 1.5.

FIGURE 1.5: EMPLOYMENT GROWTH OF MASSACHUSETTS AND BORDERING STATES

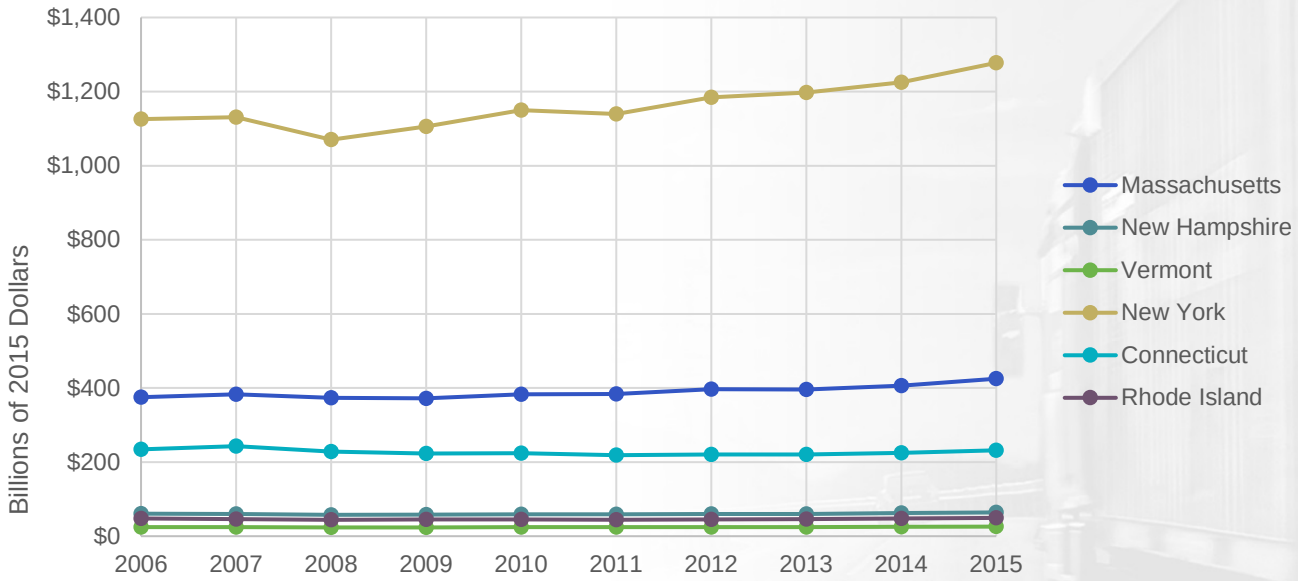


Source: US Census Bureau (2000-2014), each state (2015)

1.3. Productivity

Productivity is measured using GDP, which when applied at the state level is sometimes referred to as gross state product (GSP). GDP for Massachusetts and surrounding states is provided in Figure 1.6.

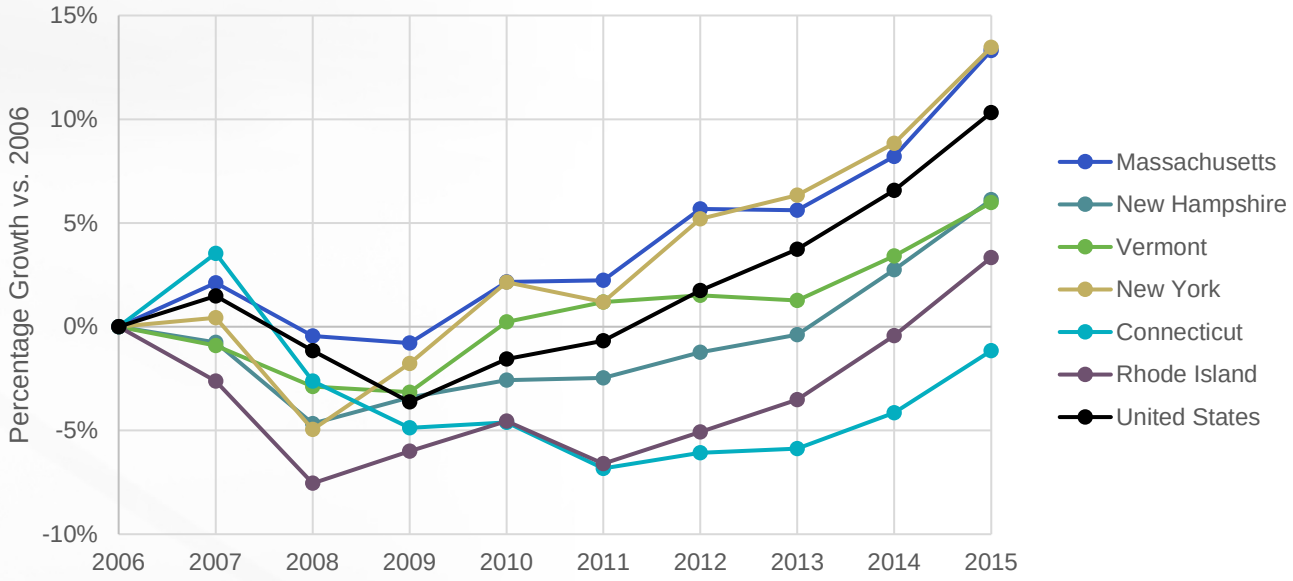
FIGURE 1.6: GDP (2015$) FOR MASSACHUSETTS AND BORDERING STATES



Source: Bureau of Economic Analysis

While Massachusetts trails New York significantly in total GDP, the Commonwealth's overall GDP growth is close to New York and higher than other neighboring states, as shown in Figure 1.7.

FIGURE 1.7: GDP GROWTH FOR MASSACHUSETTS AND BORDERING STATES

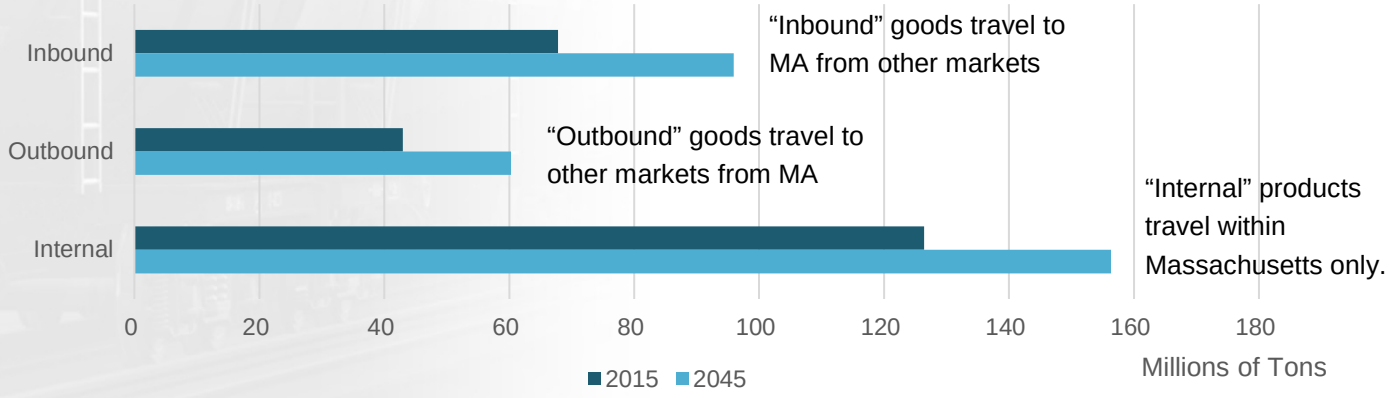


Source: Bureau of Economic Analysis

1.4. Commodities

The Federal Highway Administration's (FHWA) Freight Analysis Framework (FAF) Version 4, last conducted in 2012, analyzes commodities flows between regions, by industry, by commodity, and by mode. Figure 1.8 shows the inbound, outbound, and internal projected freight flows (in 2012) for 2015 and 2045 in terms of tonnage. Most flows are internal to the Commonwealth. This trend is expected to hold into the future.

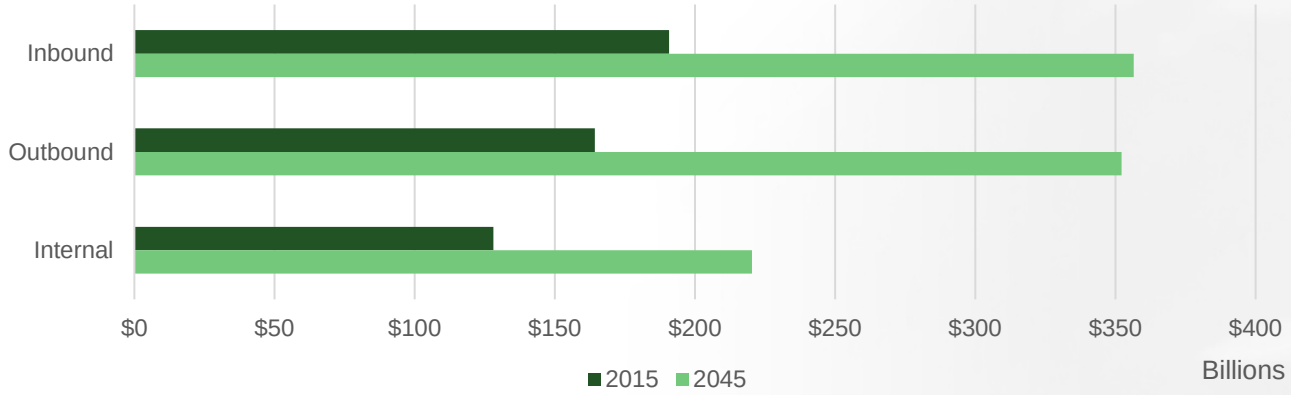
FIGURE 1.8: FAF COMMODITY TONNAGE PROJECTIONS FOR MASSACHUSETTS



Source: FHWA Freight Analysis Framework Version 4

The value of inbound, outbound, and internal statewide freight flows projected for 2015 and 2045 are shown in Figure 1.9. The most valuable goods arrive inbound into Massachusetts. This is expected to hold into the future.

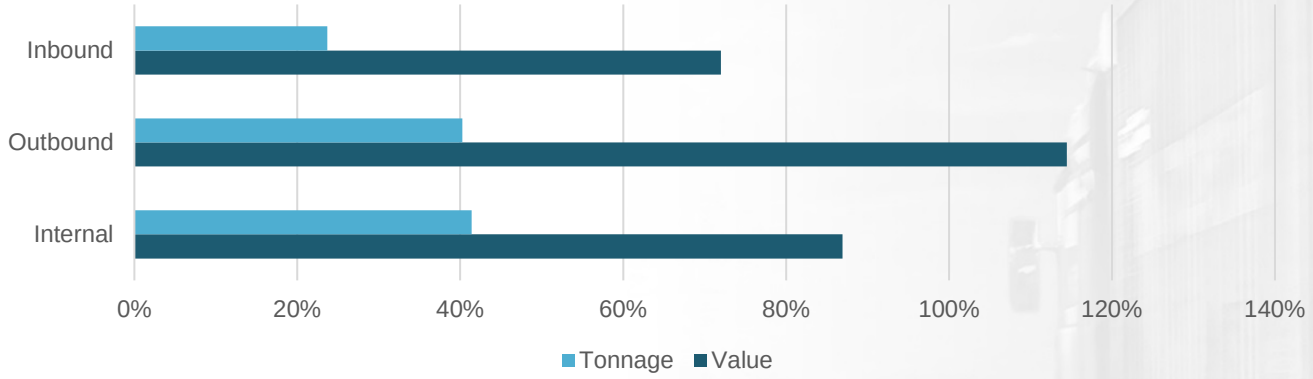
FIGURE 1.9: FAF COMMODITY VALUE PROJECTIONS FOR MASSACHUSETTS



Source: FHWA Freight Analysis Framework Version 4

As shown in Figure 1.10, the percentage growth in the value of commodity flows into, out of, and within Massachusetts is expected to exceed the growth in tonnage by a large margin, potentially indicating both that Massachusetts goods are valuable by weight and that flows will shift in favor of commodities that are more valuable by weight.

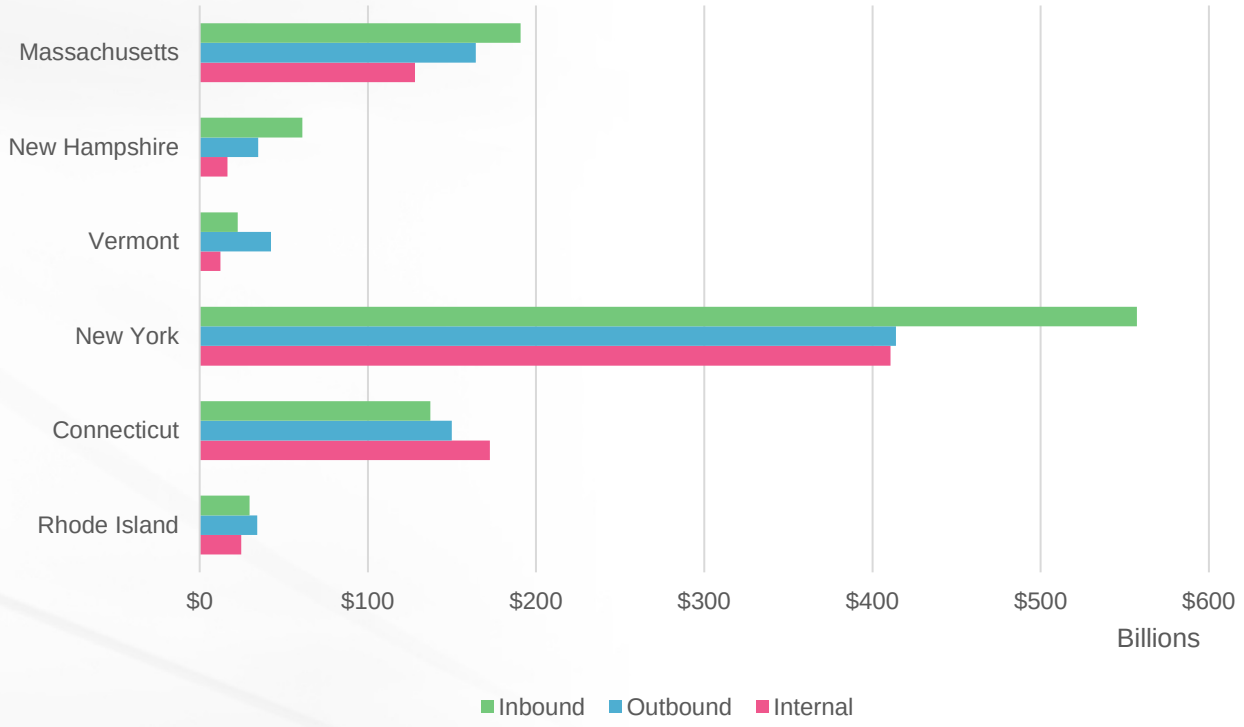
FIGURE 1.10: PERCENTAGE GROWTH IN COMMODITY FLOWS, 2015-2045



Source: FHWA Freight Analysis Framework Version 4

Among neighboring states, the scale of goods flows approximately mirror population. Massachusetts imports more goods than it exports, making it similar to New Hampshire and New York but dissimilar from Vermont and Connecticut, as shown in Figure 1.11.

FIGURE 1.11: FAF COMMODITY VALUE (2015) FOR MASSACHUSETTS AND BORDERING STATES



Source: FHWA Freight Analysis Framework Version 4

1.5. Cluster Analysis

According to the US Cluster Mapping Project (http://clustermapping.us/), a "traded" cluster is "a regional concentration of related industries" that can arise from linkages, efficiencies, or externalities in a geographic location. For example, the presence of biopharmaceutical research at the Massachusetts Institute of Technology both generates and attracts private companies in that field to Kendall Square, adjacent to campus. Once assembled there, all parties value the ease of collaboration and strong labor pool provided by close proximity. Once the neighborhood develops a reputation as a global center of the pharmaceutical industry, additional firms may choose to locate there based on perception and mystique in addition to the other factors.

"Local" clusters exist in every region and primarily serve the local market. These can include retail, schools, journalism, and entertainment.

In the context of a cluster, the "region" can be a neighborhood or it can be an entire state. The US Cluster Mapping Project primarily draws on employment, wage rates, and job creation to reveal clusters. Table 1.3 lists traded clusters for which Massachusetts falls in the top ten states in terms of 2014 employment according to the US Cluster Mapping Project, along with the rank of Metropolitan Statistical Areas (MSA) centered in Massachusetts.

TABLE 1.3: MASSACHUSETTS CLUSTER RANKINGS BY 2014 EMPLOYMENT

	States	Metropolitan Statistical Areas (MSA) – Approx. 1,000 total					
Industry	MA	Boston	Worcester	Springfield	Pittsfield	Barnstable	Greenfield
Education and Knowledge Creation	4	2	46	41	126	213	520
Information Technology and Analytical Instruments	4	3	47	105	333	172	464
Fishing and Fishing Products	4	3	N/A	N/A	152	85	N/A
Jewelry and Precious Metals	6	13	203	179	42	279	240
Biopharmaceuticals	7	6	51	N/A	244	122	277
Performing Arts	7	8	163	106	129	154	369
Recreational and Small Electric Goods	7	12	91	56	347	357	46
Financial Services	8	6	55	75	153	139	366
Marketing, Design, and Publishing	8	6	97	132	220	168	237
Communications Equipment and Services	9	14	75	105	510	158	284
Medical Devices	9	4	51	58	235	219	N/A
Video Production and Distribution	9	11	161	71	160	166	227
Footwear	10	5	110	N/A	80	N/A	N/A
Apparel	10	9	60	150	616	280	159

Source: US Cluster Mapping Project

2.0 Logistics

Our approach for the Statewide Freight Plan is to establish high-level supply chains for key regional industries to supplement freight traffic volumes. This supply chain process also provides context to volume data – we hope to not only state that a particular roadway or route sees significant freight traffic, but also what that traffic consists of, where it is going or coming from, and why that route was selected. Framing the data in this way will allow the finished plan to drill down on key insights as to how the Massachusetts freight system could function better in coming years and decades.

Central to building this context was a series of interviews with large regional shippers and carriers conducted in the fall of 2016. Interviewees were selected with the cooperation and support of several regional commercial and trade associations, including the 495/MetroWest Corridor Partnership, the Worcester Regional Chamber of Commerce, the Western Massachusetts Economic Development Council, and the Massachusetts Business Roundtable. In all, we conducted more than 25 interviews across the four regions of the Commonwealth, reflecting an effort toward geographic equity and participant diversity.

This section will establish the interview findings by grounding them in economic data – employment and productivity – that identifies key industries in each region. It then discusses the findings and develops a high-level understanding of typical supply chains for key industries. It transitions from there to a discussion of mode-specific commodity profiles, establishing how shippers and carriers in Massachusetts use each mode.

2.1. Key Industries by Region

Statewide in Massachusetts, key industries can be identified using two and three-digit North American Industry Classification System (NAICS) codes. Taking account of the fact that some industries (e.g., different types of manufacturing) use the freight system in more unique ways that others (e.g., legal services, finance, insurance, and other white collar industries), the data indicates that the Commonwealth's key industries include:

- **"White Collar" –** A super-category that includes information services (i.e., print and online journalism and communications), finance and insurance, real estate, professional, scientific, and technical services, management, education, and health. Specifically, the health care industry is the largest in Massachusetts by employment.
- **Retail and Trade –** This category includes the sale of goods and groceries but not food and drink establishments.
- **Chemical Manufacturing –** In Massachusetts, the most important category of manufactured chemicals is pharmaceuticals.
- **Computer and Electronic Product Manufacturing** – This category covers a set of products that includes consumer electronics as well as larger, specialized devices for medical and industrial use.

Employment and Productivity

Key industries for each region of Massachusetts can be identified by employment and by productivity (GDP). Employment is available for 2004-2015 from the Commonwealth's Office of Labor and Workforce Development (EOLWD), which also projects employment by industry and town in 2017 and 2024. GDP is available by NAICS

code for the entire Commonwealth, but can be split into regions using the employment statistics (with the assumption that industry workers in different parts of Massachusetts are equally productive).

Tables 2.1, 2.2, 2.3, and 2.4 provide the 2014 employment by two-digit NAICS code by region, as well as the growth in employment from 2004-2014. The three top industries for the region are highlighted in each table.

TABLE 2.1: INDUSTRY EMPLOYMENT FOR THE BOSTON REGION

NAICS Code	Industry	2014 Employment	2004-2014 Growth
23	Construction	83,782	(6,258)
31-33	Manufacturing	138,270	(29,979)
42	Wholesale Trade	72,844	(9,425)
44-45	Retail Trade	202,144	(114)
48-49	Transportation and Warehousing	58,671	(2,210)
51	Information	66,006	(402)
52	Finance and Insurance	129,003	(3,714)
53	Real Estate and Rental and Leasing	31,967	651
54	Professional and Technical Services	237,540	52,895
55	Management of Companies and Enterprises	41,092	6,741
56	Administrative and Waste Services	117,847	8,642
61	Educational Services	180,298	40,607
62	Health Care and Social Assistance	375,044	92,919
71	Arts, Entertainment, and Recreation	37,932	8,334
72	Accommodation and Food Services	184,105	36,044
81	Other Services, Ex. Public Admin	76,504	6,187

Source: Massachusetts Executive Office of Labor and Workforce Development

TABLE 2.2: INDUSTRY EMPLOYMENT FOR THE CENTRAL REGION (CONTINUES ON P.12)

NAICS Code	Industry	2014 Employment	2004-2014 Growth
23	Construction	15,000	(1,215)
31-33	Manufacturing	34,676	(8,011)
42	Wholesale Trade	11,818	567
44-45	Retail Trade	39,209	551
48-49	Transportation and Warehousing	11,522	2,482
51	Information	3,933	(891)
52	Finance and Insurance	11,564	(101)

NAICS Code	Industry	2014 Employment	2004-2014 Growth
53	Real Estate and Rental and Leasing	2,413	(508)
54	Professional and Technical Services	14,736	1,339
55	Management of Companies and Enterprises	2,362	(1,307)
56	Administrative and Waste Services	12,668	(3,193)
61	Educational Services	27,071	5,075
62	Health Care and Social Assistance	66,244	18,956
71	Arts, Entertainment, and Recreation	4,151	501
72	Accommodation and Food Services	25,937	2,493
81	Other Services, Ex. Public Admin	9,652	(1,801)

Source: Massachusetts Executive Office of Labor and Workforce Development

TABLE 2.3: INDUSTRY EMPLOYMENT FOR THE SOUTHEASTERN REGION

NAICS Code	Industry	2014 Employment	2004-2014 Growth
23	Construction	23,468	(815)
31-33	Manufacturing	33,847	(13,902)
42	Wholesale Trade	16,341	(2,857)
44-45	Retail Trade	65,725	(2,407)
48-49	Transportation and Warehousing	14,065	155
51	Information	6,087	(936)
52	Finance and Insurance	8,959	(1,023)
53	Real Estate and Rental and Leasing	4,316	(1,242)
54	Professional and Technical Services	13,323	(285)
55	Management of Companies and Enterprises	1,973	(72)
56	Administrative and Waste Services	20,769	6,075
61	Educational Services	24,995	11,905
62	Health Care and Social Assistance	80,565	17,919
71	Arts, Entertainment, and Recreation	8,389	1,465
72	Accommodation and Food Services	47,200	3,846
81	Other Services, Ex. Public Admin	2,078	(412)

Source: Massachusetts Executive Office of Labor and Workforce Development

TABLE 2.4: INDUSTRY EMPLOYMENT FOR THE WESTERN REGION

NAICS Code	Industry	2014 Employment	2004-2014 Growth
23	Construction	13,924	(846)
31-33	Manufacturing	28,123	(9,004)
42	Wholesale Trade	9,251	(570)
44-45	Retail Trade	41,487	(2,575)
48-49	Transportation and Warehousing	10,359	(686)
51	Information	4,473	(1,076)
52	Finance and Insurance	11,777	(1,334)
53	Real Estate and Rental and Leasing	3,485	(501)
54	Professional and Technical Services	10,830	1,128
55	Management of Companies and Enterprises	2,923	(770)
56	Administrative and Waste Services	11,845	3
61	Educational Services	41,827	6,250
62	Health Care and Social Assistance	75,785	19,680
71	Arts, Entertainment, and Recreation	6,201	1,970
72	Accommodation and Food Services	30,063	2,050
81	Other Services, Ex. Public Admin	11,278	(5,111)

Source: Massachusetts Executive Office of Labor and Workforce Development

Table 2.5 shows GDP by industry and region in 2014, with the top three industries highlighted in each region. It should be noted that manufacturing exhibits high productivity per employee – manufacturing is a top-three industry by GDP in two regions where it was not in the top three by employment. Boston is unique among the regions in the value it derives from finance and technical services – the remaining regions largely exhibit a shared profile across the industries.

TABLE 2.5: 2014 GDP BY INDUSTRY AND REGION (CONTINUES ON P.14)

NAICS Code	Industry	Boston	Central	Southeastern	Western
23	Construction	$10,184	$1,823	$2,853	$1,692
31-33	Manufacturing	$27,237	$6,831	$6,667	$5,540
42	Wholesale Trade	$15,508	$2,516	$3,479	$1,969
44-45	Retail Trade	$11,216	$2,175	$3,647	$2,302
48-49	Transportation and Warehousing	$4,603	$904	$1,103	$813

NAICS Code	Industry	Boston	Central	Southeastern	Western
51	Information	$19,605	$1,168	$1,808	$1,329
52	Finance and Insurance	$32,064	$2,874	$2,227	$2,927
53	Real Estate and Rental and Leasing	$50,211	$3,790	$6,779	$5,474
54	Professional and Technical Services	$43,811	$2,718	$2,457	$1,997
55	Management of Companies and Enterprises	$9,202	$529	$442	$655
56	Administrative and Waste Services	$8,999	$967	$1,586	$905
61	Educational Services	$8,626	$1,295	$1,196	$2,001
62	Health Care and Social Assistance	$26,693	$4,715	$5,734	$5,394
71	Arts, Entertainment, and Recreation	$2,858	$313	$632	$467
72	Accommodation and Food Services	$8,042	$1,133	$2,062	$1,313
81	Other Services, Ex. Public Admin	$5,900	$744	$1,242	$870

Source: Massachusetts Executive Office of Labor and Workforce Development

2.2. Interview Findings and Supply Chains

The Freight Plan team conducted more than 25 interviews in the fall of 2016. Each interviewee was asked to comment on their business and its requirements of the freight system, challenges, bottlenecks, and threats to their supply chain, and trends that they observe both in their industry and in the Massachusetts freight environment in general. This section will summarize observations from the interviews on the Massachusetts supply chain for four key industries: Institutions (i.e., universities and hospitals), the biopharmaceutical industry, fishing, and food, fuel, and consumer goods. These represent industries that support the white collar industries (i.e., those that supply goods to the general population) and some of the key regional manufacturing clusters (e.g., fishing).

Institutions

To gain insight on freight system usage by colleges, universities, and hospitals, the team interviewed representatives from Clark University in Worcester and the Medical, Academic, and Scientific Community Organization, Inc. (MASCO), which represents hospitals in Boston's Longwood Medical Area.

Institutions are large consumers of many types of goods but produce primarily solid and recycled waste. It is important to note when considering the freight needs of schools that activity is seasonal – it peaks in the fall and spring and valleys in the winter and especially in the summer.

Location is the key characteristic that sets institutions apart from most, if not all, other industries. While manufactures and distributors can strategically locate on key supply routes (e.g., Interstate interchanges, airports and seaports, along rail lines, etc.) and white collar businesses can consider moving if logistics of urban areas become untenable, institutions are almost always tied to their site. In Massachusetts, many of these sites are located in urban areas, along narrow neighborhood streets with challenging terrain for trucks. In addition, colleges may design the character of the roadways surrounding their campus in ways that do not benefit delivery trucks.

Institutions receive deliveries from many various suppliers who have inconsistent coordination with their drivers and uneven familiarity with the campus. Clark University noted in its interview that communicating with these suppliers regarding ideal routes to campus can be a significant challenge, particularly when many of the truck drivers take direction from GPS units and smartphones. These devices may route trucks inappropriately, resulting in blocked streets and long delays and detours, particularly during snowy winters.

All of the institutional interviewees source milk from Garelick Farms' Franklin distribution facility – the company operates another distribution facility in Lynn. Sysco, a key institutional food distributor, operates by truck from a facility on US-44 in Plympton.

All types of institutions share a dependence on integrated carriers (e.g., UPS, FedEx, and DHL) for deliveries of items as important as medicine and pharmaceuticals. Clark University noted that traffic to its mailroom is greatly increasing as students shift toward e-commerce.

Biopharmaceuticals

In the team's interview with a biopharmaceutical firm in Cambridge, the respondent noted that of the approximately 150 such firms in Massachusetts (100 in Cambridge and 50 on Route 128), few will ever manufacture significant product in the Commonwealth. This is largely due to the high cost of space and talent in the Boston Area. The investment is better spent on research and development laboratories – manufacturing drugs on a large scale requires them to move their operations to areas with less expensive land and talent.

Biopharmaceutical firms receive deliveries of reagents, proteins, chemicals, and laboratory equipment. One of their key incoming commodities, however, is glassware. While the team could not arrange an interview with either, two major laboratory supply companies have large presences in the Boston market, with one maintaining its world headquarters in Waltham. Outbound, the interviewee noted that his company primarily ships small batches of drugs in clinical trials on-demand to patients, which is necessary for the study to function. Any and all means of delivering the drugs are used to ensure the drugs arrive on-time, but they are small shipments.

The biopharmaceutical industry exhibits significant geographic clustering, generating delivery truck traffic in Kendall and Lechmere Squares in Cambridge and along the stretch of Route 128 between I-90 and I-93.

Fishing

The team met with officials from ports in Boston and New Bedford, as well as with a Boston fish processing and retail firm. One key insight from all interviewees was that fishing and fish processing have almost entirely decoupled. Boston and New Bedford are both processing hubs, but only New Bedford sees significant fish landed in the harbor. Boston processes fish trucked from New Bedford and other Massachusetts ports (e.g., Gloucester and Provincetown) but also fish flown from other US and international ports in belly freight to Logan Airport.

Once processed, product from both cities is flown out of Logan Airport to consumers in Europe and Asia. According to Massport (which operates both the Port of Boston and Logan Airport), 75 percent of fish processed in Boston is

exported from the United States, while more than 90 percent of fish consumed in the country is imported from or processed abroad. The presence of high-value fish processing in Boston and New Bedford aligns with Boston's direct international flights to Asian markets including Tokyo, Beijing, and Hong Kong.

Although the domestic fishing industry is experiencing continued decline, both New Bedford (the most profitable commercial fishing harbor in the United States) and Boston are expected to see increased activity in coming years. The Port of New Bedford estimates that it accounts for two percent of Massachusetts' overall GDP – more than all the traffic in the Port of Boston – due to the high value of fish. The Port expects its strong supporting services (e.g., processing, repairs, fuel, etc.) to earn it a larger piece of a shrinking pie. The Port of Boston, meanwhile, is seeing a new private development area for fish processing at the Raymond L. Flynn Marine Park, and Massport expects the existing facilities at Fish Pier to be 100 percent leased moving forward.

Food, Fuel, and Consumer Goods

The team interviewed a convenience store/gas station chain, a major grocery chain, institutional consumers of food and consumer goods, ports, warehousing firms, and a food production facility.

Produce arrives in Massachusetts by truck from in-state farms and from the surrounding region. Many of the interviewees noted that they source produce regionally. Produce also arrives by carload and intermodal rail, as well as by ship in Chelsea and New Bedford.

Gasoline for automobiles arrives in Eastern Massachusetts to ports in Chelsea and Providence, as well as through the Citgo pipeline in Braintree. Gasoline for Western Massachusetts arrives through the Port of New Haven and the Buckeye pipeline in Holyoke. Gasoline for Central Massachusetts mainly arrives through Providence. In all cases, tanker trucks make runs from these locations to individual retailers – one stop per trip. Users saw the gasoline supply chain as vulnerable to disruption – Chelsea Terminal floods frequently, and Providence Terminal is also in a portside location. Serious flooding (potentially as a consequence of climate change) could endanger fuel deliveries on a large scale, as few alternatives exist.

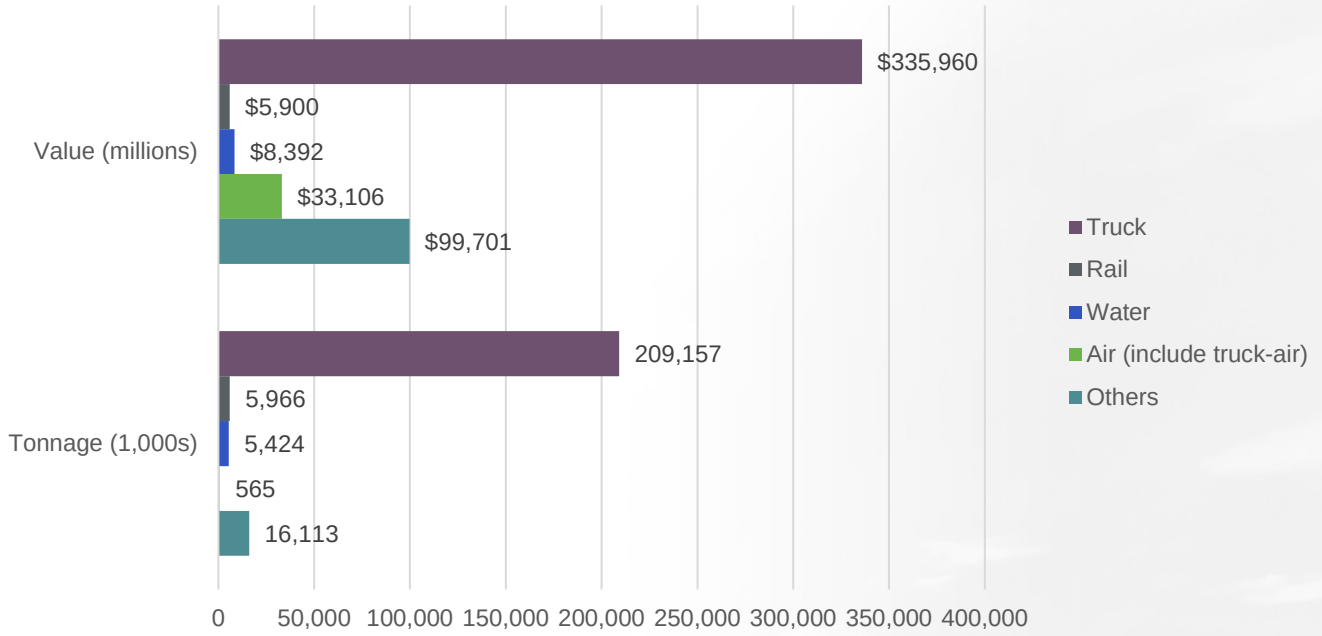
All retail food and fuel industries connect distribution centers to locations by truck. While the distribution centers may be located at key freeway nodes in Massachusetts and surrounding states (primarily New Hampshire), locations follow demand into urban areas. This makes the consumer good supply chain vulnerable to traffic congestion, particularly inside of Route 128 (Boston Region) and on Cape Cod (Southeastern Region). Increased travel times reduce the number of runs a driver/truck can make per day, which may ultimately force retailers to shift to a greater number of small distribution centers located close to cities. Increasing urban populations and land prices may also lead retailers to increase turnover in urban locations (so that they can conduct more business without growing in floor space). This model would imply more frequent deliveries using smaller vehicles.

Finally, while the team was unable to speak directly with Amazon or other online retailers, their growth was noted by several interviewees. Amazon's fast and free shipping model, as well as the correlated decline in brick-and-mortar sales, will also drive consumer retail toward many small-scale deliveries from large scale logistics.

2.3. Commodities by Mode

The majority of freight in Massachusetts travels by truck according to 2012 FAF data, as illustrated in Figure 2.1. Trucks were the main mode of transportation for 88 percent of freight tonnage and 70 percent of freight value. These totals include all commodities inbound to, outbound from, and internal to the state.

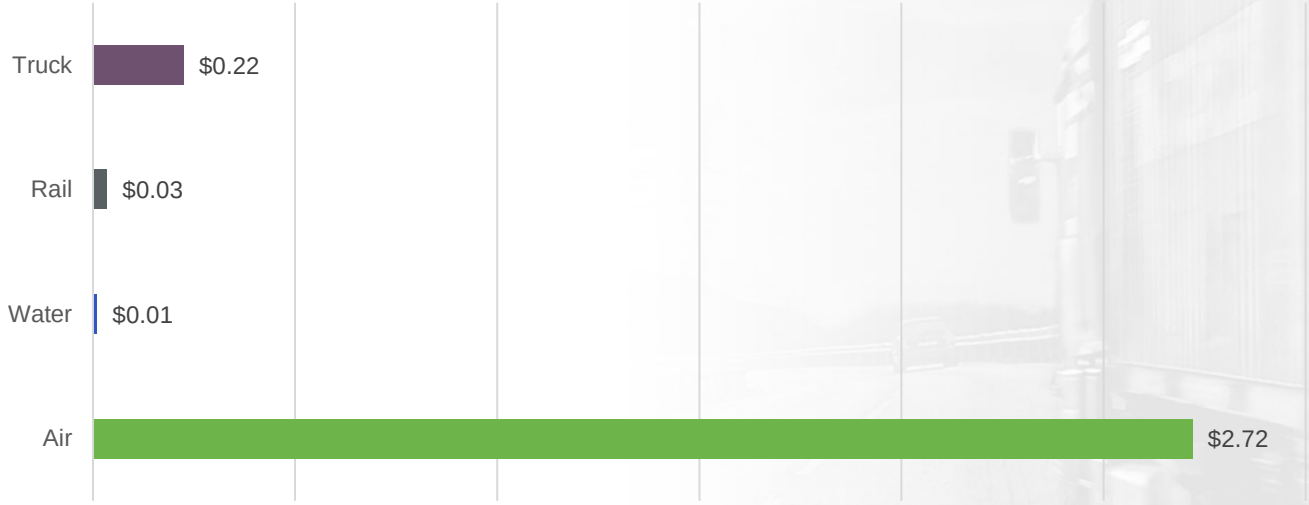
Figure 2.1: Annual Tonnage and Value (2011$) of Massachusetts Commodities by Mode



Source: FHWA Freight Analysis Framework Version 4

Figure 2.2 shows the freight transportation cost-per-ton-mile in 2011 (2011 dollars). Air is the most expensive mode by far, followed by truck, rail, and water transport.

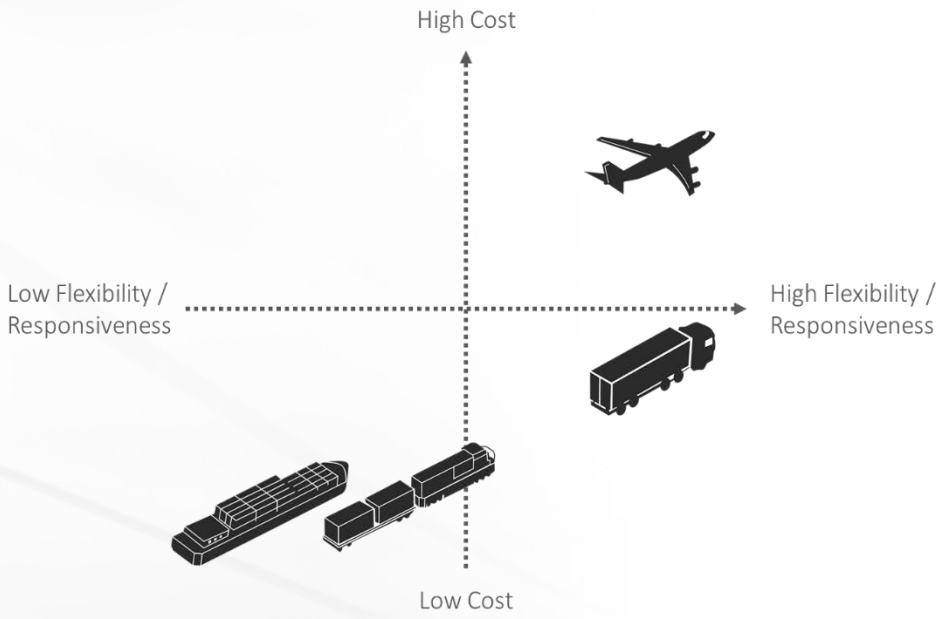
Figure 2.2: Cost-per-Ton-Mile for Freight Transportation by Mode in Massachusetts (2011$)



Source: FHWA Freight Analysis Framework Version 4

Figure 2.3 relates responsiveness and flexibility to cost for Massachusetts freight modes. Air freight is the most expensive but also very responsive and flexible. On the other end of the chart, maritime shipping is not very flexible but is very inexpensive. Truck and rail shipping fall between these modes.

FIGURE 2.3: RESPONSIVENESS/FLEXIBILITY VS. COST BY MODE



Goods Carried by Truck

Table 2.6 provides the top 10 commodities carried by truck in Massachusetts by tonnage and value. Gasoline is the top commodity in the state by tonnage and value.

TABLE 2.6: TOP TEN COMMODITIES CARRIED PRIMARILY BY TRUCK IN MASSACHUSETTS

Commodity	Tonnage (1,000s)	Commodity	Value (millions)
Gasoline	46,489	Gasoline	$46,878
Gravel	26,279	Mixed freight	$46,127
Waste/scrap	17,286	Electronics	$24,185
Nonmetal min. prods.	16,261	Misc. mfg. prods.	$16,891
Mixed freight	14,499	Motorized vehicles	$16,234
Fuel oils	11,776	Pharmaceuticals	$15,878
Other foodstuffs	10, 236	Machinery	$14,782
Coal-n.e.c.	8,226	Precision instruments	$14,001
Wood prods.	7,944	Plastics/rubber	$12,505
Natural sands	6,851	Other foodstuffs	$11,954

Source: FHWA Freight Analysis Framework Version 4

In the most recent FAF, 41 types of commodities (classified by Standard Classification of Transported Goods [SCTG]) that flow into, out of, or within Massachusetts are carried by trucks. Based on the data and on our interviews, goods carried by trucks include fuel (e.g., gasoline and other petroleum products), bulk materials (e.g., aggregate, gravel, sand), electronic products (e.g., audio equipment) and other manufactured goods (e.g., plastic, glass, pharmaceutical products), and food and produce (e.g., seafood, supplies for grocery and convenience stores).

Trucks are used to move goods from manufacturers to distribution centers, and/or from distribution centers to final markets. Trucks are also used to support other modes (i.e., freight rail, air, barge) to connect the "last mile" from distribution centers/transportation hubs to end customers. With the growth of e-commerce and the rise of "just-in-time" logistic strategies, the need for trucks (or other motor vehicles using road networks) to fulfil the last leg of supply chains is likely to increase.

The popularity of trucks as a modal choice can be attributed to a combination of low cost, high flexibility, responsiveness, and reliability, as illustrated in Figure 2.2 and 2.3.

Goods Carried by Rail

Table 2.7 provides the top 10 commodities carried by rail in Massachusetts. The top commodity by tonnage is other foodstuffs and the top commodity by value is motorized vehicles.

TABLE 2.7: TOP TEN COMMODITIES CARRIED PRIMARILY BY RAIL IN MASSACHUSETTS

Commodity	Tonnage (1,000s)	Commodity	Value (millions)
Other foodstuffs	902	Motorized vehicles	$1,495
Newsprint/paper	693	Plastics/rubber	$744
Cereal grains	670	Chemical prods.	$713
Wood prods.	642	Newsprint/paper	$509
Waste/scrap	547	Other foodstuffs	$445
Plastics/rubber	525	Coal-n.e.c.	$411
Coal-n.e.c.	521	Misc. mfg. prods.	$353
Basic chemicals	369	Wood prods.	$303
Nonmetal min. prods.	320	Basic chemicals	$209
Gravel	161	Waste/scrap	$184

Source: FHWA Freight Analysis Framework Version 4

Most commodities carried by rail in Massachusetts are bulk loads. They include lumber, cement, steel, ethanol, chemicals, papers as well as food products.

The advantage of rail comes primarily from its large hauling capacities and economies of scale that can substantially undercut the cost of trucking over long distances and/or high volumes. Because of this advantage, single-commodity unit trains and intermodal service has grown rapidly. The traditional carload "loose car" service has become more of niche product and is successful where volumes are sufficiently high to leverage the larger capacity of railcars and the origin and/or destination has direct rail access.

Goods Carried by Sea

Table 2.8 provides the top 10 commodities carried by sea into and out of Massachusetts. The top commodity by tonnage and value is gasoline.

TABLE 2.8: TOP TEN COMMODITIES CARRIED PRIMARILY BY SEA IN MASSACHUSETTS

Commodity	Tonnage (1,000s)	Commodity	Value (millions)
Gasoline	2,534	Gasoline	$2,003
Fuel oils	1,107	Mixed freight	$1,113
Coal	609	Fuel oils	$890
Nonmetallic minerals	523	Plastics/rubber	$544
Plastics/rubber	88	Electronics	$473
Newsprint/paper	74	Machinery	$407
Other foodstuffs	73	Pharmaceuticals	$366
Waste/scrap	72	Misc. mfg. prods.	$327
Alcoholic beverages	33	Textiles/leather	$318
Misc. mfg. prods.	28	Basic chemicals	$254

Source: FHWA Freight Analysis Framework Version 4

Gasoline and other fuel oils (diesel, renewable fuels, etc.) are among the top commodities carried by sea (ship and barge) in Massachusetts. Others include bulk materials (e.g. cement, stone, gravel), seafood (to be processed) and produce (e.g. fresh fruits). The Auto Port in Boston is thriving, with between 50,000 and 60,000 vehicles delivered annually. The facility is operating at its capacity. The Port of New Bedford is looking to grow through the offshore wind industry.

Waterborne freight generally has the lowest cost among all modes of freight transportation due to economies of scale, but the speed is also slow. Therefore, it is mostly used for products that are of relatively lower value and/or do not require fast delivery.

Beyond tonnage and value, seaborne freight can also be measured in twenty foot equivalent units (TEUs) when it is moved in intermodal containers. The Port of Boston – Massachusetts' only container port – is anticipated to move 245,000 TEUs in 2016. Through improved relations with the International Longshoremen's Association, the port has seen a 30 percent improvement in productivity. The expansion of the Panama Canal, however, has encouraged carriers to increasingly use 8-10K TEU vessels, as opposed to 4-6K vessels previously. Conley Terminal in Boston lacks cranes large enough to fully service these vessels, which, absent planned improvements will impact the future viability of the port as an alternative to New York/New Jersey and others. Efforts are currently underway to increase the capacity of Conley Terminal to 500,000 TEUs per year and to allow for the full handling of neo-panamax vessels. Principal improvements entail increased channel depths, extending and reconfiguring the terminal area, installing higher capacity cranes, and constructing a dedicated haul road.

Goods Carried by Air

Table 2.9 provides the top 10 commodities carried by air into and out of Massachusetts.

TABLE 2.9: TOP TEN COMMODITIES CARRIED PRIMARILY BY AIR IN MASSACHUSETTS

Commodity	Tonnage (1,000s)	Commodity	Value (millions)
Animal feed	210	Electronics	$9,402
Basic chemicals	75	Precision instruments	$6,921
Precision instruments	54	Misc. mfg. prods.	$5,303
Meat/seafood	52	Machinery	$4,199
Electronics	44	Pharmaceuticals	$1,762
Machinery	29	Basic chemicals	$1,257
Textiles/leather	15	Chemical prods.	$717
Plastics/rubber	14	Textiles/leather	$544
Misc. mfg. prods.	9	Meat/seafood	$41
Motorized vehicles	9	Waste/scrap	$96

Source: FHWA Freight Analysis Framework Version 4

As learnt from the interviews, seafood and plastic products are carried by air into and/or out of Massachusetts. In addition, FAF data show that chemical products, electronics and machinery, precision instruments, and textiles/leather are also among the top commodities carried by air. Air freight is mostly used for products that are perishable or of high value and thus require speedy transportation, which can justify the substantially higher cost of air than other modes.

Because the air freight system in Massachusetts is centered on Logan International Airport in Boston, the air freight network is closely tied to and dependent on the trucking network. Because the airport is located in Downtown Boston, trucks need to access it using urban freeways and the harbor tunnels that trucks typically would avoid. The network is centered on trucking hubs near the airport in Everett and Chelsea, which receive large varied loads from shippers around the state and distribute them onto smaller trucks bound for specific airlines and flights.

Domestic air freight is governed by tight time constraints, as aircraft spend very little time on the ground. Loads destined for international flights are often allowed to build up at the hub, often with weekly deliveries from shippers. This affects route choice – drivers are willing to take any route to the airport that allows them to meet domestic departures. Air freight generally arrives at the airport in the morning and departs in the evening, with trucks making the trip out to the Route 128 and I-495 belts in the morning with deliveries and collecting pickups in the early afternoon to return to Boston.

Logan Airport is tightly space-constrained, and the square footage available to process air freight has continuously shrunk as passenger demand has grown. As a result, Massport (the airport's operator) has looked to improve efficiency by optimizing the business practices of airlines and freight forwarders.

3.0 Transportation

3.1. Highway Freight Facilities

Highway freight facilities in Massachusetts include Interstates, other freeways and major arterials, and State-owned and local roadways. Attached to these roadways are rest and parking areas owned and operated by MassDOT, as well as truck stops operated by private owners. It should be noted that truck parking is strictly limited at most rest areas and parking lots, and unattended trucks can be issued citations if they are parked in areas meant for automobiles and motorists.

Figure 3.1 shows highway freight facilities in Massachusetts. One should note that although several rest areas and parking lots are located inside I-495, the Boston Region in general was seen as a parking "dead zone" by interviewees due to the lack of appropriate truck facilities. It should also be noted that while the stretch of I-495 between US-3 in Lowell and I-290 in Marlborough is the most critical and heavily-traveled trucking corridor in Massachusetts (based on interviews and truck counts), no truck stops and only a single parking area serve it. No parking, rest, or service facilities exist inside the I-95/Route 128 ring around the City of Boston. Truck stops primarily serve the stretch of I-90 and I-84 in the Central Region that connects the Boston Region to New York City, to the southwest along I-84.

In their Congestion Impact Analysis of Freight Significant Highway Locations, American Trucking Research Institute listed I-95 at I-93 (North) and I-93 at State Route 3 as the 68th and 82nd worst truck freight bottlenecks in the country. Interviewees added that I-95 at I-93 (South) is a third key truck freight bottleneck.

3.2. Rail, Air, and Sea Freight Facilities

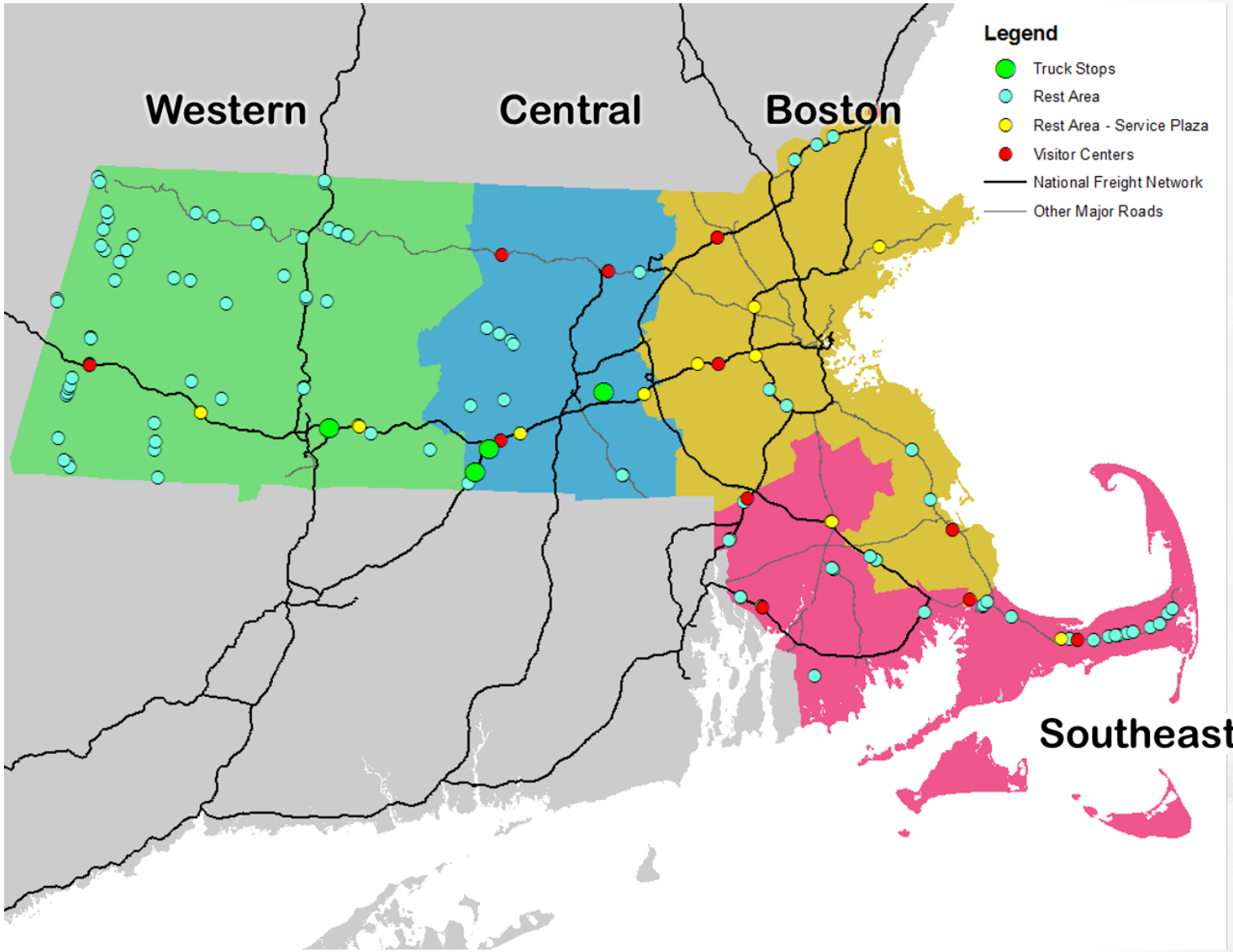
Rail freight facilities in Massachusetts include rail lines, freight yards, and intermodal and transload facilities (intermodal facilities may have the capacity to transfer standard containers). Rail freight in Massachusetts is largely centered on neighboring facilities in Worcester and Ayer in the Central Region, with additional facilities in the Springfield Area in the Western Region. Rail freight has largely retreated from Boston after the closure of the Beacon Park Yard upon its sale to Harvard University.

Figure 3.2 shows rail lines by weight restriction. 286K (i.e., 286,000lb per car) is the established national standard for standard freight cars. In Massachusetts, the principal CSX/MassDOT/MBTA route from Selkirk, New York to Boston and Pan Am Southern's route paralleling Route 2, are rated at 286K or above. Interviewees noted their desire to upgrade the segment of New England Central Railroad's north-south main line through Millers Falls and Palmer to 286K. These improvements would make the route from Canada through New England 286K capable. MassDOT is upgrading the line between Boston and New Bedford as a part of its South Coast Rail project.

At present, the only route across Massachusetts that can host domestic double-stack service is CSX's route from Worcester to Selkirk, New York. Clearance on Pan Am Southern's route is impeded by the 4.7 mile Hoosac Tunnel. As a result of these and other constraints, Massport's Conley Terminal is wholly reliant on truck access.

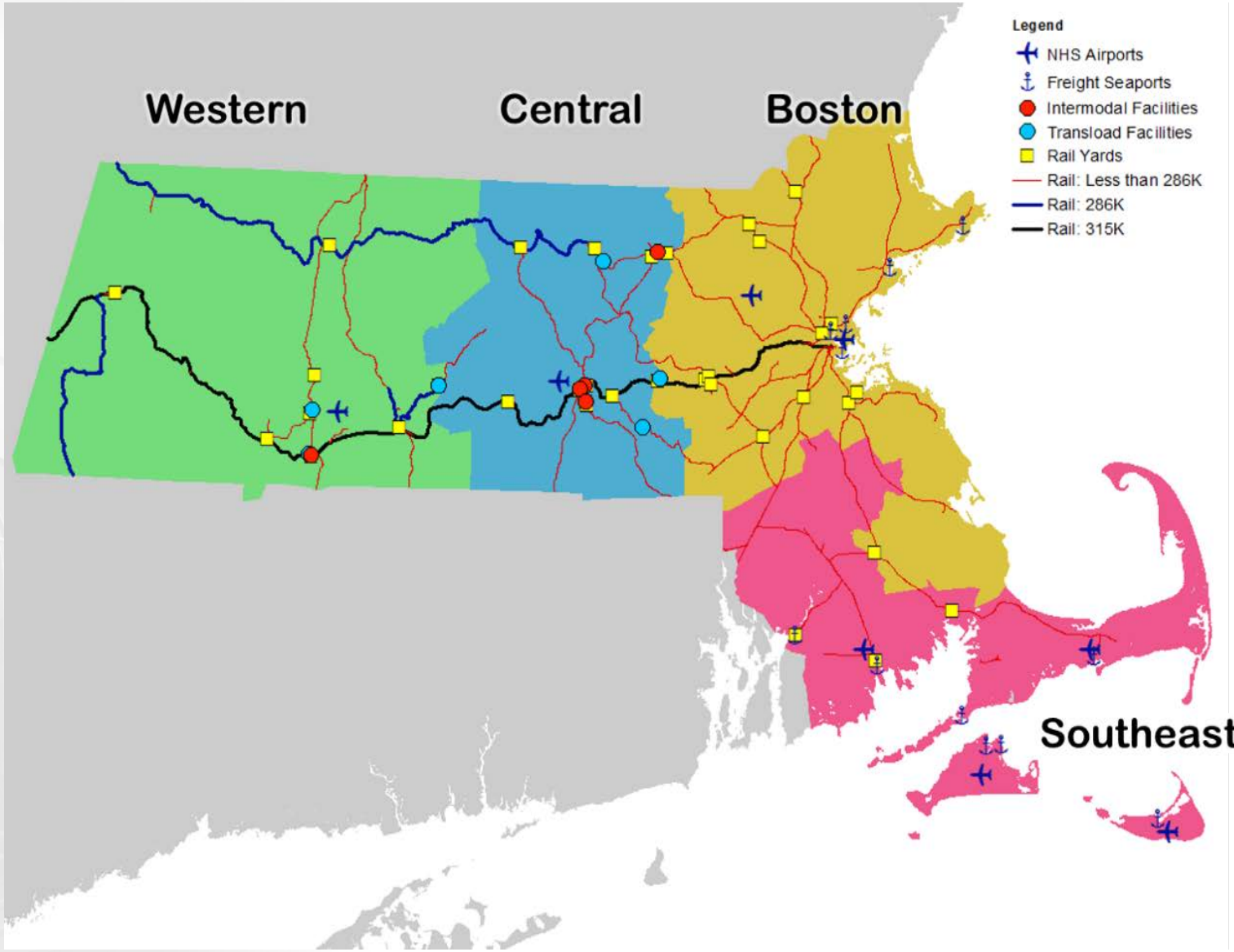
Figure 3.2 also includes airports listed as National Highway System Terminals and seaports that MassDOT identifies as having freight facilities. Only one airport – Logan International in Boston – actually sees significant air freight use, although business groups in Western Massachusetts have suggested a freight use at Westover Metropolitan Airport in Chicopee. Of the seaports, the Port of Boston (shown as its three subsections – Conley Terminal, Chelsea Terminal, and the Auto Port) and the Port of New Bedford see significant traffic.

FIGURE 3.1: MAP OF HIGHWAY FREIGHT FACILITIES IN MASSACHUSETTS



Source: FHWA (National Freight Network), MassDOT Open GIS Portal

FIGURE 3.2: MAP OF RAIL, AIR, AND SEA FREIGHT FACILITIES IN MASSACHUSETTS



Sources: MassDOT Open GIS Portal, Bulk Transporter (Transload), LoadMatch (Intermodal)

4.0 Policy and Regulation

We collected feedback on MassDOT's regulations from freight system users through our interview process. This feedback is presented here by mode.

4.1. Trucking

Freight system users provided the following feedback on trucking policy and regulation:

- Some users placed Massachusetts behind neighboring states in regard to transferring, acquiring, and renewing commercial drivers' licenses for truckers. Interviewees reported that drivers have had to be let go due to delays in the MassDOT licensure process.
- There are few truck parking, rest, and trucking services (including truck cleaning and maintenance) available along I-495 and inside of the I-495 belt. As shown in Figure 3.1, I-495, I-93, and I-90 are major trucking routes, with the former a key segment of the main freight artery in Massachusetts. System users seek more services and increased hours.
- Users had mixed feedback about oversize/overweight (OS/OW) permitting in Massachusetts:
  - Currently, carriers must secure two permits for shipments over I-90 – one for the Turnpike and another for other MassDOT roads. Carriers would like to see this arrangement simplified.
  - In contrast to other states, MassDOT requires the use of a third-party engineer for structural bridge analysis. This can cost $30,000-$50,000, and must be done every time a permit application is pending. Frequently used routes may be constantly and needlessly reassessed.
  - OS/OW permits commonly include time-of-day restrictions that specifically reflect regulations in eastern Massachusetts, even if the shipments do not touch that region.
  - New England would benefit from a region-wide approach to OS/OW permitting such as that employed in Vermont, New Hampshire, and Maine.
  - MassDOT requires that OS/OW movements be escorted by off-duty state troopers. In most other states, this duty is assigned to trained escorts who cost less and are more experienced. Further, MassDOT requires a separate trooper escort for the Turnpike (i.e., a trooper assigned to a Turnpike barracks), resulting in the need to fund multiple escorts for many shipments.
- Feedback on enforcement, and inspection of trucks in Massachusetts was reviewed positively, with MassDOT compared favorably to bordering states.
- Fuel trucks are banned in the I-93 tunnels in Boston (along with other hazardous materials). This forces deliveries to Southeastern Massachusetts into lengthy detours around the city on I-95. MassDOT does not generally have clear and uniform guidance on hazmat routing designations in Boston to avoid the tunnels, and Boston doesn't allow fuel trucks on city streets during peak hour – their enforcement of this is very strict.
- As urban areas move toward "complete streets" design approaches with marked bicycle lanes, bicycles, pedestrians and trucks have been made to interact in new and sometimes dangerous ways. Massachusetts

does not require side guards on trucks, though Boston and Cambridge have taken action to require them or install them on city-owned vehicles.

- Rhode Island is considering truck-only tolls on some major roads. If implemented, some users believed they could impact typical trucking routes into and out of Massachusetts.

4.2. Rail

Freight system users provided the following feedback on rail freight policy and regulation:

- System users would like to understand MassDOT's operational plans for the Knowledge Corridor, including leveraging the state's investment for economic development.
- MassDOT's Industrial Rail Access Program (IRAP) is seen as helpful, but is not seen as being available frequently enough – only one funding round occurs per year – and is not big enough to support large projects ($500,000 maximum).
- In 2016, the Massachusetts Legislature introduced House Bill 3037, to distribute surplus public rail assets (i.e., old but usable rail and other track materials) to private railroads for the sake of improving rail infrastructure. Users expressed enthusiasm for promoting the bill in cooperation with MassDOT.
- The condition of Massachusetts grade crossings is generally good in the opinion of users.

4.3. Seaports

- System users felt strongly that MassDOT must preserve truck access to South Boston, Chelsea, and Everett on dedicated roadways. Intermodal containers cannot be stored at Conley Terminal, and distribution centers are not located nearby, so Bypass Road is critical to move the containers off-site quickly. Massport went on the record in opposing the dual use of Bypass Road.
- Inspections of imported goods at seaports can affect the supply chain. One user noted that the Food and Drug Administration (FDA) inspections of their (perishable) products can result in significant loss of product. Inspectors choosing to economize by allowing loads to build up to inspect at once impacts the supply chain of a factory expecting the loads in sequence.

4.4. Airports

- Moving forward, it may become necessary for public agencies (Massport or MassDOT, depending on the airport/location involved) to take action to relieve air freight processing congestion at Logan Airport. Massport has considered a "bypass" freight facility, for which goods would be received at an off-airport site, condensed into sterile trucks, and passed quickly onto aircraft at a dedicated on-airport facility (replacing the carrier-specific on-airport processing facilities currently in use). Another alternative would be to identify a reliever airport or airports for Boston freight, construct/maintain the proper support facilities, and promote these to carriers.
- Eastern Ave. in Chelsea is a key access route for air freight at Logan Airport. MassDOT and the Boston MPO should consider adding it (and other nearby truck routes) to the Commonwealth's Urban Freight Network.

5.0 Summary

To identify the existing trends and conditions of freight in Massachusetts, we reviewed population, employment, GDP, productivity, commodities, and industry clusters; interviewed more than 25 companies throughout the state representing key industries to understand their supply chains; analyzed the multimodal transportation system in place to carry the goods; and detailed the real-world implications of the Commonwealth's freight-related policy decisions. In summary:

Economy

The economy is Massachusetts is strong and growing:

- Population is growing in Massachusetts but is growing more slowly than the national average. It is growing faster in the Boston and Central regions than in others. It is growing faster than neighboring states (except for NH).
- Employment is growing in Massachusetts, faster than the nation. Boston is growing faster than anywhere else in the state.
- GDP in the state is larger than any New England state. It continues to grow at the fastest pace of any New England economy and is keeping pace with New York's economic growth.
- Top industry clusters statewide include Education and Knowledge Creation, IT and Analytical Instruments, Fishing and Fishing Products, Biopharmaceuticals, and Medical Devices. Most of the employment in these industries is related to the research and design of the products (e.g., white collar jobs) rather than the manufacturing of them.

Logistics

We defined a set of key industries based on employment, population, industry clusters, GDP, and international trends identified in Technical Memorandum 1. Key industries in the state include white collar, retail and trade, chemical manufacturing (highlighting the biopharmaceutical industry), and computer and electronic product manufacturing. White collar industries are supported by food, fuel, and consumer goods. To understand the logistics patterns of these industries, we conducted interviews of people working on strategy and/or logistics from companies representing these industries from around the state. We found:

- Urban institutions see more e-commerce, buy lots of food and beverage, produce lots of waste, and have their own construction seasons. Truckers have issues with urban geometries and congestion when delivering materials and foods. Logistics for universities are seasonal.
- Biopharmaceuticals are typically manufactured elsewhere with the research and development performed in-state by an expensive, highly-skilled workforce. These companies tend to make small shipments of drugs on an ad hoc basis, targeted for clinical trials. They do take multiple inbound shipments of lab equipment.
- Fish processing and fishing are two distinct industries. 75 percent of fish processed in Boston is flown out of Logan to Europe and Asia. More than 90 percent of fish consumed here is imported from abroad. Fish processing will continue to drive productivity growth in the port areas of Boston and New Bedford.
- Fuel for Eastern Massachusetts arrives by pipeline into Braintree or into ports in Chelsea and Providence, Rhode Island; for Western Massachusetts it arrives into the Port of New Haven, Connecticut and the Buckeye

pipeline in Holyoke; and for Central Massachusetts arrives into Providence, Rhode Island. The fuel supply chain is vulnerable to disruption from flooding.

- Food is delivered from regional distribution centers throughout the state. Increasing urban populations and land prices may lead retailers to increase turnover in urban locations, perhaps requiring more frequent deliveries with smaller vehicles.

Transportation

Transportation access around Massachusetts is generally good but our research, analysis, and interviews revealed the following:

- The Boston Region needs more appropriate truck parking facilities. The stretch of I-495 between US-3 in Lowell and I-290 in Marlborough is the most critical and heavily-traveled trucking corridor in Massachusetts but there are no truck stops and only a single parking area serves it. No parking, rest, or service facilities exist inside the I-95/Route 128 ring around the City of Boston.
- I-95 at I-93 (North) and I-93 at State Route 3 rank as the 68th and 82nd worst truck freight bottlenecks in the country. Interviewees note I-95 at I-93 (South) as a third key truck freight bottleneck.
- There are several principal rail lines throughout the Commonwealth that are weight restricted and/or that need to be upgraded to accommodate domestic double stacking.

Policy and Regulation

MassDOT may wish to address some serious freight policy issues over the coming years:

- Some users experienced challenges in Massachusetts when transferring, acquiring, and renewing commercial drivers' licenses for truckers.
- There are issues with OS/OW permitting, including institutional issues with operating on the Massachusetts Turnpike and other State roads (i.e., duplicate escorts and permits), repeated need for structural bridge analysis, and regional barriers.
- Fuel trucks are required to take a long diversion around the City of Boston due to restrictions on through routes.
- Urban geometries and complete streets are creating safety issues between trucks, bicyclists, and pedestrians.
- The Industrial Rail Access Program is seen as a success but would be beneficial if it was changed to issue grants more than once each year.
- System users felt strongly that MassDOT must preserve truck access to South Boston, Chelsea, and Everett on dedicated roadways. Intermodal containers cannot be stored at Conley Terminal, and distribution centers are not located nearby, so Bypass Road is critical to move the containers off-site quickly.
- Moving forward, it may become necessary for public agencies (Massport or MassDOT, depending on the airport/location involved) to take action to relieve air freight processing congestion at Logan Airport. Eastern Ave. in Chelsea is a key access route for air freight at Logan Airport. MassDOT should consider adding it (and other nearby truck routes) to the Commonwealth's Urban Freight Network.