

**Spring 2013
Industry Study**

**Final Report
*Transportation Industry***



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TRANSPORTATION 2013

ABSTRACT: America's transportation industry is under stress. Demand for transportation services—aviation, trucking, rail, pipeline, and maritime shipping—is growing rapidly, driven by factors such as increasing domestic and international commerce, expanding North American oil and natural gas production, and America's growing population—expected to top 400 million by 2050. However, the industry faces infrastructure, labor, and technology challenges that could limit its ability to meet the nation's growing demand for transportation. Critically, public sector planning and programs do not effectively support private or public investment to alleviate capacity constraints or support other national priorities, such as reducing urban congestion and greenhouse gas emissions. This paper supports a public-policy-driven approach to expanding transportation capacity and investment—both private and public—in ways that support America's economic, environmental, and security priorities.

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PLACES VISITED

Domestic:

American Airlines Flight Academy (Fort Worth, TX)
 American Short Line & Regional Railroad Association (Washington, DC)
 American Trucking Associations (Arlington, VA)
 Association of American Railroads (Washington, DC)
 Burlington Northern Santa Fe Railway Corporate Headquarter (Fort Worth, TX)
 Burlington Northern Santa Fe Railway Classification Yard (Haslet, TX) Burlington
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 Delegation of the European Union to the United States of America (Washington, DC)
 Federal Aviation Administration Air Traffic Control System Command Center (Warrenton, VA)
 Federal Aviation Administration, Terminal Radar Approach Control & Tower, George
 Bush Intercontinental Airport (Houston, TX)
 Federal Highway Administration (Washington, DC)
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 J.B. Hunt Transport, Enterprise Solutions & Government Services (Washington, DC)
 John A. Volpe National Transportation Systems Center,
 Research and Innovative Technology Administration (Cambridge, MA)
 Maritime Administration (Washington, DC)
 Maersk Line Limited (Norfolk, VA)
 National Highway Traffic Safety Administration (Washington, DC)
 National Railroad Passenger Corporation (Amtrak) Headquarters (Washington, DC)
 National Transportation Safety Board Training Center (Ashburn, VA)
 Norfolk International Terminals, Inc., Port of Virginia (Norfolk, VA)
 Pipeline & Hazardous Material Safety Administration (Washington, DC)
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 Shell Pipeline Company LC (Houston, TX)
 Transportation Research Board (Washington, DC)
 United Parcel Service Freight Headquarters (Richmond, VA)
 United Parcel Service Freight Service Center (Richmond, VA)
 US Coast Guard Sector Houston-Galveston (Houston, TX)
 US Coast Guard Sector New York (Staten Island, NY)
 US Department of Transportation (Washington, DC)
 USNS Gilliland (Baltimore, MD)
 The Vane Brothers Company (Baltimore, MD)
 Washington Metropolitan Area Transportation Authority (Washington, DC)
 Wells Fargo-Wachovia Securities (New York, NY)

International:

None



INTRODUCTION

The nation's demand for transportation services is growing rapidly, driven by factors such as increasing domestic and international commerce, expanding North American oil and natural gas production, and America's growing population, which is expected to top 400 million by 2050. The bow wave of this growth already strains our nation's transport capacity. Growing airport, highway, rail, and port congestion costs Americans billions of dollars annually in wasted time and fuel, higher shipping costs, and lost productivity. It is unclear whether capacity will expand rapidly enough to keep pace with the growing demand. In 2007, for example, a national transportation study commission concluded that maintaining and expanding the U.S. freight transport system would require more private investment and public funding for projects that alleviate capacity constraints.¹ However, in an era of constrained federal and state budgets, public funding likely will be limited and there is no guarantee that private investment will take up the slack. In addition, new labor, safety, and security regulations may actually work to reduce available capacity and increase stress on the entire system.

This study is divided into five parts. Part I defines the five transportation modes discussed in this report and examines their current condition and outlook over the next 5 years thru 2018 using selected financial data. Part II identifies infrastructure, labor, and technology challenges facing the modes. Part III outlines areas where, within the context of a high-level national transportation strategy, government can play a constructive role in addressing these challenges in ways that support the nation's economic, security, and other priorities. Part IV presents the paper's conclusions. Finally, Part V presents four student essays that examine infrastructure, labor, and technology challenges in more detail.

PART I: INDUSTRY DEFINITION, CONDITION, AND OUTLOOK

America's transportation industry consists of five modes—aviation, trucking, rail, pipeline, and maritime shipping—that are both competitive and complementary. These modes are comprised of multiple sectors; for example, trucking includes, among other sectors, long-distance and local freight trucking. In addition, although they do not provide transport services themselves, freight forwarders and third party logistics firms play an increasingly critical role in selecting, combining, and integrating services provided by the different modes to meet customer needs. In 2012, the transportation industry earned \$46.1 billion (5.9 percent) on revenue of \$778.2 billion.² This total represents about 5 percent of U.S. gross domestic product. Most transportation sectors are characterized as *mature*, meaning their annual revenue growth roughly tracks the annual growth in gross domestic product. However, several sectors—such as petroleum products pipelines—are characterized as *declining*, meaning their annual revenue growth now lags behind the annual growth in gross domestic product.³ Nevertheless, revenue for all transportation industry sectors is projected to grow over the next 5 years to \$916 billion.

Revenue and profitability differ widely between the five transportation industry modes. Aviation, for example, generated about 34 percent of industry revenue but only 15 percent of industry profit. In contrast, pipelines generated only about 4 percent of industry revenue but more than 14 percent of industry profit. These differences in profitability reflect differences in competitive intensity across the five modes. This paper uses “Porter's five forces analysis” framework to assess the competitive intensity of an industry to determine its “attractiveness” or profitability.⁴ The framework assesses the threat of new entrants to the industry, the bargaining power of industry suppliers, the bargaining power of industry customers, the threat of substitute



products, and the strength of competitive rivalry within the industry. Industries characterized by high threats, high bargaining power, and intense competitive rivalry are considered less attractive because these forces will interact to drive down profitability. As table 1 shows, the modes that generate the most transportation industry revenue—aviation and trucking—are the most competitive and the least profitable.

Table 1: Transportation Industry Revenue, Profits, and Competitiveness by Mode (2012)

Mode	Revenue (billions)	Percentage of revenue	Profit (billions)	Percentage of profit	Intensity of competition
Aviation	\$ 267.8	34.4	\$ 6.9	15.0	High
Trucking	351.0	45.1	20.2	43.8	High
Rail	81.0	10.4	7.5	16.3	Moderate
Pipelines	29.4	3.8	6.5	14.1	Low
Maritime shipping	49.0	6.3	5.0	10.8	Moderate
Total	\$ 778.2	100.0	\$ 46.1	100.0	

Source: Analysis of IBIS, Reuters, and Bloomberg data.

Aviation

The aviation industry provides domestic, international, and charter air transport of passengers and cargo. U.S. airlines are privately owned and can be categorized as domestic, international, and charter carriers. (See table 2.) The industry also includes firms that maintain, repair and overhaul aircraft⁵ and firms that operate airports.⁶ In 2012, the aviation industry as a whole earned \$7 billion (2.6 percent) on revenue of \$268 billion. Industry revenue is projected to grow over the next 5 years at an average annual rate of 4 percent to \$325 billion.

Table 2: U.S. Airlines at a Glance

Sector	Definition, Current Conditions, and Outlook
Domestic Airlines	<ul style="list-style-type: none"> ❖ Transport passengers and cargo on regular routes and schedules. ❖ Network (legacy) carriers operate a significant portion of flights using at least one hub where connections are made for other flights. ❖ Regional carriers provide service from smaller cities, mostly using smaller aircraft, to support the network carriers' hub and spoke systems. ❖ Carriers earned \$3 billion (1.8 percent) on revenue of \$165 billion (2012). ❖ Passenger service between major cities and regional service accounted for 54 and 31 percent of revenue, respectively; cargo service accounted for 5 percent. ❖ Declining and moderately concentrated sector, with the top four carriers (United, Delta, American, and Southwest) generating about 56 percent of revenue.
International Airlines	<ul style="list-style-type: none"> ❖ Carrier revenue projected to grow over the next 5 years at an average annual rate of 5 percent to \$210 billion. ❖ Transports passengers and cargo on regular routes and schedules on flights that end or originate internationally. ❖ Carriers earned \$2 billion (3.3 percent) on revenue of \$60 billion (2102). ❖ Leisure, business, and cargo transport accounted for 68, 15, and 10 percent of revenue, respectively. ❖ Mature and highly concentrated sector, with the top four carriers (United, Delta, American, and U.S. Airways) generating about 70 percent of revenue. ❖ Carrier revenue projected to grow over the next 5 years at an average annual rate of 2.3 percent to \$68 billion.



Charter Airlines	<ul style="list-style-type: none"> ❖ Provide irregular or unscheduled transport services for passengers and cargo. ❖ Carriers earned \$436 million (3 percent) on revenue of \$14.5 billion (2012). ❖ Domestic and international passenger charters account for 60 and 18 percent of carrier revenue, respectively; cargo charters account for 11 and 7 percent. ❖ Military and government charters—both passenger and cargo—account for about 21 percent of revenue; most business conducted under the Civil Reserve Air Fleet. ❖ Mature and highly fragmented sector, with the top four carriers generating only 13 percent of revenue. ❖ Carrier revenue is projected to grow over the next 5 years at an average annual rate of 3.6 percent to \$17 billion.
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Source: Analysis of IBIS, Reuters, and Bloomberg data.

Since deregulation 35 years ago, the airline industry has been characterized by high competitive rivalry, low profitability, and multiple bankruptcies, as rising equipment, fuel, and labor costs have reduced carrier profit margins. The bargaining power of industry suppliers is high. Airlines rely on two large aircraft manufacturers (Airbus and Boeing), and airline labor is largely unionized. In addition, they use infrastructure—such as airports and the national air traffic control system—that is publicly built, maintained, and operated. The threat of new entry is low for the major domestic and international airlines. New entry is deterred by the industry's capital intensive, oligopolistic (concentrated) structure; high regulatory requirements; and limited access at major airports. New airlines are regional or point-to-point carriers operating in smaller markets. Table 3 summarizes the competitive forces affecting the aviation industry.

Table 3: Five Forces Analysis for the U.S. Aviation Industry

Threat of New Entrants	Supplier Bargaining Power	Customer Bargaining Buyer Power	Threat of Substitute Products	Industry Competitive Rivalry
LOW	HIGH	MEDIUM	MEDIUM	HIGH
<ul style="list-style-type: none"> ▪ Capital intensive oligopoly, although aircraft can be leased ▪ Entry deterred by high regulatory requirements & airport access 	<ul style="list-style-type: none"> ▪ Few aircraft manufacturers ▪ Fuel & (largely unionized) labor drive carrier costs ▪ Carriers operate on public infrastructure 	<ul style="list-style-type: none"> ▪ Low for passengers & time-sensitive shippers due to high cost of switching to other modes ▪ High for less time-sensitive shippers, who can switch modes 	<ul style="list-style-type: none"> ▪ Preferred mode for time-sensitive, long-haul travel & cargo ▪ Technology provides increasing options for business travel ▪ Leisure travelers can switch modes or forego travel 	<ul style="list-style-type: none"> ▪ Overlapping route structures foster price wars; market share vital in price-driven oligopoly ▪ Cost controls & ancillary revenue define competitive advantages

Source: Analysis of IBIS, Reuters, and Bloomberg data.

In response to these industry forces, U.S. airlines have pursued several strategies. All carriers have taken steps in response to rising fuel prices—such as replacing older, inefficient aircraft with newer, more fuel-efficient models; increasing the fuel efficiency of existing aircraft by adding winglets;⁷ imposing fuel surcharges on passengers and cargo; and working to reduce inflight and other delays. In addition, some carriers (such as Southwest) have engaged in fuel price hedging—with mixed results.⁸ In April 2012, Delta purchased a refinery for \$150 million that the airline estimates will trim its annual jet fuel costs by \$300 million.⁹

Air carriers have taken other steps to compete more effectively on price and improve profitability. Many carriers have sought to improve profitability by charging passengers for



baggage, meals, movies, and other “ancillary” services. Pressured by low cost, point-to-point carriers, network (legacy) carriers have sought higher margins through economies of scale using a hub-and-spoke operating model and by expanding route coverage to gain more market share. Low cost carriers have sought to compete by offering regional service from smaller cities and minimizing operating costs by, for example, using standardized fleets, smaller aircraft, and lower cost airports. Low cost carriers, such as Allegiant, have been able to generate higher profits. The most well-known low cost carrier, Southwest, has expanded to the point where it can compete with the legacy carriers on a more even footing. However, it is uncertain whether Southwest can operate profitably as a large, national carrier operating out of major airports.

The U.S. airline industry also has witnessed several rounds of consolidation among the major carriers, with the recent merger of American and U.S. Airways creating the nation’s largest airline. Faced with growing foreign competition, U.S. international airlines may form new commercial alliances to obtain access to more markets to gain economies of scale and greater negotiating leverage with suppliers. This process has the potential to create global airlines, operating with hubs in many countries.

Trucking

The trucking industry includes five major sectors—long-distance freight trucking, tank and refrigeration trucking, local trucking, local specialized freight trucking, and couriers and local delivery services—that transport a wide variety of freight. (See table 4.) In 2012, the industry earned \$20 billion (5.7 percent) on revenue of \$351 billion. Over the next 5 years, industry revenue is projected to grow at an average annual rate of 3.2 percent to \$407 billion.

Table 4: U.S. Trucking Industry at a Glance

Sector	Definition, Current Conditions, and Outlook
<i>Long-Distance Freight Trucking</i>	<ul style="list-style-type: none"> ❖ Provides transport between urban areas at distances over 500 miles. ❖ Includes truckload or less-than-truckload carriers that handle a variety of commodities—generally palletized and transported in containers or van trailers. ❖ Carriers earned \$8 billion (5 percent) on revenue of \$160 billion (2012). ❖ Mature and fragmented sector, with the top four carriers (YRC Worldwide, J. B. Hunt, Con-way, and Swift Transportation) generating only 11 percent of revenue ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 3.6 percent to \$191 billion.
<i>Tank and Refrigeration Trucking</i>	<ul style="list-style-type: none"> ❖ Provides long-distance transport of cargo requiring specialized equipment because of its size, weight, shape, or other characteristics—such as automobiles, livestock, frozen food, and petrochemicals. ❖ Carriers earned \$1.5 billion (4.4 percent) on revenue of \$34 billion (2012). ❖ Mature and fragmented sector, with the top four carriers generating less than 20 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 2.7 percent to \$39 billion.



Local Freight Trucking	<ul style="list-style-type: none"> ❖ Provides general freight trucking at distances less than 500 miles. ❖ Carriers transport a variety of commodities—generally palletized and transported in containers or trailers—and usually provide services in an urban area. ❖ Local trucking transports intermodal freight "the last mile" within urban areas, for example, from rail intermodal yards to factory warehouses. Carriers earned \$2.2 billion (6.7 percent) on revenue of \$33 billion (2012). ❖ Truckload and less-than-truckload services accounted for 72 and 28 percent of revenue, respectively. ❖ Mature and fragmented sector, with the top four carriers generating less than 20 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 4.6 percent to \$43 billion.
Local Specialized Freight Trucking	<ul style="list-style-type: none"> ❖ Provides short-distance transport for cargo that requires specialized equipment for transportation because of its size, weight, shape, or other characteristics. ❖ Carriers earned \$2.6 billion (6.8 percent) on revenue of \$38 billion (2012). ❖ Shipments of food and beverages, chemicals and gasoline, and agricultural products accounted for 43, 34, and 10 percent of revenue, respectively. ❖ Mature and highly fragmented sector, with the top four carriers generating less than 10 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 2.4 percent to \$41 billion.
Couriers and Local Delivery Services	<ul style="list-style-type: none"> ❖ Transports goods, materials and documents for individuals, businesses, institutions, and government agencies (1) between urban centers using a network of air and surface transportation and (2) within a single urban area. ❖ Carriers earned \$5.9 billion (6.9 percent) on revenue of \$86 billion (2012). ❖ Ground deliveries, domestic air transit deliveries, international air transit deliveries, and local deliveries and messenger services accounted for about 56, 29, 9, and 7 percent of revenue, respectively. ❖ Mature and moderately concentrated sector, with the top two carriers (United Parcel Service and Federal Express) generating 68 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 1.8 percent to \$93 billion.

Source: Analysis of IBIS, Reuters, and Bloomberg data.

The trucking industry is characterized intense price competition and low profitability. The threat of new entry is high due to low capital costs and the ease of obtaining a commercial driver's license. As a result, industry concentration is low. Owner-operators account for about 94 percent of long-distance trucking firms; and nearly 86 percent of local trucking firms and 80 percent of tank and refrigeration trucking firms employ fewer than 10 people. The bargaining power of industry suppliers and customers is high. Customers, for example, have many shipping options due to the large number of trucking firms. These firms seek customers and market share by offering lower prices, driving down profit margins. Although trucking will continue to be the most common mode of freight transport, the industry faces increased competition from rail due to high fuel prices, highway congestion, driver shortages, and concern for environmental sustainability. In addition, trucking uses infrastructure that is mostly publicly built, maintained, and operated, and the industry is subject to increasing labor, safety, and environmental regulation. Table 5 summarizes the competitive forces affecting the trucking industry.



Table 5: Five Forces Analysis for the U.S. Trucking Industry

Threat of New Entrants	Supplier Bargaining Power	Customer Bargaining Buyer Power	Threat of Substitute Products	Industry Competitive Rivalry
HIGH	HIGH	HIGH	MEDIUM	HIGH
<ul style="list-style-type: none"> ▪ Low capital costs of new equipment ▪ Commercial licenses easily obtained ▪ Driver shortages create opportunities 	<ul style="list-style-type: none"> ▪ Fuel & labor drive operating costs ▪ Driver shortage & unions increase wages, benefits & turnover ▪ Labor enters & exits industry easily 	<ul style="list-style-type: none"> ▪ Shippers have multiple options due to the large number of trucking firms & competition from other modes 	<ul style="list-style-type: none"> ▪ Low for regional & local shipments due to lack of alternatives to trucking ▪ High for long-haul shipments due to competition from rail & other modes 	<ul style="list-style-type: none"> ▪ Low switching costs between firms & other modes ▪ Buyer options fuel competition for market share ▪ Firms compete fiercely for drivers

Source: Analysis of IBIS, Reuters, and Bloomberg data.

Larger trucking firms have responded to these industry forces in several ways. Long-distance trucking firm J.B. Hunt, for example, is positioning itself to be the industry leader for domestic intermodal shipments by purchasing thousands of additional 53-foot shipping containers and using rail to move shipments long distances to reduce fuel costs and avoid growing highway congestion. In contrast, United Parcel Service is working to increase the competitiveness and productivity of local delivery services by using global positioning and other technology to improve truck routing, driver efficiency, and freight tracking for customers. At the same time, the company seeks to transform itself into a full-service logistics provider.

Rail

The U.S. freight rail industry comprises 7 major and more than 500 regional and short line railroads. Most freight railroad infrastructure is privately owned and operated by the carriers. Most U.S. railroads are common carriers, and various aspects of their operations are regulated by federal and state agencies. In addition, Amtrak and some commuter passenger trains operate on freight railroad lines. In 2012, the freight rail carriers earned \$7.5 billion (9.3 percent) on revenue of \$81 billion. The 5-year return on investment was 7.7 percent. Table 6 summarizes the current condition and outlook for the U.S. freight rail industry.

Table 6: U.S. Freight Rail Industry at a Glance

Sector	Definition, Current Conditions, and Outlook
Freight Rail	<ul style="list-style-type: none"> ❖ Major railroads operate about 94,000 miles of freight lines with about 152,000 employees in 44 states and concentrate largely on long-haul intercity traffic. ❖ Regional and short line railroads operate about 45,200 miles of freight lines with about 18,000 employees in every state except Hawaii. They typically feed traffic to the major railroads or receive traffic from the major railroads for final delivery. ❖ Carriers earned \$7.5 billion (9.3 percent) on revenue of \$81 billion (2012). ❖ Bulk freight (such as coal, agricultural products, and chemicals) and intermodal shipments accounted for 65 and 28 percent of revenue, respectively. ❖ Mature and highly concentrated industry, with the top four carriers (Union Pacific, BNSF, Norfolk Southern, and CSX) accounting for 86 percent of revenue. ❖ Revenue is projected to grow over the next 5 years at an average annual rate of 3.3 percent to \$95 billion.

Source: Analysis of IBIS, Reuters, and Bloomberg data.



The rail sector is highly concentrated with a few major companies dominating the market and is characterized by moderate competition and profitability. The threat of new entry is low due to the high cost of equipment, infrastructure, and right of way required to establish service in multiple markets. The bargaining power of rail industry suppliers and customers is medium. Although fuel prices affect rail less than competing modes, labor unions drive up industry costs by demanding higher wages and benefits. Some shippers maintain the flexibility to shift between modes to gain better rates, and captive shippers may seek government rate regulation. The threat of substitutes also is medium. In many areas, bulk shippers have limited options besides rail due to the limited availability of pipeline or water transport. Moreover, intermodal shippers often find their options constrained by truck capacity shortages and highway congestion. Within the industry, competitive rivalry is low for captive and bulk shippers, but high for intermodal shipments. Table 7 summarizes the competitive forces affecting the freight rail industry.

Table 7: Five Forces Analysis for the U.S. Freight Rail Industry

Threat of New Entrants	Supplier Bargaining Power	Customer Bargaining Buyer Power	Threat of Substitute Products	Industry Competitive Rivalry
LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM
<ul style="list-style-type: none"> ▪ High cost of establishing service in multiple markets ▪ High regulatory requirements 	<ul style="list-style-type: none"> ▪ Increased fuel prices impact rail less than other modes (rail is more fuel efficient) ▪ Labor unions drive up wages & benefits 	<ul style="list-style-type: none"> ▪ Some shippers can shift between modes for better rates ▪ “Captive” shippers seek government rate regulation 	<ul style="list-style-type: none"> ▪ Bulk shippers have limited options ▪ Intermodal shippers have more choice but face capacity & congestion limits 	<ul style="list-style-type: none"> ▪ Low for captive & bulk shipments ▪ High for intermodal & high value shipments

Source: Analysis of IBIS, Reuters, and Bloomberg data.

Demand for freight rail service will grow as the economy improves and firms look to railroads to carry more merchandise and raw materials. In particular, growing trade will strengthen demand for intermodal shipments and expanding North American oil and natural gas production will strengthen demand for bulk freight shipments. BNSF, for example, is rapidly expanding bulk oil transports from North Dakota (Bakken) oil fields to Gulf Coast and, in conjunction with other rail carriers, East Coast refineries. Fuel prices also are expected to remain high over the next 5 years, placing the industry in a strong competitive position to gain market share because freight rail is 3-to-4 times more fuel-efficient than trucking, its main competitor. Railroads are expected to extend alliances with other transportation providers (including trucking companies) that create more convenient intermodal transport solutions for customers. Norfolk Southern, for example, has teamed with trucking firm J.B. Hunt to expand long- and medium- distance intermodal shipments. Moreover, railroads will benefit from consumer and government concern about environmental sustainability and emissions.¹⁰

Pipelines

The U.S. pipeline industry carries natural gas, crude oil, refined petroleum products, and a variety of chemicals through a 2.5-million-mile privately-owned and operated network.¹¹ The industry includes three major sectors: natural gas, oil, and refined petroleum products pipelines. (See table 8.) In 2012, the industry earned \$6.5 billion (22.2 percent) on revenue of \$29.4 billion. The industry’s 5-year return on investment was 4.7 percent.



Table 8: U.S. Pipeline Industry at a Glance

Sector	Definition, Current Conditions, and Outlook
<i>Natural Gas Pipelines</i>	<ul style="list-style-type: none"> ❖ Almost all natural gas in the United States is transported by pipeline.¹² ❖ Carriers earned \$4.2 billion (23.3 percent) on revenue of about \$18 billion (2012). ❖ Shipments for local gas distribution, electricity generation, and large industrial users accounted for 50, 30, and 20 percent of revenue, respectively. ❖ Mature and moderately concentrated sector, with the top four carriers generating about 58 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 2.7 percent to \$21 billion.
<i>Oil Pipelines</i>	<ul style="list-style-type: none"> ❖ Transport mostly crude oil. ❖ Carriers earned \$822 million (17.1 percent) on revenue of \$4.8 billion (2012). ❖ Shipments of heavy and medium crude oil, light crude oil, and refined petroleum products and chemicals accounted for 58, 32, and 10 percent of revenue, respectively. ❖ Mature and highly concentrated sector, with the top four carriers generating about 78 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 3.5 percent to \$5.7 billion.
<i>Refined Petroleum Products Pipelines</i>	<ul style="list-style-type: none"> ❖ Transport gasoline, diesel, and aviation fuel. ❖ Carriers earned \$1.5 billion (22.7 percent) on revenue of \$6.6 billion (2012). ❖ Gasoline, diesel, and jet fuel shipments accounted for 50, 22, and 13 percent of revenue, respectively ❖ Declining and moderately concentrated sector, with the top four carriers generating 44 percent of revenue ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of just 0.8 percent to \$6.9 billion.

Source: Analysis of IBIS, Reuters, and Bloomberg data

The U.S. pipeline industry is characterized by low competition and high profitability. The threat of new entry is low. The high capital costs and time-consuming planning and regulatory process involved in building new pipelines limit new entrants. The bargaining power of customers is low, partly because shippers and receivers typically are served by a single pipeline. The threat of substitutes is medium overall. It is low in areas already served by pipelines and for certain products, particularly natural gas. However, the threat is higher in some areas because of a shortage of pipeline capacity and for some products because of more flexible shipment routings afforded by rail or water. Competitive rivalry within the industry is low. Pipelines have limited geographic overlap and seldom compete head-to-head. Moreover, pipelines are considered common carriers, and the Federal Energy Regulatory Commission sets the rates for interstate transport of natural gas, crude oil, and refined petroleum products. Table 9 summarizes the competitive forces affecting the pipeline industry.



Table 9: Five Forces Analysis for the U.S. Pipeline Industry

Threat of New Entrants	Supplier Bargaining Power	Customer Bargaining Buyer Power	Threat of Substitute Products	Industry Competitive Rivalry
LOW	MEDIUM	LOW	MEDIUM	LOW
<ul style="list-style-type: none"> ▪ High capital costs ▪ Medium right of way costs ▪ High regulatory requirements (safety, environment) ▪ Long-term... 	<ul style="list-style-type: none"> ▪ Dependent on low interest rates ▪ Equipment providers have few alternative customers ▪ Development of new fields drives pipeline expansion 	<ul style="list-style-type: none"> ▪ Refineries, power generators & exporters are not served by multiple pipelines ▪ Rail & trucking available but more expensive 	<ul style="list-style-type: none"> ▪ High for new shale gas fields due to prominence of rail movement ▪ Low in regions served by existing pipeline networks 	<ul style="list-style-type: none"> ▪ Segmented oligopoly ▪ Limited overlap among firms within a geographic region

Source: Analysis of IBIS, Reuters, and Bloomberg data.

Pipelines are the cheapest, most reliable mode to transport natural gas and liquids. Obtaining access to a specific geographic area is the primary factor underpinning industry competitiveness and profitability. In general, the pipeline company with access to a particular region and right-of-way will dominate that market segment. However, the time and money required to build or expand a pipeline means that the industry cannot quickly respond to changing patterns of demand. Despite the industry's recent experience with the Keystone XL pipeline proposal, pipeline companies ultimately will expand capacity for natural gas and oil shipments. Electricity generation firms will drive demand for increased natural gas pipeline capacity as gas prices stay near historical lows, due to increased gas production in shale basins. Likewise, the continued growth in domestic and Canadian oil production will drive demand for oil pipeline capacity. Although demand for gasoline and other fuel is projected to grow as the economy improves, refined pipeline capacity has hardly grown over the past decade, constraining the sector's long-term growth potential.

Maritime Shipping

The maritime shipping industry transports commodities, merchandise, and passengers by sea and inland waterway, with connections to intermodal systems. It includes four major sectors: ocean and coastal shipping, inland waterways shipping, tugboat and shipping navigational services, and port and harbor operations. (See table 10.) The industry also includes dry docks and cargo inspection services¹³ and stevedoring and marine cargo handling sectors.¹⁴ In 2012, the industry earned \$5 billion (10.2 percent) on revenue of \$49 billion. Industry revenue is projected to grow over the next 5 years at an average annual rate of 2.5 percent to \$55.3 billion.



Table 10: U.S. Maritime Shipping Industry at a Glance

Sector	Definition, Current Conditions, and Outlook
<i>Ocean and Coastal Shipping</i>	<ul style="list-style-type: none"> ❖ Provides deep-sea, coastal, and Great Lakes shipping and deep-sea cruise ships. ❖ Deep-sea shipping includes both U.S. and non-U.S. flagged ships. ❖ Carriers earned \$2.7 billion (9.2 percent) on revenue of \$29.4 billion (2012). ❖ Deep-sea, coastal, and Great Lakes shipping accounted for 30, 10, and 5 percent of revenue, respectively; deep-sea cruise ships accounted for 40 percent. ❖ Mature and moderately concentrated sector, with the top four carriers generating about 50 percent of revenue. Sector revenue is projected to grow over the next 5 years at an average annual rate of 2.7 percent to \$21 billion. ❖ Driven by growing trade and an aging population's increasing demand for cruise vacations, sector revenue is projected to grow over the next 5 years at an average annual rate of 2.4 percent to about \$33 billion.
<i>Inland Waterways Shipping</i>	<ul style="list-style-type: none"> ❖ Provides inland water transport for passengers and cargo on lakes, rivers and intra-coastal waterways. Carriers earned \$822 million (17.1 percent) on revenue of \$4.8 billion (2012). ❖ Carriers earned \$769 million (11.8 percent) on revenue of \$6.5 billion (2012) ❖ Shipments of bulk liquids and gases and dry bulk cargo accounted for 33 and 21 percent of revenue; towing and ferry transport accounted for 24 and 13 percent. ❖ Mature and moderately concentrated sector, with the top four firms generating about 62 percent of revenue. ❖ Sector revenue is projected to grow over the next 5 years at an average annual rate of 2.9 percent to about \$7.5 billion.
<i>Tugboat and Shipping Navigational Services</i>	<ul style="list-style-type: none"> ❖ Provides navigational services that ensure safe passage of ships in/out of harbors, mainly docking and piloting vessels. It also includes marine salvage services. ❖ Firms earned \$383 million (14.7 percent) on revenue of \$2.6 billion (2012) ❖ Mature and fragmented sector, with the top three firms generating only 16 percent of revenue. ❖ Reflecting growing trade and waterborne freight, sector revenue is projected to grow over the next 5 years at an average annual rate of 3.5 percent to \$3.1 billion.
<i>Port and Harbor Operations</i>	<ul style="list-style-type: none"> ❖ Operates ports, harbors, and canals ❖ Activities include loading and unloading cargo containers from ships, arranging shipment paperwork to meet customs requirements, operating computer systems to connect cargo with customers, and transferring cargo to trucks and trains. ❖ Operator earned \$93 million (6.2 percent) on revenue of \$1.5 billion (2012). ❖ Mature and highly concentrated sector with the top four ports (Los Angeles, Long Beach, Houston, and New Jersey/New York) generating 82 percent of revenue. ❖ U.S. trade is expected to grow substantially and, in response,

Source: Analysis of IBIS, Reuters, and Bloomberg data

The maritime shipping industry is characterized by high competition among existing carriers and ports but moderate profitability. The threat of new entry is low due to the high cost of infrastructure, maritime equipment, and ships; specialized knowledge and skills (such as piloting); and high environmental and other regulatory requirements. The bargaining power of suppliers is



high. Rising bunker fuel prices, fuel price volatility, unionized labor, and a relatively few number of vessel manufacturers all act to drive up costs. The threat of substitutes is medium. In ocean and coastal shipping, intermodal rail offers cost- and time-effective competition for Asian shipments. The expansion of the Panama Canal, however, will make all-water shipments more attractive. Inland waterways shipping faces growing competition from railroads for bulk shipments. Competitive rivalry between shipping firms and ports is high as they seek to gain market share in an industry characterized by large economies of scale. Table 11 summarizes the competitive forces affecting the maritime shipping industry.

Table 11: Five Forces Analysis for the U.S. Maritime Shipping Industry

Threat of New Entrants	Supplier Bargaining Power	Customer Bargaining Buyer Power	Threat of Substitute Products	Industry Competitive Rivalry
LOW	HIGH	MEDIUM	MEDIUM	HIGH
<ul style="list-style-type: none"> ▪ High cost of infrastructure & ships ▪ Significant environmental regulatory requirements for port improvements or expansion 	<ul style="list-style-type: none"> ▪ Fuel volatility dictates operating costs ▪ Unionized labor drives wages & benefits ▪ Few manufacturers of vessels & port equipment (cranes) 	<ul style="list-style-type: none"> ▪ Low fixed cost of international shipping 	<ul style="list-style-type: none"> ▪ International: cheapest shipping option ▪ Domestic: other mode options are viable at reasonable cost 	<ul style="list-style-type: none"> ▪ Intense between ports for international business ▪ Moderate between shippers on established routes

Source: Analysis of IBIS, Reuters, and Bloomberg data.

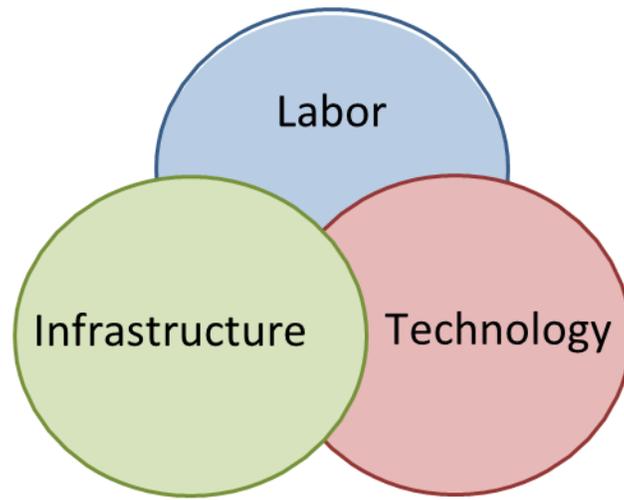
Maritime shipping firms have responded to these industry forces in several ways. Maersk and other large ocean and coastal shipping firms, for example, are investing in ever-larger ships and improved technology to achieve greater economies of scale and productivity. These firms also have reduced vessel steaming speeds to reduce fuel costs. In contrast, other companies compete by differentiating themselves and operating in niche markets. Tug and barge operator Vane Brothers, for example, specializes in coastal barge shipments of petroleum products and the delivery of petroleum products to the shipping industry. In the port and harbor operations sector, several U.S. ports are planning or implementing substantial infrastructure upgrade to accommodate the expected growth in U.S. international trade and container ship size.

PART II: INDUSTRY CHALLENGES

Growing domestic and international commerce, burgeoning North American oil and natural gas production, a recovering economy, and a growing population is driving increasing demand for transportation services in the United States. The bow wave of this growing demand already is straining transport capacity—and this stress is likely to increase over time as the industry is challenged to accommodate further growth in demand. In aviation, for example, some of the nation’s busiest airports may be unable to handle projected increases in demand, even if new air traffic control technologies are implemented. Similarly, the rapid expansion of North American energy production presents tremendous challenges for pipeline and rail capacity. Part II discusses the challenges putting stress on the industry in three broad categories: infrastructure, labor, and technology. As figure 1 suggests, these three categories of challenges are both independent and interconnected—they have the potential individually and collectively to retard network throughput and result in lost economic activity due to congestion.



Figure 1: Transportation Industry Challenges



Infrastructure

Growing demand is straining America's transportation infrastructure. The resulting congestion contributes to longer and more unpredictable passenger and freight transit times and increases freight transportation costs. Perhaps more importantly, chronic and variable delays make modern, just-in-time logistics strategies less effective. Shippers are concerned that, without improvements to alleviate congestion, freight transportation will become increasingly less efficient and reliable, undermining productivity, international competitiveness, and growth.

Increasing air traffic is straining our national air space and airport capacity. The number of daily flights is projected to grow from about 50,000 in 2013 to between 100,000 and 150,000 in 2025.¹⁵ Planned modernization of the national airspace management system would substantially increase the volume of traffic that can be handled safely. However, despite this expanded capacity, persistent ground bottlenecks will challenge the industry. By some estimates, even if arrivals, departures, and ground flow are optimized, projected traffic levels will substantially exceed capacity—such as runway and ramp space—at busy major airports, where expansion is nearly impossible.¹⁶

Similarly, growing truck traffic is straining U.S. highway capacity. The number of tractor-trailer trucks is projected to grow about 14 percent over the next 5 years and 34 percent over the next 10 years. At the same time, data show a widening gap between traffic and highway capacity. As more highways approach capacity, the result is increasing congestion and bottlenecks on exit ramps and access roads linking highways to ports and intermodal terminals. Moreover, rising labor costs are increasing the cost of congestion delays to shippers. In addition, congestion at the U.S.-Mexican border increases trucking costs and pollution. (See Essay 1 in Part V for further discussion of this challenge.) The Department of Transportation estimates that the annual cost of congestion to carriers, businesses, consumers, and the public approaches \$200 billion. Prospects for addressing capacity shortfalls are limited. The cost of building more highways is prohibitively high in many areas and even when building more capacity is possible, several factors have substantially slowed efforts, such as the growing cost of projects.

Rail capacity is likewise strained by growing traffic. Since 1980, rail freight ton-miles



have doubled and traffic density has tripled. According to the Department of Transportation, population growth, economic development, and trade will almost double demand for rail freight by 2035. However, current trends in traffic and capacity have generated concerns about rail's ability to maintain its market share. In recent years, for example, railroads have struggled to keep up with the efforts of some large shippers to tighten delivery standards to improve service. Another factor straining rail capacity is the difficulty of efficiently operating faster passenger trains on the same lines as slower freight trains, particularly as oil and petrochemical shipments grow. Federal law gives Amtrak trains priority, so freight trains must routinely stop on sidings to let Amtrak trains pass. This makes rail freight less reliable and less competitive with truck freight. Government and industry studies agree that there is little ability to expand Amtrak and commuter rail services without adding substantial new rail capacity or severely limiting the ability of railroads to carry freight traffic. Recognizing the conflict between passenger and freight rail, foreign nations have developed high-speed passenger rail on dedicated rights-of-way. Rail's growing capacity constraints would obstruct efforts to shift some of the growing truck traffic to rail as an effective means of relieving urban congestion as well as increasing fuel efficiency, reducing emissions, and improving public safety.¹⁷

Growing demand for oil and natural gas shipments is straining U.S. pipeline capacity. New technologies for exploiting shale oil and gas deposits have generated a boom in domestic light crude and natural gas production, and customers are relying increasingly on domestic oil and gas transported by pipelines.¹⁸ In particular, nearly all growth in natural gas demand is expected to come from the U.S. electricity sector. This development, however, faces obstacles due to differences in how the natural gas and electric power industries plan, manage operations, and conform to regulatory frameworks; the proprietary nature of most operations coordination information; the need for temporary gas storage to accommodate the power generator's demand swings; and the ease with which gas pipeline companies can instead service residential, commercial, and industrial customers.

The growing size and capacity of container ships is straining U.S. seaports, which handle about 90 percent of U.S. international trade.¹⁹ New ships are substantially larger and deeper in draft than current vessels and carry triple the cargo.²⁰ To remain internationally competitive, U.S. ports will need to increase the depth of harbors and navigation channels, as well as their cargo handling capacity and landside links to accommodate these ships. However, available public and private funding appears insufficient to address capacity constraints at several southeastern U.S. ports (Charleston, Jacksonville, and Savannah). Population and trade in the southeastern U.S. are projected to increase by about 25 percent over the next decade.²¹ Failure to address these constraints and accommodate the growth would limit shipper choices and increase transportation costs. (See Essay 2 in Part V for further discussion of this challenge.)

Labor

Aviation and trucking face substantial pilot and driver shortages that will constrain their ability to accommodate increasing demand. U.S. aviation faces a looming shortage of pilots that will constrain commercial capacity and the industry's ability to meet national security requirements for the Civil Reserve Air Fleet. Several factors—including an aging workforce, high barriers to entry for new pilots, and a growing exit of pilots from U.S. carriers—are combining to generate this shortage. The industry faces several constraints on its ability to address this shortage. (See Essay 3 in Part V for further discussion of this challenge.) Similarly, trucking faces a shortfall of about 20,000-25,000 qualified long-haul drivers; by some estimates



this gap could grow by a factor of 10 within a decade.²² Although the U.S. economy depends on rapid and timely truck transport, long-haul drivers face low and inconsistent hourly wages compared to jobs requiring similar skills, often work long hours, and endure poor working conditions that can include weeks living in a truck away from family and friends. The “romance of the open road” is no longer sufficiently attractive to new workers to overcome these drawbacks.²³ New hours-of-service regulations will exacerbate the shortage.²⁴

Technology

Changing technology poses a tremendous challenge to the aviation industry. Advanced data-processing and communications technology has the industry poised for revolutionary improvements in the management of the national air space. System enhancements promise to provide multiple benefits, such as increased airspace capacity, fuel savings, reduced burden on controllers, and improved safety. Yet many challenges remain. Federal funding for these improvements is at risk in an era of tight budgets. Total costs (estimates range from \$40 to \$160 billion) are likely understated and industry officials fear higher taxes.²⁵ Global interoperability is also an issue. The International Civil Aviation Organization plans to establish interoperability, but schedule variations are driving incompatibilities between the United States and Europe.²⁶ Implementing the Next Generation Air Transportation System (NextGen) poses several challenges, such as defining who is at fault in the case of an accident.²⁷ NextGen is an initiative spearheaded by the federal government to modernize the national air space. It is an upgrade of all aspects of the national air space to include air traffic management, weather, communications, and environmental issues.²⁸ Innovations include collaborative air traffic management technologies and national air space voice systems, which will enhance data sharing and decision-making across the national air space. Collectively, these innovations will allow better collaboration between air traffic controllers, enhance air traffic management, and mitigate congestion, system outages, and other issues. Moreover, managing much greater volumes of traffic within an automated system will require improved understanding of human capacity to maintain situational awareness and process information. Finally, the potential introduction of unmanned systems into the national air space will place an entirely new and unpredictable strain on Federal Aviation Administration flight rules that date back to the early days of U.S. aviation. (See Essay 4 in Part V for further discussion of this challenge.)

The pipeline industry faces a growing technological challenge with respect to cybersecurity. Although a few large oil and natural gas pipeline operators have developed and promoted industry-wide cybersecurity standards, carriers transporting other materials have been less aggressive in protecting their information technology and supervisory control and data acquisition computer systems. In February 2013, to address the threat of cyberattack on critical infrastructure such as pipelines, the President issued an executive order initiating voluntary measures after the Senate failed to pass legislation that would have created mandatory standards.²⁹ Efforts to improve pipeline cybersecurity should strengthen over the next few years as these measures begin to take effect.

The maritime industry will also be challenged by security technologies. Security operating principles must adapt to support the increased volume of trade. Safe and reliable maritime shipping is critical to modern logistics practices. Securing containers, ships, and ports presents a challenge to the maritime shipping industry and the viability of global supply chains.



Layering security on top of a just-in-time logistics system geared toward velocity management will present further challenges.

PART III: GOVERNMENT GOALS AND ROLE

An efficient and reliable transport network is the backbone of the U.S. economy and plays a crucial role in the nation's military capability and readiness. Transportation is the connective tissue that links producers and consumers to the domestic and global economies. Failure to address U.S. transportation challenges effectively will constrain American economic productivity, prosperity, and international competitiveness, and undermine national security. Accordingly, government should facilitate the development and implementation of strategies to address the three categories of challenges. Planning for infrastructure expansion smartly will be critical to meeting capacity challenges. Similarly, addressing looming labor challenges in aviation and trucking will be critical to controlling costs and providing sufficient capacity to meet growing demand. Likewise, successfully implementing promising technologies will be critical to improving network efficiency, safety, and security. To achieve these goals, specific recommendations are offered in the following subsections that address each of the three categories of challenges. At the strategic level, the broad choice for policymakers is between market-driven evolution and public policy-driven expansion of the U.S. transportation network to serve national and global markets, relieve pressure on overburdened infrastructure, and support national and local social, economic, and environmental goals.

Infrastructure

State and local governments should plan for airport expansion in dense airport environments. Expansion should consider opportunities to privatize and introduce market forces into airport operations, such as auctioning gate "slots" (spaces). With respect to cross-border trucking issues, the United States and Mexico must work to ensure better participation in the current cross-border trucking pilot program. Both countries also must work together to synchronize national and state-level border policies and actions. Finally, both should develop policies to screen shipments prior to the border to enhance efficiency at border crossing sites. (See Essay 1 in Part V for further discussion of this proposal.)

To ease highway congestion, government policies should encourage a shift from trucks to rail. Shifting some of the growing truck traffic to rail would be an effective means of relieving urban congestion, as well as increasing fuel efficiency, reducing emissions, and improving public safety.³⁰ However, as previously discussed, U.S. railroads have limited capacity to carry more freight and may be unable to support the investments necessary to meet additional demand.³¹ At the same time, current public-sector planning and federal funding programs and financing tools do not effectively support investment in additional freight rail capacity. Public support is necessary because railroad investment decisions ordinarily do not consider public benefits, since reducing highway congestion or emissions does not increase railroad revenue or profits.³² In 2007, a national transportation study commission concluded that maintaining and expanding the

U.S. freight transportation system would require encouraging more private investment and directing public funds toward projects that alleviate capacity constraints and increase rail's share.³³ To facilitate this development, governments should incentivize private investment in freight rail projects by authorizing investment tax credits, accelerated depreciation allowances, and railroad-issued tax-exempt bonds. In addition, the federal government should expand eligibility guidelines



for programs to cover a broader range of (intermodal) freight projects, authorize environmental programs to consider projects that shift truck traffic to rail, modify federal matching formulas to facilitate multi-state investments, and coordinate eligibility guidelines and application and approval processes for separate programs to provide “one-stop- shopping” for state and local planning agencies.³⁴ Finally, the government should encourage network planning and greater use of public-private partnerships to improve the ability of public- sector planning to consider broader solutions to highway and rail congestion.

To meet burgeoning oil and natural gas transportation demand, additional pipelines are needed. More pipelines would add resiliency to a system for supplying oil and gas that suffers extreme stress from increased consumption and interruptions due to weather and mishaps. The growth of rail solutions in transporting oil and gas has temporarily satisfied the additional capacity needs but with much greater cost and less safety than pipelines afford. Additional government investment and regulatory changes related to “green” energy sources would complement the expansion of the domestic oil and gas industry and would ameliorate concerns of environmental activists opposed to expanding the U.S. pipeline network. Improving the gas pipeline-power sector interface should emphasize reliability coordination, fuel infrastructure standards, and formalized communications between the two industries. The 2010 *U.S. National Security Strategy* and President Obama’s *Blueprint for a Clean and Secure Energy Future* already center on pipelines as the most environmentally sound mode to bring America’s cleanest fuel to the electricity generation market. Government coordination with industry through honest brokers such as the North American Electric Reliability Corporation would help to overcome the regulatory and operational disconnects between the pipeline and power industries.

For port expansion, public policy should seek to leverage increased cost sharing and public-private partnerships. Local governments and industry need to consider alternative funding strategies to finance national port requirements. Instead of relying on the federal government to cost-share port deepening, the industry should consider financing these endeavors independently. (See Essay 2 in Part V for further discussion of this proposal.)

Labor

To address imminent air pilot shortages, the federal government should develop and implement public-private partnerships with schools like Embry-Riddle Aeronautical University, the current leader in training civilian pilots, and the major airlines. Developing such partnerships for commercial pilot training would build resilience and contribute to the solvency of the airline industry while sustaining capacity for the Civil Reserve Air Fleet program. (See Essay 3 in Part V for further discussion of this proposal.)

Government should assist the trucking industry to address the driver shortage by adopting policies that will help increase the pool of qualified drivers and reduce driver turnover. Government should work with industry to improve driver pay by incentivizing firms to adopt an hourly wage structure that is more appropriate than paying drivers by the mile. Firms should embrace a “drivers first” culture to reduce turnover by improving communication between drivers, dispatchers, and senior firm management. Savings from increased retention could be used to improve driver wages and invest in better truck technology. Government and industry should (1) reach out to former commercial and military drivers, youth, and women; (2) classify truck driving as “skilled” labor; and (3) provide tuition assistance or other incentives for young men and women seeking to obtain commercial driver’s licenses.



Technology

To support national air space modernization, the federal government should properly resource NextGen. Expanding capacity and implementing fuel-saving technologies lowers consumer prices and encourages industry growth. Tax increases should be minimal so as not to counteract growth for an industry that generates narrow margins. Alternatively, the government should create incentives for investment to pull in industry leaders and develop an equitable cost-sharing plan; for example, implement a “best-equipped best-served” concept in which early users receive preferential treatment in certain flight phases. The government should follow a phased implementation approach. By deploying elements of upgraded systems as soon as ready and encouraging early use, governments will improve stakeholder confidence in the system. To integrate unmanned aircraft systems into the air traffic network, the Federal Aviation Administration should promulgate “detect, sense, and avoid” guidance. This would utilize NextGen as a data-link architecture where all aircraft act as “nodes” in the national air space to provide situational awareness to properly equipped aircraft. Unmanned aircraft systems must have the capability to “sense” other aircraft around them, as well as systems to mitigate midair collisions and provide the best chance of safe separation with other aircraft. Such equipment and procedural requirements should be accompanied with comprehensive training to ensure safe implementation. (See Essay 4 in Part V for further discussion of this proposal.)

Voluntary coordination with industry is the most effective policy approach in the near term to encourage pipeline operators to tighten their cyber defenses. In addition, the government should eliminate any redundant reporting requirements for industry and establish a clear, single point of contact to which firms can take their concerns.

In the maritime shipping security domain, the federal government, in concert with foreign governments and industry, should continue to develop secure operating practices and principles to minimize risk. Steps include improving asset visibility and security by equipping containers with radio frequency technology, working with allies to combat piracy and terrorism threats, and improving container inspection capabilities. The federal government should incentivize firms to improve supply chain security by offering streamlined throughput at U.S. ports for demonstrated excellence in security practices and by expanding the Container Security Initiative already established by the Department of Homeland Security.

PART IV: CONCLUSIONS

Efficient and reliable transportation is the backbone of the nation’s economy. Failure to effectively address the infrastructure, labor, and technology challenges facing the industry would constrain American productivity and prosperity. The increasing strains on all transportation modes from factors in each of these three broad areas pose a threat not only to economic growth but also to national security. Worsening congestion at the nation’s ports, on its highways, in its skies, and along its rail lines already costs the nation billions of dollars annually in wasted time and fuel, higher shipping costs, and lost productivity. Similarly, prospective shortages of critical skilled workers could substantially limit the U.S. transportation industry’s ability to meet the needs of a growing economy and inhibit the mobilization of national resources in time of crisis. In addition, challenges and threats posed by new technologies add to the stresses felt in each of the main transport modes.

To date, policy measures to address the challenges stressing U.S. transportation have tended to be segmented along modal lines. Notably, the U.S. government’s bureaucracy for



regulating transportation is itself divided among several mode-centered agencies that focus almost exclusively on issues tied to their own segment of the industry. The importance and multi-modal nature of the challenges suggest the need for a comprehensive national strategy to coordinate and integrate government policy with industry action. Although the most effective format to articulate such a strategy—in particular, whether it should be driven by government or by industry—is open to debate, the increasingly complementary interaction of the different modes suggests that a more holistic approach to the industry could yield substantial efficiencies and economies, particularly with respect to those modes where competition is intense and profitability is weak. Government, at a minimum, could facilitate the development of such a strategy at relatively little cost and without imposing new regulatory burdens through the research and advocacy resources at its disposal. However conceived, a comprehensive strategy that fully considers the organic relationships both among the different modes and between the industry and the larger economy would be a significant step toward relieving the stresses which challenge the U.S. transportation industry and, which, if not addressed adequately, could jeopardize the security of the United States of America.

PART V: ESSAYS ON MAJOR ISSUES AND CHALLENGES

Essay 1: Improving U.S.-Mexico Cross-Border Trucking

Inefficient operations at the U.S.-Mexico border are straining truck transportation. Despite close economic ties between the United States and Mexico, Mexican trucks are not authorized to make deliveries within the United States beyond a 25 mile commercial zone. Implementation of the North American Free Trade Agreement has significantly increased trade between the United States and Mexico. However, the agreement's provision allowing Mexican carriers to make deliveries to U.S. destinations was not activated. Although there are benefits and challenges, transportation stress due to inefficient trucking operations at the U.S.-Mexican border can be reduced through bilateral cooperation and policy actions. There would be significant benefits to having an open transit border with Mexico for delivery of goods. These include cost savings, improved shipment and border security, increased truck capacity, and reduced pollution. Realizing the benefits of an open transit border will require the United States and Mexico to address several challenges, such as hazardous and polluting trucks, driver safety, the potential loss of U.S. jobs, and possible threats to U.S. national security. Nevertheless, each of these challenges can be addressed or mitigated to ensure safe, secure transit of Mexican carriers within the United States. To enhance efficiency at border crossing sites, the two nations must partner to ensure better participation in the current cross-border trucking pilot program, synchronize border actions and policies, and develop policies to screen shipments prior to the border.

A System under Stress: Inefficient Trucking Operations at the U.S.-Mexico Border

Currently, Mexican trucking companies are restricted to operating within a commercial zone, generally limited to within 25 miles of the border. Most Mexican companies use long-haul Mexican carriers to transport goods to the border, where the goods are then unloaded into a warehouse. Next, a short-haul Mexican carrier transports the goods to a warehouse within the commercial zone. Finally, the goods are loaded onto a U.S. long-haul truck for final delivery within the United States.³⁵ The inherent inefficiency in this system is magnified as materials and parts often cross the border repeatedly during production or assembly. The system increases transport costs, the likelihood of damaged goods, raises the cost of Mexican goods in the United States, and serves as an unofficial tariff on Mexican goods.³⁶



Benefits to an Open Transit Border with Mexico

The United States would realize several benefits in opening the border to Mexican trucking companies. One benefit would be to reduce transportation costs through direct delivery of goods by Mexican truckers, which could lower costs and benefit consumers.³⁷ The current system is estimated to add 2.7 percent (about \$1 billion) annually to the cost of Mexican goods. Eliminating these costs would provide significant savings to businesses and customers. A second benefit would be the additional capacity added by Mexican carriers. As previously discussed, the United States faces a substantial projected shortfall of truck drivers and truck freight capacity.³⁸ A third benefit would be a significant gain in air quality by eliminating long wait times at border crossings.³⁹ Trucks delayed at the border idle for hours, emitting carbon and air particulates. Also, the additional trucks needed to ferry the goods from warehouse to warehouse, as well as additional time spent loading and unloading freight within the commercial zone, adds to air pollution. A fourth benefit would be improved security of freight and reduced trafficking of illicit goods. Inspection prior to the border or point of origin, coupled with a quick border transit, can reduce the likelihood of lost or stolen shipments and opportunities to introduce illegal goods.

Efficiency gains at the border, as well as decreased delays for Mexican carriers, could also improve national security.

Keep the Border Closed—Challenges to an Open Transit Border with Mexico

There are several challenges to opening the U.S.-Mexico border for cross-border trucking. One challenge is the potential loss of jobs for U.S. truck drivers. Several unions and trade associations estimate that opening the U.S. market to Mexican carriers would result in a loss of employment for U.S. drivers as corporations replaced U.S. drivers with lower-wage Mexican drivers to cut costs.⁴⁰ A second challenge is ensuring adequate safety regulation of

Mexican carriers (trucks and drivers) operating within the United States. Department of Transportation studies have identified severe safety and environmental issues associated with Mexican carriers.⁴¹ A third challenge is preventing the erosion of national security from a more open and porous border. Weakened control at the border and tracking of shipments could result in an increase in drug trafficking and the violence that often follows.⁴²

Evaluating America's Options: An Open or Closed Transit Border

The benefits of an open transit border with Mexico outweigh the disadvantages of permitting Mexican trucks to deliver to final destinations within the United States. First, while opening the border could result in a loss of U.S. truck driver jobs, additional actions can be taken to mitigate the losses. The United States should establish a safety net to assist workers in transitioning to another career.⁴³ There is a significant shortage of truck drivers and truck transportation capacity and the demand for freight transportation is expected to double by 2050. Mexican drivers may help fill this requirement rather than replace U.S. drivers.⁴⁴ Second, the safety concern is debatable. Mexican carriers had a better safety record than U.S. carriers while operating in the U.S. during a 2-year pilot program (2007-2009). The Department of Transportation concluded at the end of the pilot program that there was no proof that the Mexican trucks presented anymore of a hazard than U.S. trucks.⁴⁵ Next is the consideration of national security. With an already increased level of violence in the border zone due to drug trafficking and enforcement initiatives, it would be safer and more secure to minimize stops in these areas.⁴⁶ Also, decreasing the 6,900 trucks operating within the commercial zone could have a significant impact on



increasing security and also greatly lower the impact on the environment.⁴⁷ Finally, trade expansion benefits people and companies by supporting higher paying jobs in the export sectors and supporting economic growth. With 79% of Mexico's exports entering the U.S. and Mexico purchasing over \$163 billion in U.S. goods annually, there is a close economic tie between the two countries.⁴⁸ Also, with shared production, auto parts required to manufacture a car in Mexico cross the U.S.-Mexico border an estimated eight times during the assembly process.⁴⁹ A more efficient and effective cross-border transportation system could be a great economic development.

America's Best Choice: Open the Transit Border for Mexican Carriers

With the proper regulation and activities to address these concerns, an open transit border can be a great benefit to both the United States and Mexico. First, it is important to improve participation in the current, on-going pilot program. Many of the largest Mexican trucking firms are not participating because of the regulatory requirements and uncertainty about program continuation. Both U.S. and Mexican government officials must work together to streamline the process and to incentivize participation. Second, the United States and Mexico must partner to secure the border, with due consideration to both security and commercial concerns.⁵⁰ It is important for U.S. federal, state, and local governments to synchronize national policies, as well as bilateral policies with Mexico. The United States also should encourage Mexican agencies working at the border to mirror their U.S. counterparts to coordinate border management and facilitate bilateral communication and problem-solving.⁵¹ Third, two additional policies would support the realization of an open-transit border: (1) Continued development and funding of pre-clearance facilities along the U.S.-Mexican border, such as the Tijuana road inspection station; and (2) Facilitation of U.S. Customs and Border Patrol inspections and screenings within

Mexico. These measure would increase the volume of goods moving efficiently across the border and decrease risk to the commodities.⁵²

--Lieutenant Colonel Laura Elliot, U.S. Army

Essay 2: Investing in Improved U.S. Port Capacity

Federal maritime investments are under stress in America due to projected population growth, increases in the size of vessels calling on U.S. ports, and the inadequate port capacities in certain regions in the United States. The main impediment is the availability of federal funding for waterside maritime investments, which are typically funded "50/50" with local port authorities and state governments. Before the 2008-2009 economic downturn, annual federal funding for maritime waterside infrastructure was flat at \$1.5 to \$2 billion.⁵³ Now, with financial austerity policies likely to be implemented for the foreseeable future, times will be even leaner. This could not happen at a worse time for ports looking to expand to meet changing industry needs. This current situation, however, does offer an opportunity for the United States to reexamine its national maritime strategy, or lack thereof, and lay out a clear path forward for maritime investments.

Current Conditions

Due to globalization, U.S. international trade is expected to increase drastically in the coming years. Imports are expected to quadruple, and exports are expected to increase seven-fold by 2042.⁵⁴ The U.S. population is expected to increase 17 percent by 2030, with the largest increases (25 percent) in the Southeast and West by 2025. "Panamax" vessels are those ships that can traverse the existing Panama Canal, while "post-Panamax" vessels are those that will be able



to pass through the Panama Canal once the expansion project is complete in 2015. Panamax vessels can carry up to 4,000 shipping containers (measured in terms of 20-foot equivalent units). Post-Panamax vessels will handle as many as 12,000 units. Global trade is not dependent on the Panama Canal, but it is a factor in what routes and ports are used. Vessels are getting larger and larger with the newer, larger vessels projected to displace the smaller fleet currently operating due to efficiencies gained in size. Where these post-Panamax vessels will load and discharge their cargo is based on the locations of their markets and capacities of the ports.

Analysis of U.S. Post-Panamax Ports

With the maritime industry prospectively using post-Panamax vessels on a large scale, it is important to identify the requirements of a post-Panamax port: a navigation channel at least 50 feet deep with allowances for tide; sufficient channel width; adequate turning basin, dock and crane capacity; sufficient laydown space for containers; and sufficient rail and truck capabilities to efficiently transport additional containers from the port.⁵⁵ Currently there are only five U.S. ports and a few offshore options allowing unrestricted access to post-Panamax vessels. On the West Coast, only the Los Angeles, Oakland, and Seattle ports can service post-Panamax vessels along with the projected increase in regional population and trade. These ports also have extensive intermodal capabilities where the rail system acts as a land bridge to points inland reaching the East Coast. On the East Coast, only Norfolk and Baltimore currently can service post-Panamax vessels. The Port Authority of New York and New Jersey is deepening the Port of Newark and, once the Bayonne Bridge is raised at a cost of \$1 billion, post-Panamax vessels will be able to service the Northeast. The Port of Miami also is deepening its channel and harbor at a total cost of \$150 million, without waiting for federal financial assistance.⁵⁶ This project is a first for a major port endeavor and perhaps is a model for the future. However, it appears Miami will be only a regional port, because it will lack sufficient intermodal (rail) capability to transport the increased cargo to and from the population and manufacturing centers of the Southeast.

With the West Coast and Northeast captured under the umbrella of at least one post-Panamax port, that leaves only the Southeast without a suitable facility. With no post-Panamax port between Norfolk, Miami, and the Gulf Coast, the Southeast is in desperate need of maritime investment to meet the demand projected from its estimated population and trade growth. There are several Southern ports jockeying their way thru this process with the goal of tapping into the post-Panamax trade. The ports of Charleston, Savannah, and Jacksonville are located just 2 hours apart and have secured significant commitments for the non-federal portion of the cost share agreement, but face a challenging future competing for the limited federal funding. Now is the time to consider alternative strategies for financing and prioritizing our nation's maritime infrastructure investments. The piecemeal approach to date provides some funds to multiple ports and drags out projects. What the nation needs is a bold new National Maritime Strategy.

National Maritime Strategy

A National Maritime Strategy should consider the following three options to identify and to finance the required future maritime investments:

- *Option 1: Laissez faire approach.* If the United States adopts the laissez faire approach to investment in maritime infrastructure, then no Southeastern ports will be post-Panamax ready in the near future. Goods will still move to and from Southeastern markets, but at a higher cost to businesses and customers. The maritime industry likely will utilize Norfolk as a transshipment hub and then use coastal shipping, rail, or truck to service destinations in the



Southeast. Additionally, the industry could utilize West Coast ports and the established land bridge to the Southeast or could expand transshipment ports in the Bahamas or Caribbean. Due to the higher costs imposed by these alternatives, some businesses in the Southeast may choose to close or to relocate near Panamax ports in the United States or abroad. As a result, in businesses where post-Panamax shipping efficiencies are critical to competitiveness, jobs in the Southeast may be lost to other regions or countries. Bottom line, this option does nothing to improve the economy or make the United States a leader in the maritime industry.

- *Option 2: National Maritime Investment Trust Fund.* This option requires the modification of the law requiring federal port projects to be authorized and funded by two separate acts of Congress. This second hurdle, obtaining annual funding (appropriations), drags out projects and increases costs. One option is to create a National Maritime Investment Trust Fund that collects fees from those entities that profit most from post-Panamax shipping. This facility would be similar to the Harbor Maintenance Trust Fund that currently collects fees to fund maintenance dredging. The National Maritime Investment Trust Fund would be available for post-Panamax investment projects once the project was authorized by Congress without going back for annual funding.
- *Option 3: Increase Cost Sharing and Partnerships.* This option would increase the port authorities' portion of the cost sharing agreement from 50 percent to up to 100 percent and would transfer the investment decision from the federal government to the port authorities and private sector. If the maritime project is a good investment, then the port authority should be able to obtain the required capital from local government or private industry. If capital is hard to obtain, then this situation may indicate the investment is not worth pursuing. However, not all port authorities have access to capital. One measure the federal government should encourage is partnering with the private sector. Shippers who have invested in post-Panamax vessels directly reap the benefits from port deepening. If shippers believe the investment is worthwhile, they will partner with port authorities and make the required investments, but if not, it may indicate the investment is not economically viable.

Final Thoughts

Federal maritime investments are under stress in America due to projected population growth, increases in the size of vessels calling on U.S. ports, inadequate port capacities in certain

U.S. regions, and the current ability of the federal government to finance infrastructure projects. This current problem offers an opportunity to debate and to implement a new National Maritime Strategy that effectively invests both public and private funds and prioritizes infrastructure projects to secure our Nation's future in the global economy. Nowhere is there a better place to implement such a strategy than in the Southeast, where there is an identified shortcoming in port capabilities and where population and trade are expected to grow 25 percent by 2025. The United States must decide how to proceed. Do we stay with the status quo—or do we change our approach to our maritime investments?

-- Colonel Thomas Tickner, U.S. Army



Essay 3: Reducing the Airline Pilot Shortage

Impacts on the U.S. Airline Industry and National Security

Aging demographics, exorbitant private pilot's license training costs based on a new Federal Aviation Administration certification mandate, and low entry-level salaries are combining to create an impending labor crisis for the U.S. airline industry. The negative spillover effects to generating sufficient capacity for the Civil Reserve Air Fleet that supports military operations should not be overlooked. Because more than half of U.S. domestic airline pilots are 50 or older,⁵⁷ the industry will need to hire 65,000 new pilots over the next 8 years just to maintain its current workforce of 96,000 pilots as many reach the mandatory retirement age of 65.⁵⁸ This problem is exacerbated by a low intake of pilots in the past decade due to the economic recession, low pay scales, fewer military pilot transfers to commercial airlines due to active duty service commitments,⁵⁹ and tighter regulations.⁶⁰ Furthermore, the increase from 250 to 1,500 minimum flight hours for federal pilot certification starting in 2014 is estimated to increase private pilot licensing costs over six-fold (to \$142,500).⁶¹ Given low entry-level salaries (\$20,000/year on average) for regional carriers, which are the major entry stream into the legacy carriers based on seniority and flying experience, few individuals interested in an aviation career will be able to afford the training needed to enter the industry. Thus, the ramifications of the pilot shortfall will place increasing pressure on airlines to raise customer fares, reduce the number of flights, and cancel routes to small and medium-sized communities where regional carriers operate.⁶² Addressing the impending shortage requires a change in the underlying premise that pilot candidates must bear the financial burden to reach the federal certification requirement. The airlines and the departments of Defense and Transportation have a vested stake in rectifying this issue given national security interests.

Moreover, this shortage will adversely affect the Civil Reserve Air Fleet program. In 2011, 32 carriers and 898 aircraft were enrolled in the fleet—based on a voluntary commitment under the Department of Transportation program.⁶³ Designed as a partnership to augment the Department of Defense in times of a national defense-related crisis (whether domestic or international),⁶⁴ the pilot shortfall will most likely cause legacy carriers to opt out of re-competing for Civil Reserve Air Fleet contracts because they will have an insufficient pilot pool to draw on to support the program.

A Public-Private Partnership Solution

Based on the criteria of affordability, risk spread, ability to close the pilot shortage gap, and the ability to sustain Civil Reserve Air Fleet requirements, a public-private partnership with suitable educational institutions would offer the U.S. government and industry a viable recruiting strategy for meeting pilot demand for both domestic airlines and the Civil Reserve Air Fleet. The public-private partnership bidding process for Civil Reserve Air Fleet contracts would require a transparent competition in order for carriers to compete. Carriers awarded a contract would be obligated to enter into a public-private partnership to fund prospective students' tuition, and hire graduates. The partnership governance structure would include the departments of Defense and Transportation and the airlines awarded Civil Reserve Air Fleet contract. The Department of Transportation would retain oversight responsibility for the Civil Reserve Air Fleet program. The Department of Defense and the carriers would share costs for the partnership with the department contributing solely to partnership contract oversight thereby reducing its financial risk. While risk would be placed heavily on the respective educational institutions for capital investment and



overhead costs, this public-private partnership presents a long-term investment opportunity for the selected schools through closing the pilot gap and building future capacity for the airline industry.

One example of such an educational institution is Embry-Riddle Aeronautical University, which offers a worldwide and world-class aviation-training program, including two domestic undergraduate aviation programs,⁶⁵ consisting of a civilian aviation degree program and the Reserve Officers' Training Corps program at several campuses. Pilots receive full training requirements to meet and pass federal requirements, including flight-hours certification. Moreover, the curriculum includes a heavy emphasis on leadership so that by the time the students graduate, “they know how to be captains.”⁶⁶ Options offered within the aeronautical degree program include familiarization in jet transport aircraft and strong skill sets that are immediately transferable into the commercial airlines.⁶⁷ The public-private partnership with a school like Embry-Riddle would not include the Reserve Officers' Training Corps program as these graduates form part of the selection process for future U.S. armed forces' senior leadership positions, for which the number of billets in the program is strictly managed.⁶⁸

The public-private partnership policy would require congressional approval and due diligence to ensure that fair and equitable competition could be assured for airlines who choose to compete for Civil Reserve Air Fleet contracts. This would not be difficult given that the majority of carriers who compete in the fleet are both legacy and regional carriers due to the stringent criteria stipulated for the program.⁶⁹

Conclusion

Labor costs continue to plague the U.S. airlines' profitability, and the challenge to inspire new pilots to join the aviation industry when they are required to bear an ever heavier financial burden for their training, will only exacerbate this problem. A new recruiting strategy that embraces a public-private partnership between government and the private sector would pave the way to address the pilot shortage facing this country. A public-private partnership between schools like Embry-Riddle Aeronautical University, the departments of Defense and Transportation, and air carriers is recommended to address the imminent pilot shortage facing the

U.S. airline industry and to meet national security needs based on the Civil Reserve Air Fleet program mandate. A partnership with suitable educational institutions would involve a small cost increment to national defense budgets, which could be managed should the Congress approve the partnership proposal. Such a partnership would provide greater flexibility and risk spread for all stakeholders and would build resilience for the U.S. airline industry and for national security requirements related to generating sufficient capacity for the Civil Reserve Air Fleet program. In addition, securing a stable source of civilian pilots would contribute to the domestic airline industry's solvency and would sufficiently address the long-term national security requirements of the Civil Reserve Air Fleet program.

--Captain Mary-Ellen Clark, Canadian Navy

Essay 4: Integrating Unmanned Aircraft Systems into the National Air Space

Because of existing and emerging technologies and proven concepts of unmanned aircraft systems integration demonstrated by the Department of Defense, the Federal Aviation Administration can promulgate regulations that allow for unmanned aircraft systems to conduct operations safely in the national airspace, increase situational awareness for all aircraft operating in the national air space, and enhance safety of flight. This paper reviews current “see and avoid” guidance and examines technological advances that have occurred in position, navigation, and timing; cockpit situational awareness; and managing air traffic. It also proposes a new regulatory



framework that would see all aircraft operating in the national air space operate in a data-link architecture to allow for full unmanned aircraft systems integration into the national air space, expand situational awareness for all aircraft operating in the national air space, and enhance safety of flight.

See and Avoid Guidance

While not always specifically called “see and avoid,” the concept has been in existence since the federal government became more involved in aviation regulation in 1926.⁷⁰ “See and avoid” rules are outlined in the in several areas of the Code of Federal Regulations and the Aeronautical Information Manual. For example, 14 CFR 91.113(b) states “When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft.”⁷¹ As in the 1920’s, the basis of this guidance centers on a pilot in the cockpit; however; it ignores improvements in technology that may provide alternatives to this requirement.

Improvements in Navigation/Cockpit Situational Awareness/Air Traffic Management

Perhaps the greatest technological leap in navigation is the advent of the global positioning system. Because of global positioning and the capabilities it delivers, experts now reference position, navigation, and timing when discussing positional situational awareness. The global positioning system provides at least 7.8-meter accuracy 95 percent of the time.⁷² Furthermore, a Federal Aviation Administration study revealed that certain global positioning receivers have a horizontal accuracy of 3 meters.⁷³ This innovation gives pilots and air traffic controllers unprecedented awareness of an aircraft’s position in the national air space.

Along with these navigational innovations, a pilot’s ability to gain situational awareness about the flight environment also has increased since the 1920’s. Two innovations for increasing cockpit situational awareness are the Traffic Collision and Avoidance System and the Automatic Dependent Surveillance-Broadcast system. The first is an airborne collision prevention system designed to lower chances for midair collisions. The Federal Aviation Administration says the system increases cockpit awareness of proximate aircraft and serves as a “last line of defense” for the prevention of mid-air collisions.⁷⁴ The system scans for transponder signals from similarly equipped aircraft, calculates potential collision paths, and provides audible and visual warnings to aircrew of impending traffic conflicts.

The second innovation is the Automatic Dependent Surveillance-Broadcast system—a new situational awareness technology designed to supplement and eventually replace the current surveillance radar system.⁷⁵ The system uses global positioning system information and other data to calculate and transmit aircraft positional information across a radio frequency to both ground controllers and properly equipped aircraft.⁷⁶ Implementing this innovation will change the national air space to a data-link like architecture where all participating aircraft and controllers will have situational awareness of one another. Therefore, the Federal Aviation Administration has mandated that all aircraft that operate with a transponder must have Automatic Dependent Surveillance-Broadcast “out” capabilities by 2020 as a part of its NextGen concept of operations.⁷⁷

Putting It All Together—Military Unmanned Aircraft Systems Integration Today

The Department of Defense and U.S. partner nations have used similar technologies to overcome issues of “see and avoid” and to safely integrate unmanned aircraft systems into combat operations by having all aircraft operating in a combat zone connected to a data-link system. Once



airborne and under a command and control agency, unmanned aircraft proceed to the combat area and maintain an assigned altitude. Other aircraft have situational awareness of the unmanned aircraft from a data link picture in their cockpits and de-conflict as appropriate.

Unmanned aircraft systems operators “see” the link picture and de-conflict as needed from other aircraft in the airspace. Airborne Warning and Control System aircraft or some other command and control platform manages the air picture and de-conflicts aircraft as necessary.

A Civil Framework Using the Department of Defense’s Example

Building from the Department of Defense’s template and using the technological upgrades in navigation, aircraft situational awareness tools, and air traffic management, there is a way to overcome an unmanned aircraft’s inability to comply with the “see and avoid” regulatory guidance and yet still allow safe unmanned aircraft systems operations in the national air space. When the Automatic Dependent Surveillance-Broadcast system policy is fully implemented, the national air space will become a data-link system similar to what the Department of Defense uses in combat operations. Consequently, these aircraft become nodes in the national air space communicating with one another providing situational awareness of their position and flight paths. Properly equipped aircraft equipped will “see” track files of aircraft in proximity, thereby offering a more comprehensive assessment of the air picture. Unmanned aircraft systems can use this picture to assess and clear their flight path and safely integrate in the national air space. While not a perfect substitute for see and avoid, using this framework, unmanned aircraft systems can detect the aircraft around them, sense their flight plan relative to the unmanned aircraft systems, and avoid as needed to prevent mishaps.

Federal Aviation Administration Regulatory Recommendation

Given this framework, as a part of the NextGen upgrade, the Federal Aviation Administration should promulgate “detect, sense, and avoid” regulations for the inclusion of full unmanned aircraft systems operations in the national air space.⁷⁸ Promulgation of this regulatory guidance is predicated on full implementation of the 2020 Automatic Dependent Surveillance-Broadcast policy. In this “detect, sense, and avoid” guidance, unmanned aircraft systems must have Automatic Dependent Surveillance-Broadcast “In” equipment to have the ability to “sense” other aircraft around them. Unmanned aircraft systems also must have Traffic Collision and Avoidance System II to mitigate midair collisions and provide the best chance of safe separation with other similarly equipped aircraft. Because of data update rates and until another flight rule category is developed, unmanned aircraft systems should remain on an instrument flight rules clearance with restrictions when operating in the national air space. Restrictions would include the inability to conduct visual approaches or other “visual” maneuvers permitted by manned aircraft under instrument flight rules.

Challenges

There are several challenges to this regulatory guidance to include pilot training impacts, security issues, and costs. The benefits of implementation, however, far outweigh these challenges. Furthermore, with proper planning, management, and strategic communications, the Federal Aviation Administration, industry and developers of unmanned aircraft systems can overcome these challenges. With respect to training, Federal Aviation Administration flight training will have to include Automatic Dependent Surveillance-Broadcast “In” training courses as a part of their syllabi. While detect, see, and avoid guidance integrates unmanned aircraft systems into the national air space, requirements for see and avoid for manned aircraft still apply.



Security challenges are numerous and the Federal Aviation Administration, industry and developers of unmanned aircraft systems must remain vigilant to these issues. This regulatory initiative is predicated on several technological innovations that are vulnerable to disruption.

Global positioning system jamming will degrade an aircraft's ability to assess its position and could lead to mid-air collisions or mishaps during landing. Also, communication with unmanned aircraft systems, ground controllers, and unmanned aircraft controlling stations may be disrupted. While national air space voice systems address some of these issues, to ensure the integrity of the communication structure of the national air space remains intact, unmanned aircraft systems and Automatic Dependent Surveillance-Broadcast technologies must address these vulnerabilities, provide redundancies in the case of failures, and demonstrate the validity of these redundancies to comply with this guidance.

Finally, while there will be increased costs to implementation, the benefits unmanned aircraft systems technology provides along with increased situational awareness present a great return on investment. With respect to unmanned aircraft systems, this regulatory initiative will allow exploitation of capabilities where an aircraft is the appropriate tool for execution. Because of human limitations such as endurance and fatigue, however, the aircraft option is not feasible. Along with this benefit, requiring all aircraft to operate on the NextGen Automatic Dependent Surveillance-Broadcast network will greatly enhance situational awareness for all participants in the national air space. This will allow smoother flow of traffic in congested areas, better coordination between pilot and controller, and present more opportunities to mitigate midair collisions and other near misses.

-- Lieutenant Colonel Kenneth Smith, U.S. Air Force



ENDNOTES

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- ¹ National Surface Transportation Policy and Revenue Study Commission, 1, 19, 56.
- ² The industry total does not include revenue (or losses) from subsidized Amtrak and commuter passenger train operations. In 2012, Amtrak reported revenues of about \$3 billion.
- ³ No transportation industry sectors are characterized as *expanding* with revenues growing faster than gross domestic product.
- ⁴ The five forces analytical framework was developed by Michael E. Porter of the Harvard Business School.
- ⁵ Aircraft Maintenance, Repair and Overhaul: This sector provides support services—such as aircraft inspection and testing, aircraft maintenance and repair, and aircraft and parts overhaul. In 2012, firms earned \$1.2 billion (5.6 percent) on revenue of \$21.3 billion. The sector is mature and fragmented, with the top four firms (Boeing, General Electric, General Dynamics, and United Technologies) generating only 18 percent of revenue. Increasing demand for domestic and international travel, a larger general aviation fleet, and longer average trips will boost sector revenue. Over the next 5 years, revenue is projected to grow at an average annual rate of 1.2 percent to \$23 billion.
- ⁶ Airport Operations: This sector includes firms and government agencies that operate international, national, or civil airports in the United States, as well as firms that offer aircraft refueling and parking, cargo and baggage handling, hangar space rental, and other services. In 2012, operators earned \$267 million (3.8 percent) on revenue of \$7 billion. The sector is in decline and moderately concentrated, with the top four firms or agencies (BBA Aviation PLC, The Port Authority of New York and New Jersey, The City of Los Angeles, and Macquarie Infrastructure Company LLC) generating about 50 percent of revenue. Over the next 5 years, revenue is projected to grow at an average annual rate of 0.9 percent to \$7.3 billion.
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- ¹⁴ Stevedoring and Marine Cargo Handling: This sector provides stevedoring and other marine cargo handling. In 2012, firms earned \$887 million (12.2 percent) on revenue of \$7.3 billion. Stevedoring services for bulk and container shipments accounted for 63 percent and 33 percent of revenue, respectively. The sector is mature and fragmented, with the top four firms generating less than 40 percent of revenue. Over the next 5 years, as growing global trade increases demand for cargo handling services, revenue is projected to grow at an average



annual rate of 2.2 percent to \$8.1 billion.

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¹⁷ Cambridge Systematics, 2.2; AAR, *Freight Railroads Help Reduce Greenhouse Gas Emissions*, 1; GAO-11-290, 9; Cox, ii; National Surface Transportation Policy and Revenue Study Commission, 29; Bryan, et al, 149-150.

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- 69 In addition to strict requirements, Civil Reserve Air Fleet carriers must "meet minimum participation levels (15 percent of Civil Reserve Air Fleet capable fleet offered to government for cargo operations or 30 percent of fleet for passenger operations)," for which few LCCs have sufficient capacity to meet these standards. Since many of the LCCs own a limited number of aircraft, they fail to meet these criteria with the exception of Allegiant who is the sole LCC in the Civil Reserve Air Fleet program as of January 2013. Department of Transportation, "Civil Reserve Airfleet Allocations by Month – January 2013," *Dot.gov*, www.dot.gov/mission/administrations/intelligence-security-emergency-response/civil-reserve-airfleet-allocations, March 15, 2013. "How to become a Civil Reserve Air Fleet carrier," *Amc.af.mil*, last modified November 29, 2011, <http://www.amc.af.mil/library/factsheets/factsheet.asp?id=3508>, March 30, 2013.
- 70 Department of Transportation, Federal Aviation Administration, *Literature Review on Detect, Sense and Avoid Technology for Unmanned Aircraft Systems*, (Washington, DC: Federal Aviation Administration, September 2009), 4.



- 71 Code of Federal Regulations, *Right of Way rules: except water operations*, Title 14, sec. 91.113.
- 72 National Oceanic and Atmospheric Administration, “GPS Accuracy,” <http://www.gps.gov/systems/gps/performance/accuracy/>, (accessed March 25, 2013).
- 73 Ibid.
- 74 Federal Aviation Administration, “About TCAS,” <http://adsb.tc.faa.gov/TCAS.htm>, (accessed March 26, 2013).
- 75 Paul Takemoto, Tammy Jones, *Fact Sheet–Automatic Dependent Surveillance-Broadcast*, (Washington DC: Federal Aviation Administration, May 27, 2010), 1.
- 76 Ibid.
- 77 Code of Federal Regulations, *Automatic Dependent Surveillance-Broadcast Out Performance Requirements to Support Air Traffic Control Service*, Title 14, sec. 91.
- 78 The terminology of “detect, sense, avoid” is not new. The Federal Aviation Administration and MITRE use this concept when discussing integration of unmanned aircraft systems into the national air space. More on MITREs ideas on this terminology can be found at <http://www.mitre.org/news/events/tech07/2612.pdf>.

