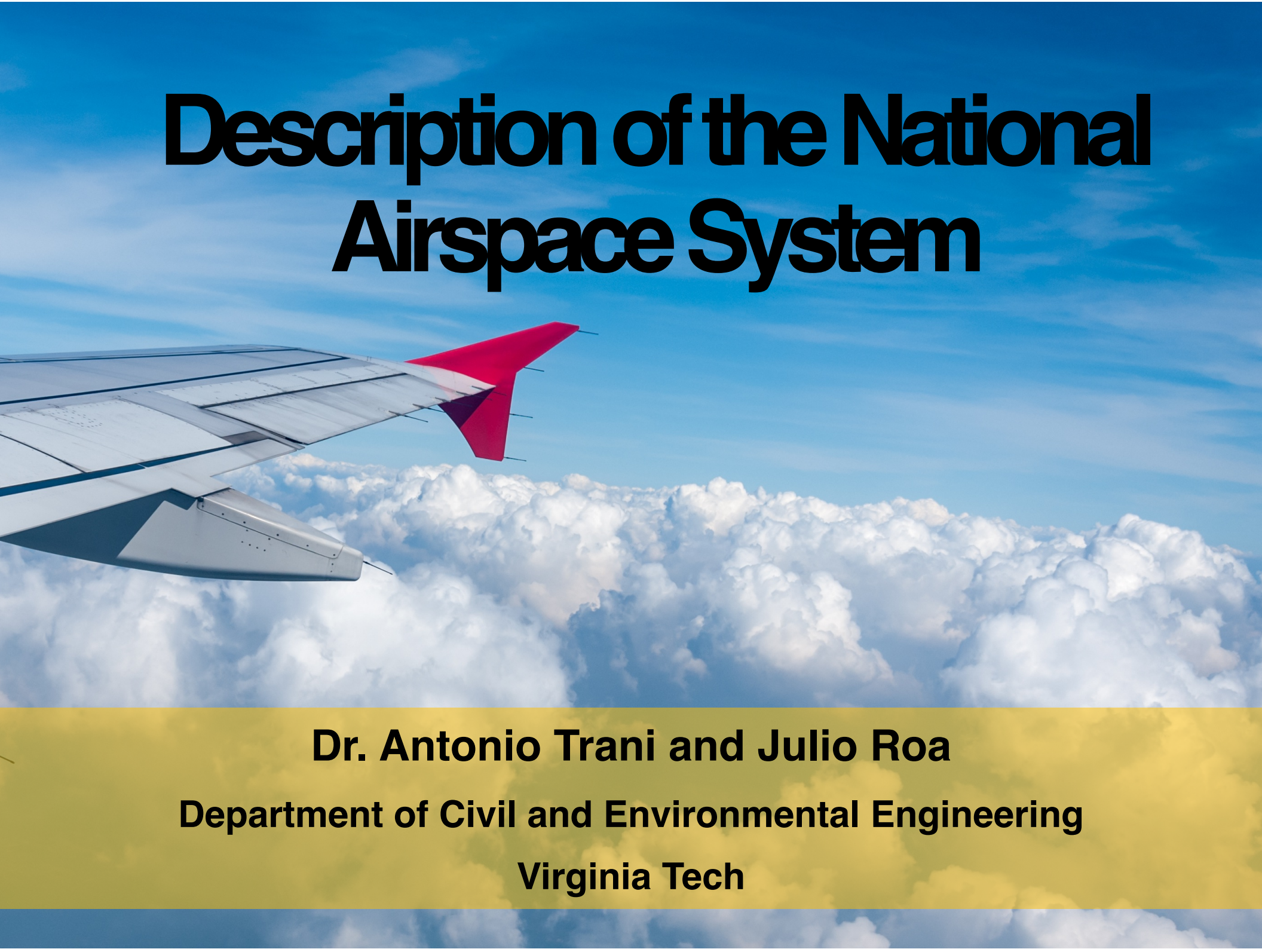
Description of the National Airspace System



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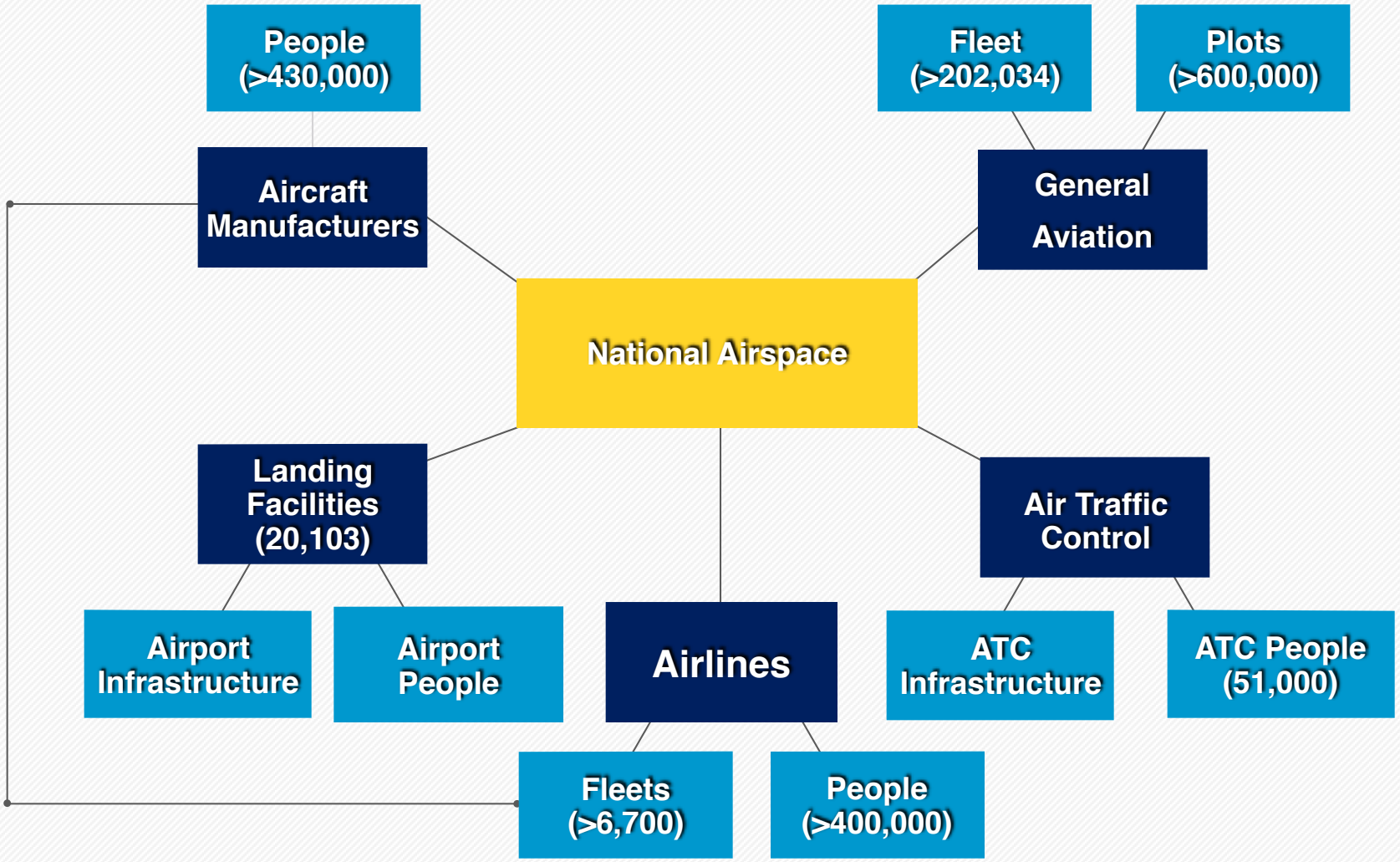
What is the National Airspace System (NAS)?

- A very complex system made up of **airports**, **airway routes** (like highways in the sky), **airlines** and **people** (air traffic controllers, pilots and the flying public).
- In the National Airspace System (**NAS**) there are 60,000 flights controlled by Air Traffic Control services every day (>35,000 performed by airlines).
- Air Traffic Control in NAS handles more than **22 million flights** per year.
- More than **94 million passengers** arrive or depart Atlanta International Airport in a year.
- Atlanta Hartsfield Intl. airport handled more than **952,000** operations in 2012 (FAA 2012).

Flowchart of the National Airspace System (NAS)



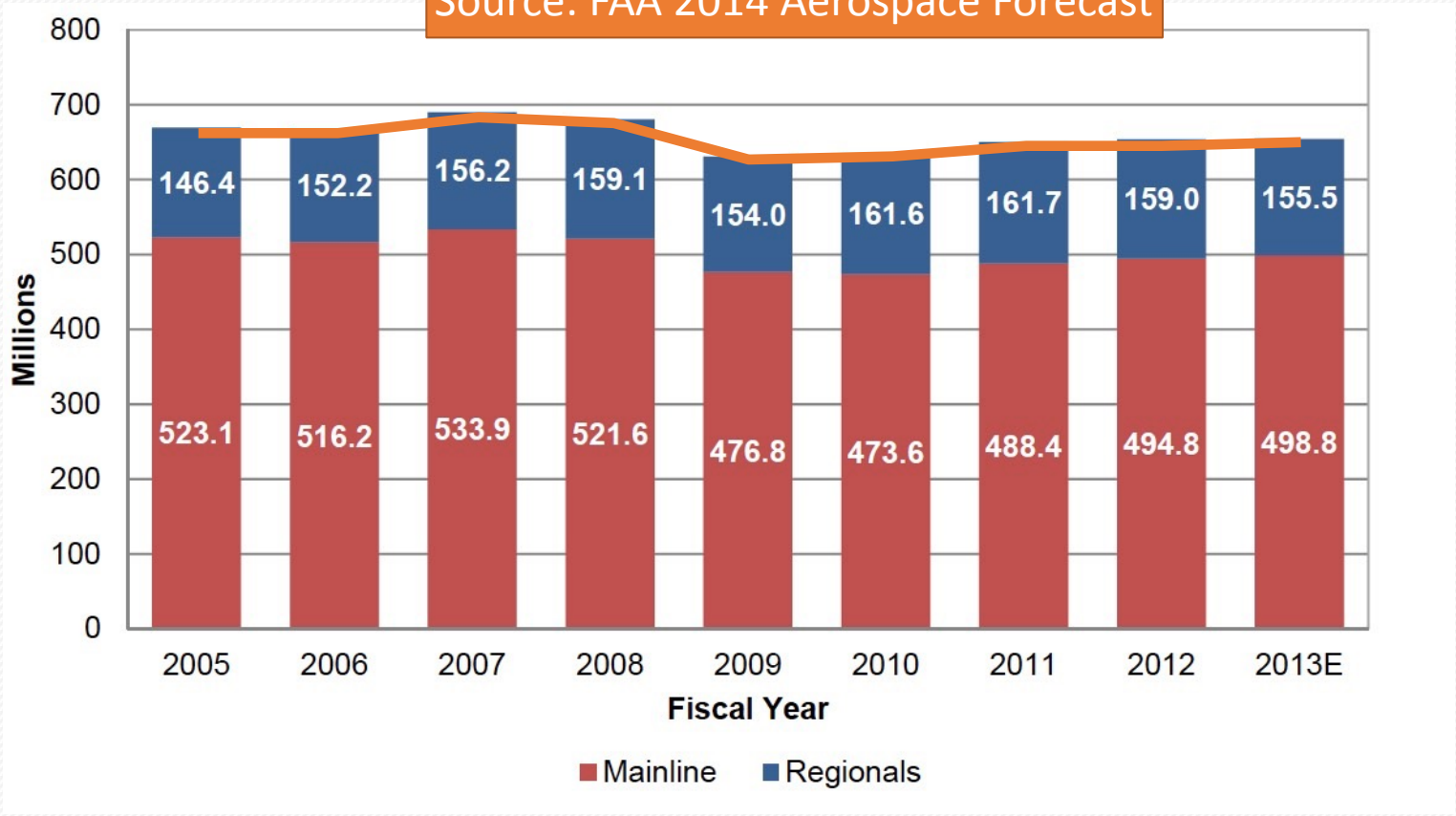
NAS Traffic and Asset Characteristics

Airport Transportation Demand Activity in the National Airspace System

Parameter	Year 2014	Remarks
Number of Annual Operations at 516 FAA towers	49,000,000	FAA 2014 Forecast
Domestic Passenger Emplanements (per year)	654,000,000	FAA 2014 Forecast
International Passenger Emplanements (per year)	85,100,000	FAA 2014 Forecast
Number of Air Carrier Aircraft in the US	6,727	Includes 760 cargo aircraft
Number of GA Aircraft	209,034	FAA 2014 Forecast
Annual Hours Flown by Air Carriers	15,600,000	Estimated
Annual Hours Flown by GA Aircraft	24,000,000	Declined in the last 10 years

US Domestic Enplanements

Source: FAA 2014 Aerospace Forecast

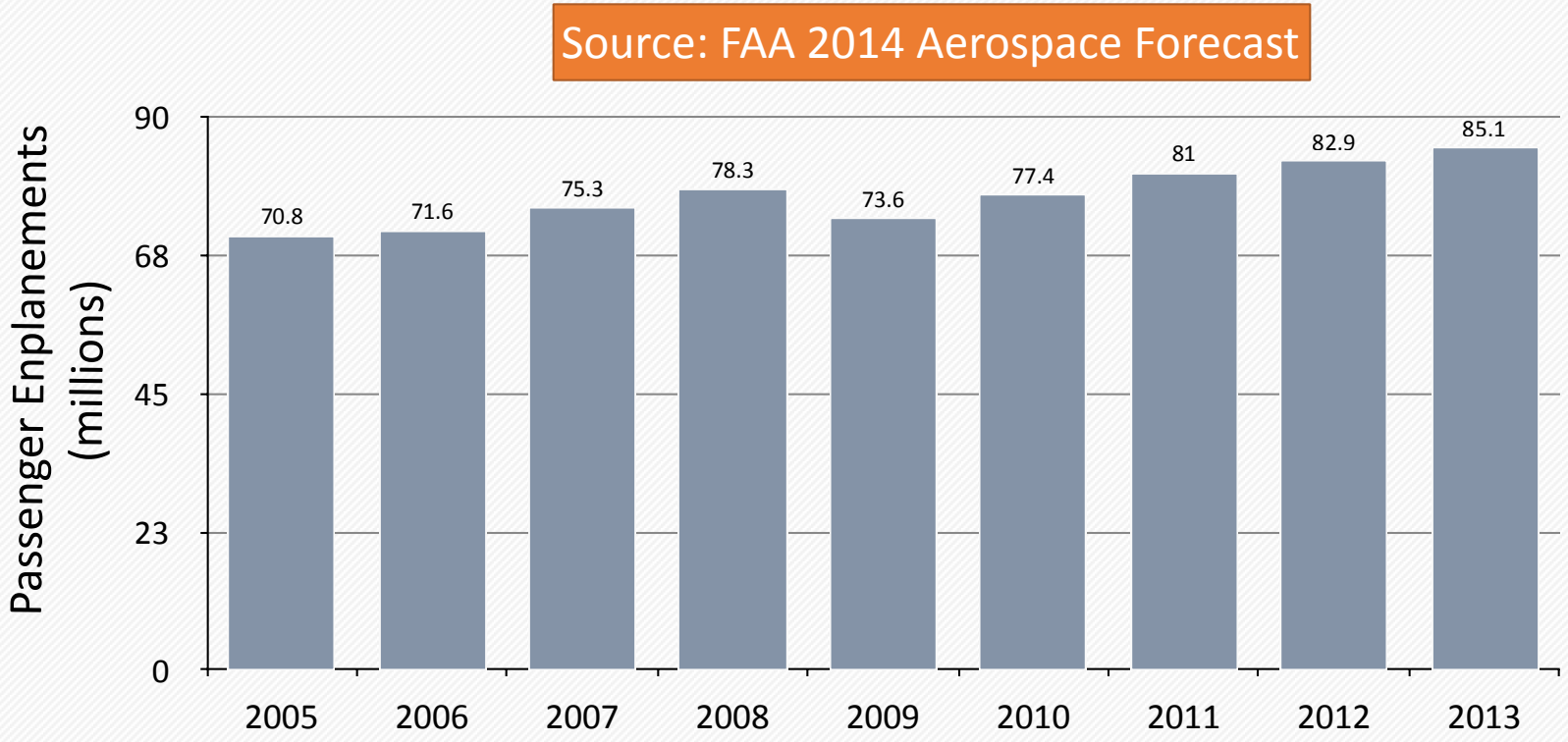


Enplanement = One passenger boarding at an airport

Observations:

1) The highest number of enplanements was recorded in the year 2007 before the economic recession
2) System is recovering but slowly
3) International travel is up

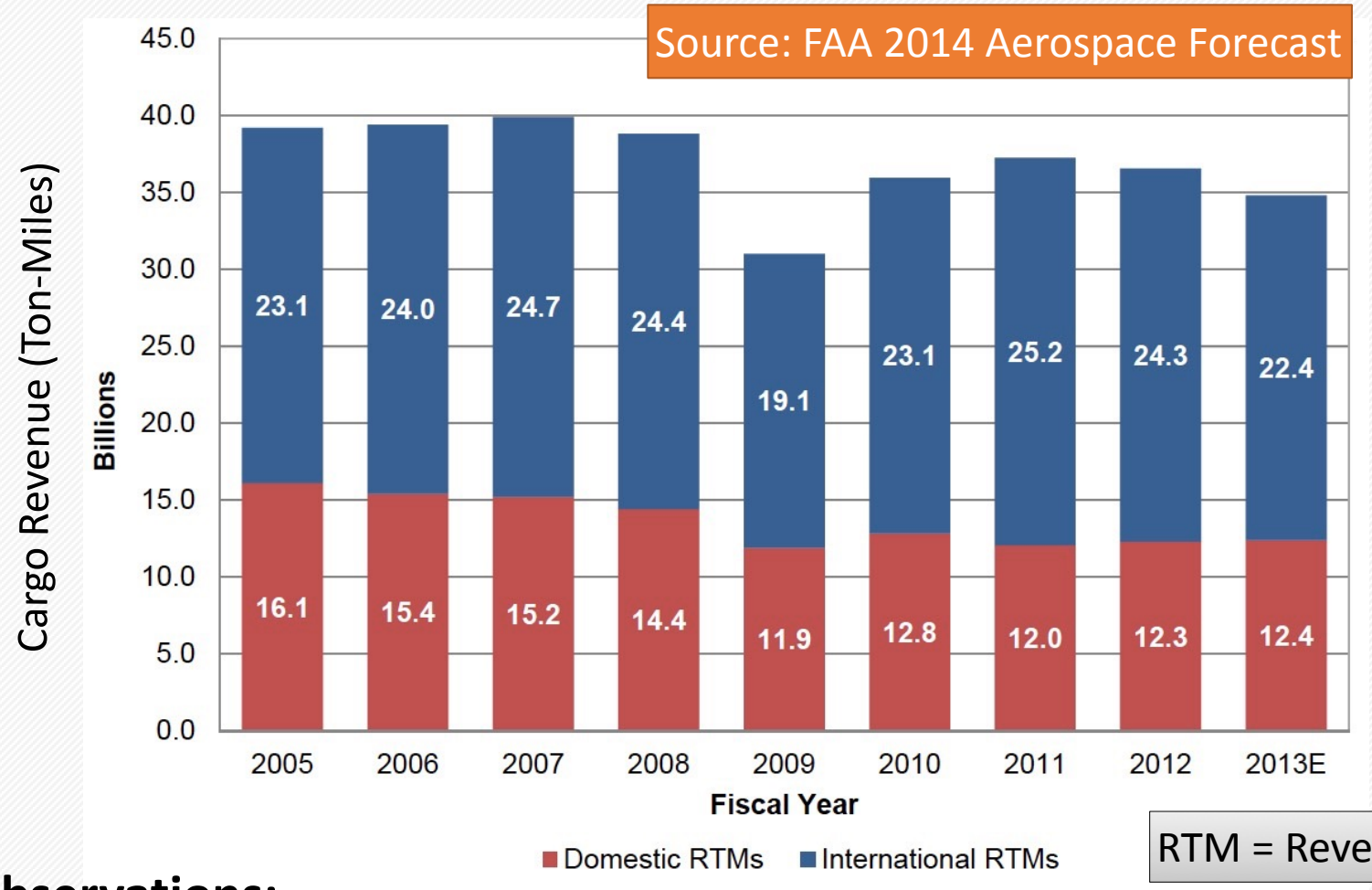
US International Enplanements



Observations:

1) The economic recession had an impact on international travel (less money for discretionary travel)
2) Foreign international travelers helped reverse the trend
3) International enplanements could reach 134 million in the year 2022 of all travel in the US in 2024

US Domestic Cargo Markets

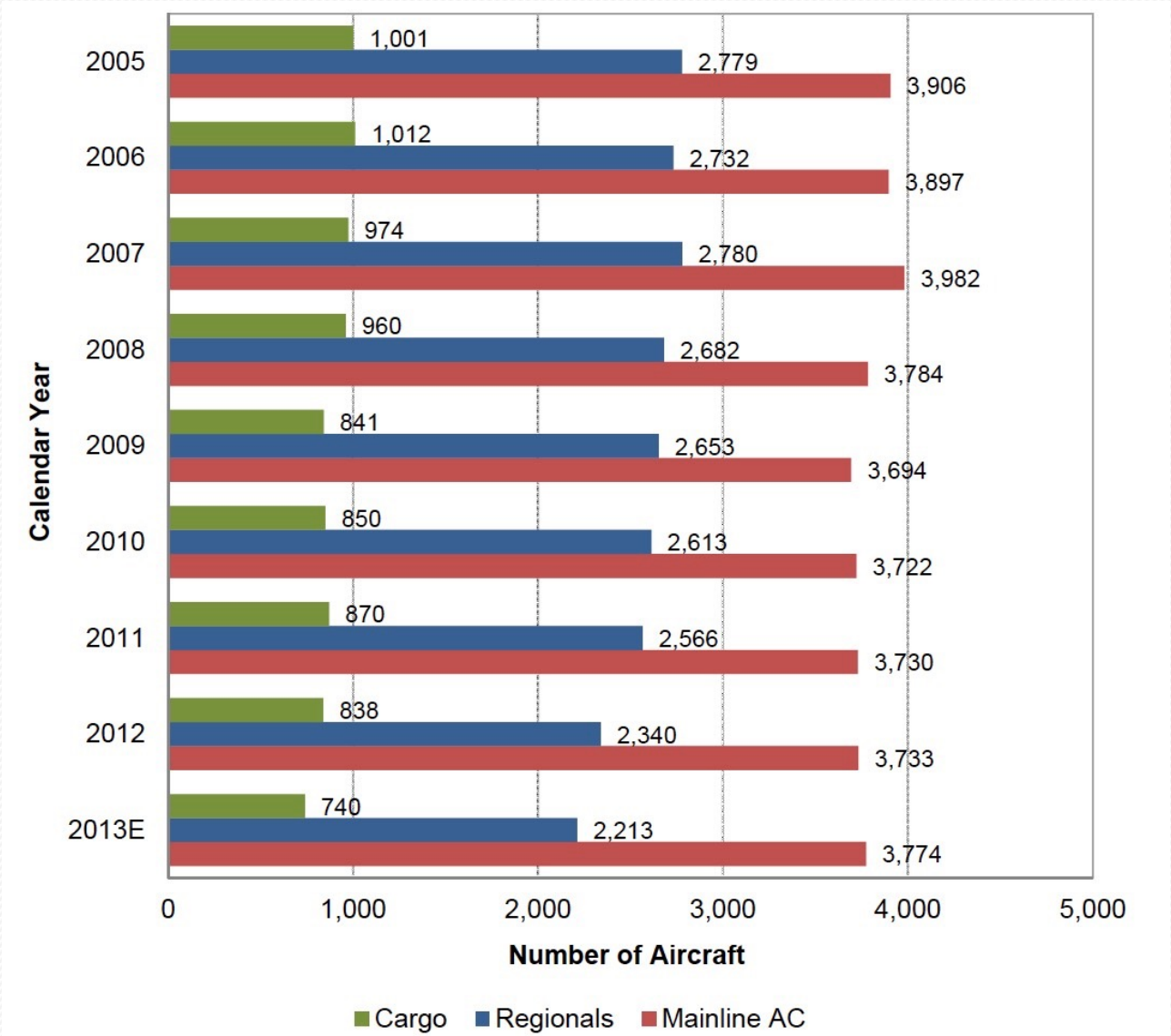


RTM = Revenue Ton-Mile

Observations:

1) Cargo has been hit hard by the economic recession
2) System recovered somewhat in the period 2010 to 2012
3) Cargo carriers moved deliveries to ground transportation modes due to high Jet-A fuel prices in the period 2010-2012

US Airline Fleet



Source: FAA 2014 Aerospace Forecast

Observations:

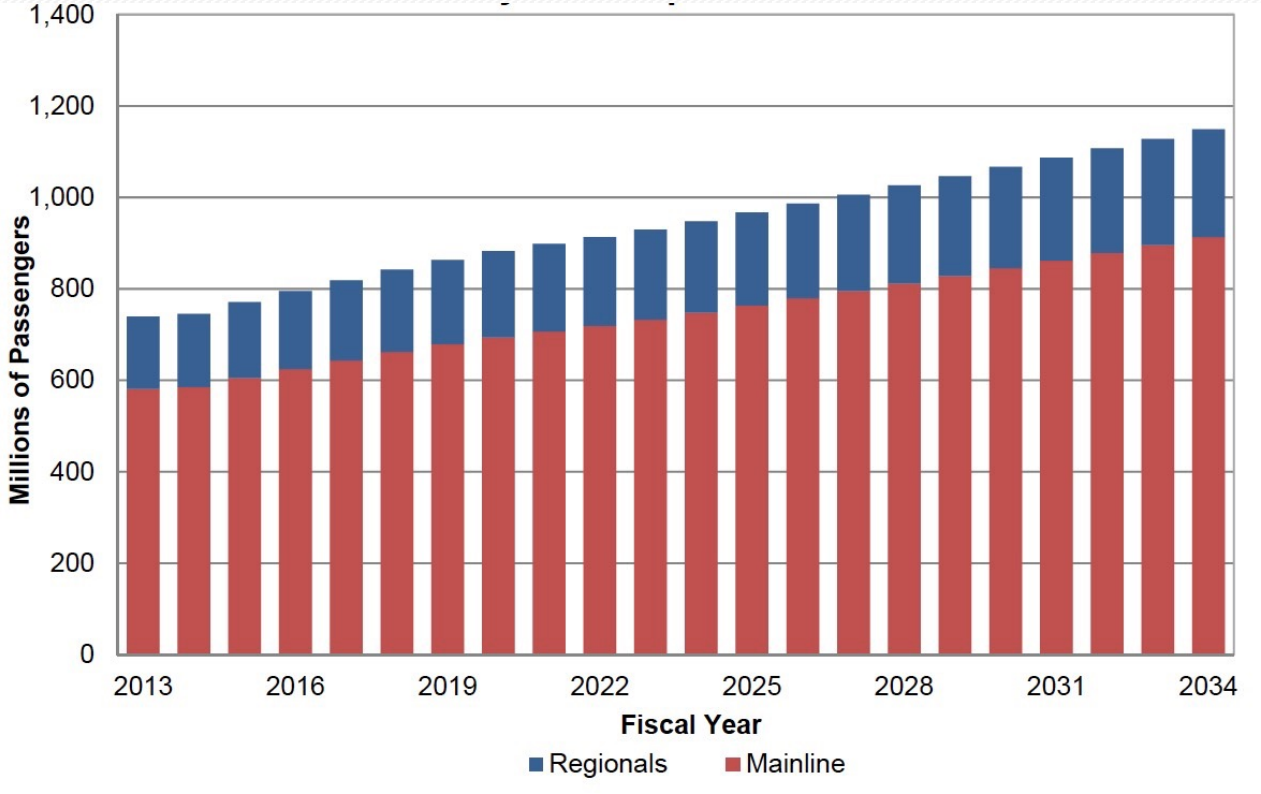
1) Cargo fleet has decreased by 25% since year 2005
2) Mainline fleet has remained stable (-3% change)
3) Regional fleet has decreased by 25% since year 2005

Airlines have been very cautious to add capacity (i.e., seats)

Airline consolidation results in higher passenger load factors (number of seats used in every flight)

FAA Future Passenger Demand Projections

Passenger Enplanements



Source: FAA 2014 Aerospace Forecast

If present economic trends persist:

1) Passenger boardings system-wide (domestic + international) could reach 1,000 million by 2027
2) According to the FAA forecast, both mainline and regionals are expected to grow

- Commercial passenger demand is very sensitive to economic factors
- Airlines will add aircraft to the system if the demand grows per FAA forecasts
- In the past the FAA forecasts have been a bit optimistic due to optimistic assumptions of the economic factors used in the forecast

Why is the National Airspace System Important?

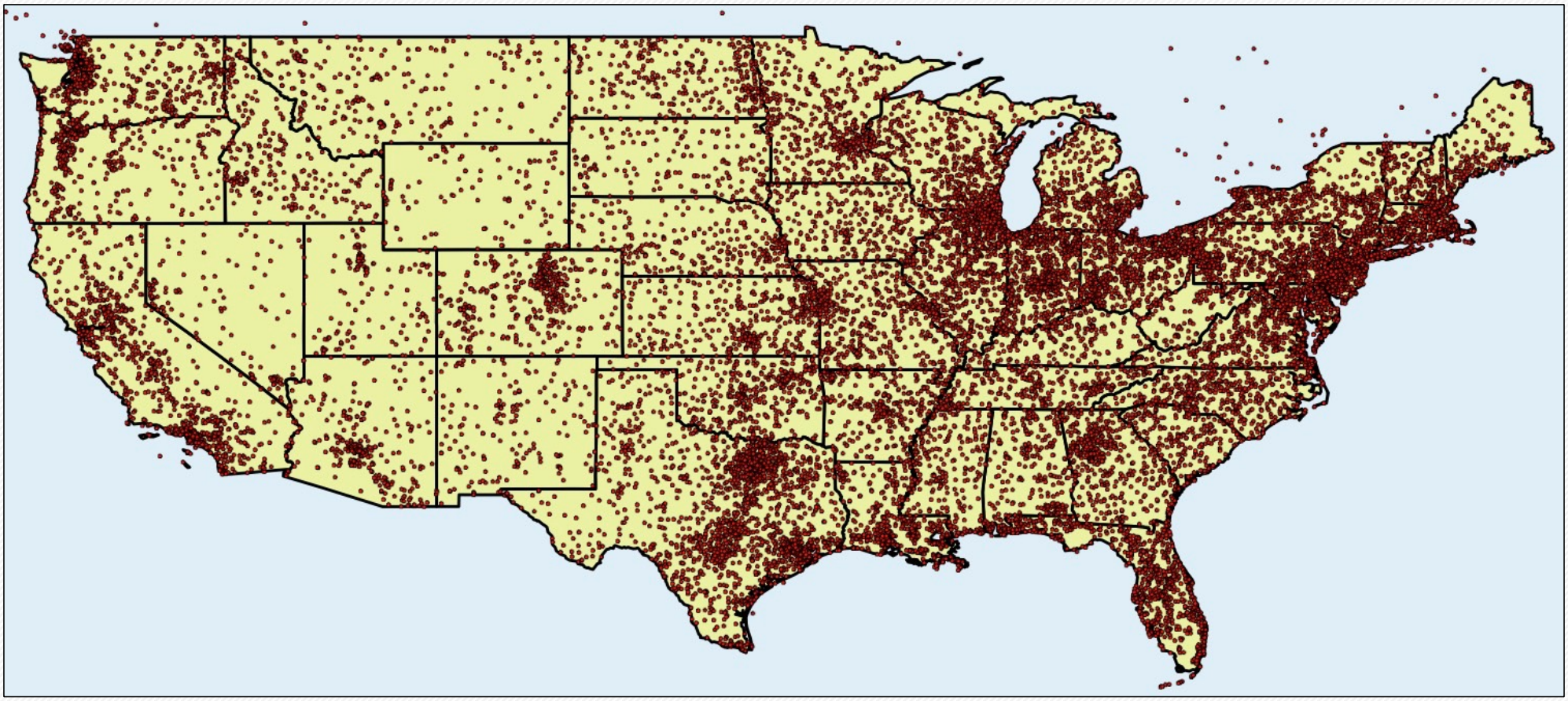
- Many people travel by air every day (more than **2 million passengers per day**)
- The economy of the country depends on a **reliable** and **safe air transportation system**
- Air transportation is the **most economical way** to travel over long distances (i.e., 1,000 kilometers or more)
- More than **eight million people** in the U.S. work in this industry directly or indirectly (supporting the air transportation sector).

Airports in the US

- There are 20,103 landing facilities in the U.S.
- There are more than 3,400 public airports with at least a paved runway equal or greater than 3,000 ft.
- There are thousands of private airport facilities.
- Today, 84% of the passengers using the National Airspace System (NAS) use the top 55 airports in the U.S.
- In 1989, 77% of the passenger traffic used the top 55 airports in the U.S.
- The Federal Aviation Administration considers 3,200 airports critical to the aviation system (NPIAS).

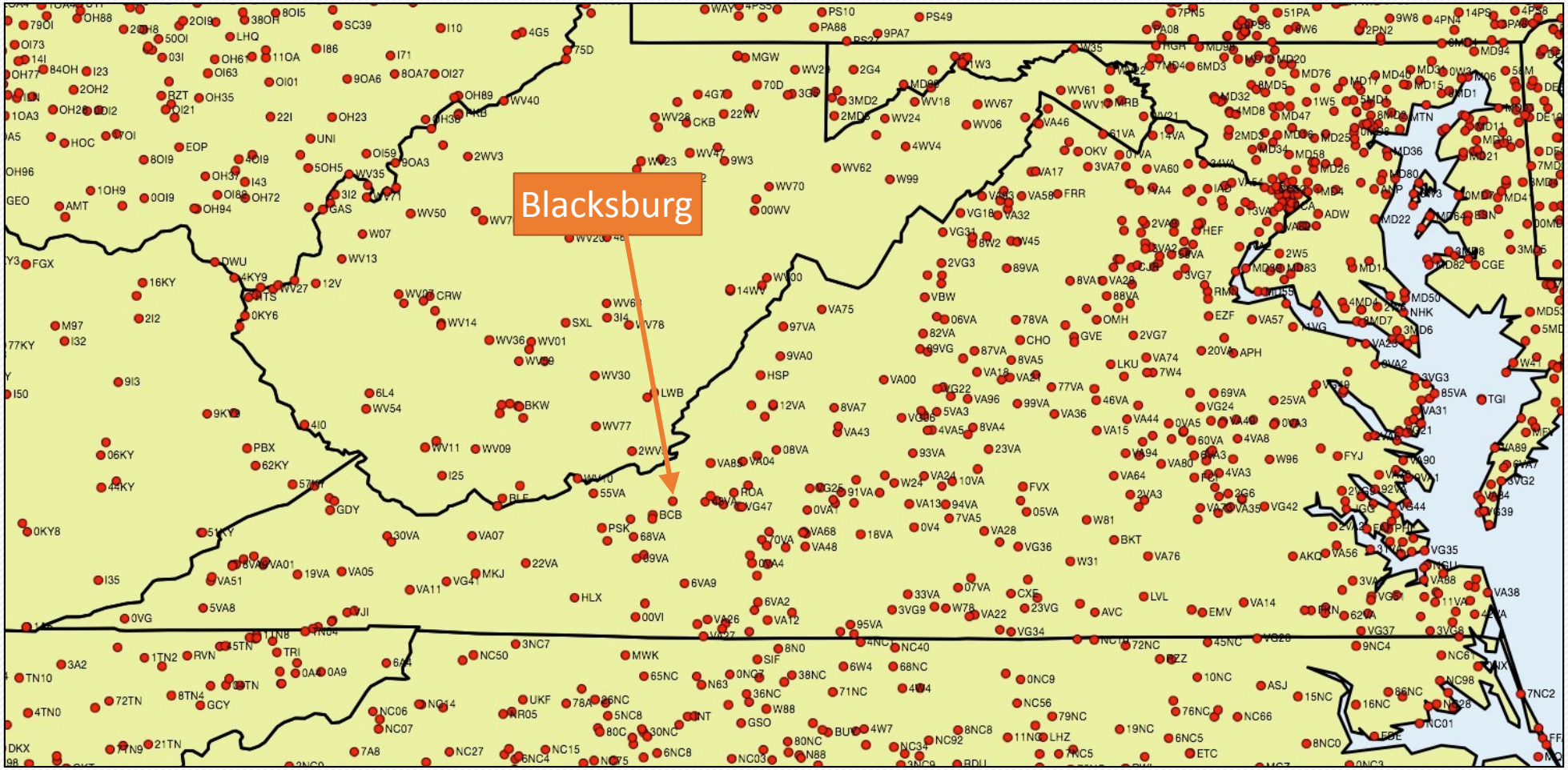
Airports in the US

- There are 20,103 airports (public and private) in the U.S.
- Each dot in this graph is an airport
- Some airports in Canada are also shown



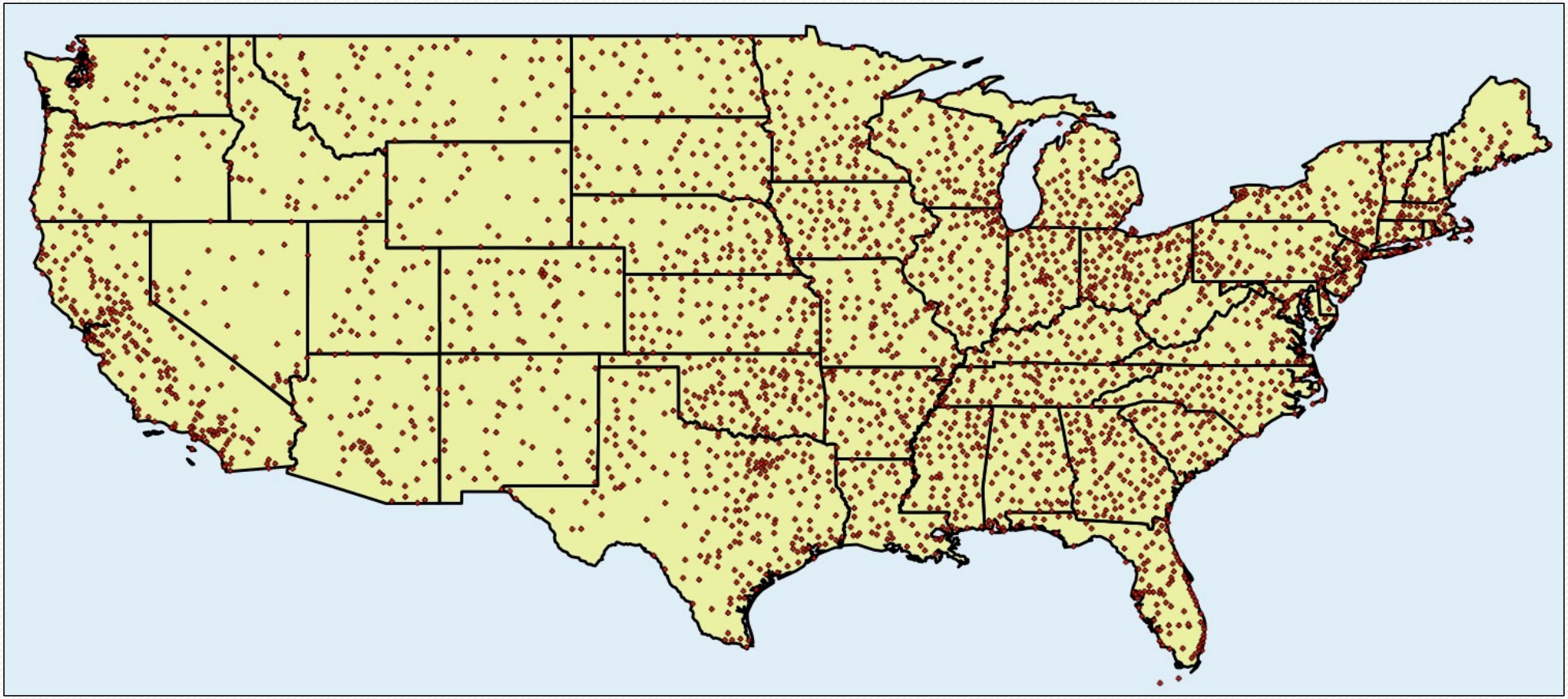
Airports in the Commonwealth of Virginia

There are 583 airports (public and private) in the State of Virginia



National Plan for Integrated Airports (NPIAS)

- Airports considered important to FAA (3,300 airports)
- These airports are eligible for Federal funding



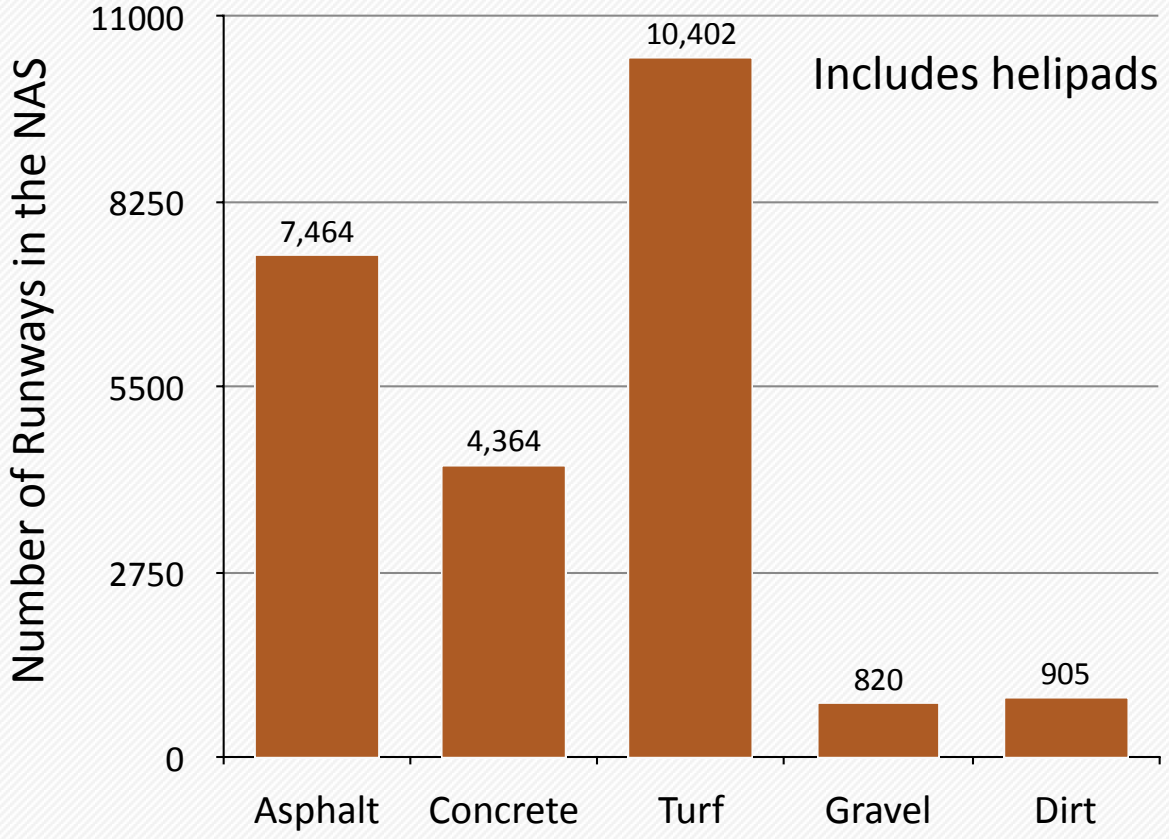
Some Airport Statistics

- The top 100 airports in the United States, as measured by 2013 passenger enplanements, accounted for almost 97 percent of the 726 million passengers in the U.S.
- More than 94 million passengers arrived or departed from Atlanta Hartsfield Airport in 2012.
- By 2040, aircraft operations at the top 100 airports are projected to increase by 57 percent.
- There is an obvious need for engineers to maintain and develop plans and designs for new facilities (i.e., new airports and airport improvements).

Runway Statistics (NAS Airports)

- A total of 24,356 runways in the NAS (includes helipads)
- There are 11,490 paved runways in the NAS (includes helipads)

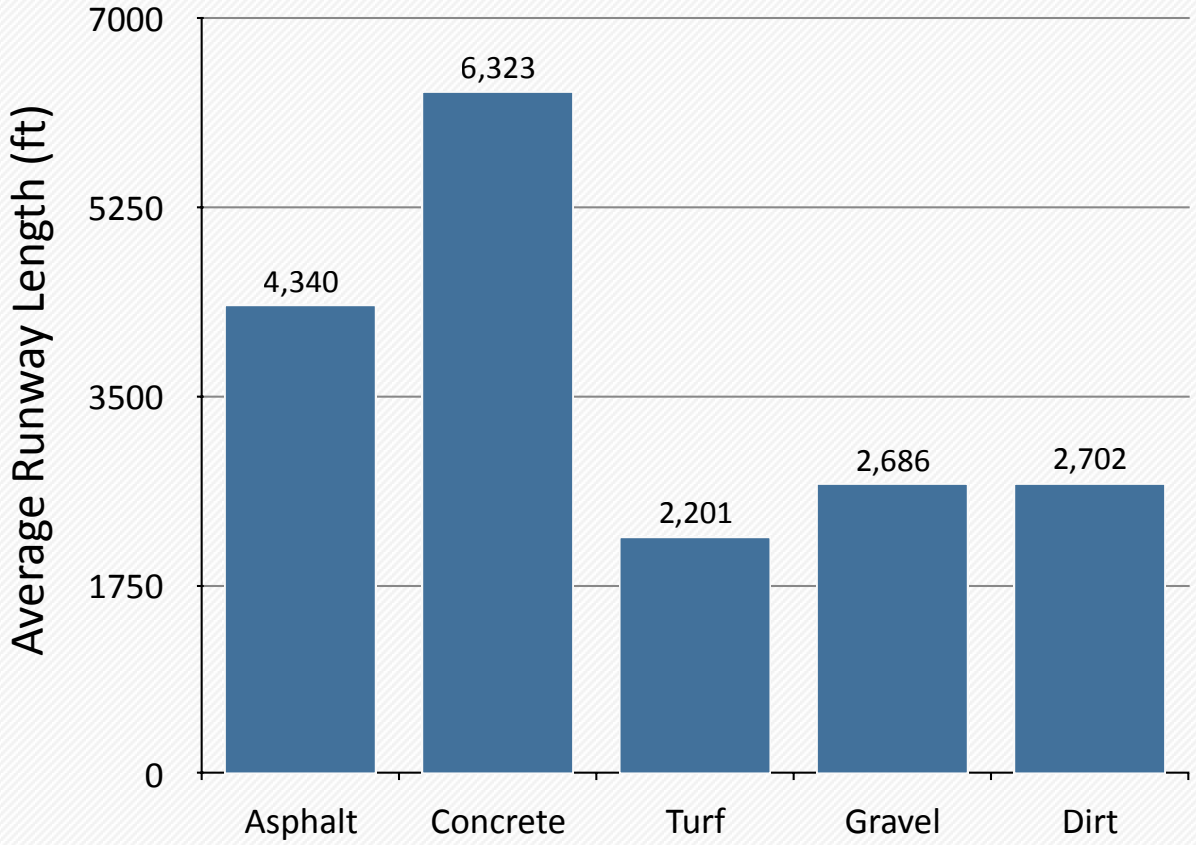
- Some overlap exist in the data
- 333 runways are listed as asphalt-concrete
- US has the largest number of runways in the World



Source: FAA Landing Facilities Database

Runway Length Statistics (NAS)

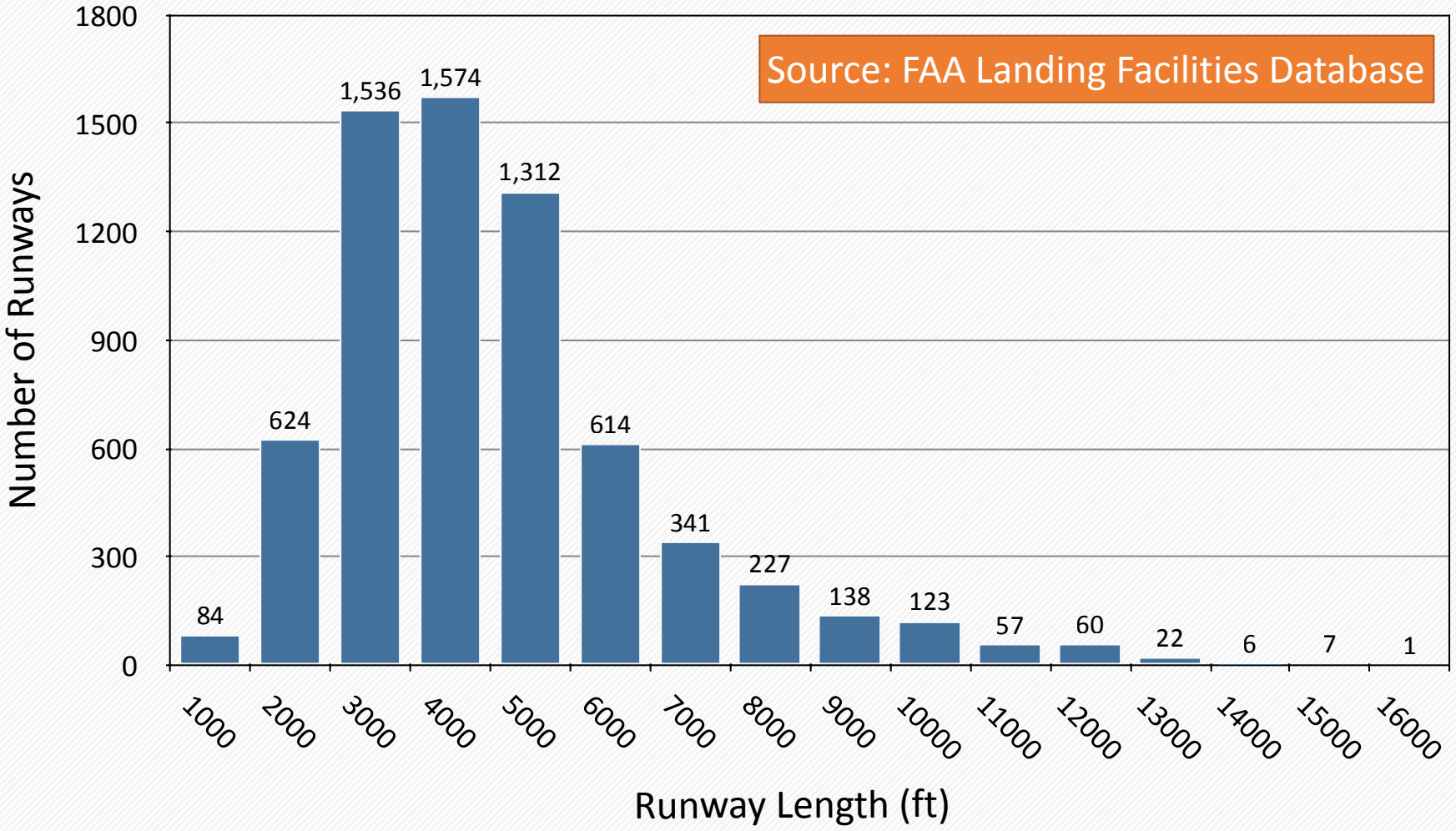
- The average runway length for asphalt runways is 4,340 feet (with helipads removed)
- Concrete runways average 6,323 feet if helipads are removed
- Most private airports have runways made up of turf, gravel or dirt



Source: FAA Landing Facilities Database

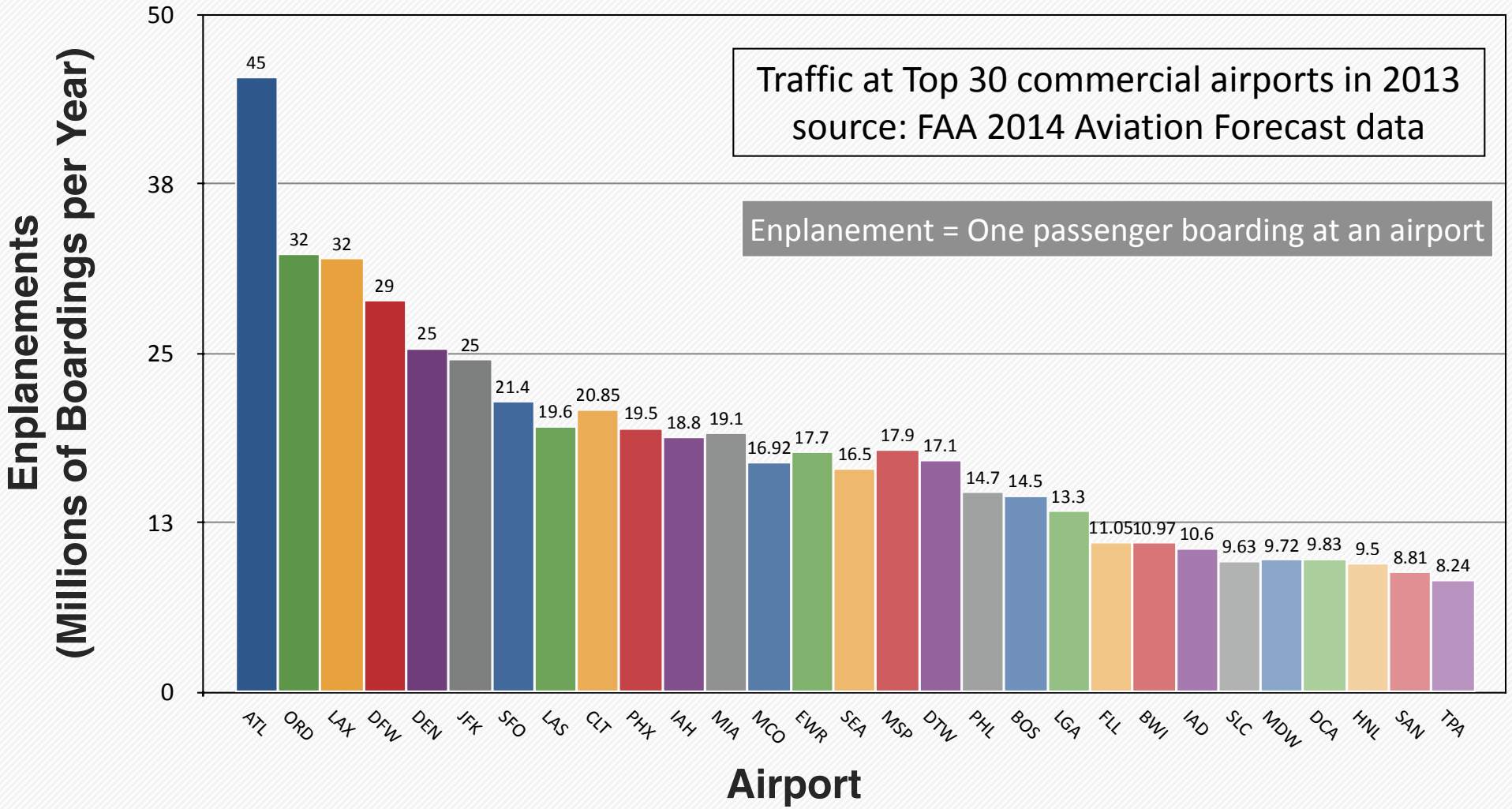
Distribution of Runway Lengths

- Paved runways length distribution (NAS-wide)



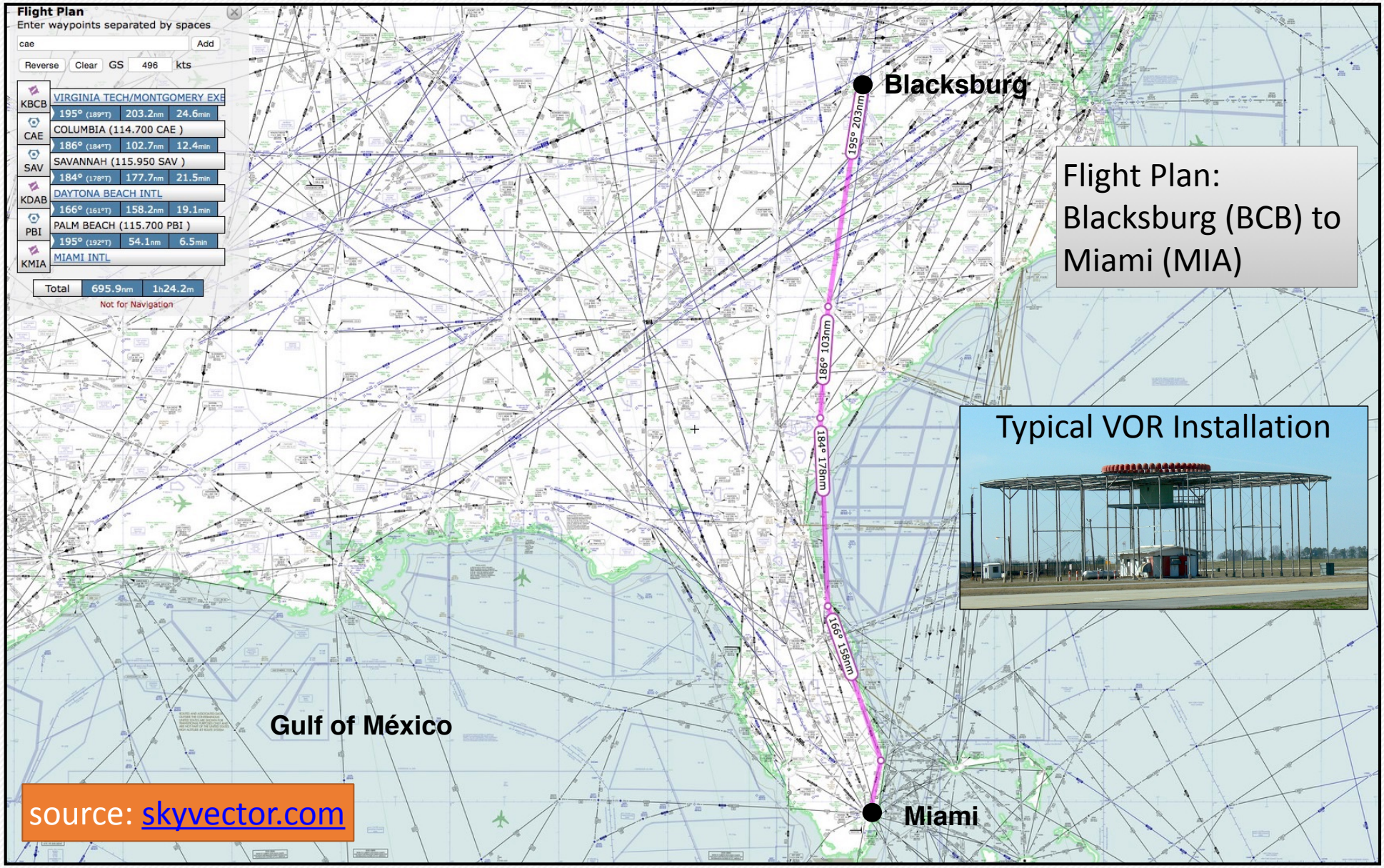
Passenger Boardings at US Commercial Airports

There are about 450 commercial airports in the continental US



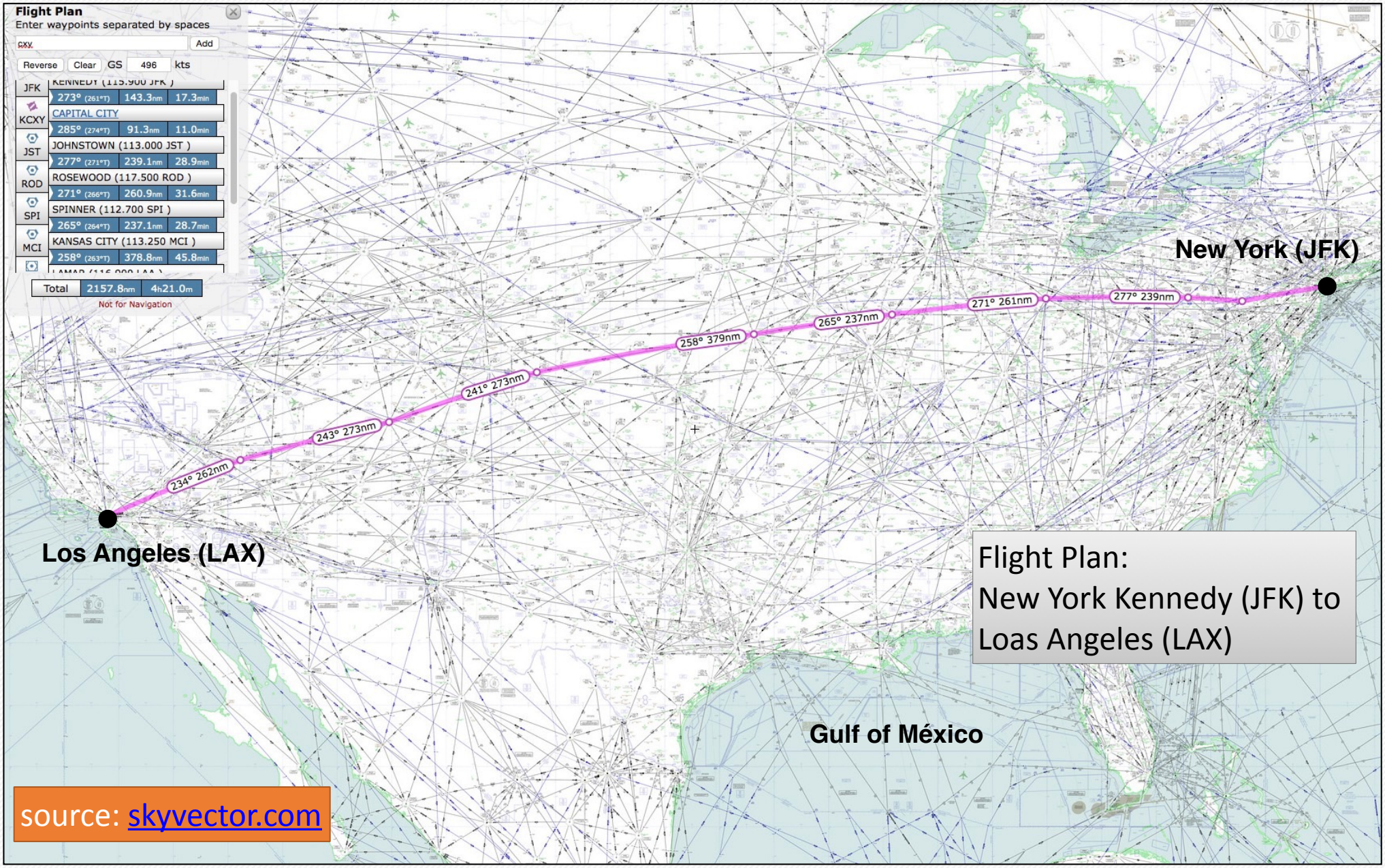
Airways : Highways in the Sky

Most operations in the NAS still use routes supported by VORs

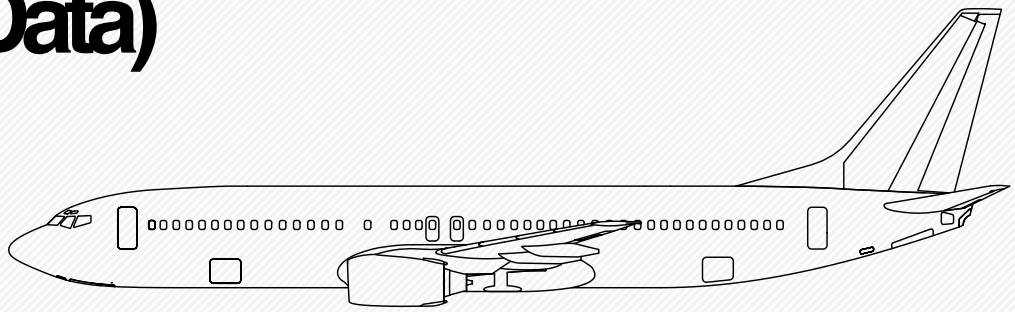


Airways : Like Highways in the Sky

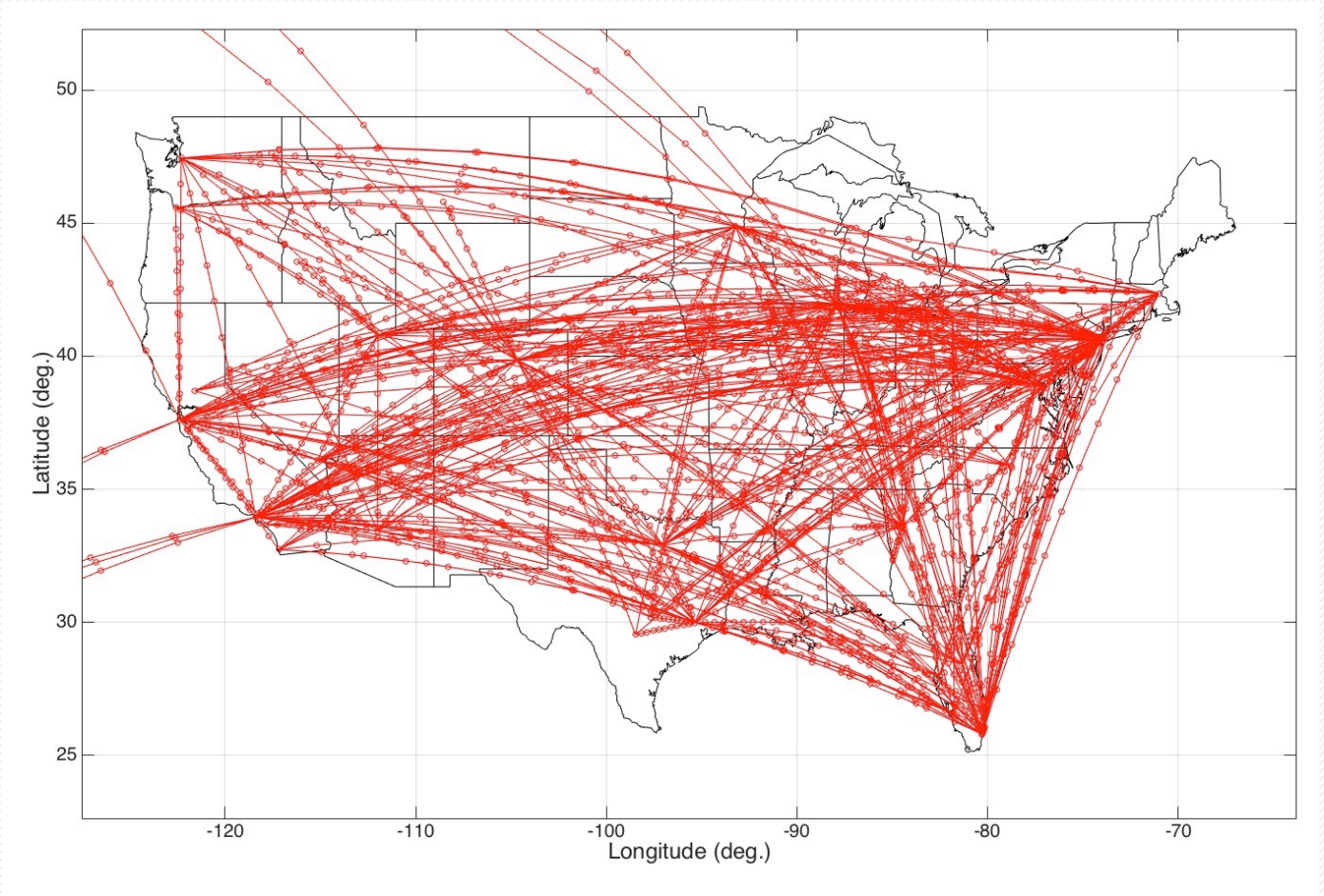
Most operations in the NAS still use routes supported by VORs



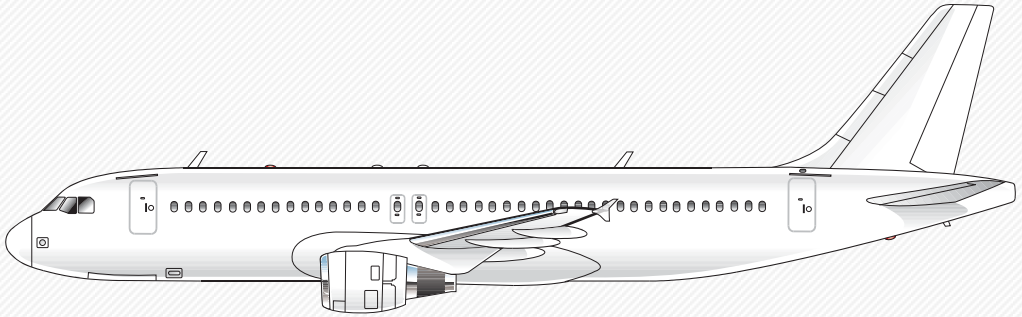
Origin-Destination Flown by Boeing 737-800 in the NAS (year 2014 Data)



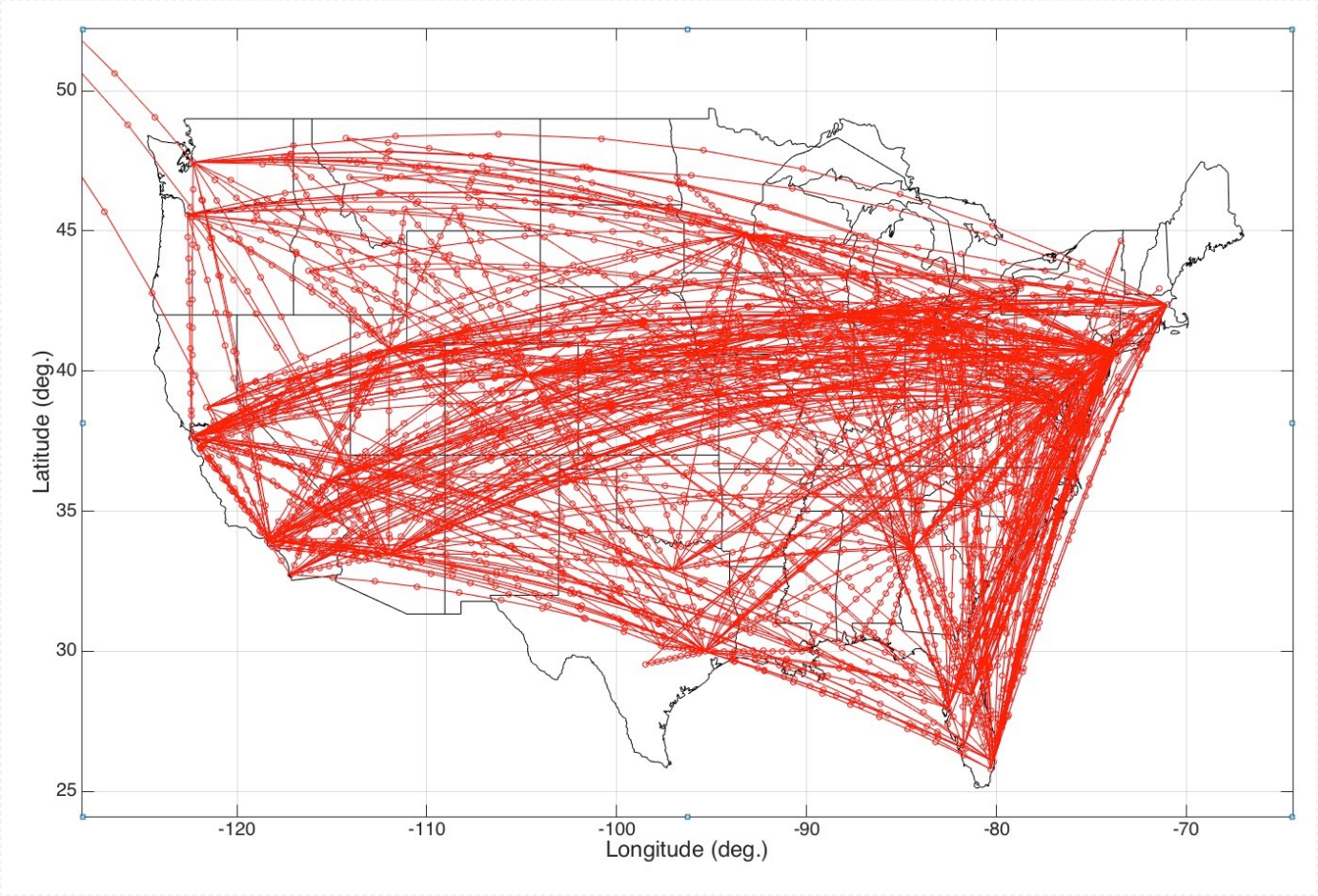
- OD airport pairs with flights by Boeing 737-800 aircraft
- Flights to Alaska and Hawaii are included in the plot
- 1,054 flights daily on average by B738
- Average flight distance = 1,074 statute miles



Origin-Destination Flown by Airbus A320 in the NAS (year 2014 Data)

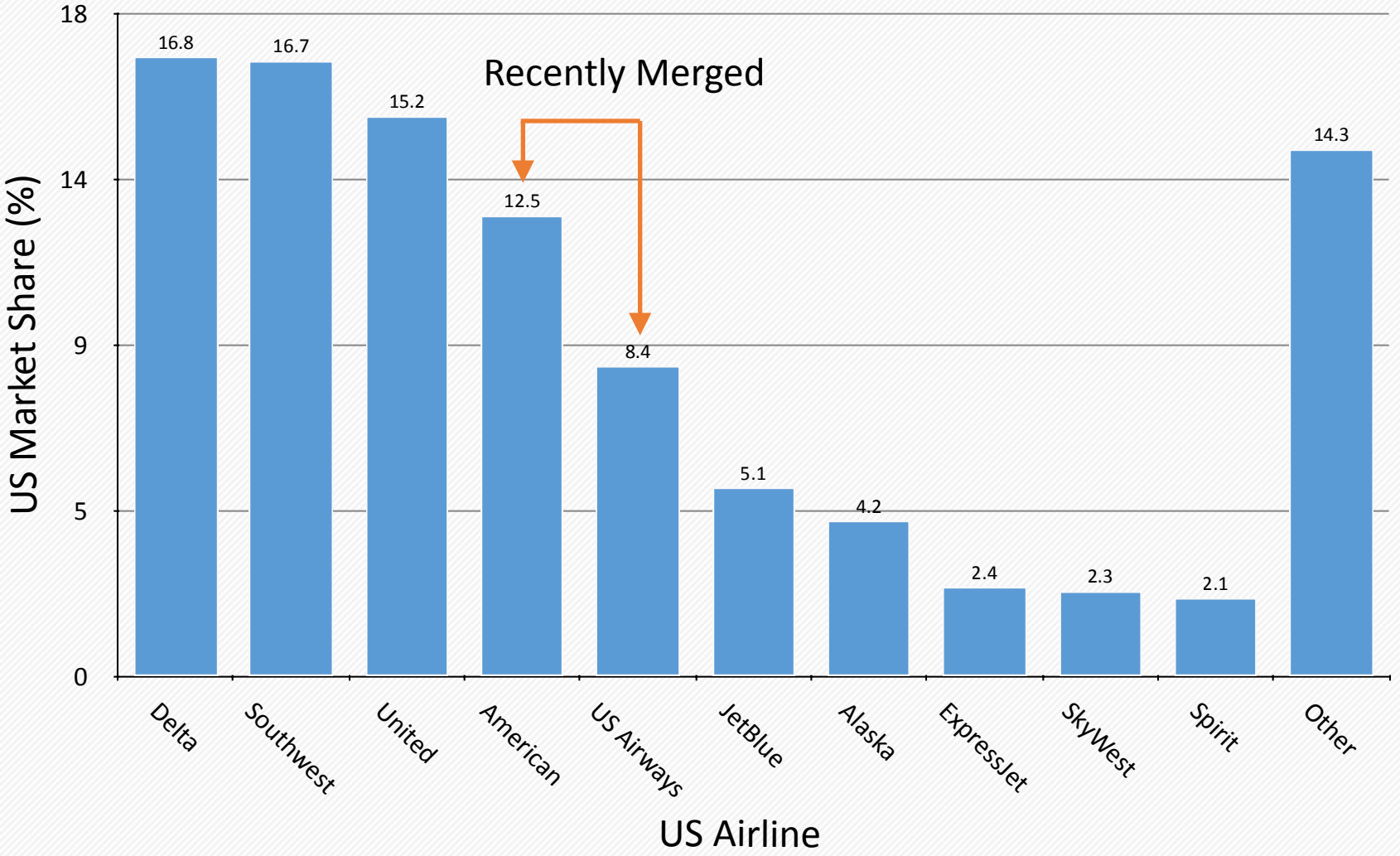


- OD airport pairs with flights by Airbus A320 aircraft
- Flights to Alaska are included in the plot
- 1,420 flights daily on average by Airbus A320
- Average flight distance = 1,209 statute miles



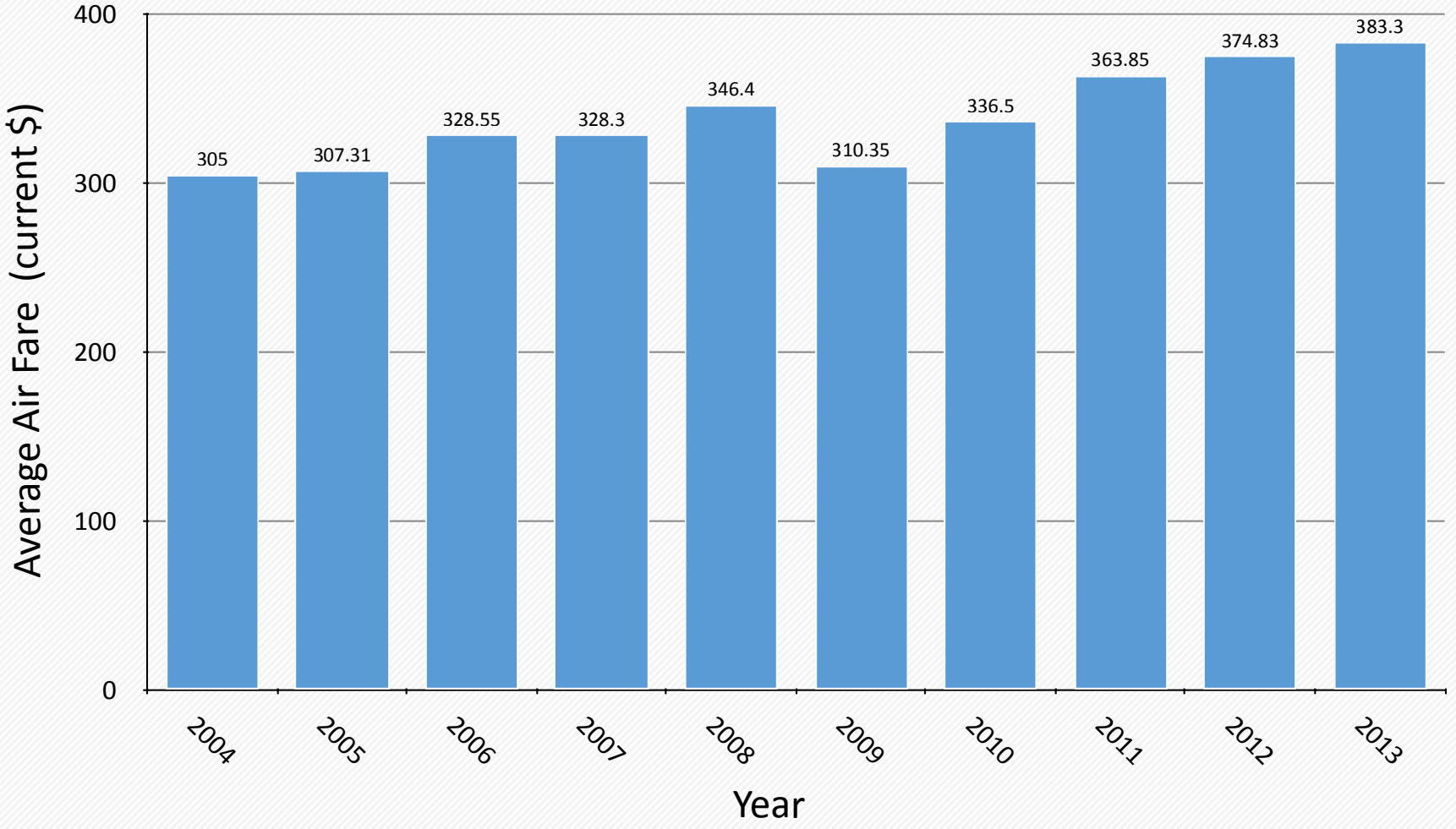
Airline Market Share

- Airlines have been very structured in only adding capacity in markets that need more seats
- Below are airline market shares nationwide



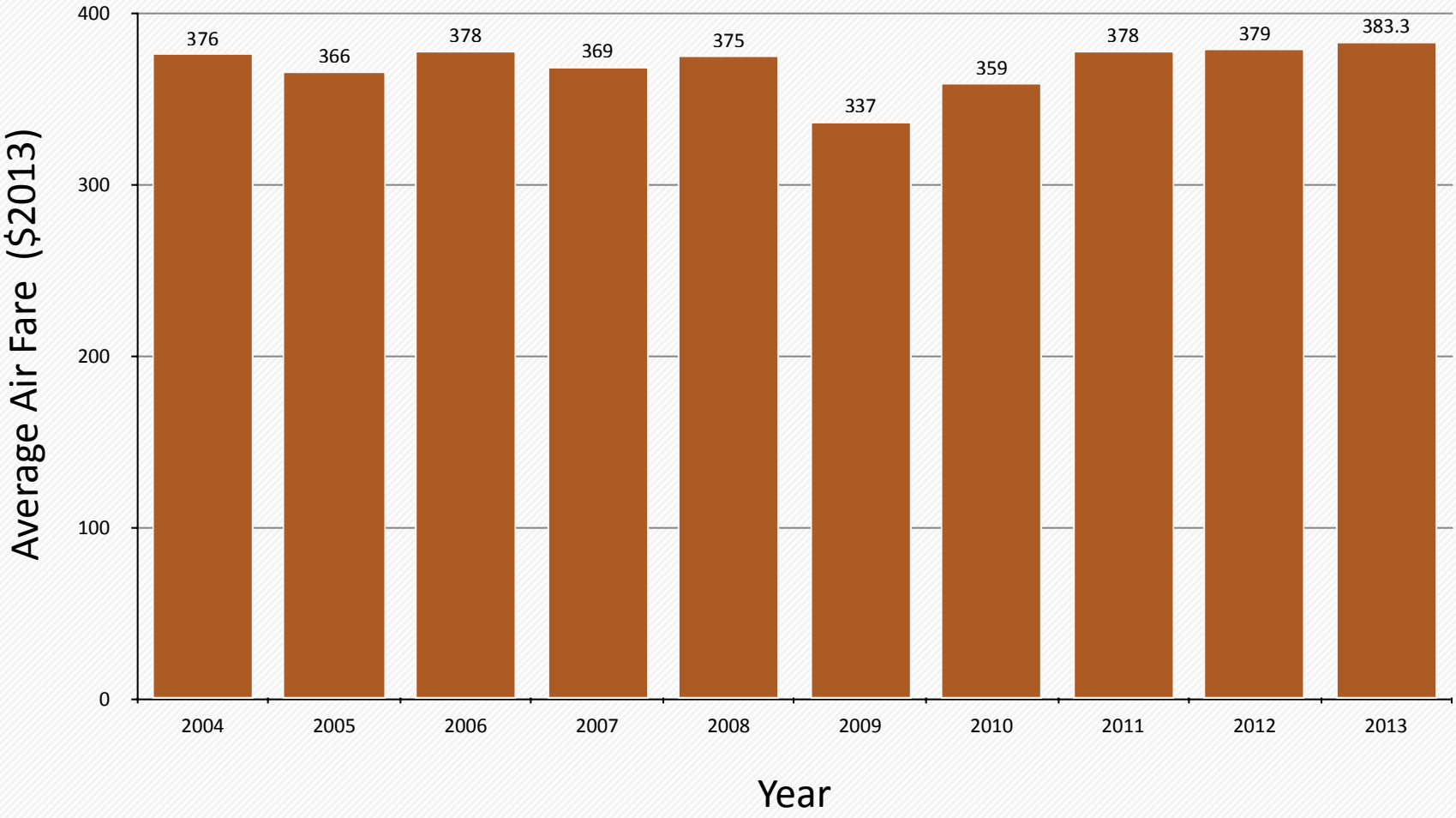
Airline Fares Nationwide (in current dollars)

- Airlines have been very cautious by only adding capacity in markets that need more seats
- Below are airline fares nationwide



Airline Fares Nationwide (in 2013 dollars)

- When discounted for inflation, air fares have not increased appreciably in the last decade (except during the 2008 recession)
- The average distance flown has not changes appreciably



Why Learn About NAS Operations?

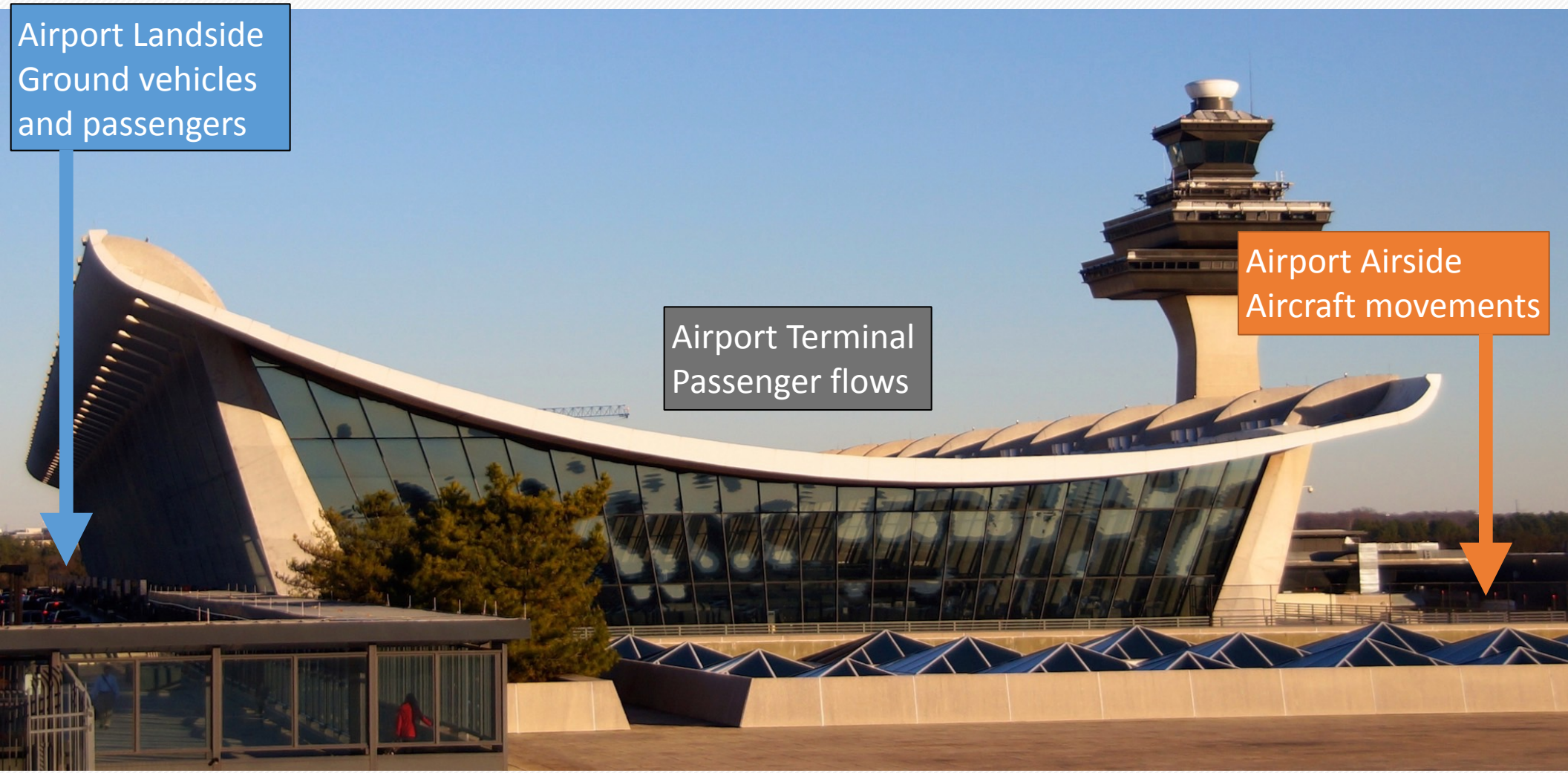
- To understand this complex system (how airports, flights, and air traffic controllers interact).
- To plan and design new airport/airspace infrastructure.

  Airports are very expensive (12 billion dollars were invested in Kansai airport in Japan)

  Air traffic services cost 9 billion dollars every year in the U.S. alone
- To improve the safety of the system (i.e., to reduce midair collisions and accidents).
- To improve the capacity of the system (i.e., to handle more flights or operations without building more airports).

Airports are Complex Intermodal Transportation Facilities

Dulles International Airport



Modeling Approach to NAS Operations

- We use **computer simulation models** to replicate the real system (i.e., airports, aircraft, airways, sectors, etc.)

  Simulation models are mathematical abstractions on how the system works

  Simulation models have a lot of logic and math behind them

- Computer simulations integrate mathematics and computer science expertise.
- Air traffic control and aircraft simulators are sometimes linked via high-speed networks to design changes to NAS without risking lives.
- Hard work and a lot of patience is what it takes to model airport and airspace operations.

Important Agencies for Airport Engineers

FAA - regulates and promotes aviation in the US

ICAO - International Civil Aviation Organization

- Based in Montreal, Canada
- Part of the UN charter
- Promotes and oversees aviation activities in the world

State Departments of Aviation

- Promote aviation development in individual states
- Normally part of State DOTs (Virginia has a separate entity called Department of Aviation)

Airport Authorities

- Promote development at the local level
- Individual or multiple airports

Federal Aviation Regulations

- Most air transportation activities are carried out using Federal Aviation Regulations (FAR)

  FAR 23 and 25 (Certification of aircraft)

  FAR 121 (Operation of aircraft by air carriers)

  FAR 77 (Obstructions to navigation)

- FAA provides designers and planners with Advisory Circulars (AC) to guide airport planning and design activities

  AC 150/5060-5 (Airport Capacity and Delay)

  AC 150/5300-13 (Airport Design)

- The regulations are quite strict and enforced. The FAA provides guidelines to even how install a light fixture on a taxiway.

- FAA Terminal Operation Procedures (TERP)

Things to Read

The following is a partial list of magazines and journals that I recommend reading if you like to know more about airports.

- Airports of the World (monthly) (http://www.airportsinternational.com)
- Aviation Week and Space Technology (weekly) (http://aviationweek.com)
- Business and Commercial Aviation (monthly) (http://aviationweek.com/business-aviation/bca)
- Air Transport World (monthly) (http://atwonline.com)
- Airliner World (monthly) (http://www.airlinerworld.com)
- Journal of Air Traffic Control (quarterly)
- Transportation Research (monthly)