FMTP24
FREIGHT MOBILITY AND TRADE PLAN

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Technical Memorandum 3
Freight System Trends

FDOT

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List of Acronyms

AAM	Advanced Air Mobility
ATI	Automated Track Inspections
BEA	Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
CAAGR	Compound Average Annual Growth Rate
CCTV	Closed-Circuit Television
CNG	Compressed Natural Gas
DATP	Driver Assisted Truck Platooning
EDR	Office of Economic and Demographic Research
EIA	U.S. Energy Information Administration
EV	Electric Vehicles
EVSE	Electric Vehicle Supply Equipment
eVTOL	Electric Vertical-Takeoff-and-Landing
FAF	Freight Analysis Framework
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
FOX	Freight Operations eXchange
FRA	Federal Railroad Administration
FRATIS	Freight Advanced Traveler Information System
FSP	Freight Signal Priority
GDP	Gross Domestic Product
GSP	Gross State Product
IIJA	Infrastructure Investment and Jobs Act
ILC	Intermodal Logistics Center
ITS	Intelligent Transportation System
LNG	Liquefied Natural Gas
LPG	Liquid Propane Gas
MCSAW	Motor Carrier Size and Weight Office
MPO	Metropolitan Planning Organization
MSA	Metropolitan Statistical Area
NAFTA	North American Free Trade Agreement
NEVI	National Electric Vehicle Infrastructure
NextGen NHTS	Next-Generation National Household Travel Survey
O-D	Origin-Destination
PROTECT	Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation
PTC	Positive Train Control
RAP	Resilience Action Plan
RDT&E	Research, Development, Training, and Evaluation
RIP	Resilience Implementation Plan
RNG	Renewable Natural Gas

SAF	Sustainable Aviation Fuel
SCTG	Standard Classification of Transported Goods
SCTG2	Two-Digit Standard Classification of Transported Goods
SHS	State Highway System
SIS	Strategic Intermodal System
STRACNET	Strategic Rail Corridor Network
STRAHNET	Strategic Highway Network
TPAS	Truck Parking Availability System
U.S.	United States
USMCA	Agreement between the United States of America, Mexico, and Canada
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Anything
VMT	Vehicle Miles Traveled

Introduction

The trends influencing freight in Florida are borne from worldwide-effects. Supply chains are global and interconnected, meaning the businesses, workers, infrastructure processes, and practices that underlie the sourcing, manufacturing, transportation, and sale of goods, are impacted by a multitude of factors and have trickle-down impacts. In 2022, the USDOT looked at America's supply chains and identified the trends below[1]:

- Growing freight demand
- Changing consumer preferences
- Increasing need for qualified logistics workforce
- Increasingly complex global supply chains
- Increasing weather disruptions
- New technologies

These trends are being felt in Florida and are connected to Florida's growth opportunities and supply chain resiliency. The purpose of this section is to describe how these key trends are impacting Florida - specifically pertaining to freight flows, demographics, economics, weather, and technology - and how they may affect future freight needs in the state. This memorandum also highlights Florida's current supply chain resilience initiatives as well as specific constraints that the state is facing.

The data deployed in assessing the trends were sourced from various state and federal governmental agencies.

[1] Supply Chain Assessment of the Transportation Industrial Base: Freight and Logistics | US Department of Transportation

Freight Flow Trends

Throughout this section, freight data summaries and key findings are presented to enhance comprehension of the flow of commodities in Florida. Derived from the dataset of the Federal Highway Administration's (FHWA) Freight Analysis Framework Version 5 (FAF5), these summaries include information on freight tonnage, value, commodity type, and trade type, with the following definitions:

- Freight Tonnage: total weight of commodities shipped
- Freight Value: total monetary value (2017 $) for the commodities shipped
- Commodity Type: goods category as per the Bureau of Transportation Statistics (BTS)'s Standard Classification of Transported Goods (SCTG), referenced at a two-digit level
- Trade Type: a distinction between domestic freight, which only includes domestic shipments moved between origins and destinations inside the United States (U.S.), and foreign trade flows

Statewide Commodity Flow Analysis

Figure 1 illustrates the commodity flows (tonnage) for the state of Florida using the Freight Analysis Framework (FAF), 2022 data (5.5.1 version). Approximately 74 percent of commodity movements (tonnage) originate and terminate within Florida as intrastate movements. The imports to Florida (19 percent) outnumber the exports (7 percent). This pattern underscores that Florida is predominantly a consumer state. Subsequent figures and tables provide a comprehensive breakdown of the commodity flows for the state of Florida that identifies the major trading partners, modal splits, and the commodity types for different commodity flow movements.

Figure 1 | Commodity Movement Inside, Outside, and Within Florida (2022)

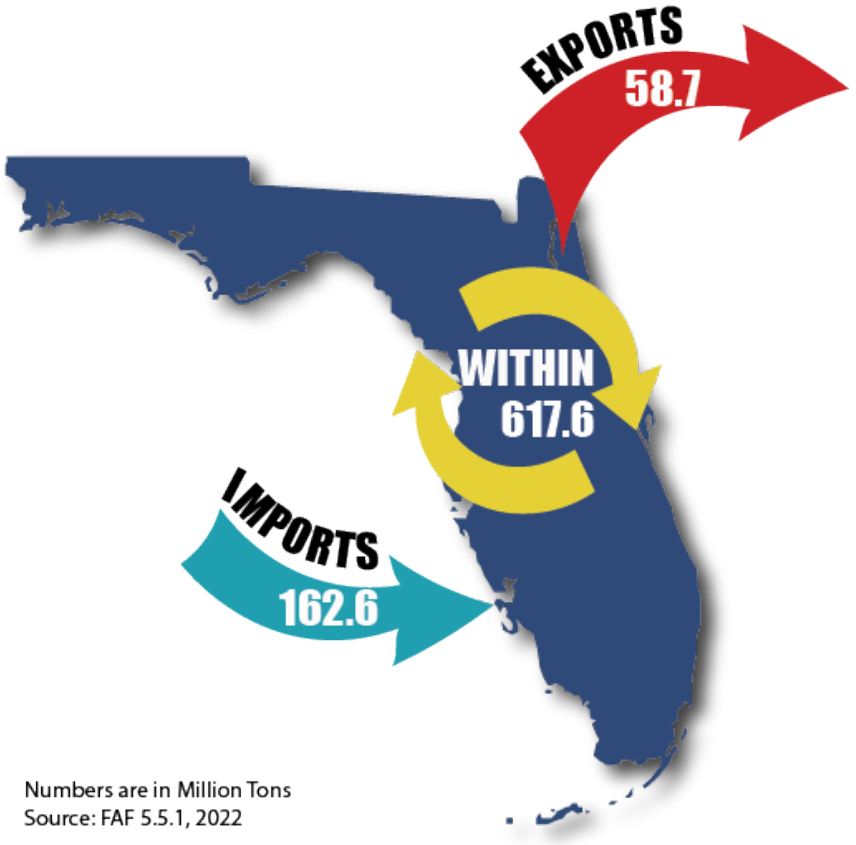
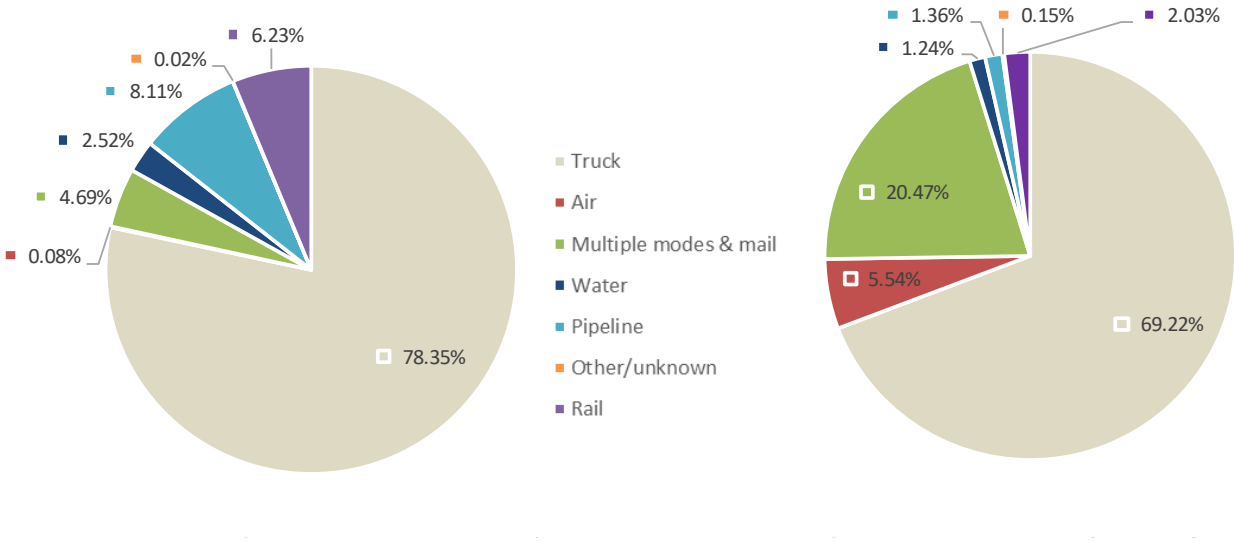


Figure 2 displays the percent modal share of commodity flow in terms of both tonnage and value. Trucks overwhelmingly dominate both tonnage and value shares. However, the share of air transport and 'multiple modes and mail' are notably low in tonnage but high in value, suggesting a prevalence of high-value commodities transported by these modes. Conversely, pipelines account for a substantial tonnage share, but exhibit a relatively low value share, indicating the transportation of lower-value commodities via pipelines. Similar patterns are observed for the rail and water modes.

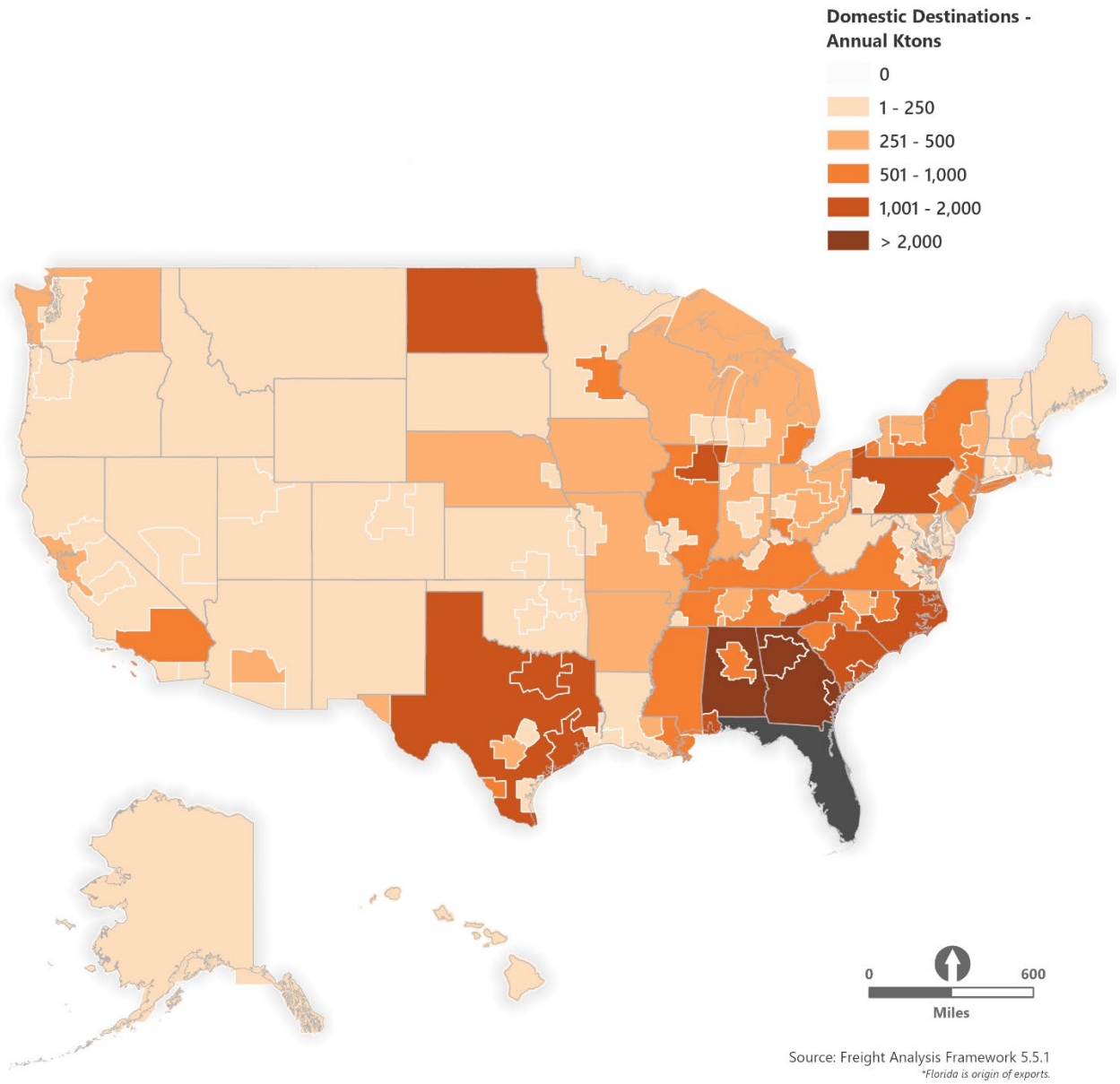
Figure 2 | Percent Mode Shares by Tonnage (Left) and by Value (Right) (2022)



Data Source: Freight Analysis Framework 5.5.1.

Figure 3 depicts the domestic destinations of commodity movement from Florida. The destinations are categorized by FAF zones. FAF zones include the 132 domestic regions in the U.S. These regions are defined by FHWA. In terms of total tonnage movements, the top five destination FAF zones include the rest of Georgia (11.6 percent), Atlanta-Georgia (8.5 percent), the rest of Alabama (5.6 percent), Savannah-Georgia (4 percent), and the rest of South Carolina (2.8 percent).

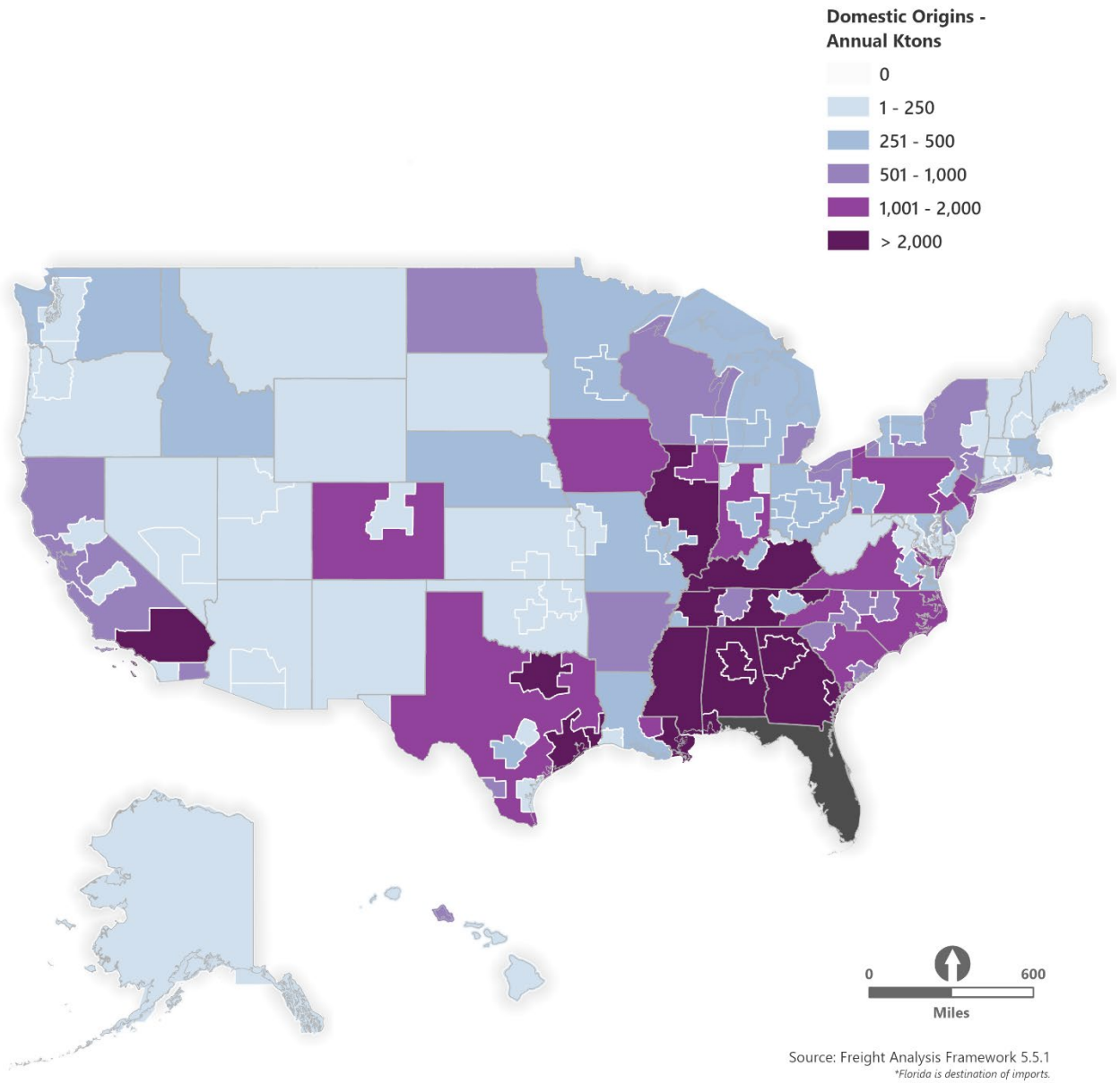
Figure 3 | Domestic Destinations for Florida Exports (in ktons, 2022))



Data Source: Freight Analysis Framework 5.5.1.

Figure 4 depicts the domestic origins of commodity movement to Florida. The origins are categorized by FAF zones. In terms of total tonnage movements, the top five origin FAF zones include the rest of Alabama (12.9 percent), the rest of Georgia (11.5 percent), Mobile-Alabama (9.4 percent), New Orleans LA-MS (6.7 percent), and Mississippi (4.8 percent).

Figure 4 | Domestic Origins to Florida (in ktons, 2022)



Data Source: Freight Analysis Framework 5.5.1.

Table 1 presents a detailed breakdown of domestic imports and domestic exports categorized by different commodity types, utilizing the two-digit Standard Classification of Transported Goods (SCTG2) classification system. The top five commodities for domestic imports and exports, both in terms of tonnage and value, are visually emphasized in red. Notably, the leading domestic imports by tonnage include coal, gasoline, natural gas, nonmetal mineral products,

and other foodstuffs. Conversely, the top domestic imports by value consist of electronics, machinery, mixed freight, motorized vehicles, and pharmaceuticals. Examining domestic exports, the primary commodities by tonnage include fertilizers, newsprint/paper, nonmetal mineral products, other agricultural products, and other foodstuffs. In contrast, the foremost domestic exports by value involve electronics, motorized vehicles, pharmaceuticals, precision instruments and textiles/leather. Gravel, natural gas/fossil products, natural sand, nonmetal mineral products, and waste/scrap rank as the primary commodities for intrastate transportation based on tonnage. In terms of value, the leading intrastate movements include electronics, machinery, mixed freight, motorized vehicles, and pharmaceuticals.

Table 1 | Commodity Types of Domestic Movements (2022)

Commodity Types (SCTG2)	Domestic Imports		Domestic Exports		Intrastate Movements	
	ktons	$M (2017 $)	ktons	$M (2017 $)	ktons	$M (2017 $)
Alcoholic beverages	2,372.8	5,875.1	1,359.9	3,818.8	7,421.3	15,712.6
Animal feed	1,417.7	1,427.5	2,844.3	561.2	4,404.5	2,551.5
Articles-base metal	1,846.5	7,042.0	1,186.2	4,401.5	2,683.1	9,126.4
Base metals	2,501.4	5,201.8	1,224.2	2,654.5	3,200.4	5,794.4
Basic chemicals	4,791.4	5,660.2	2,434.1	2,543.9	5,162.3	7,113.2
Building stone	42.6	40.7	49.1	36.2	2,608.2	1,010.2
Cereal grains	1,462.3	284.9	345.3	87.5	5,646.2	1,037.9
Chemical prods.	2,039.6	11,775.5	920.1	4,578.3	2,703.2	7,186.1
Coal	***8,747.5***	407.7	77.9	13.2	419.0	24.0
Crude petroleum	812.6	63.5	86.6	25.9	4.1	17.6
Electronics	2,204.3	***52,753.2***	803.9	***24,122.3***	2,180.3	***40,183.9***
Fertilizers	1,286.5	496.4	***5,630.9***	1,623.7	19,710.5	5,879.7
Fuel oils	3,512.1	1,959.8	136.6	50.9	15,360.0	8,070.9
Furniture	1,391.6	7,498.5	333.6	2,021.3	1,783.9	10,309.9
Gasoline	***15,833.9***	9,125.7	925.1	500.3	38,016.2	20,955.5
Gravel	6,743.8	127.2	1,331.7	32.9	***123,938.4***	1,531.5
Live animals/fish	69.9	283.4	652.3	1,609.1	272.4	955.9
Logs	322.1	116.8	1,349.3	307.2	19,062.2	509.4
Machinery	2,112.2	***29,066.6***	2,767.0	10,708.7	4,492.6	***27,241.8***
Meat/seafood	2,910.6	13,588.2	846.5	5,110.9	2,168.9	14,731.2
Metallic ores	208.2	256.0	255.9	340.7	150.4	107.0

Commodity Types (SCTG2)	Domestic Imports		Domestic Exports		Intrastate Movements	
	ktons	$M (2017 $)	ktons	$M (2017 $)	ktons	$M (2017 $)
Milled grain prods.	2,082.9	4,488.5	661.6	1,542.5	2,221.4	4,937.3
Misc. mfg. prods.	1,794.3	24,798.4	527.3	11,913.6	3,936.0	16,555.1
Mixed freight	6,826.1	***34,720.6***	2,681.3	9,434.8	20,794.6	***83,003.5***
Motorized vehicles	3,468.6	***39,544.2***	1,083.8	***14,957.0***	3,049.2	***31,829.0***
Natural gas and other fossil products	***35,686.6***	6,658.3	653.4	804.3	***39,210.9***	11,004.3
Natural sands	7,577.0	151.1	536.6	93.7	***61,517.5***	1,267.0
Newsprint/paper	2,892.6	2,686.3	***3,493.8***	2,431.6	2,314.8	2,400.3
Nonmetal min. prods.	***8,267.2***	4,530.7	***3,221.0***	1,246.7	***85,169.3***	10,993.7
Nonmetal minerals	2,635.9	460.4	2,211.2	481.5	9,666.4	1,158.9
Other ag prods.	4,399.3	4,984.9	***3,160.4***	4,426.7	32,441.5	11,927.0
Other foodstuffs	***9,376.2***	13,424.3	***6,538.7***	6,108.3	24,228.5	21,702.1
Paper articles	1,618.1	3,587.7	652.1	1,467.1	1,701.4	3,053.8
Pharmaceuticals	1,605.1	***27,046.7***	247.2	***19,835.3***	2,195.4	***46,874.0***
Plastics/rubber	4,440.8	14,357.0	1,774.2	7,138.0	4,121.8	13,993.6
Precision instruments	345.5	19,106.8	484.8	***16,911.7***	922.6	8,565.7
Printed prods.	459.3	3,317.1	244.6	1,966.3	751.4	2,706.9
Textiles/leather	1,633.6	21,613.1	1,012.7	***12,373.2***	991.7	8,793.4
Tobacco prods.	84.5	724.1	60.4	2,295.4	174.8	2,005.9
Transport equip.	242.5	7,863.8	208.1	7,876.3	319.1	7,977.5
Waste/scrap	862.6	527.4	1,369.9	751.0	***42,147.0***	1,323.6
Wood prods.	3,686.8	3,268.6	2,300.3	1,543.7	18,349.8	10,778.0
Grand Total	**162,615.1**	**390,910.6**	**58,684.0**	**190,747.7**	**617,613.1**	**482,901.2**

Data Source: Freight Analysis Framework 5.5.1.

Table 2 illustrates the movement of commodities exported from Florida gateways (including Florida airports and seaports) to international destinations, categorized according to FAF data. It is crucial to emphasize that 77 percent of these international exports by tonnage are directed towards the rest of the Americas. It should also be noted that these international exports from

Florida gateways may have their origin within Florida or outside the state. Additionally, Table 2 presents the percentage of international exports originating within Florida, revealing that 65.4 percent of the total export tonnage comes from the state.

Table 2 | International Export and Import Trading Partners from Florida Gateways (2022)

International Trading Partners*	Total Exports	Originating in Florida	Total Imports	Terminating in Florida
	ktons	% ktons	ktons	% ktons
Africa	91	80.67%	393	85.98%
Canada	116	99.91%	1,076	68.21%
Eastern Asia	773	77.94%	4,028	83.60%
Europe	715	83.84%	6,703	82.45%
Mexico	742	88.71%	2,170	61.00%
Rest of Americas	11,662	60.52%	10,824	73.05%
SE Asia & Oceania	425	87.52%	1,921	86.93%
SW & Central Asia	754	68.22%	4,220	80.15%
Total	**15,278**	**65.41%**	**31,335**	**77.39%**

Data Source: Freight Analysis Framework 5.5.1.

*Includes commodities that are exported or imported via Florida gateways (airports/seaports)

Table 2 also delineates the movements of commodity flow imported into Florida gateways from international origins. The notable origins are Asia, Europe, and the rest of the Americas. The imports arriving at Florida gateways may terminate either within the state or extend beyond its borders. Table 2 further depicts the percentage of international imports originating within Florida. It is noteworthy to highlight that 77.4 percent of all imported tonnage is consumed within Florida. The total tonnage imported into Florida gateways is twice that of the total tonnage exported from these gateways.

Table 3 presents a detailed breakdown of international imports and exports categorized by different commodity types, utilizing the two-digit SCTG2 classification system. The top five commodities for international imports and exports, in terms of tonnage, are visually emphasized in red font. Notably, the leading international imports by tonnage encompass gasoline, gravel, motorized vehicles, nonmetal mineral products, and nonmetal minerals. Examining international exports, the primary commodities by tonnage include chemical products, fertilizers, mixed freight, newsprints/paper, and pharmaceuticals. An essential observation is that high-value goods like pharmaceuticals and electronics are exported more from Florida gateways.

Table 3 | Commodity Types of International Movements via Florida Gateways (2022)

Commodity Types (SCTG2)	International Imports (ktons)	International Exports (ktons)
Alcoholic beverages	216	47
Animal feed	17	49
Articles-base metal	585	305
Base metals	1,168	71
Basic chemicals	242	331
Building stone	3	1
Cereal grains	47	61
Chemical prods.	469	***739***
Coal	418	5
Crude petroleum	4	0
Electronics	492	593
Fertilizers	963	***3,689***
Fuel oils	1,055	312
Furniture	228	57
Gasoline	***2,609***	345
Gravel	***1,256***	3
Live animals/fish	4	2
Logs	16	25
Machinery	373	675
Meat/seafood	537	153
Metallic ores	120	1
Milled grain prods.	37	43
Misc. mfg. prods.	131	87
Mixed freight	138	***961***
Motorized vehicles	***1,307***	646
Natural gas and other fossil products	216	324
Natural sands	2	8
Newsprint/paper	888	***1,139***
Nonmetal min. prods.	***9,317***	199
Nonmetal minerals	***3,118***	29
Other ag prods.	1,019	520
Other foodstuffs	317	244
Paper articles	76	212
Pharmaceuticals	45	***1,039***
Plastics/rubber	974	528

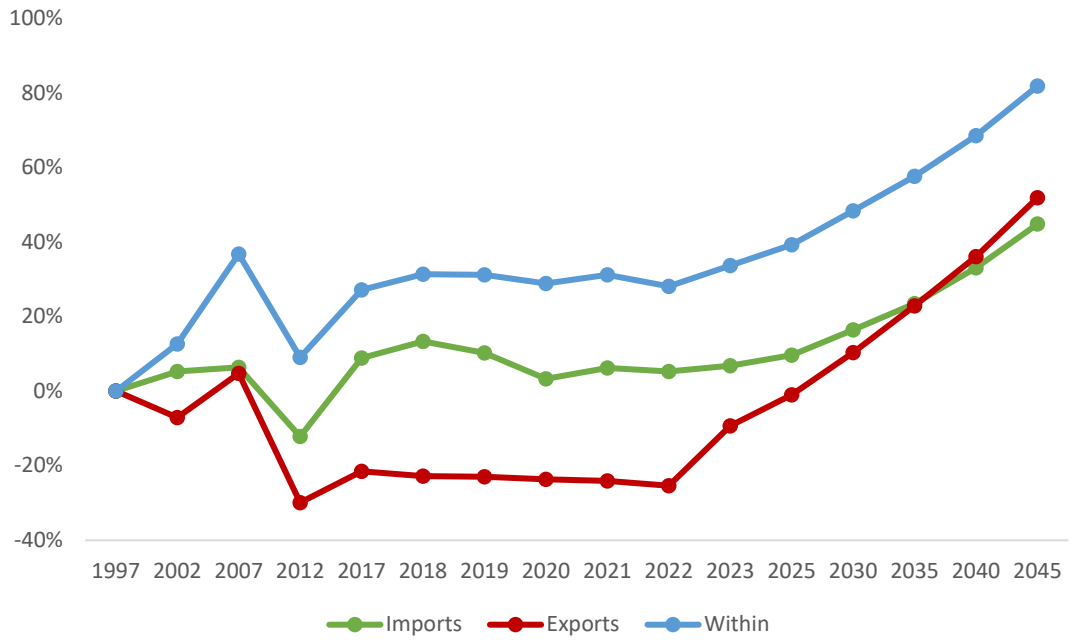
Commodity Types (SCTG2)	International Imports (ktons)	International Exports (ktons)
Precision instruments	210	147
Printed prods.	36	103
Textiles/leather	1,100	321
Tobacco prods.	153	8
Transport equip.	213	171
Waste/scrap	172	706
Wood prods.	1,044	378
Total	**31,335**	**15,278**

Data Source: Freight Analysis Framework 5.5.1.

In terms of modal splits, Florida seaports, are major gateways for international imports (97 percent) and international exports (96 percent) when considering tonnage. However, airports play a noteworthy role in the realm of international imports (30 percent) and international exports (51 percent) when assessed based on value.

Figure 5 illustrates the percentage change in commodity tonnage relative to the 1997 statistics. It is crucial to note that the recession that affected the U.S. in 2007-2009 led to a substantial decline in exports in 2012. The trendlines in the figure below indicate that the projected growth rates in exports from 2022 onward are significantly higher compared to imports and intrastate movements within Florida. By 2045, the forecasted tonnages stand at 223.57 million tons for domestic imports, 119.39 million tons for domestic exports, and 876.67 million tons for intrastate movements.

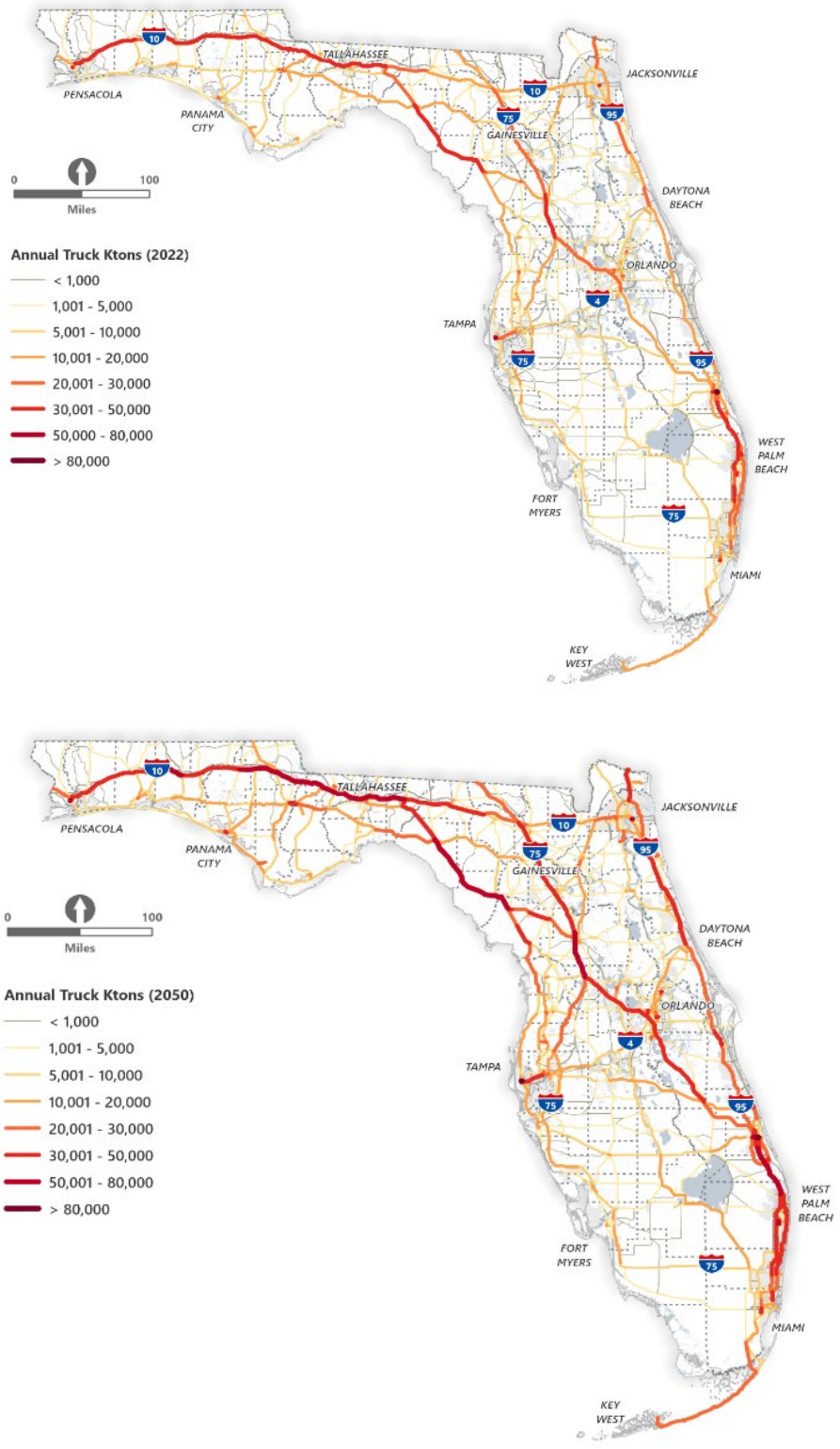
Figure 5 | Percent Change in Commodity Tonnage Imported, Exported, and Within Florida



Data Source: Freight Analysis Framework 5.5.1.

Figure 6 depicts the estimated tonnage movement on different roadways for years 2022 and 2050. The roadways identified with high 2022 truck tonnage movements and 2050 (forecast) truck tonnage movements are the roadway segments that should be potentially prioritized for freight and freight related projects.

Figure 6 | Freight Analysis Framework Roadway Tonnage (Ktons) Moved in Florida, 2022 and 2050

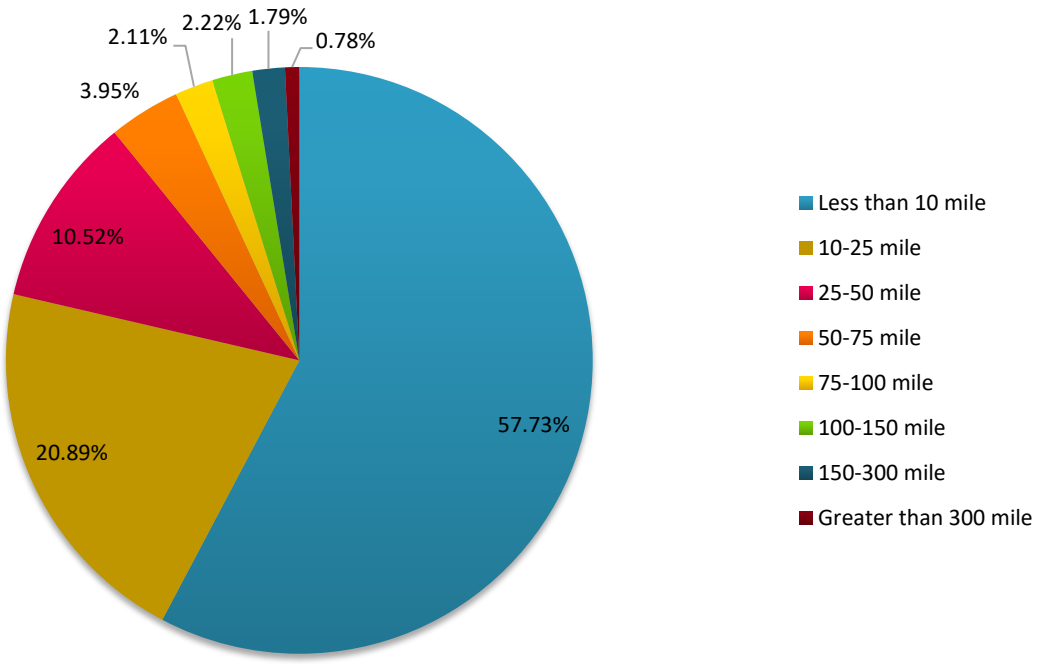


Truck Origin-Destination Flows

This section uses the 2021 Next-Generation National Household Travel Survey (NextGen NHTS) information to analyze the truck flows in Florida. The emphasis is on understanding the truck flows between origins and destinations, including trips within Florida and interzonal truck trips outside Florida. The zones referred to here are the Next Gen Metropolitan Statistical Area (MSA) zones.

The national-level Origin-Destination (O-D) tables for truck travel have been generated by the FHWA using passively collected mobile device location data (sourced from INRIX and ATRI). In 2021, the total annual truck trips within Florida amounted to 801.5 million. Additionally, there were 23.2 million interzonal truck trips originating or terminating outside Florida. Figure 7 visually represents the distribution of Florida-based truck trips (with either origin or destination in Florida) across various distance ranges. As expected, most of these truck trips cover distances of less than 10 miles (57.7 percent), while approximately 4.8 percent of all trips extend beyond 100 miles.

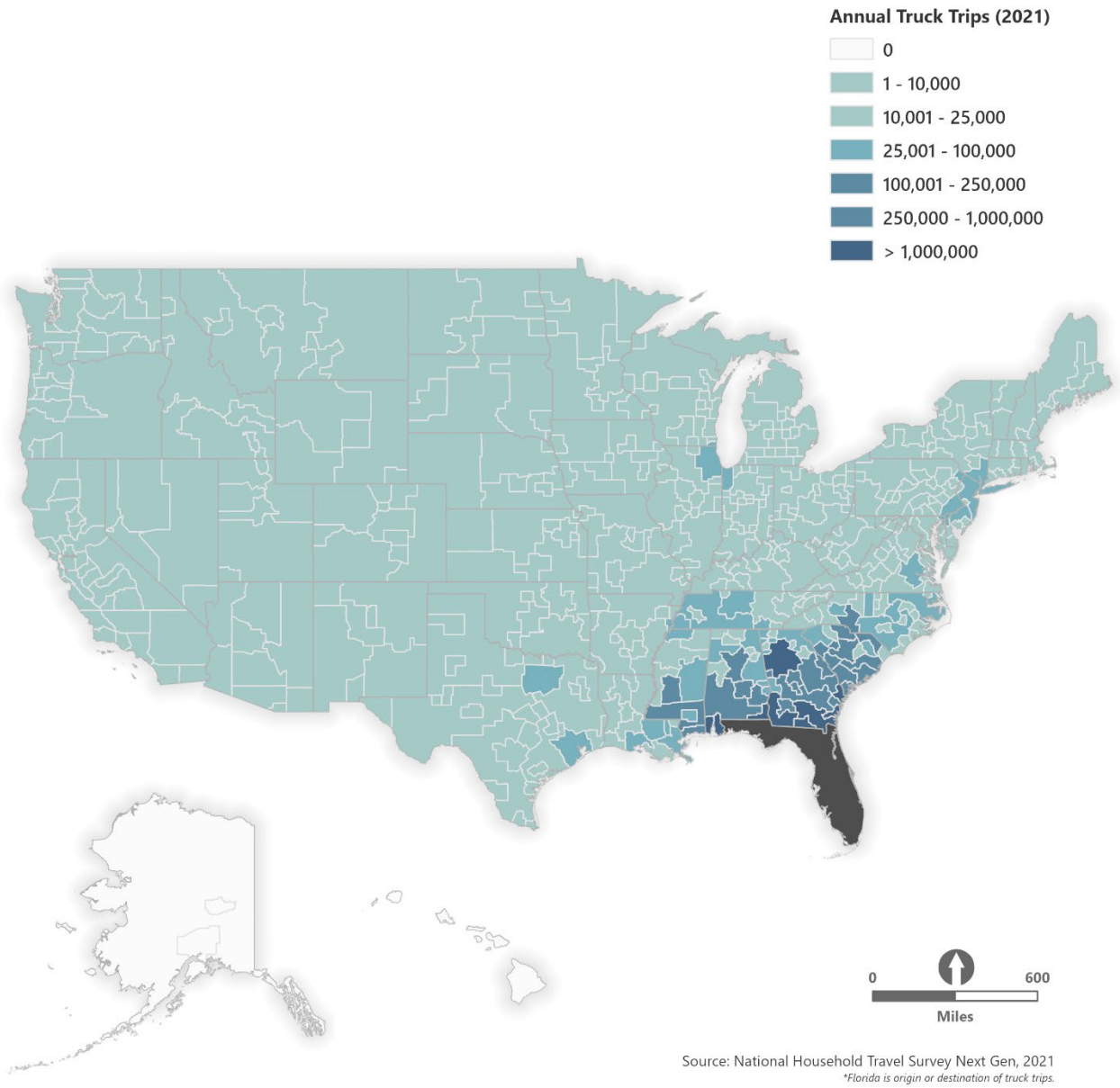
Figure 7 | Florida Annual Truck Trip Distribution by Distance Ranges (2021)



Data Source: National Household Travel Survey Next Gen, 2021

Figure 8 depicts the interzonal trips that either originated from or terminated in Florida. Significant zones of origins and destinations beyond Florida's borders includes zones in nearby states, such as Georgia, Alabama, and South Carolina.

Figure 8 | Annual Truck Trips with Either Origins or Destinations Outside Florida (2021)



Data Source: National Household Travel Survey Next Gen, 2021

Demographic Trends

Demographic trends are a key factor driving freight movements in the state. Growth in the state population, its distribution by age, and shifting urban versus rural areas all influence the amount of freight demand and changing consumer preferences, impacting freight flows.

Total Population

Larger population correlates with greater consumption of freight (60 tons annually on average per U.S. resident), which amounts to a need for increased freight movement and related transportation infrastructure as the state's population grows.

Per Freight Facts and Figures, published by BTS, the average American resident accounts for approximately 60 tons of freight per year.

Historical

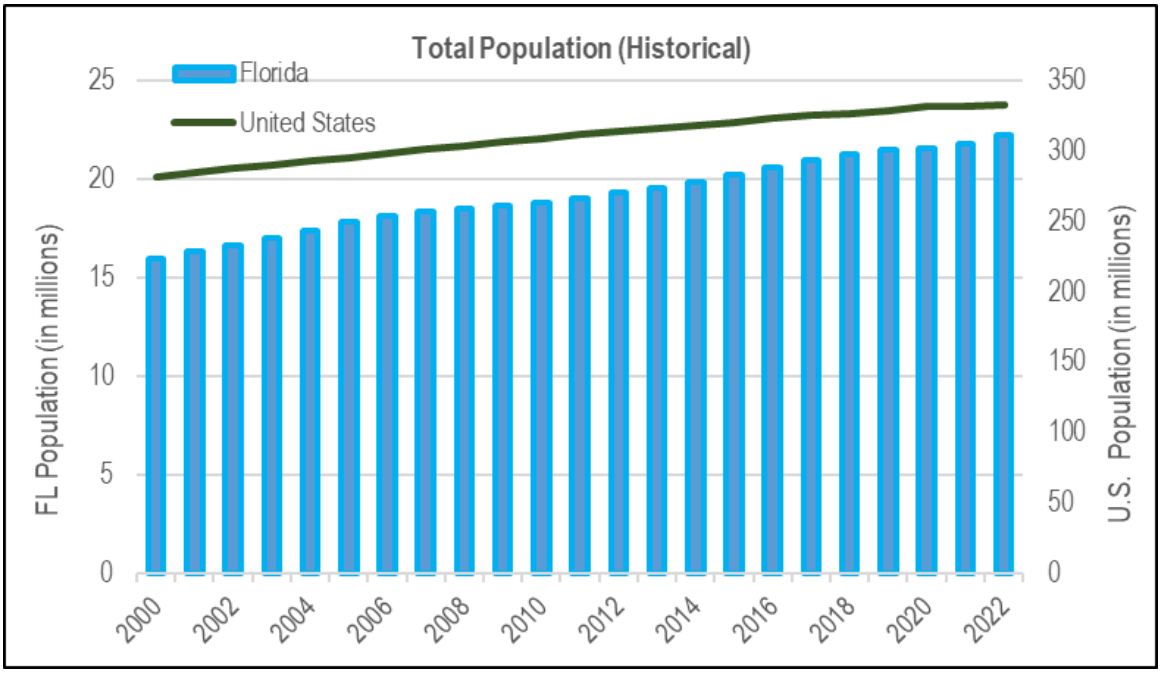
Florida's statewide total population increased by almost 6.3 million during the 2000 through 2022 timeframe, reaching the estimated total of 22.2 million in 2022, based on the Census Bureau data, as summarized in Table 4. This equated to a total percentage growth of 39 percent or a compound average annual growth rate (CAAGR) of 1.5 percent, which was almost double the U.S. national average rate of 0.8 percent per year over the same period since 2000. Florida is now the third most populous state in the nation, behind California (at 39 million residents), and Texas (at 30 million). A comparison of the state and national population growth trajectories since 2000 is presented in Figure 9. Furthermore, Florida's 2022 population density of 415 residents per square mile is more than four times greater than the nation as a whole (at 94), which is favorable for freight market concentration. It is worth noting that there is significant variation in density across the state.

Table 4 | Florida Historical Population Growth

Area	Population		Absolute Increase	Annual Growth Rate
	2000	2022	2000-2022	2000-2022
Florida	**15,982,378**	**22,244,823**	**6,262,445**	**1.5%**
United States	281,421,906	333,287,557	51,865,651	0.8%

Date Source: Census, 2023.

Figure 9 | Florida and U.S. National Historical Population Trends

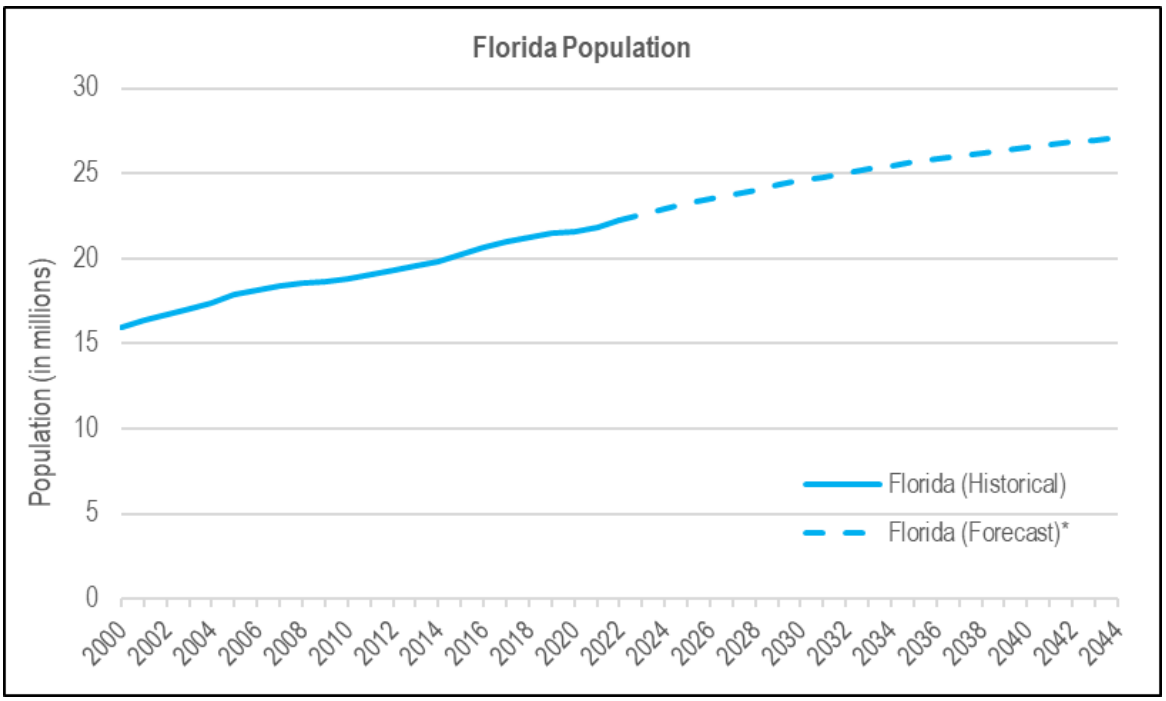


Data Source: Census, 2023.

Forecasted

Florida's statewide population is expected to rise to 25.0 million in 2032 and 27.1 million in 2044, based on the Bureau of Economic and Business Research (2023) projection, see Figure 10. This is an increase of 4.9 million relative to the 2022 estimate, and equivalent to the CAAGR of 0.9 percent (or an absolute increase of 22 percent). While decelerating from the historical growth rate of 1.5 percent, this growth rate is still forecasted to exceed the corresponding national average of 0.6 percent (Census, 2023). The projected population net growth of millions of new residents indicates that the state will continue to attract more people, and hence more freight demand, and grow faster than the national average over the coming two decades.

Figure 10 | Florida Forecasted Population Trend



Data Sources: Census, 2023, and BEBR, 2023.

* Forecast annual values interpolated based on BEBR's five-year interval projections.

Aging

As Florida's population has increased over time, so has the median age of the state residents. Over just the past two decades, the median age of Florida residents has gone up by four years from 38.7 years in 2000 to 42.7 years in 2022, based on the U.S. Census data. This aging trend has also applied to the nation as a whole, and generally to the larger industrialized world. The median age in the U.S. has risen by 3.6 years since 2000, and stands at 39 years as of 2022 (see Table 5). The share of the older population (those 65 years of age plus) was 21.6 percent compared to the national average of 17.3 percent in 2022, while the share of children (those 18 years or younger) was 19.3 percent statewide vs. 21.7 percent nationally, both indicating a relatively older population fabric in Florida.

Table 5 | Historical Median Age

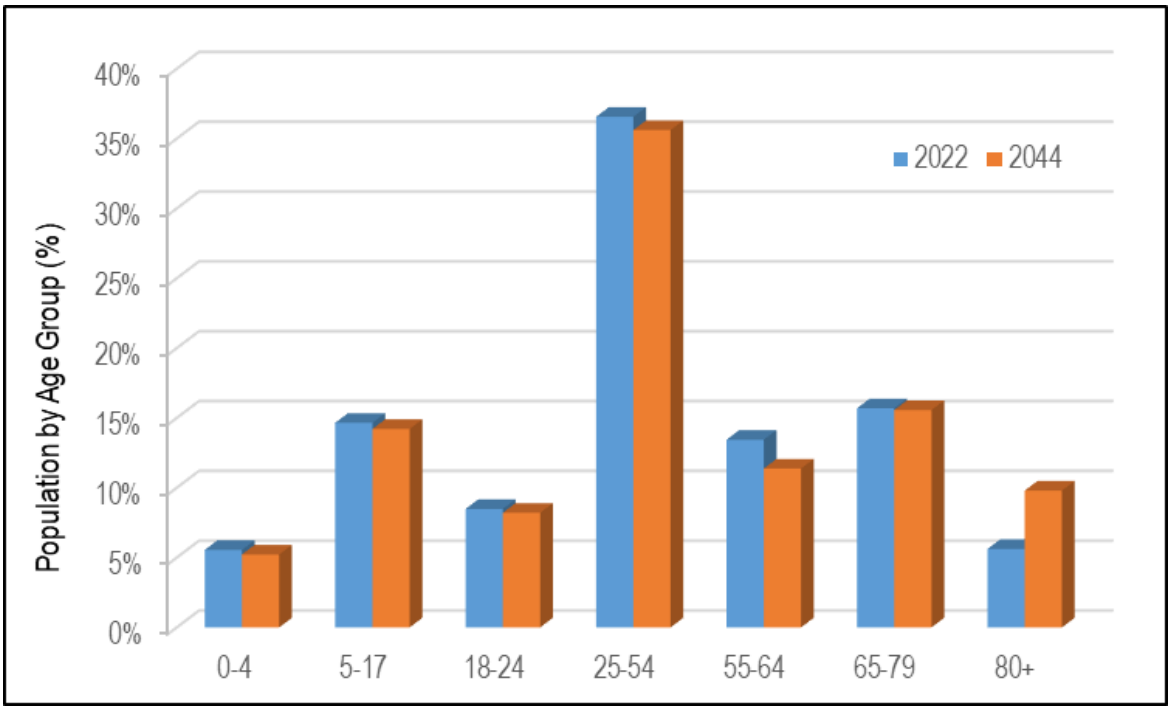
Area	Median Age		Absolute Increase
	2000	2022	2000-2022
Florida	**38.7**	**42.7**	**4.0**
United States	35.4	39.0	3.6

Data Source: Census, 2023.

Going forward, the aging of the state population is expected to continue. According to the recent BEBR projection, the share of the younger age groups, particularly those 24 years of age and younger, will shrink by 2044, while the share of seniors 80 years and older will likely almost double by 2044, as per Figure 11.

The aging phenomenon will have impacts on retirements and overall structure of the labor market as well as the types of goods and freight services that will be demanded in the upcoming decades.

Figure 11 | Florida Forecasted Population by Age Group



Data Source: BEBR, 2022. Annual values interpolated based on BEBR's five-year interval projections.

The aging population will have impacts on the consumer consumption patterns as well as the labor market in Florida, and consequently on the freight distribution.

Urbanizing

Increasingly, Americans, including Florida residents, have chosen to make their homes in urban settings. By 2022, 92 percent of Florida's population lived in urban areas, compared to 80 percent for the nation (see Table 6). Both of these urban percentages are high and have risen substantially over the decades.

Table 6 | Urban Population Shares

Area	Urban Population Share	
	2000	2020
Florida	**89%**	**92%**
United States	79%	80%

Data Source: Census, 2023.

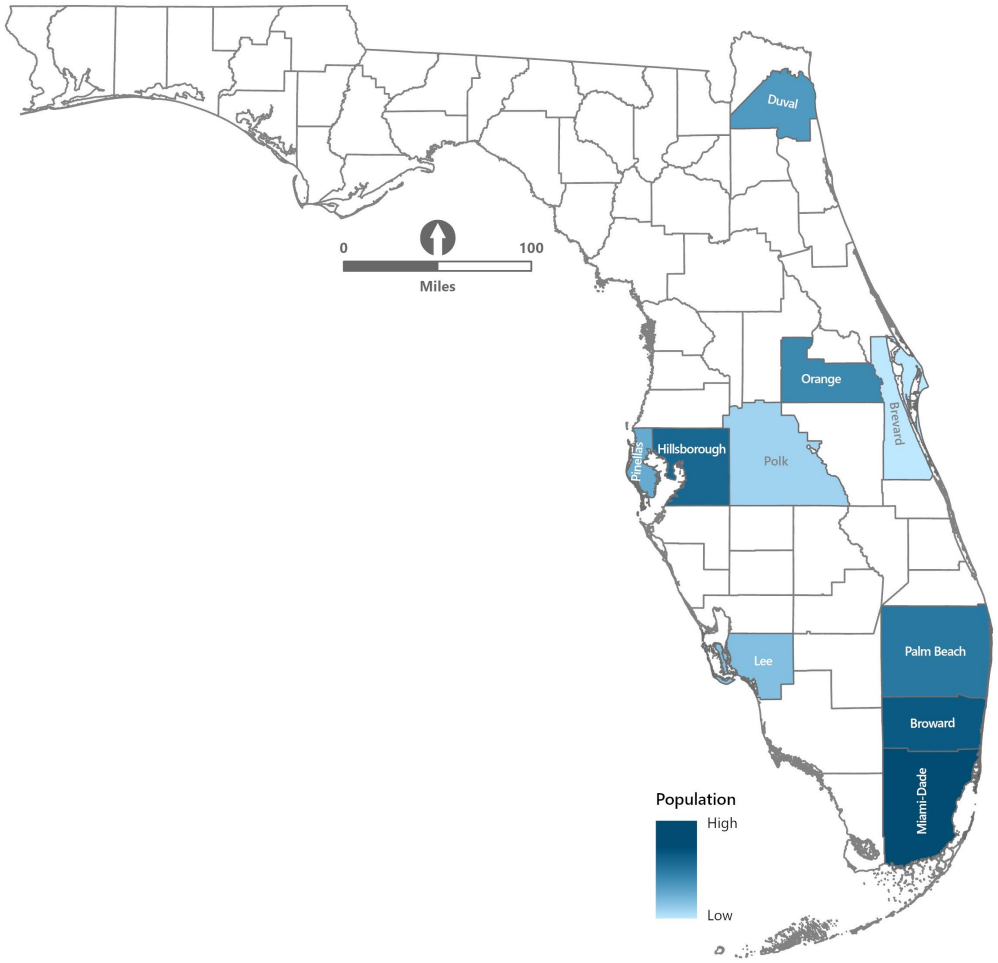
Currently, the ten most populous counties in Florida comprise 60 percent of the statewide population total, see Figure 12. These counties contain the largest metropolitan/urban areas in the state.

Going forward, almost 60 percent of the population growth through 2044 is projected to be concentrated in ten counties.[2] As presented in Figure 13, these counties with highest population growth over the next 20 years are located in and around the largest urban areas of Miami/Ft. Lauderdale/Palm Beach, Jacksonville, Ft. Myers-Cape Coral, and the Tampa-Orlando/I-4 Corridor.

Greater urbanization will lead to higher concentration of freight deliveries and likely increased congestion in metro areas.

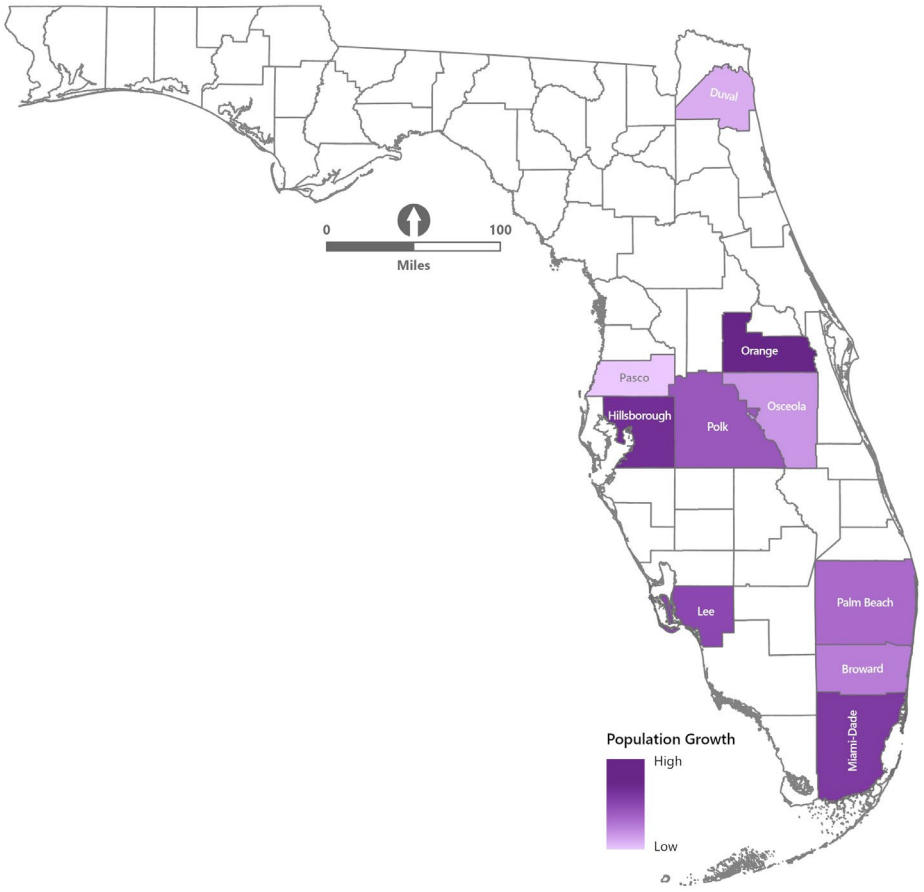
[2] Source: BEBR, 2023 data.

Figure 12 | Florida's Most Populous Counties (2022)



Data Source: BEBR 2023 data.

Figure 13 | Urban Population Growth (2022-2044)



Data Source: BEBR, 2023.

Economic Trends

Economic trends largely influence production and consumption of goods. Trends include growth in the state employment and gross state product, which are subject to the economic cycles, and are typically more volatile than population and other demographic trends. Economic trends impact freight flows due to influence on the amount of freight demand, changing consumer preferences, and the influence of the production of goods and availability of the workforce.

The progressive global integration of Florida's economy means its trade, tourism, and other industries can be impacted by recessions, instability, and supply chain disruptions around the world.[3] Recent disruptions have been caused by global events, such as the COVID-19 pandemic, shortages in labor and production, trade policies, shifting trade lines, and global conflicts.

The threat of cyberattacks continues to increase due to improved hacking methods, limited oversight, and pandemic-related challenges. More companies have digitized their supply chain processes, which provides more entry points for hackers. Globally, cybersecurity breaches have impacted 93 percent of firms as of early 2022. In 2021, the Colonial Pipeline cyberattack severely impacted southern states in the U.S.—71 percent of gas stations ran out of fuel.[4]

Total Employment

Employment is a key economic consideration because it has a direct impact on the production and consumption of goods. It is a key driver of economic growth and prosperity; Employment provides people with an income, which gives them the confidence to buy goods and services, which in turn helps businesses grow and boosts economic growth.

Historical

Florida's total employment grew by 5.3 million (equivalent to 60 percent in total, or 2.2 percent CAAGR) between 2000 and 2022, reaching the level of 14.2 million in 2022, based on the Bureau of Economic Analysis (BEA), as shown in Table 3. In comparison, the U.S. nation employment increased by less than half of Florida's pace (28 percent in total, or 1.1 percent CAAGR) since 2022, see Table 7 and Figure 14.

[3] Florida Transportation Plan, Emerging Trends, 2022

[4] "The Supply Chain Is the Next Big Cyberattack Target," SDC Executive, March 16, 2022

Table 7 | Florida Historical Employment Growth

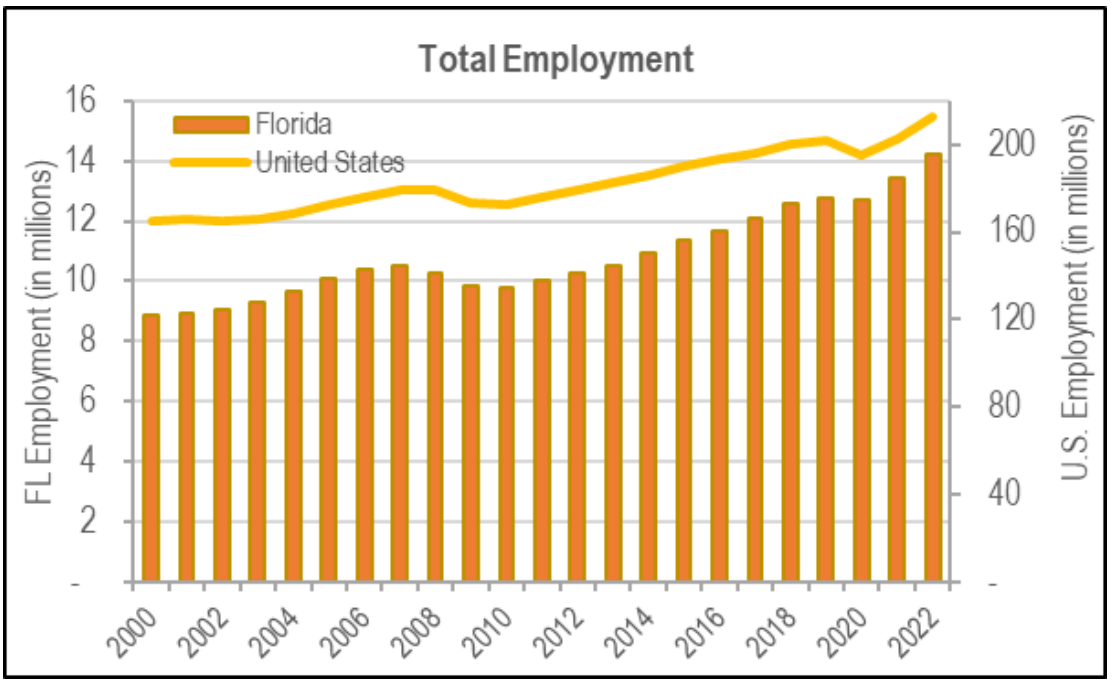
Area	Employment		Absolute Increase	Annual Growth Rate
	2000	2022	2000-2022	2000-2022
Florida	**8,881,279**	**14,227,252**	**5,345,973**	**2.2%**
United States	165,370,800	212,442,000	47,071,200	1.1%

Data Source: BEA, 2023.

Forecasted

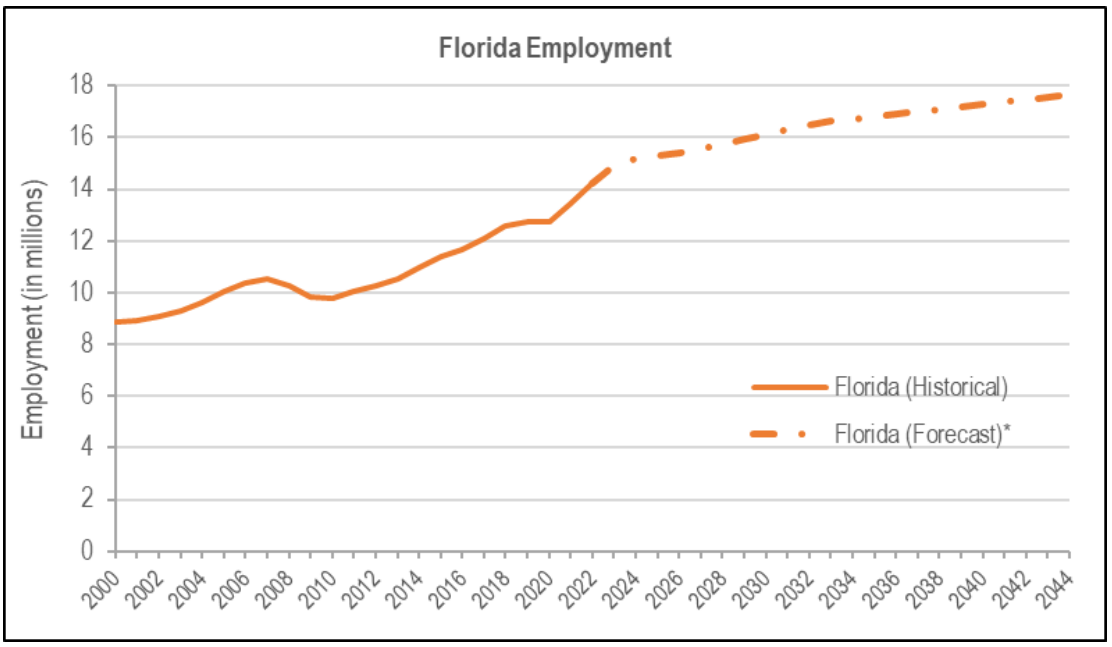
As shown in Figure 15, future statewide employment growth trend is expected to continue its upward trajectory. Based on growth rate forecast by the Office of Economic and Demographic Research (EDR), Florida employment is expected to increase by about 1.0 percent on average through 2044, with total employment at 16.5 million in 2032 and rising to 17.7 million in 2044.

Figure 14 | Florida and U.S. National Historical Employment Trends



Data Source: BEA, 2023.

Figure 15 | Florida Forecasted Employment Trend



Data Sources: BEA, 2023; and EDR, 2023. * Past 2033, the projected volumes are based on half the average growth rate of the preceding five years forecasted by EDR.

Gross State Product

Gross State Product (GSP) is the total value of goods and services produced by a state's economy. Similarly, the national-level Gross Domestic Product (GDP) represents a market valuation, both private and public, of goods and services produced within a given country.

Historical

Florida's total real (inflation-adjusted) GSP expanded at a strong rate of 2.3 percent annually (or 67 percent in total) between 2000 and 2022, reaching the level of $1.1 trillion in 2022 (in constant 2012-dollar terms), according to the BEA. Comparatively, the nationwide growth rate in real GDP was 1.9 percent per annual (or 52 percent in total) over the same timeframe, see Table 8.

Table 8 | Historical Real Gross Domestic Product Growth

Area	GSP\ (in millions of 2012$)		Absolute Increase	Annual Growth Rate
	2000	2022	2000-2022	2000-2022
Florida	**$642,708**	**$1,070,930**	**$428,222**	**2.3%**
United States	$13,138,035	$20,014,100	$6,876,065	1.9%

Data Source: BEA, 2023.

As of 2022, Florida's GSP (at $1.4 trillion, in current dollar terms) stands as the fourth highest in the nation, behind California (at $3.6 trillion), Texas (at $2.4 trillion), and New York State ($2.0 trillion), according to the BEA. Florida's economy also fares well size-wise in comparison to the top 20 national economies globally, per the World Bank data.

GSP by Industry

Some industries are more heavily reliant on freight movement than others. In Florida, as seen in Table 9, the value of the production generated by the private good-producing industries along with trade, transportation, and warehousing was over $327 billion (or almost 27 percent of the state's total GSP) in 2022. The other industries still depend on freight movement for their operations, but typically to lesser extent than the goods-producing industries.

Table 9 | Florida 2022 GSP by Industry

Industry Description	Value (millions of 2017$)	%
Agriculture, forestry, fishing, and hunting	$5,250	0.4%
Mining, quarrying, and oil and gas extraction	$959	0.1%

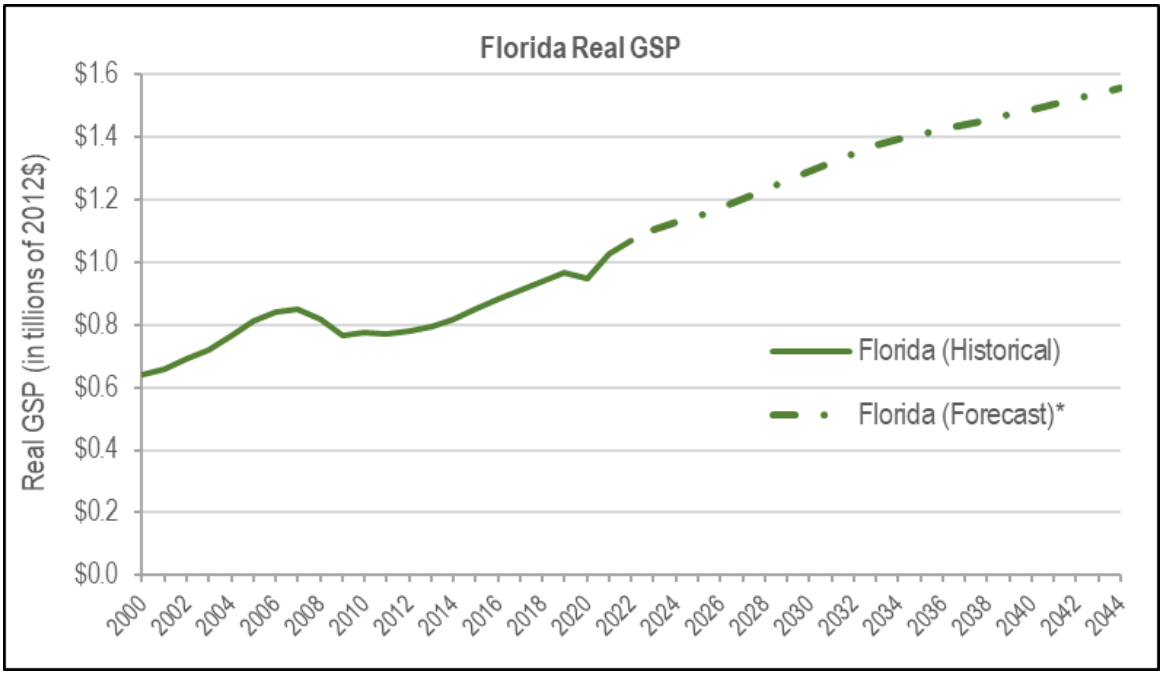
Industry Description	Value (millions of 2017$)	%
Construction	$58,841	4.8%
Manufacturing	$61,947	5.1%
Wholesale trade	$72,796	5.9%
Retail trade	$83,944	6.9%
Transportation and warehousing	$43,653	3.6%
Subtotal: Private goods-producing industries and trade and transportation and warehousing	**$327,389**	**26.7%**
Utilities	$18,991	1.6%
Information	$55,444	4.5%
Finance, insurance, real estate, rental, and leasing	$304,253	24.9%
Professional and business services	$188,582	15.4%
Educational services, health care, and social assistance	$112,562	9.2%
Arts, entertainment, recreation, accommodation, and food services	$71,102	5.8%
Other services (except government and government enterprises)	$28,767	2.3%
Subtotal: Private service-producing industries	$779,700	63.7%
Government and government enterprises	$117,133	9.6%
All Industry Total	$1,218,430	100.0%

Data Source: BEA, 2023.

Forecasted

Florida's total real GSP is forecasted to decelerate to an average annual growth pace of 1.7 percent through 2044, yielding total value of all final goods and services produced in the state at $1.3 trillion in 2032 and rising to $1.6 trillion in year 2044. This trajectory is shown in Figure 16. These amounts of annual economic activity in the State will require very large freight movements to support it.

Figure 16 | Florida Forecasted GSP Trend

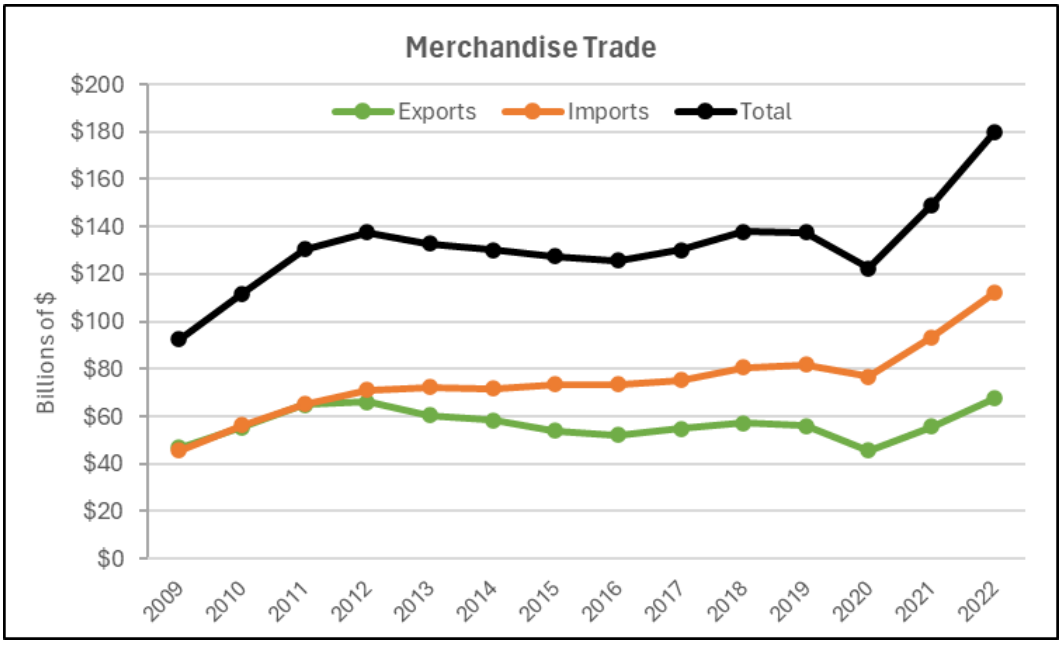


Data Sources: BEA, 2023; and EDR, 2023. * Past 2033, the projected volumes are based on half the average growth rate of the preceding five years forecasted by EDR.

Global Trade

Florida's international merchandise trade has grown over the years. As shown in Figure 17, both exports and imports stood at around $46 billion in 2009 (first year of available data from the U.S. Trade Administration), but grew at different rates through 2022. Exports grew by about 44 percent (equivalent to 2.9 percent per annum) over the 14-year period, while imports rose much more robustly, at 145 percent (7.1 percent/year) over the corresponding timeframe. Florida's total merchandise trade (both international exports and imports combined) increased from close to $93 billion in 2009 to about $180 billion in 2022, equivalent to 94 percent in total (or 5.2 percent/year). In comparison, the total merchandise trade for the United States as a whole grew by 103 percent (or 5.6 percent/year) from 2000 through 2022, with growth in exports and imports at more similar rates of 5.3 percent and 5.8 percent on average per annum, respectively.

Figure 17 | Florida Historical Merchandise International Trade Trends



Data Source: U.S. International Trade Administration, 2023.

As can been seen in Figure 16, following the previous peak for total merchandise trade and exports in particular in 2012, Florida experienced several years of decline in traded values, until a double-digit plunge in 2020. This trade trend in the U.S. and the larger world as a whole has been somewhat similar. These were caused by a combination of various geopolitical factors and the COVID-19 pandemic. These headwinds included various protectionist measures (e.g., tariffs on metals, lumber, etc.), Brexit, the pandemic with its related lockdowns and ensuing recession in 2020, and Russia's invasion of Ukraine that contributed to various global supply chain disruptions, including shortages of energy and agricultural products that exacerbated the resurgence of inflation, including higher transportation costs. Global trade, including Florida's exports and imports, has rebounded sharply, albeit from the low 2020 levels, in both 2021 and 2022, but, given continuing and additional trade impedances, such as resurgence of conflicts in the Middle East, those double-digit annual gains are expected to moderate substantially going forward.

Global Trade by Product

Florida's top five export product categories included Computer and Electronics (21.3 percent of total exported dollar value), Transportation Equipment (18.1 percent), Chemicals (15.5 percent), Machinery (except electrical, at 8.7 percent), and Processed Foods (5.3 percent). Table 10 shows the top 10 merchandise products exported from Florida in 2022. When combined, the other products not in the top 10 accounted for only 14 percent of the state total.

Table 10 | Florida 2022 Top Merchandise Exported Products

Product Category	Value (millions of $)	% Share
Computer & Electronic Products	$14,446	21.3%
Transportation Equipment	$12,272	18.1%
Chemicals	$10,474	15.5%
Machinery, Except Electrical	$5,859	8.7%
Processed Foods	$3,594	5.3%
Miscellaneous Manufactures	$3,207	4.7%
Electrical Equipment, Appliances & Components	$2,531	3.7%
Fabricated Metal Products	$2,406	3.6%
Paper	$1,803	2.7%
Used Or Second-Hand Merchandise	$1,640	2.4%
Other (combined)	$9,498	14.0%
Total	$67,729	100.0%

Data Source: U.S. International Trade Administration, 2023.

On the imports side, Florida's top five products included Transportation Equipment (13.8 percent of total imported value), Computer and Electronics (11.7 percent), Chemicals (8.7 percent), Agricultural Products (5.8 percent), and Machinery (except electrical, at 5.2 percent). Table 11 shows the top 10 merchandise products imported from Florida in 2022. The other products combined but not in the top 10 amounted to 32.1 percent of the state total.

Table 11 | Florida 2022 Top Merchandise Imported Products

Product Category	Value (millions of $)	% Share
Transportation Equipment	$15,483	13.8%
Computer & Electronic Products	$13,082	11.7%
Chemicals	$9,721	8.7%
Agricultural Products	$6,457	5.8%
Machinery, Except Electrical	$5,822	5.2%
Goods Returned (Exports and Imports) and Reimports - Canada Only	$5,448	4.9%
Beverages & Tobacco Products	$5,132	4.6%
Processed Foods	$5,015	4.5%
Electrical Equipment, Appliances & Components	$4,951	4.4%

Product Category	Value (millions of $)	% Share
Primary Metal Manufactures	$4,879	4.4%
Other (combined)	$35,993	32.1%
Total	$111,982	100.0%

Data Source: U.S. International Trade Administration, 2023.

Global Trade Partners

Florida has foreign trade relationships with multiple countries. In 2022, Florida exported $67.7 billion worth of merchandise to 219 countries across the world. Brazil (at 8.3 percent), Canada (at 8 percent), and Mexico (at 6 percent) are currently Florida's top exporting partners, with the other destinations in the top 10 located in Europe and Latin America. Table 12 summarizes the shares of the state exports for the top 10 country-level partners, which collectively purchased over 47 percent of Florida's exports in 2022.

Table 12 | Florida 2022 Top Merchandise Export Partners

Partner	Value (millions of $)	% Share
Brazil	$5,644	8.3%
Canada	$5,402	8.0%
Mexico	$4,034	6.0%
United Kingdom	$3,863	5.7%
Colombia	$2,724	4.0%
Dominican Republic	$2,491	3.7%
Chile	$2,100	3.1%
Argentina	$1,959	2.9%
Germany	$1,805	2.7%
Peru	$1,596	2.4%
Rest of the World	$36,110	53.3%
World Total	$67,729	100.0%

Data Source: U.S. International Trade Administration, 2023.

On the imports side, Florida purchased $112 billion of merchandise from 221 countries in 2022. China (at 12.4 percent), Mexico (at 8.6 percent), and Canada (at 5.2 percent) are Florida's top importing partners, with the other origins in the top 10 located in Europe, the Far East, and South America. Table 13 shows the shares of the Florida import for the top 10 country-level partners, accounting for over 56 percent of Florida's total imports in 2022.

Table 13 | Florida 2022 Top Merchandise Import Partners

Partner	Value (millions of $)	% Share
China	$13,866	12.4%
Mexico	$9,638	8.6%
Canada	$5,797	5.2%
Ireland	$5,551	5.0%
Japan	$5,472	4.9%
Germany	$5,136	4.6%
Brazil	$4,993	4.5%
France	$4,530	4.0%
Chile	$3,989	3.6%
Vietnam	$3,948	3.5%
Rest of the World	$49,062	43.8%
World Total	$111,982	100.0%

Data Source: U.S. International Trade Administration, 2023.

Going forward, it will be important for Florida to maintain and diversify its trade relationships with dependable partners, such as those that trade fairly and can be confidently considered American allies and friends relative to the origins and destinations in adversarial and unreliable countries. This should help strengthen reliability and resilience of the state's supply chain.

Tourism

Florida has been fortunate to attract large numbers of visitors every year over the past several decades. The state's freight system caters to the needs of these visitors as well.

Historical

Visitors to Florida expanded by almost 65 million annually between 2000 and 2022, reaching 137.4 million in 2022. This was almost 5 percent above the previous (pre-pandemic) annual peak in 2019. This corresponds to an annual growth rate of 2.9 percent (or 89 percent in total) over the recent 22-year period, as seen in Table 14.

Table 14 | Florida Historical Visitors Growth

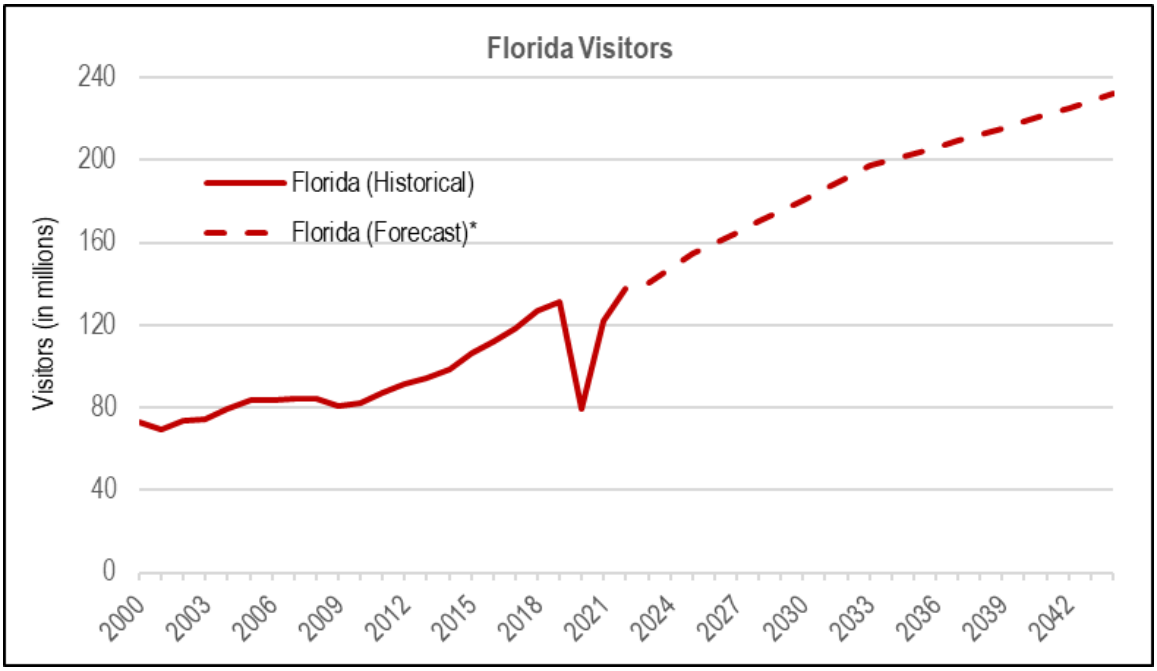
Area	Visitors (in millions)		Absolute Increase	Annual Growth Rate
	2000	2022	2000-2022	2000-2022
Florida	72.8	137.4	64.6	2.9%

Data Sources: Visit Florida, 2023.

Forecasted

As shown in Figure 18, future visitations to Florida will continue to trend upward. Based on growth rate forecast by the EDR, Florida can expect 2.4 percent average annual growth in visitors through 2044, with total annual visitors at 191 million in 2032 and increasing to 232 million annually in 2044.

Figure 18 | Florida Forecasted Visitors Trend



Data Sources: Visit Florida, 2023; and EDR, 2023. * Past 2033, the projected volumes are based on half the average growth rate of the preceding five years forecasted by EDR.

Fuel

Fuel costs are an important factor in the total cost of moving freight and can also influence modal choices. Fuel supply chains are also especially critical in supporting emergency response.

Historical

Florida average retail gasoline prices have fluctuated and gone up markedly since 2004 (earliest year of available data), doubling from $1.9/gallon to $3.8/gallon through 2022, or at an average annual rate of 3.9 percent per annuum, as shown in Table 15 and Figure 19. This increase is below those experienced nationwide (in nominal and percentage terms) for both gasoline and diesel fuel. U.S. crude oil, of which retail prices are based, also rose substantially – by 4.7 percent per annum on average or 139 percent in total between 2004-202 period.

Table 15 | Historical Fuel Cost Change

Metric	Fuel Price ($/gallon)*		Absolute Increase	Annual Growth Rate
	2004	2022	2004-2022	2004-2022
FL Gasoline	**$1.91**	**$3.81**	**$1.90**	**3.9%**
U.S. Gasoline	$1.90	$4.18	$2.29	4.5%
U.S. Diesel	$1.81	$4.99	$3.18	5.8%
U.S. Crude Oil	$41.51	$94.90	$53.39	4.7%

Data Source: EIA, 2023.

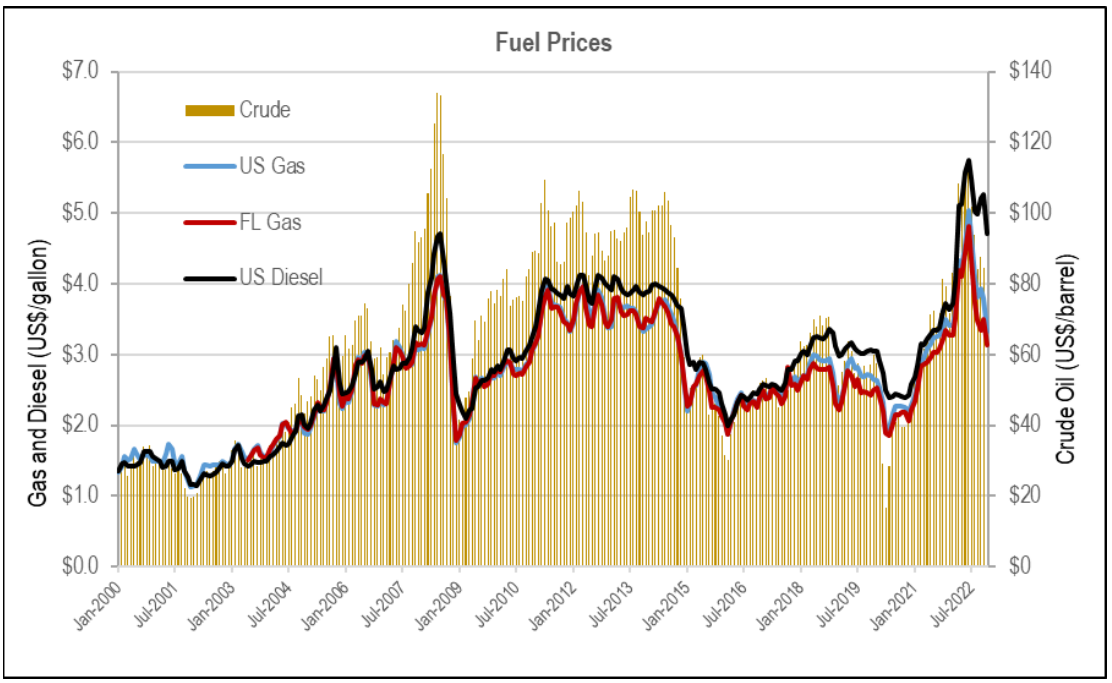
* The prices are average annual in dollars per gallon, except for Crude Oil, which is in dollars per barrel. Gasoline prices are for all grades. Crude oil is for Cushing, West Texas Intermediate (WTI). 2004 is the earliest year of available pricing data for all the four fuel categories.

Forecasted

Fuel prices are projected to continue to rise through 2044. According to the latest projections by the U.S. Energy Information Administration (EIA), U.S. gasoline (all grades) retail prices are forecast to reach $5.3/gallon in 2044, which equates to a CAAGR of 1.1 percent in nominal (inflation-unadjusted) terms relative to the recent peak of $4.2/gallon in 2022. U.S. diesel retail prices are forecasted to increase by an average of 1.0 percent annually, extending to $6.4/gallon in 2044 from the recent high of $5.1/gallon in 2022. See Figure 20.

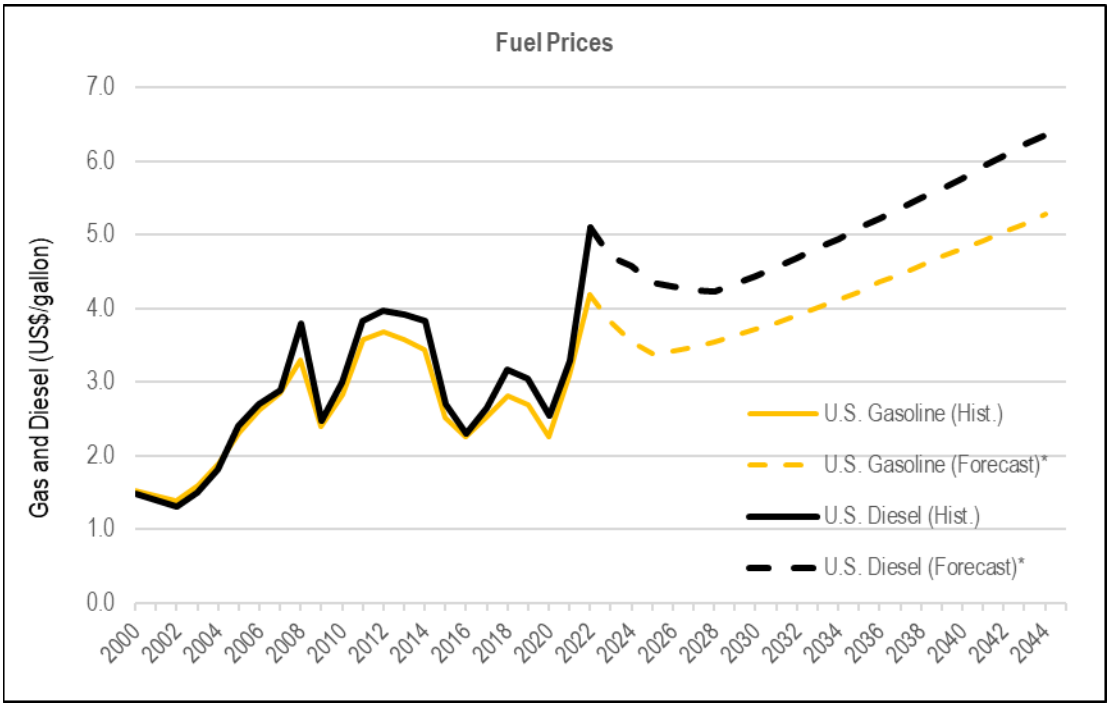
In summary, based on the demographic and economic trend indicators one can conclude that economic growth and related freight in Florida and the larger U.S. is likely to decelerate in the coming 20 years. Additional freight will still be demanded, but the pace of growth will likely be slower over time.

Figure 19 | Historical Fuel Price Trends



Data Source: EIA, 2022.

Figure 20 | Forecasted Fuel Price Trends

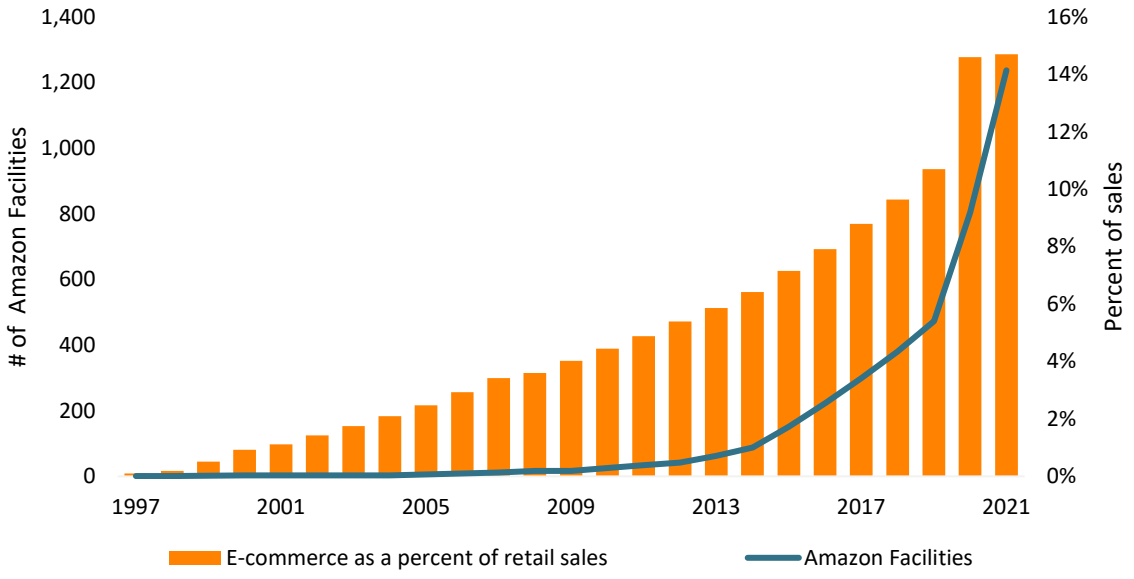


Data Source: EIA, 2023.

E-Commerce and Emerging Freight Land Uses

E-commerce has changed the way people shop and consume products and services. The growth of e-commerce and the associated demand for quick delivery has dramatically changed logistics strategies. It has accelerated construction of fulfillment centers and distribution hubs closer to populated areas, and created innovations in who makes final deliveries and when, where, and how those deliveries occur. In 2020, the global pandemic disrupted supply chains, and freight and goods movements were slowed for a variety of reasons, including disrupted shipping lanes, labor and material shortages, and fluctuating demand. As the nation responded to the pandemic and the economy rebounded, e-commerce growth accelerated. Today, global trade faces many unknowns as the supply chain returns to a 'new normal.' Fueled by post-pandemic economic growth and other factors, demand for goods is surging. Consumers have increasingly turned to e-commerce, and the market share is expected to continue to rise. At this pace, the percentage of e-commerce retail sales may reach 25 percent by 2025. The projected growth rate is derived from historical trends and estimates provided by Statista. The number of Amazon facilities in the U.S. is displayed in Figure 21 on a graph that also shows the growth of e-commerce as a percentage of total retail sales.

Figure 21 | E-commerce as a Percentage of Retail Sales and Growth of Amazon Facilities



Data Source: U.S. Census Bureau.

There are various types of emerging freight land uses identified in the state of Florida. The numbers of each type of facility located in Florida are listed in Table 16, and graphically depicted in Figure 22. Some of the facilities are co-located.

Table 16 | Emerging Freight Land Uses/Facilities in Florida

Facility Type	Number of Facilities
Amazon Inbound Cross Dock*	1
Amazon Fulfillment Centers**	27
Sortable facilities (450,000 – 1,000,000 sq.ft.)	*8*
Non-sortable facilities (1,000,000 sq.ft.)	*7*
Mini facilities (150,000 – 250,000 sq.ft.)	*4*
Specialty facilities	*3*
Seasonal facilities/shared	*2*
To be decided	*2*
Amazon Sortation Centers	9
Amazon Small Package Delivery Stations	62
Amazon Heavy Merchandize Delivery Center	11
Amazon Air Hub	1
Amazon Fresh Hubs	7
Amazon/Whole Foods Retail Food Distribution Center	1
Sam's Club Distribution Centers	2
Sam's Club E-commerce Store	1
Target E-commerce Distribution Centers	2
Target Food Distribution Centers	1
Walmart E-commerce Fulfillment Centers	2
Walmart Food Distribution Centers	4
Walmart Regional General Merchandise Distribution Centers	3
Total	134

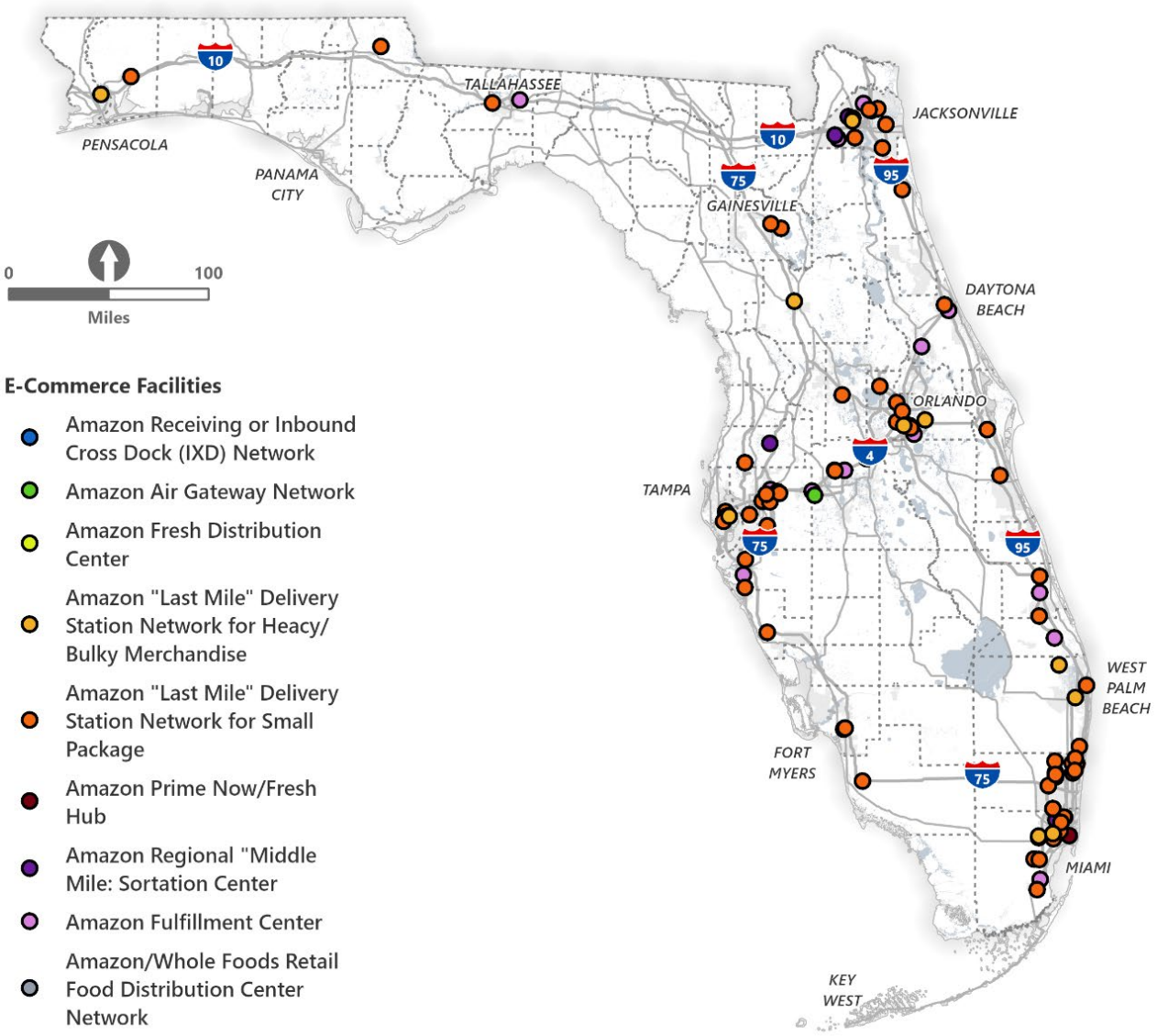
Data Source: FDOT Systems Implementation Office, 2022.

**Cross dock refers to a specially designed logistics facility where goods can be directly transferred from inbound trucks or railcars to outbound vehicles*

***Fulfillment centers process and ship orders directly to end customers; distribution centers store and distribute goods to retailers or other locations*

****Middle mile (from Figure 22) is part of the supply chain between the first and last mile, focused on moving products from the manufacturing facility to the warehouse, distribution center or retail facility*

Figure 22 | Emerging Freight Land Uses/ Facilities in Florida



Source: FDOT Systems Implementation Office, 2022

Military Freight

The U.S. military has a significant and strategic presence in Florida. Twenty-one military installations in Florida provide resources and power projection platforms to enable all branches of the military to maintain a high level of readiness, fulfill national security requirements, and to support the overarching mission of national defense. The Florida Strategic Intermodal System (SIS) and multimodal freight system are critical for military mobility needs and to support the movement of cargo to support not only the installations, but to deploy personnel and equipment rapidly for national defense purposes.

Florida is home to:[5]

- Twenty-one military installations
- Three of ten unified combatant command headquarters
- Hosts two (of only four) deep water naval ports with adjacent airfields
- The military's only east coast space launch facility
- The Marine Corps' only maritime prepositioning force facility
- One of only three Navy Fleet Readiness Centers
- The Joint Gulf Range Complex
- State National Guard Joint Training Center
- Several critical research, development, training, and evaluation (RDT&E) centers

Over 860,000 jobs are directly linked with the military, which accounts for 8.5 percent of Florida's economy.

Diverse and complex supply chains are necessary to efficiently and reliably provide logistics support to Florida-based military sites and for deployment of military units. Large amounts of fuel, food, ammunition, maintenance, equipment and materials, and medical supplies are critical to maintaining military units in a combat and mission-ready posture. Transportation infrastructure including highways, rail, water ports, airports, and pipelines are critical to supporting many military-related supply chains and to support deployment of units. The state's military installations serve as freight generators due to mobilization and deployment of military units and forces and consumer markets needing large and diverse quantities of supplies.

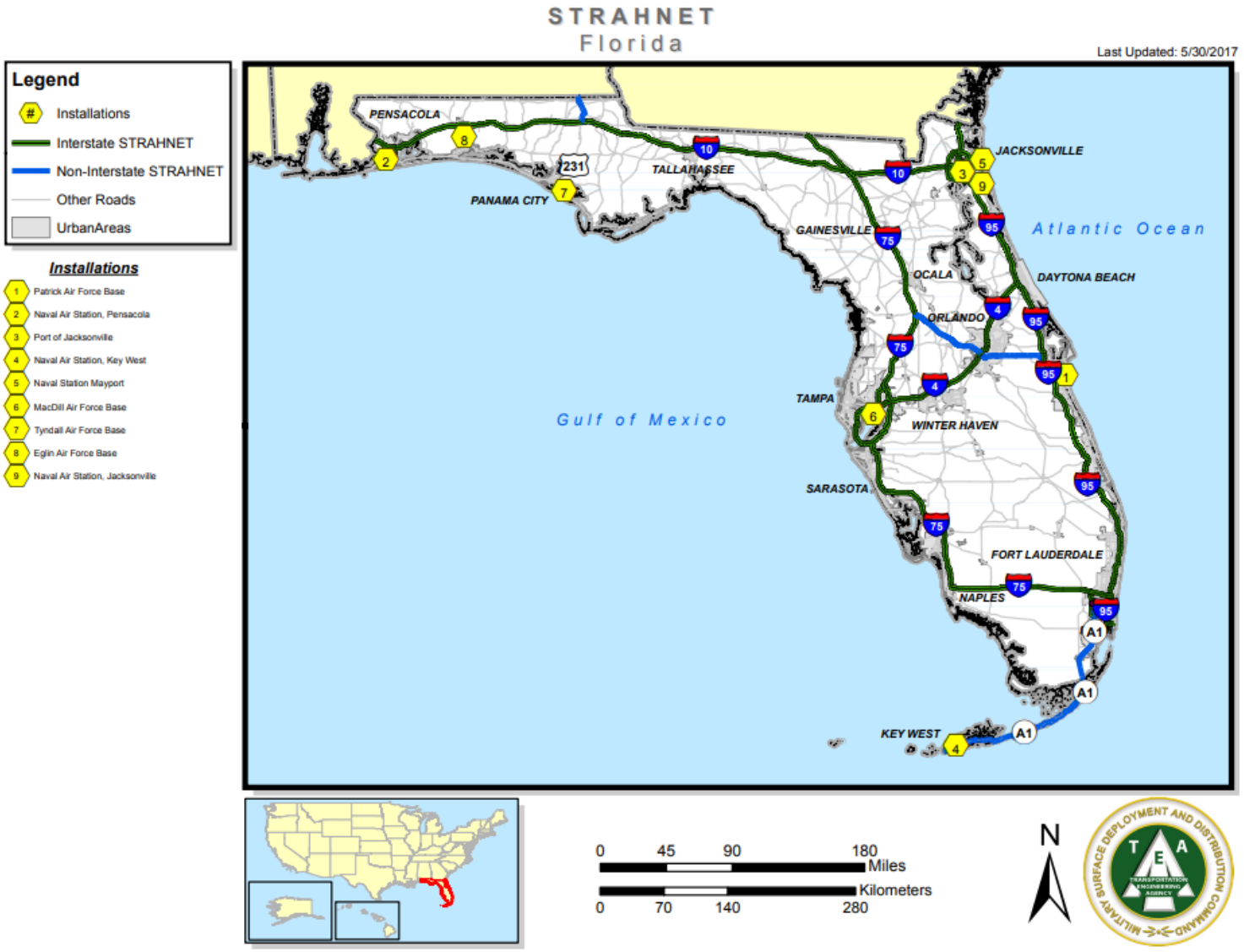
In 2020, JaxPort facilitated an "Elite" cargo move, transporting over 1,000 pieces of U.S. military equipment to Europe for use in a training mission (see photos below). JaxPort is one of 17 ports in the United States that are on-call to move equipment for national security reasons.[6]

[5] Florida Military & Defense Economic Impact Study, January 2022
[6] Jacksonville conducts elite U.S. Army deployment operation

The Strategic Highway Network (STRAHNET) and the Strategic Rail Corridor Network (STRACNET) were developed by the U.S. Department of Defense in coordination with the FHWA and Federal Railroad Administration (FRA). The STRAHNET and STRACNET are networks of interconnected highways and rail lines, respectively, which support the U.S. military with access, continuity, and emergency capabilities for defense purposes.

Florida's STRAHNET installations and routes are shown in Figure 23.

Figure 23 | Florida's STRAHNET Installations



Florida's STRACNET system is shown in Figure 24. It includes multiple CSX and FEC rail lines throughout the state.

Figure 24 | Florida's STRACNET Network

Weather Trends

The U.S. has sustained 371 weather and climate disasters since 1980 (8.4 per year) where overall damages/costs reached or exceeded $1 billion. The total cost of these 371 events exceeds $2.615 trillion. In the last five years (2018-2022) alone, there were 90 of these such events (18.0 per year).[7] Since these events have intensified in duration, magnitude, and frequency, transportation agencies are identifying ways to protect, preserve, and improve their assets to combat extreme events and protect communities and local economies.[8]

With 1,350 miles of coastline, Florida is particularly vulnerable to flooding, hurricanes, and other tropical storms. More than 15 million people live in coastal counties today. Since 2000, tidal flooding across Florida has increased by 352 percent.[9]

Florida's geographic position makes it a target to increasingly severe storms. In 2017 and 2018, Florida was hit by two catastrophic hurricanes in Irma and Michael, respectively. These two events caused devastating storm surge and major wind damage, flooding, road and port closures, power outages, surges in demand for essential supplies, and forced millions of people to evacuate. Combined they caused an estimated $17 billion in insurance loss.[10] Hurricane Ian struck the west coast of the peninsula as a category 4 storm in September 2022, and damage is estimated at $115 billion, including insured and uninsured losses, making it the third costliest cyclone to strike the United States according to NOAA.[11]

Weather disruptions go beyond hurricanes and flooding. Florida has a higher frequency of tornadoes per 10,000 square miles than any other state. It is also among the top 10 states most impacted by wildfires.[12] Smoke from fires causes visibility issues, inciting safety concerns and major delays. Additionally, while not as common, freezes cause disruptions to the agricultural industry. Citrus fruit left on trees goes bad during a freeze, and bridges and roads ice over, creating dangerous conditions for truckers.

FDOT incorporates resiliency into statewide planning efforts, manages infrastructure assets like roadway pavements through analysis and implementation, and invests in hazard reduction measures in advance of floods and hurricanes.

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[7] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2023). https://www.ncei.noaa.gov/access/billions/, DOI: 10.25921/stkw-7w73
[8] lrtp-resilience-quick-guide-4-5-2023.pdf (windows.net)
[9] FDOT_EmeringTrends_2022_Final.pdf (floridatransportationplan.com)
[10] lrtp-resilience-quick-guide-4-5-2023.pdf (windows.net)
[11] One Year Later, Hurricane Ian Recovery Continues with Nearly $8.7 Billion in Federal Support | FEMA.gov
[12] FDOT Resiliency Subject Brief, 2022

Florida's State Hazard Mitigation Plan (SHMP) is the state source for hazard identification. The SHMP not only identifies Florida's risk and vulnerability to hazards, but also sets the mitigation strategy, priorities, and actions for reducing the potential impacts from future hazards.[13]

[13] FL SHMP (arcgis.com)

Freight Technology Trends

Technologies continue to evolve the freight industry. Alternative fuels, blockchain, automation, data collection, smart sensors, modeling, and drone technology are cutting across the modes and having significant impacts on global supply chains. New fuels provide new opportunities to reduce local air pollution caused by freight vehicles. Blockchain allows for an entire supply chain network to contribute to data validation, helping build trust and confidence among users in the data and information industry. Automation is filling labor shortage gaps. Data collected from new types of sensors can provide the timely and valuable data underpinnings to power analytical insights. Scanning technology and drones are helping conduct safety and regulatory inspections in record time. COVID-19 vaccine distribution has led to innovations in the storing, loading, and movement of temperature-sensitive products. Digital representations utilizing AI and advanced computing can model real world effects and help plan for future shifts in cargo flows.

Alternative Fuels

For each type of alternative fuel, there are unique opportunities and challenges associated with its use. Due to high up-front costs of fleet conversion and infrastructure investment, there is a hesitancy in the alternative fuel freight industry to commit to a type of alternative fuel that may not be the best option down the line, especially in an arena where technological advancements are happening quickly. A breakdown of the opportunities and challenges by fuel type is found in Table 17.

Table 17 | Opportunities and Challenges by Alternative Fuel Type

Type	Opportunities	Challenges
Biodiesel	• Not made from fossil fuels, but from vegetable oils and/or animal fats • Biodiesel can directly replace traditional diesel in common diesel engines • Biodiesel can improve the lubricity of the fuel at blend levels as low as 1% • The federal government is pushing requirements for incremental blending of fossil fuels with alternative fuels • Biodiesel and renewable diesel are the most common • Using biodiesel in place of petroleum diesel	• Biodiesel is only used for blending (B20 is most common blend, which ranges from 6% to 20% biodiesel blended with petroleum diesel) • Pure biodiesel can crystallize and gel in cold temperatures, potentially damaging a truck's engine (most major engine manufacturers void warranties if a blend above 20% is used in a diesel engine) • High cost of production

Type	Opportunities	Challenges
Compressed Natural Gas (CNG)	• Natural gas is abundant in the U.S. • CNG experiences less price volatility than diesel due to supply • A growing amount of natural gas is being produced from landfills, sewage plants and agricultural waste as opposed to fossil fuel extracts (Renewable Natural Gas/RNG/Biomethane) • Increasingly being used for dedicated fleets and regional deliveries • On average, natural gas engines are up to 10 decibels quieter than a comparable diesel engine	• When diesel prices are low, diesel is more cost-effective than CNG • CNG vehicles require different engines and fueling stations than diesel trucks, so upfront investment is significant • For long-haul, LNG offers a greater energy density than CNG, meaning the fuel range is more comparable to conventional fuel • Mostly still comes from fossil fuels from large-scale drilling operations, leaving a large carbon footprint
Liquified Natural Gas (LNG)	• Natural gas is abundant in the U.S. • LNG is suitable for trucks that require longer ranges than CNG (more energy can be stored by volume), but still less range than diesel (one GGE equals about 1.5 gallons of LNG) • Air quality benefits over diesel, but less than CNG due to necessity of cooling	• High production cost (purifying natural gas and super-cooling it to -260°F to turn it into a liquid) • LNG must be kept cold and stored in double-walled, vacuum-insulated pressure vessels (expensive cryogenic tanks) • Mostly still comes from fossil fuels
Propane (Liquid Propane Gas/LPG)	• Propane is a well-established alternative fuel and typically costs less per gallon than gasoline • Propane vehicles provide a comparable driving range to conventionally fueled vehicles • Potential for lower maintenance costs - popular choice for high-mileage vehicles •	• Propane vehicles are usually more expensive than gasoline counterparts • Energy density is significantly less than diesel (more fuel needed to go the same distance)
Hydrogen Fuel Cell Electric Vehicles (Hydrogen /FCEVs)	• Battery-powered vehicles; energy source comes from a fuel cell combining pure hydrogen and oxygen to produce electricity • Emits only water vapor and warm air • Great range (Nikola claims its hydrogen fuel cell trucks can travel over 1,000 miles at a time) • As battery technology improves, cost will go down	• Price point - hydrogen is expensive, difficult to process, and expensive to transport – and purchase point of vehicles is high • Need specific fueling stations that are different from regular EV (only 40 public hydrogen fueling stations in the U.S. in 2019, most in California, 0 in Florida)
Electric Vehicles (BEV, PHEV)	• Encompasses electric motors powered by electricity stored in batteries or a combination of electric and internal combustion engines • Electricity to charge the batteries can be generated by any type of fuel, including renewable sources • Cost is decreasing, charging stations are becoming more widely available, and range is increasing • Excellent opportunities for last-mile solutions with lighter-duty freight vehicles	• Very heavy batteries, not enough range for long-haul • Need for dedicated infrastructure, as businesses cannot afford to have trucks waiting in line behind passenger vehicles to charge
Ethanol (E85)	• A liquid alcohol fuel that is frequently fermented from corn, but many other plant materials, including other grains, sugar cane, or even algae can be used. • Added to gasoline and used as blends in common diesel engines (flex-fuel vehicles can run on 85% ethanol blend - E85) • Cost of E85 on a per gallon basis is generally less than gasoline	• Less energy dense than gasoline, so it requires a greater volume of fuel to travel a given distance • Lower fuel economy may mean higher cost, especially for long-distances

Trucking

While there is promise for alternative fuels in the trucking industry, the two biggest barriers remain for their use in fleets: up-front investment and availability of infrastructure/re-fueling stations. The trucking industry relies almost exclusively on diesel today.

Electric

In general, the practicality of medium- and heavy-duty long-haul truck electrification is challenged due to the weight of the trucks combined with the haul distances and geographies that involve substantial energy surges for greater inclines. A changing regulatory landscape, technology improvements leading to smaller and cheaper batteries, more truck models, and more demand are all helping to grow a nascent electric-vehicle industry serving heavy-duty trucking and farming vehicles.[14]

Electric vehicles have started to break the barrier of fueling stations, with over 8,450 electric vehicle charging stations (EVSE ports) throughout the state in September 2023 (96 percent of all Alternative Fuel charging stations in Florida).[15] EV is already serving the passenger (non-freight) and light-duty markets. However, heavy-duty fleet vehicles currently use heavy-duty EV charging equipment which operate at greater than 150 kW and require their own dedicated EV charging network. As the network gets built out, heavy-duty EV charging will primarily be located along the SHS, at truck stops, intermodal hubs, and distribution centers.

Florida will receive approximately $198 million in National Electric Vehicle Infrastructure (NEVI) formula funds through the federal FY 26. These funds will be used to grow the network of EV chargers by installing, maintaining, and operating direct current fast charger sites for the duration of the five-year Program. Working in tandem with industry partners to fill in the gaps and identify innovative solutions that support charging in rural, disadvantaged, and underserved areas, Florida's goal is for the market to continue to self-support after the program ends.[16] Figure 3 in Tech Memo 1 shows a map of Florida's current Alternative Fuel Corridors. In 2022, FDOT added over 4,000 miles (a 58 percent increase) to the network. This represents a great opportunity for Florida's communities to utilize all available funding to build a complete EV network in the state.

Natural Gas

Natural gas vehicles are often seen in the form of corporate and government fleets, due to the manageable size of the fleets (the up-front investment cost is recouped relatively quickly by lower fuel prices), the state and federal incentives and efficiency requirements, and the ability of

[14] "Experts: The Heavy-Duty Vehicle Sector Is Primed for Growth", 2021
[15] Florida Transportation Data for Alternative Fuels and Vehicles
[16] Florida's Electric Vehicle Infrastructure 2023 Update

these types of vehicles to return to terminals for re-fueling daily. As of September 2023, Florida has 56 Compressed Natural Gas (CNG) and three Liquefied Natural Gas (LNG) refueling stations.[17]

Some logistics companies are investing in natural gas as fuel for their fleets, including Amazon and UPS. Amazon is hoping to run a carbon neutral business by 2040 and has ordered more than 700 CNG class 6 and class 8 trucks. UPS aims to reduce the environmental impact of its 123,000-vehicle fleet by phasing in more than 6,000 natural gas-powered trucks over three years and stepping up purchases of renewable natural gas (RNG).[18]

Saddle Creek is a nationwide third-party logistics and trucking company based in Lakeland, Florida. They currently have a fleet of 200 CNG trucks, which represents more than 40 percent of their total for-hire fleet. Saddle Creek estimates that their trucks have traveled more than 55 million miles on CNG. The company is continuing to invest in CNG, converting 50 of their older diesel trucks into dual CNG-diesel fuel vehicles, and recently completing a $1.5 million upgrade to their fueling facility in Lakeland to accommodate the growing fleet.[19]

Hydrogen Fuel Cell

Hydrogen fuel cell vehicles have potential benefits for heavy duty vehicles compared to electric. The vehicle can be lighter, the driving range is longer, and the fueling time is shorter. A growing number of developers are adopting hydrogen fuel cells as a complementary technology to battery-electric powered vehicles.[20] Hyundai, Nikola and Toyota are all working on hydrogen fuel cell powered trucks. The hydrogen fuel cell stack works like a mini power plant, converting hydrogen to electricity that can run the trucks. Drivers can fuel their vehicles almost as quickly as they can with diesel, and the system is lighter than the power supply for a similar battery-electric truck. There are currently no hydrogen refueling stations in Florida.[21]

Ports

The current standard for freight vessel fuel is diesel, but Florida seaports are on the leading edge of alternative fuel utilization nationally. Florida is already deploying LNG for its cargo and cruise vessels and is poised to deploy the world's largest shore power system.

LNG

There are two primary applications for LNG in the maritime shipping industry - a fuel source for the motive power in maritime vessels, and a commodity cargo for import and export – both of

[17] Florida Transportation Data for Alternative Fuels and Vehicles
[18] "Exclusive-Amazon orders hundreds of trucks that run on natural gas", 2021
[19] "Demand Grows for CNG"
[20] "The Dawn of Electric Trucks", 2019
[21] Florida Transportation Data for Alternative Fuels and Vehicles

which are growing. LNG offers a lower energy cost per ton than traditional maritime heavy fuel oil and is fast approaching the status of a fully developed technology. A limiting factor is the lack of available infrastructure to supply LNG-powered vessels. Using LNG requires retrofitting existing vessels or purchasing new LNG powered vessels, and LNG bunkering requires specialized infrastructure for supply, storage, and delivery to vessels.[22]

Jacksonville currently has the largest LNG bunkering operation at a U.S. port. JaxPort can store ~16 million gallons of LNG and has 1.9 million gallons of daily LNG production. The only other LNG bunkering facility in the U.S. is Port Fourchon, Louisiana. In 2020, Port Canaveral was the homeport for the first fully LNG powered cruise ship in North America, Carnival Cruise Line's Mardi Gras.[23]

Shore Power

With shore power (or cold ironing) technology, a vessel shuts down all on-board power generation from diesel engines and connects to shore power supplied by the local utility. PortMiami is establishing itself at the forefront of pushing shore power with its project to install five shore power systems for cruise ships at the port. When installed in PortMiami by the end of 2023, it will be the largest shore power system in the world.[24]

Rail

Railroads are the most environmentally friendly mode of surface transportation for moving freight. On average, railroads are three to four times more fuel efficient than trucks on a ton-mile basis. Railroads are continuing to embrace innovative solutions, like exploring alternative fuel use in existing locomotive fleets and hybrid diesel-electric propulsion technology. Class I railroads are also upgrading yard equipment, such as switcher locomotives, cranes, and service trucks.[25]

LNG

Like seaports, LNG has proven to be the most cost effective and beneficial alternative fuel source for rail. Technology includes dual-fuel trains that use both LNG and diesel fuel. Unlike the shipping industry, the bunkering market is not experiencing the growth necessary to support Class I railroad operators for cross-country rail lines, so regional rail companies are the sole users of LNG powered locomotives.[26]

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[22] Florida Seaport Transportation and Economic Development Council (2020). Alternative Fuels Study.
[23] ibid
[24] PortMiami to deploy world's largest shore power system - Marine Log
[25] AAR-Climate-Change-Fact-Sheet.pdf
[26] Florida Seaport Transportation and Economic Development Council (2020). Alternative Fuels Study.

There are currently four freight rail operators in Florida, including CSX, Florida East Coast Railway, Seminole Gulf Railway, and Genesee Wyoming Railroad. Florida East Coast Railway has been operating on LNG since late 2015 and completed the conversion of its entire mainline thru-haul fleet to run on LNG. [27]

Biodiesel

CSX is finishing up testing a 20% soybean oil-based fuel blend (B20 biodiesel) in its Tampa locomotive fleet with over 200,000 gallons burned.

Aviation

The aviation industry is focused on delivering sustainable aviation fuels (SAF), innovative new propulsion technologies, and other efficiency improvements (such as improvements to air traffic navigation).[28] Advanced Air Mobility is an emerging aviation ecosystem that leverages new aircraft and an array of innovative technologies to provide the opportunity for more efficient, more sustainable, and more equitable options for transportation.[29] As the aviation industry looks toward alternative fuels, Florida is poised to take advantage of the latest developments.

SAF

Fort Lauderdale Executive Airport and Melbourne Orlando International Airport are leading the industry and partnering with companies to bring Sustainable Aviation Fuel (SAF) to Florida's aviation community. According to the United States Department of Energy, SAF is a biofuel used to power aircraft with similar properties to conventional jet fuel.

Electric

Electric-powered aircrafts are being tested in the U.S. for short (500-800 mile) express feeder air cargo routes. A new type of aircraft known as eVTOL (electric vertical-takeoff-and-landing) is also being explored for passenger and air cargo. eVTOL differs from traditional helicopters and offers lower maintenance, lower noise, reduced environmental impact, and better safety prospects.[30] Applicable federal regulations still are emerging, but the FAA's "Innovate28" plan has a goal for multiple origin/destination service in at least one geographic area by 2028.

[27] See https://www.railwayage.com/mechanical/locomotives/fec-rolls-out-lng/ and https://fecrwy.com/news/blog-lng-operations/ for more information.
[28] Net zero 2050: sustainable aviation fuels (iata.org)
[29] AAM Implementation Plan, Version 1.0
[30] FDOT Advanced Air Mobility Roadmap

Space

Florida's space industry is on the cutting edge of fuel technology. The two predominant fuel types today are highly refined kerosene (RP-1) and liquid hydrogen. However, LNG is the new alternative fuel in the rocket business and becoming a primary fuel in the form of methane. The proximity of Port Canaveral to the Cape Canaveral Space Force Station and Kennedy Space Center provides a nexus for development of regional LNG infrastructure capable of meeting the needs of growing space and maritime industries.

Space X uses methane as fuel for its Raptor engine, the critical propulsion for the Falcon 9 rocket and future Starship launches.[31] In its New Glenn rocket, schedule to fly for the first time in 2024, Blue Origin will also use methane as the primary fuel for its BE-4 engines, the most powerful LNG fueled rocket motor ever developed.

Beyond alternative fuels, the following technologies listed by mode are helping to optimize the efficiency of freight movement by reducing human error, increasing operational speed and safety, and improving overall productivity. Florida is on the cutting edge of advances that play a critical role in the success of the state's economy and global position.

Highway Technology

Connected vehicle technology utilizes a combination of vehicle- and infrastructure-based radio units that exchange messages to improve mobility and safety. Relevant connected vehicle applications include freight-specific traveler information, curve speed warnings, and oversize/overweight detection. Connected vehicle hardware and software can complement planned intelligent transportation system (ITS) and signal projects.

Automated vehicle technology utilizes on-board sensors to interpret roadway conditions and make driving decisions on behalf of the driver. This may range from simple assistive tasks such as emergency braking to fully automated operations without the need for driver inputs. Near-term opportunities include vehicles with low speeds and small form factors, such as delivery robots and automated airside vehicles at airports. Twenty-four states allow level 4 autonomous semi-truck commercial deployment.[32]

SunTrax is a large-scale, state-of-the-art facility being developed by FDOT and Florida's Turnpike Enterprise dedicated to the research, development, and testing of emerging transportation technologies in safe and controlled environments. The entire site is a connected environment for

[31] Florida Seaport Transportation and Economic Development Council (2020). Alternative Fuels Study.
[32] FDOT, Emerging Trends, 2023 emergingtrends.pdf (windows.net)

the testing of vehicle-to-infrastructure (V2I), vehicle-to-vehicle (V2V), and vehicle-to-anything (V2X) communications.

Driver Assisted Truck Platooning (DATP) utilizes a combination of connected and automated vehicle technologies to establish connectivity between multiple trucks, with a front driver making driving inputs and following trucks automated to replicate these inputs in real time, enabling drastically shorter headways. This could result in fuel savings, reduced driver fatigue, and increased roadway capacity. FDOT has conducted two pilot projects involving truck platooning, with Peloton (2017), and Starsky Robotics (2019).

While the technology is novel, the real-world use cases are currently limited. The trucking industry has not identified cost-effective or operational efficiencies with DATP, and owner-operator linkages are not likely due to safety and interoperability issues. Most fleets plan for single tractor-trailer movements (52' of cargo, not 104' of cargo).

Freight signal priority utilizes infrastructure-based sensors, which could include connected vehicle radios, to detect the presence of trucks and extend green lights to allow their passage. Freight signal priority has been demonstrated to reduce truck travel times by 10 percent. FDOT has developed several projects with freight signal priority including the I-4 and I-75 FRAME, Smart Bay, Florida Keys COAST, and SR 60 CAV projects.

Freight traveler information applications use real time data to allow drivers and operators to make informed trip planning and completion decisions. Example freight applications include freight-specific trip planning, drayage optimization, and dynamic eco routing to minimize fuel consumption. South Florida was the site of one of three U.S. DOT Freight Advanced Traveler Information System (FRATIS) pilot projects.

Data-driven decision making is helping to add new truck parking locations. Utilizing big data, advanced data processing software, and novel methodologies are what spurred the success of FDOT's Truck Parking Study. Truck parking availability uses infrastructure-based sensors to detect the presence of trucks via in-ground or microwave sensors or closed-circuit television (CCTV) cameras to detect activity in and out of a parking lot. Real-time parking is disseminated to truck drivers using in-vehicle radios, dynamic message signs, mobile apps, websites, or a combination. Florida has installed the truck parking availability system (TPAS) at approximately 68 locations along interstates: I-4, I-10, I-75, and I-95. Results show that the sensor installation exhibited 95 percent accuracy providing occupancy information and 90 percent accuracy with turnover information.

Weigh-in-motion technologies use ITS infrastructure that measures the weight of a vehicle as it passes over roadway sensors. This electronic clearance allows wireless screening of trucks at heading speeds, eliminating the need for trucks to pull over at weigh stations. The FDOT Motor Carrier Size and Weight Office (MCSAW) deployments show approximately 50 percent of the commercial vehicles receive a bypass due to size and weight compliance. FDOT has also developed the Freight Operations eXchange (FOX) database, which will be a primary driver for how weigh stations work in the future. The FOX dataset will allow MCSAW to determine if the truck has recently been processed at another station and if so, provide an additional bypass based upon previous compliance checks.

Electronic tolling facilities use electronic detection equipment like in-ground sensors to assess the number of axles and apply an appropriate toll. Tolls may be paid using prepaid toll transponders or mailed to the owner based on their license plate. Florida's Turnpike is a key example of electronic tolling, with additional through lanes constructed to bypass local traffic. This reduces stop and go activity for toll payments.

Truck-only lanes are lanes constructed and reserved for commercial vehicles on major freight corridors. Truck-only lanes have been constructed along part of I-5 in California and are currently under consideration along I-75 in Georgia. While they have the potential to significantly alleviate truck traffic in limited access facilities and reduce time delays for deliveries, truck-only lanes have a high initial cost and result in a reduction in general purpose travel lanes. By establishing truck-only lanes, technologies such as Weigh in Motion and Freight Signal Priority (FSP) can be integrated as a design feature from the ground up.

On a smaller scale, personal delivery devices are being explored for consumer-oriented/last mile freight operations in Miami. "Tiny Mile" robots have joined a series of pilots that have turned Miami into a testing haven for autonomous innovation.[33]

Rail Technology

Positive Train Control (PTC) systems are designed to prevent train-to-train collisions, over-speed derailments, incursions into established work zones, and movements of trains through switches left in the wrong position. PTC technology is in operation on all 57,536 required freight and passenger railroad route miles nationally as of the December 31, 2020 statutory deadline set forth by Congress.[34]

[33] Tiny Mile's pink robot pilot joins Miami's autonomous testing ground - Axios Miami
[34] Positive Train Control (PTC) | FRA (dot.gov)

Smart Sensors for train wheels are an important part of rail safety. Investments in a variety of smart sensors, including infrared, acoustic monitoring, and laser technology, monitor the health of railcar wheels. They alert railroads to wheel anomalies, which can affect their performance, damage track, or indicate brake problems. This allows railroads to fix small problems before they become serious.[35] Aided by smart sensors deployed across the network and advancements in track inspection technologies, railroads have amassed databases with hundreds of terabytes of information about the condition of track and equipment. This virtual goldmine of data coupled with improved data analytics software allows railroads to uncover critical data trends and apply this learning to enhance safety and operations.[36]

Automated Track Inspections (ATI) hold great promise for the future of railroad safety and efficiency. An advanced algorithm can analyze track geometry of more than 1,500 curves in track in just a few hours, whereas it would take a team of four people 10 months to manually complete the same task. All Class I railroads use some sort of automated technology for inspections to supplement the manual inspections required by federal regulation. With increased use enabled by next-generation technology and modifications to federal regulation, railroads will be able to conduct safety inspections more frequently, detect more flaws more reliably and respond more quickly while keeping workers out of harm's way.

Seaport Technology

Smart Ports can help ensure the port has a steady supply of work. Connected shipping and container management vessels can ensure efficient utilization of space at the port. These connections can be made to other modes and inland ports to maximize space and the movement of goods. BlockChain will be a critical technology for ensuring that these cargo movements are tracked safely and securely. It will provide each port with a verifiable and non-fungible tracking ID that can be traced between ports around the globe.

IR Sensors are critical for BlockChain as this is where the information will be stored. The Smart Ports of the future will have infra-red detectors at all points of entry to ensure detection of the information.

Port Automation for seaports could significantly improve on-facility operations resulting in greater throughput of cargo and passengers. Automated cranes could improve capacity/throughput/productivity (containers per hour), and automated submersibles (underwater drones) can be used for ship inspections.

[35] Technology Makes Freight Railroads Safer - Association of American Railroads (aar.org)
[36] Technology Drives the Future of Rail - Association of American Railroads (aar.org)

Modeling Behavior (Digital Twins) will help ports determine workloads and capacity well ahead of time to avoid bottlenecks and backlog. By creating a digital representation of the port utilizing AI and advanced computing and applying real world effects such as weather, worker capacity, and cargo throughput the port can more appropriately plan around future shifts in cargo flows.

Security and Scanning are critical facets of ports being international areas of entry. Through the use of x-ray and other directed energy scanning technologies, ports will be able to protect against human and contraband trafficking in a more thorough and efficient manner. As these issues grow, it is becoming more critical to ensure that all ports of entry (not just seaports) invest in and adopt these technologies. Radiation portal monitors are used at the Port of Miami.[37]

Aviation Technology

NextGen is the FAA's multibillion-dollar program to modernize the U.S. National Airspace System. It helps airlines, general aviation operators, pilots, and air traffic controllers get access to data and tools that help passengers and cargo arrive at their destinations more quickly. This transformation involves an ongoing rollout of improvements which began in 2007.[38]

As part of the AAM landscape, delivery drones can deliver packages to their final destination once a truck reaches a strategic location and deploys them. The benefits include significant fuel/time savings for parcel delivery services and a reduction in costs for maintenance of unpaved roads to rural counties. Delivery vehicles currently add significant wear and tear on these facilities as a result of e-commerce. Amazon is currently testing a service that will drop its pharmacy patients' medications on their doorsteps via drone in an hour or less with customers in College Station, Texas.[39] UPS used drones to deliver COVID-19 vaccines in Winston Salem, North Carolina. Drones were also used to deliver prescription medication in The Villages, Florida.[40]

AI Scanning Systems are being used as a quick way of recording cargo dimensions. The system uses advanced machine-learning, scales, cameras, and 3D scanners to provide instantaneous, accurate scans of parcels and pallets. Sensors are used to collect data from millions of points simultaneously rather than a single laser scanned point. The machine-learning algorithm can

[37] The Port of Miami, Florida, US - Ship Technology (ship-technology.com)
[38] Next Generation Air Transportation System (NextGen) | Federal Aviation Administration (faa.gov)
[39] Amazon is testing drones to deliver your medications in an hour or less - CBS News
[40] emergingtrends.pdf (windows.net)

improve the accuracy with every scan and can be used on black plastic surfaces which have traditionally been a challenge for freight scanners. [41]

Miami International Airport is building four-story cargo facility (Vertically Integrated Cargo Community, or VICC) at that will be the first of its kind in the Western Hemisphere and, when completed, will increase the airport's total cargo capacity by at least 50% or potentially up to two million tons annually.[42]

Space Technology

Cargo Delivery Via Rockets is an experiment sponsored by the Air Force Research Lab and the Transportation Command, with the potential for delivering masses of cargo and smaller more targeted deliveries (e.g. medical supplies) at great speed.[43] If successful, a program of record could be planned as early as 2026.

Deep Space Freight Corridors and an infrastructure of reliable systems for transporting supplies to space are critical for establishing colonies on the moon and Mars. The development of a next-generation supply chain will require larger rockets carrying heavier payloads, automation to compensate for communication time lag over large distances and new lightweight, affordable, reusable, and recyclable packaging to withstand radiation and the rapid changes in temperature found in space. [44]

Pipeline Technology

Pipelines may be used to transport liquids, gas, and in some cases solids like grain, rocks, cement, and solid waste over long distances. Advancements in pipeline technology aim to improve monitoring and detection of conditions which represent a threat to the integrity of the pipeline and thereby the safety of the system.

Intelligent Pig technology is a type of in-line inspection equipment used to examine a large portion of a pipeline. The "pig" is inserted into the pipeline and is carried by the product flowing through the pipe. Intelligent pigs are equipped with sensors and data recording equipment. These sensors can detect and measure corrosion, material loss, cracks, dents, and other deformation within the pipeline as well as the exact location markers of the abnormalities.

[41] aircargonews.net/technology/cargo-spectre-offers-speedy-ai-cargo-scanning/
[42] MIA receives approval of a $400+ million cargo facility (miami-airport.com)
[43] Space Force envisions 'freight trains' to space, 'Walmarts on orbit' - Breaking Defense
[44] NASA to develop deep-space freight corridors - FreightWaves

Intelligent pigs are nondestructive to the pipeline and may use magnetic resonance or ultrasonic waves to identify potential abnormalities. [45]

[45] 1 (liquidenergypipelines.org)

Florida Growth and Supply Chain Resilience Initiatives

The impacts of disruption to the nation's freight system have become more apparent to planners, policy makers, freight stakeholders, and the public at large. Supply chains are impacted by disruptions from shocks (individual events) and stresses (longer-term shifts). These events and conditions can result in unanticipated transportation system impacts and increasing constraints on infrastructure, impeding access to reliable mobility for people and goods.[46]

In response to numerous disruptions, Florida's freight transportation systems must become more resilient, in terms of their ability to: resist disruption; adapt quickly and provide emergency services immediately following disruption; and re-establish full operations following disruption. With more awareness about these threats at a national level, there is more federal money, along with new project standards and updated policies, upon which Florida can capitalize to improve the state's freight system resilience.

Resilience Policies

The Infrastructure Investment and Jobs Act (IIJA) created the Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) program providing $7.4 billion nationally in both formula and discretionary funding programs for transportation resilience. These programs provide approximately $70 million annually to the Florida Department of Transportation (FDOT) to cover resilience projects and incremental costs to make projects and facilities more resilient.

In 2021, Senate Bill 1954 was signed into law to protect Florida's inland waterways, coastlines, shores, and coral reefs. This bill, combined with the 2021-2022 budget, was part of the largest investment in the state's history – over $640 million – to support efforts to ensure state and local communities are prepared.[47] It included:

- $12.5 million for the Resilient Coastlines Initiative for resilience projects and coral reef protection
- $29 million for establishment and planning efforts of the Resilient Florida Grant Program
- $500 million in federal funding for implementation of statewide resilience projects
- $100 million for Resilient Florida Grant Program projects in partnership with local communities

[46] briefing_sheets_resilience_0630.pdf (windows.net)
[47] Governor Ron DeSantis Signs Bill to Further Strengthen Florida's Resiliency Efforts, 2021

- Federal Regulation 23 CFR Part 450 requires Metropolitan Planning Organization (MPO) and statewide transportation planning processes to improve the resiliency and reliability of the transportation system and reduce or mitigate stormwater impacts of surface transportation.

In 2020, FDOT adopted a resilience policy that defines the principles of resilience as "the ability to adapt to changing conditions and prepare for, withstand, and recover from disruption."[48]

In July 2023, FDOT published its Resilience Action Plan (RAP) required by Florida Statute. The plan focuses on four specific hazards that may impact the Florida State Highway System (SHS) and the communities it serves. The plan assesses the potential impacts on the SHS and identifies strategies to improve the resiliency of transportation facilities. The RAP Data Viewer allows users to view and download data, and the vulnerability assessment is included as part of the FMTP24 prioritization process.

[48] FDOT Resiliency Subject Brief, 2022

Florida Growth and Supply Chain Resilience Constraints

As global economic competition increases, trade patterns change, social patterns shift, and strides are made in alternative fuels and supply chain technologies, decisions about how best to invest limited public resources in freight capacity are increasingly critical.

Considerations include what infrastructure capacity is needed and where, how to make the best use of existing capacity, and how local policies, constraints, and investments may affect the performance of regional and national networks. Locally driven decisions about freight capacity can create regional competition that leads to inefficient national investments.

Statutory and Constitutional Constraints

Funding – Transportation projects, whether they involve maintenance, new installations, upgrades, replacements, or operations, have become more costly. Solutions that could be instrumental in relieving freight congestion, such as public transit systems to get cars off the road, truck bypasses at major intersections, or highway-railroad grade separations, are often unrealistic to fund with a single agency. There are both opportunities and hurdles in aligning transportation investments with federal and state legislative goals and capitalizing on multi-state investments and public-private partnerships.

Additionally, some project types can't be funded, like local roads due to CRFC/CUFC mileage limitations or short line railroad maintenance due to ownership restrictions. With the Build America, Buy America Act in the IIJA, certain specialized modal products built overseas, like cranes, can no longer be purchased without exemption. Competition with other transportation priorities adds another layer of difficulty – freight projects require greater visibility/understanding by local leaders to get put on the docket. Statutory restrictions on local government funding, such as recent changes affecting impact fees and sales taxes, constrains the ability to affect the overall safety, capacity, efficiency, and partnership capability of Florida's transportation network at a local level.

Trade Patterns – The growing shift from global (offshoring) manufacturing to regional (re-shoring or near shoring) has changed trade and corresponding job growth, which could bring more freight to Florida because of its proximity to Mexico, the Caribbean, and Latin America. A notable measure of these shifts is the removal of NAFTA (North American Free Trade Agreement) from the Mexico-Canada-United States trade partnership. It was replaced with the United States-Mexico-Canada Agreement. The changes between the agreement between the United States of America, Mexico, and Canada (USMCA) and NAFTA are subtle but distinct in their efforts towards reshoring.

The Jones Act, which refers to Section 27 of the Merchant Marine Act of 1920 (P.L. 66- 261), requires that vessels transporting cargo from one U.S. point to another U.S. point be U.S.-built, and owned and crewed by U.S. citizens. The act once provided protection for U.S. shipyards, domestic carriers, and American merchant sailors. Now it is a subject of debate because some experts argue that it leads to high domestic ocean shipping costs and constrains the availability of ships for domestic use.[49] Similarly, the Build America, Buy America Act in the IIJA expands on the Federal government's work to ensure that the future is made in America by American workers by strengthening and expanding Buy America rules to all taxpayer-funded infrastructure and public works projects.[50]

Coupling this with other global re-shoring efforts, such as Brexit, it is becoming clearer that supply chains need to further prepare for increased Trade Barriers that have an intent of reshoring. This could mean many things to the supply chain; whether it be more raw materials from abroad or less imports altogether is unknown.

Intermodal Logistics Center (ILC) Policy/Economic Incentives – Florida could benefit from additional intermodal facilities to make intermodal shipping more efficient. However, the development of a new facility can require hundreds of millions of dollars in investment and go beyond the transportation and distribution functionality. Other states compete for these new facilities, and they often offer economic incentives valued highly. These investments are designed to attract the key anchor tenant, which often consists of a major manufacturer that provides the host community significant economic benefits well beyond a transportation hub.

Previously, Florida had an ILC Infrastructure Support Program, which provided at least $5 million annually from the State Transportation Trust Fund for infrastructure enhancements such as road construction, rail expansion, and dock improvements, with maximum awards of $2.5 million per applicant. The program sunset in July 2020, and funding was considered again during Florida's 2024 Legislative Session.

Many of Florida's existing programs do not provide sufficient support and make it difficult for local communities to compete against larger economic incentive packages. Florida's programs have primarily focused on surrounding transportation infrastructure improvements whereas other state incentive packages include a broad scope of benefits such as a reduction in property

[49] Shipping Under the Jones Act: Legislative and Regulatory Background (congress.gov)
[50] FACT SHEET: Biden-Harris Administration Ensuring Future is Made in America | The White House

taxes and community college training. Florida could improve support in this area by offering larger economic incentives for companies to relocate to the state.[51]

Compatibility of land uses – With increasing population and limited space comes increasing conflicts that arise between the transportation demands for freight, passengers, businesses, and residents. Community concern about freight facilities can stem from impacts of the externalities on surrounding neighborhoods. There is an increasing need for more truck parking and distribution centers, but such freight operations near residential neighborhoods also face substantial opposition. Policymakers have a significant role to play in assessing those tradeoffs to set policies and regulatory standards that effectively address issues of economic development, public safety, and environmental sustainability.

[51] Florida ILC Study, 2023

FMTP24

FREIGHT MOBILITY AND TRADE PLAN

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