Air Traffic Control (ATC) System

Updated April 2025


WORLD'S BUSIEST CONTROL TOWER

Air Traffic Control System

- Federal Aviation Act of 1958
- ATC – Air Traffic Control
- ARTCC – Air Route Traffic Control Center
  - Traffic Separation
- ARTCC Services
  - Weather, Safety Alerts, Emergency Assistance
- Radar and ADS-B
- Terminal Facilities
  - ATIS
  - Clearance Delivery
  - Control Tower
  - Approach and Departure
  - Radar Services
- Pilot Responsibilities


YOU ARE CLEAR TO DO WHATEVER..
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Federal Aviation Act of 1958

- Created the Federal Aviation Administration (FAA) effective 23 August 1958
- 30 June 1956 – United Air Lines Flight 178 collides with TWA Flight 2 over the Grand Canyon
- 21 April 1958 – United Air Lines Flight 736 collides with F-100 Sabre fighter jet
- 20 May 1958 – Capital Airlines Flight 300 collides with US Air Force T33 trainer jet

Some More Notable Accidents

- 16 December 1960 – United Air Lines Flight 826 (Douglas DC-8) collides with Trans World Airlines Flight 266 (Lockheed L-1049 Constellation)
  - Max speed 250 KTs < 10000 feet
- 15 July 1970 – Piper PA-28-140 collides with Allegheny Airlines 853 (McDonnell Douglas DC-9)
- 6 June 1971 – F-4 Phantom Fighter collides with Jet Hughes Airwest Flight 706 (McDonnell Douglas DC-9)
  - Military agrees to fly via IFR and also limits speed to 250 KTs < 10000 feet
- 25 September 1978 – Cessna 172 collides with Pacific Southwest Airlines 182 (Boeing 727)
  - The concept of Terminal Radar Service Area (TRSA) is introduced

Air Traffic Control (ATC)

Our Objective:

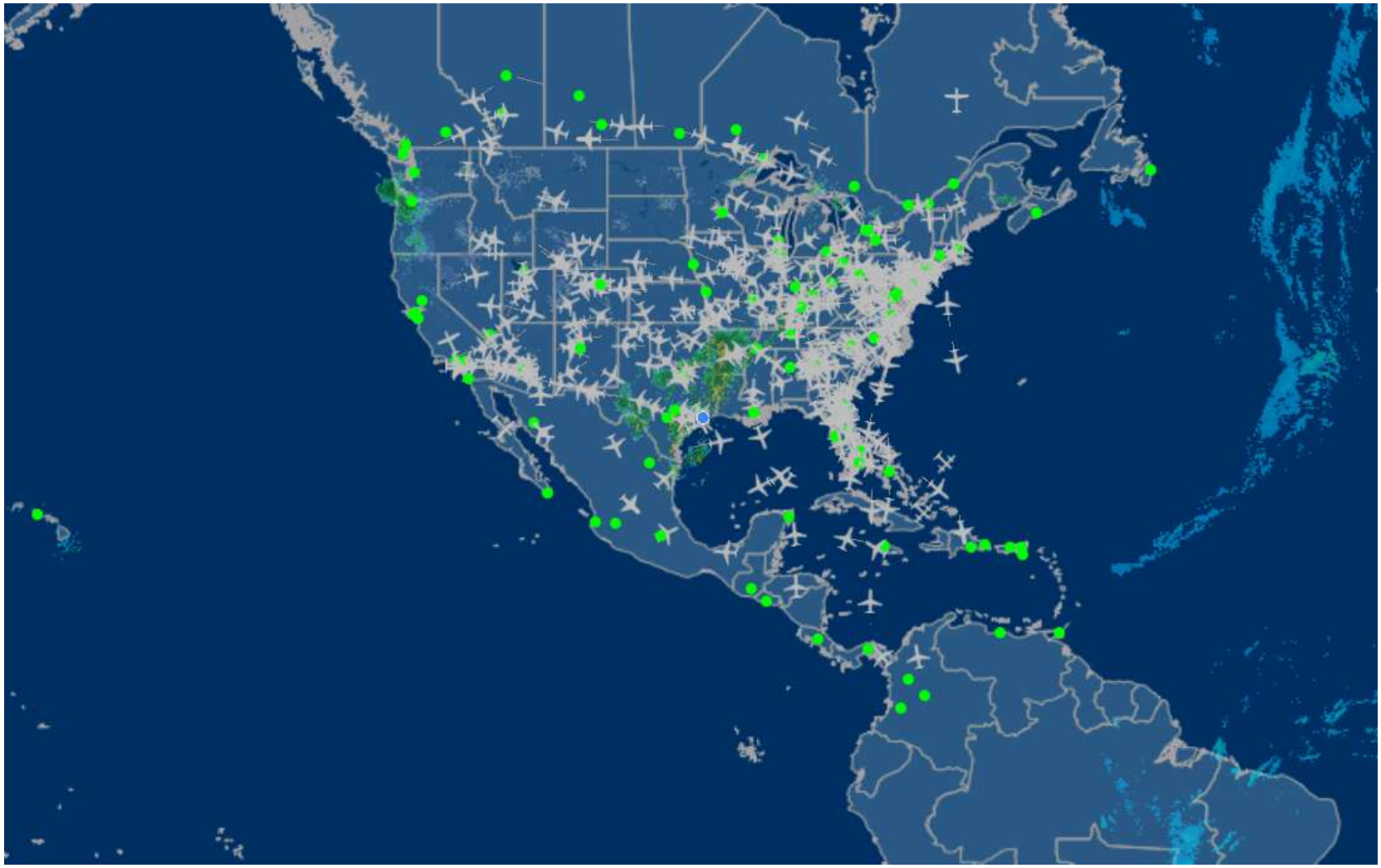
1. Describe the different components and functions of the modern air traffic control system in use today.
2. Know the basic structure, components and functions of the modern air traffic control system

Air Traffic Control (ATC)

- During peak air travel times in the United States, there are about 5,000 airplanes in the sky every hour. This translates to approximately 50,000 aircraft operating in our skies each day.

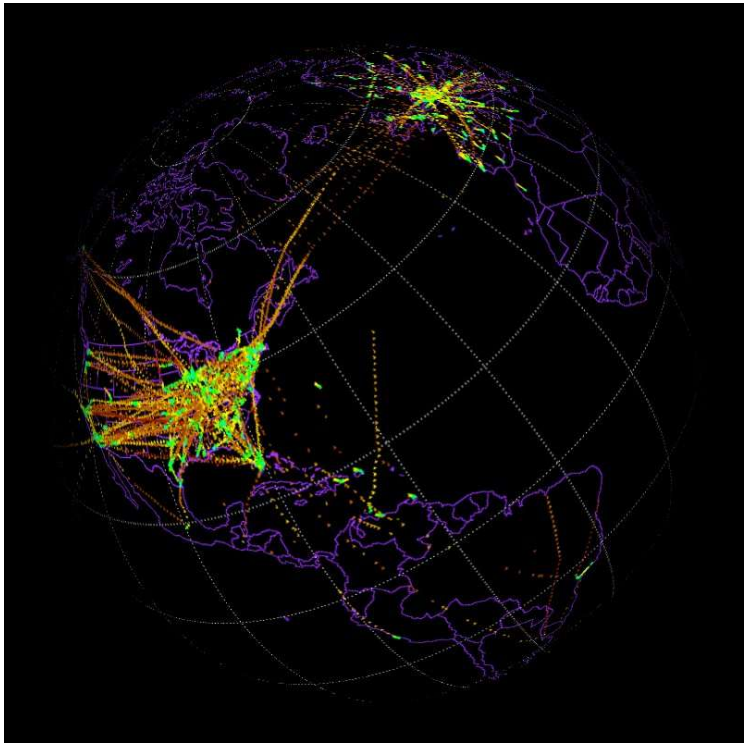
- How do aircraft avoid each other? AIR TRAFFIC CONTROL (ATC)

Air Traffic Control (ATC)



Air Traffic Control (ATC)

• Modern Air Traffic Control (ATC) is a complex system that monitors, controls and assists all aircraft to safely transit the skies from takeoff to landing.



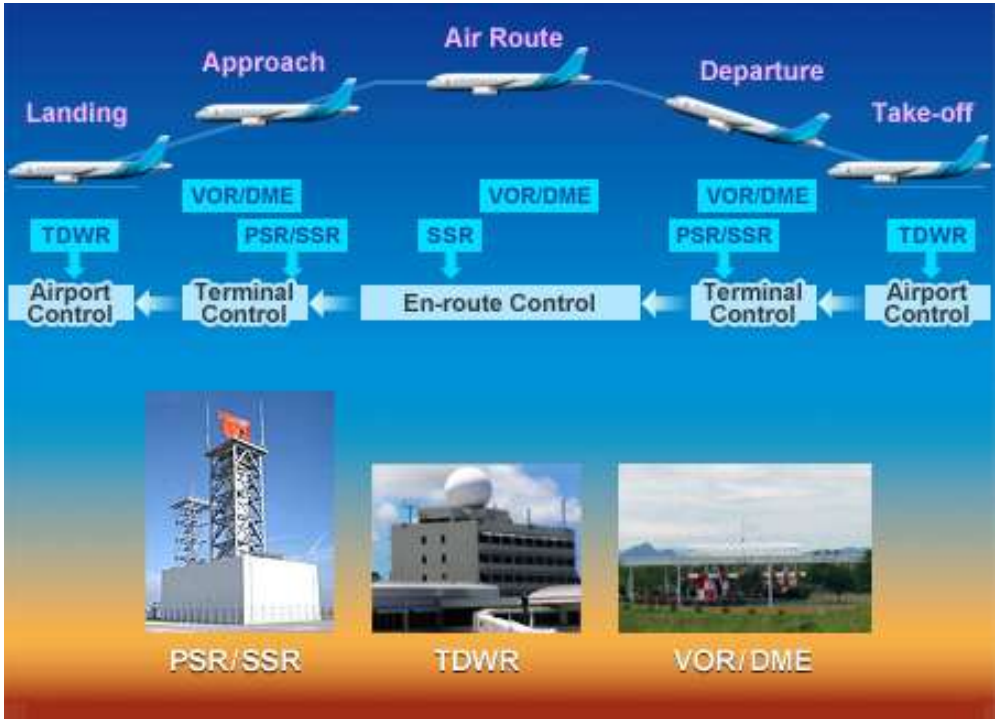
• While there may be slight local differences, ATC is a worldwide system regardless if you are flying in the United States, Europe or Africa.

Let’s explore at the components of ATC

Air Traffic Control (ATC) Numbers

- ATC consist of a network of radar and non-radar facilities for traffic separation of all IFR traffic
- ATC consist of enroute and terminal facilities.
- ARTCC facilitates enroute traffic
- Terminal facilities consist of approach, departure (TRACON), control tower, ground control and clearance delivery.

- Terminal Radar Facilities = 200
- FAA Controllers = 17,000
- Field Maintenance = 8,000
- Centers = 21
- Control Towers = 500
- Flight Service Stations = 100

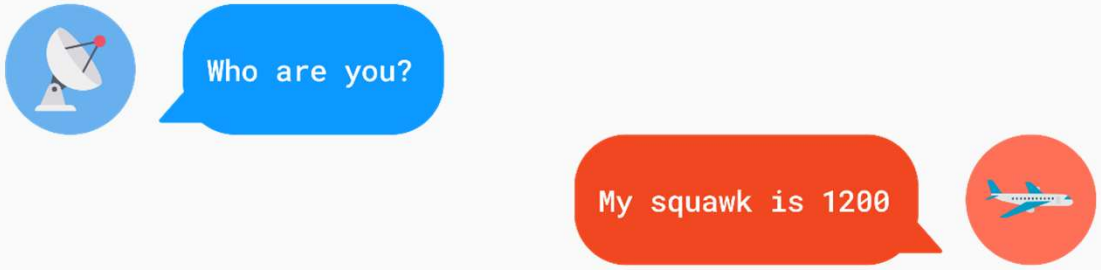


Primary and Secondary Surveillance Radars

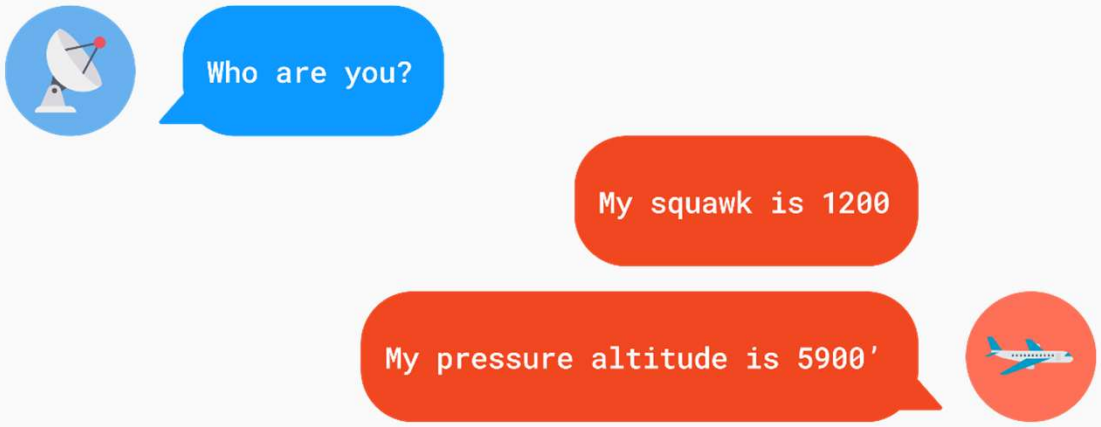
Transponder

- Squawk – 4-digit octal codes allowing secondary radar to identify aircraft
  - 1200 – VFR (no radar service)
  - 7500 – hijack/unlawful interference
  - 7600 – radio failure
  - 7700 – emergency
- Mode: Standby, On (Mode A), Alt (Mode C/Mode S), Ident
- Mode S address – 24-bit addresses fixed to a unique aircraft

Mode A



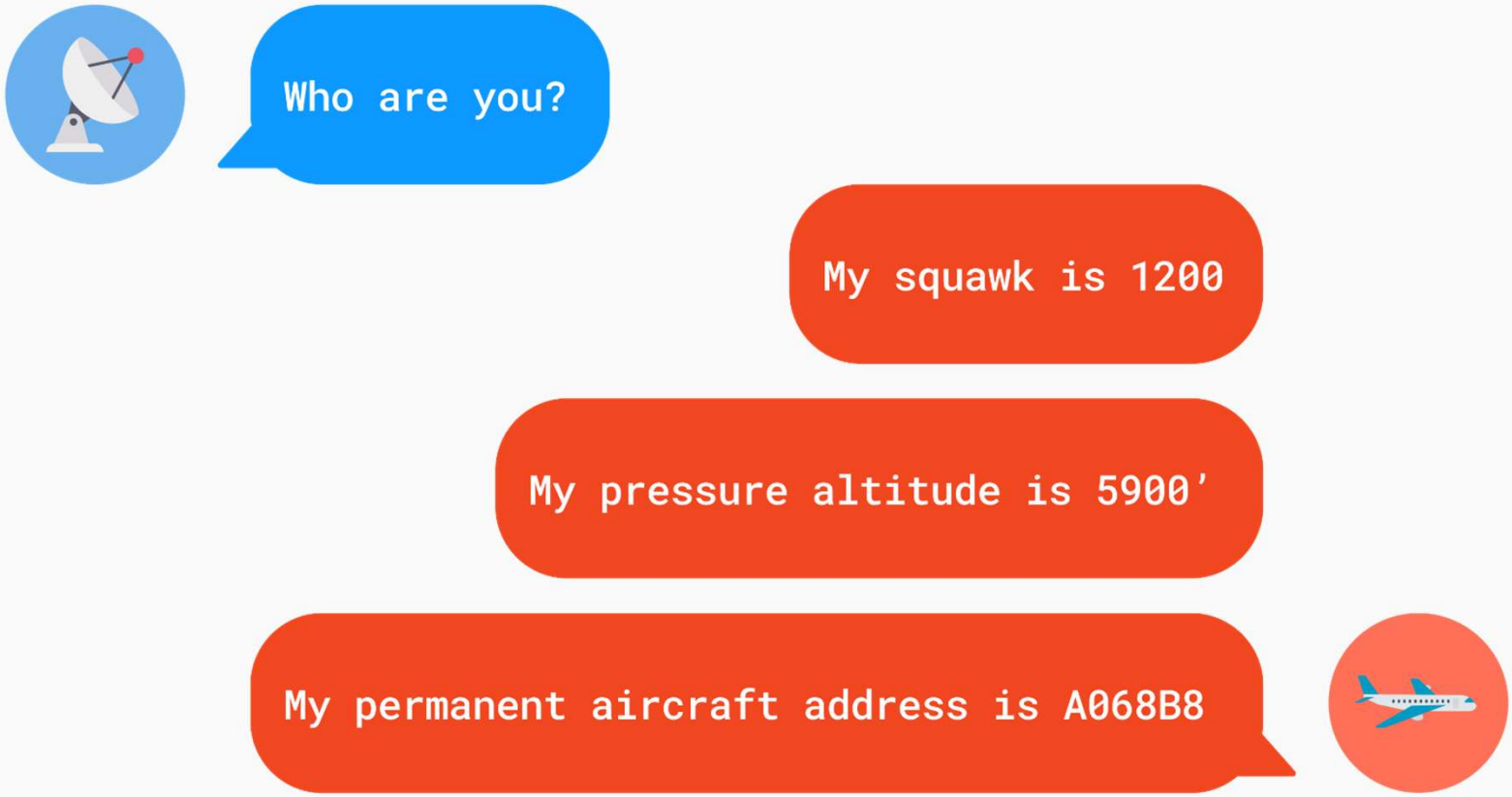
Mode C



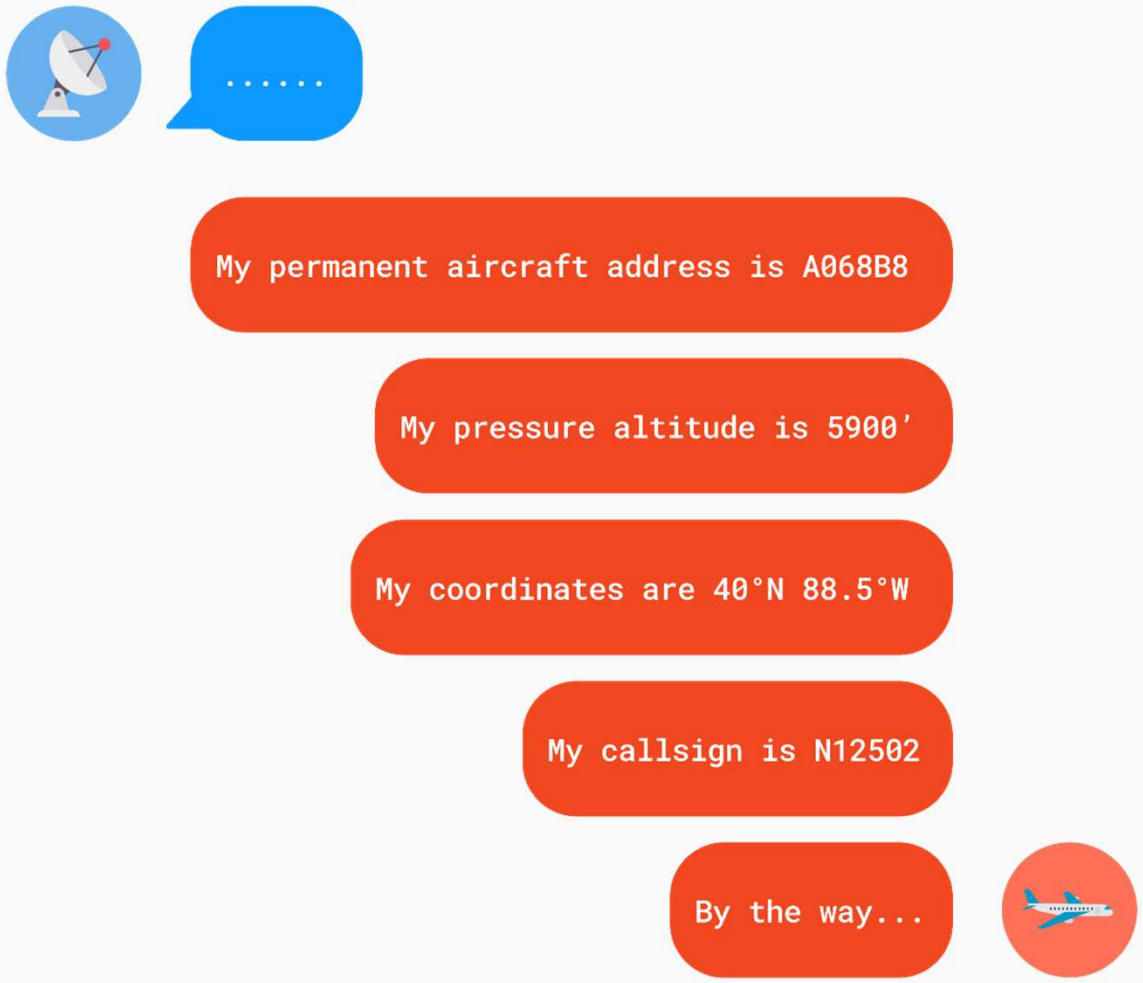
Mode C Equipage Requirements

- Inside Class A, B and C airspaces
- Above Class B and C airspaces
- In Class E airspace and over 10,000’ MSL, except within 2500’ AGL
- Within Mode C Veil (30 nm from the primary Class B airport)

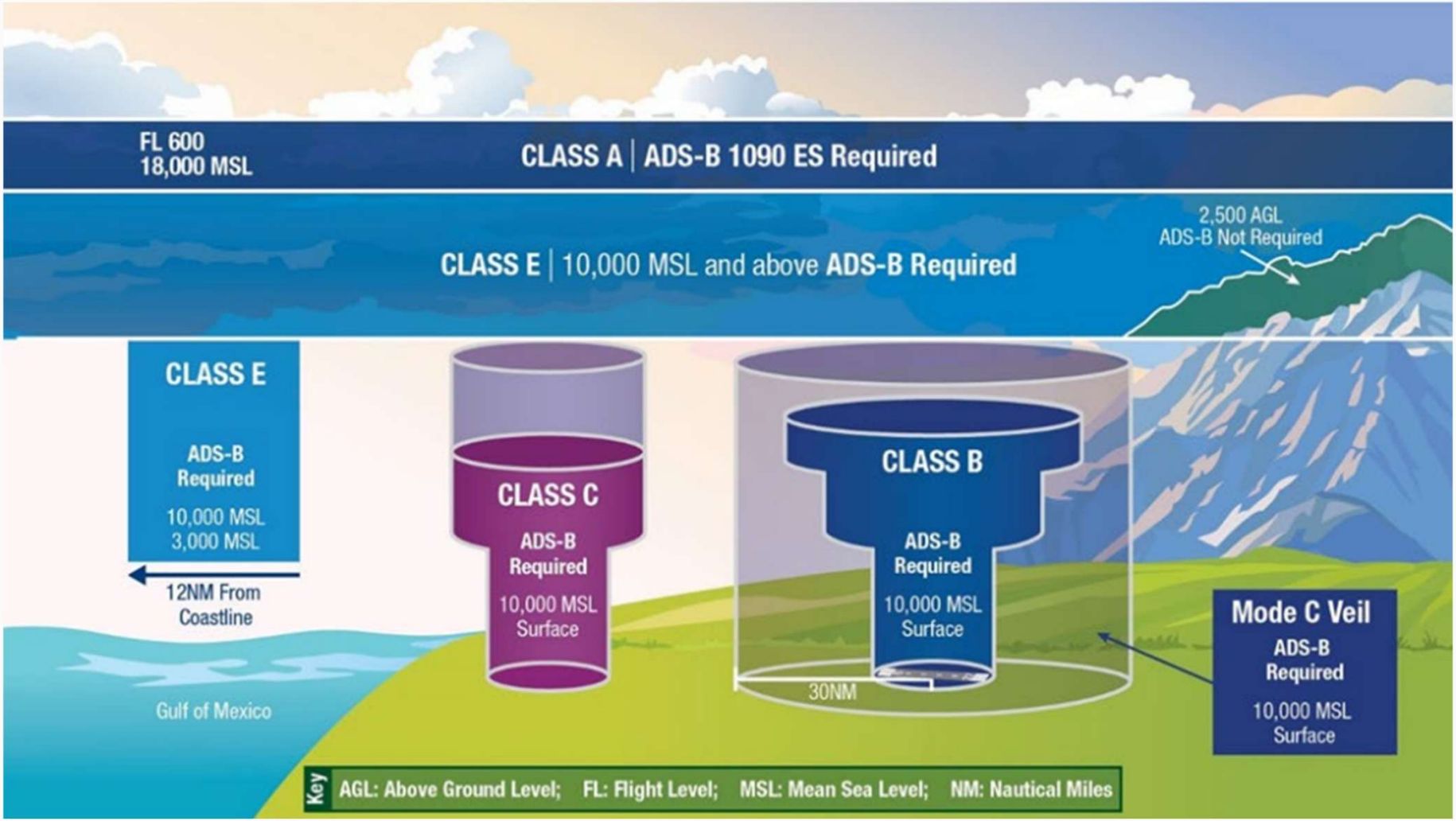
Mode S


Who are you?
My squawk is 1200
My pressure altitude is 5900’
My permanent aircraft address is A068B8

ADS-B Out


.....
My permanent aircraft address is A068B8
My pressure altitude is 5900’
My coordinates are 40°N 88.5°W
My callsign is N12502
By the way...

ADS-B Out



[FAA AC 90-114B CHG 1]

ADS-B In

- ADS-B In-equipped aircraft have access to
  - Positions of other traffic, if available
  - Graphical weather displays in the cockpit
  - Text-based advisories, including NOTAMs and significant weather

Automatic Dependent Surveillance – Notes

- UAT (Universal Access Transceiver) is considered a type of transponder that can support ADS-B rebroadcast, which means it can receive and retransmit position data from other aircraft, allowing aircraft with UAT capability to see traffic from aircraft using different ADS-B frequencies through a system called ADS-R (Automatic Dependent Surveillance - Rebroadcast).

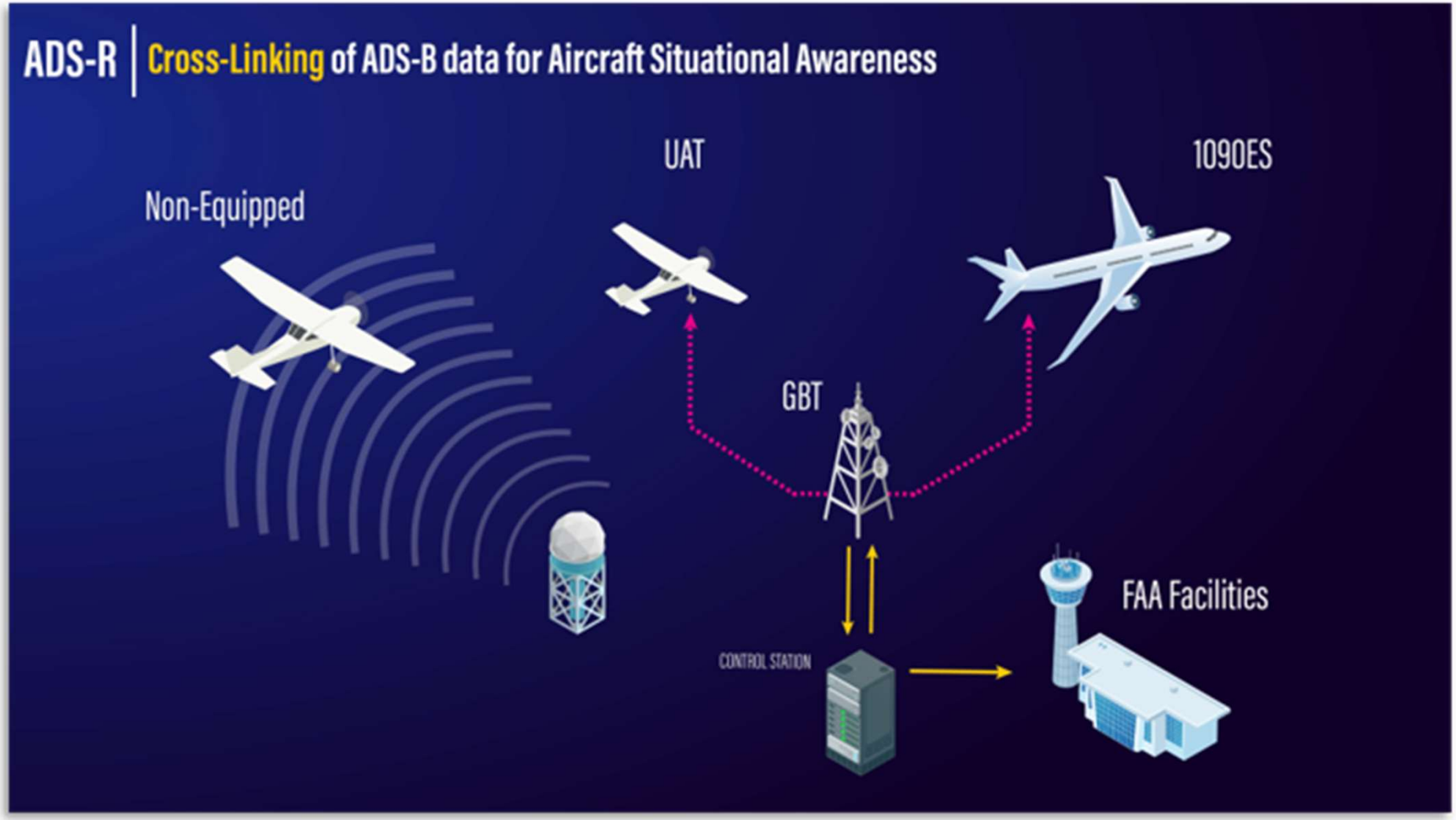
- Used in the United States and operating on the 978 MHz frequency, enabling pilots to receive weather information and traffic updates on their cockpit displays; essentially enhancing situational awareness and safety during flight

- Aircraft equipped with either a 1090ES transponder or a UAT ADS-B Out transponder can participate in Automatic Dependent Surveillance – Rebroadcast (ADS-R).

- ADS-R is a service that rebroadcasts aircraft positions to other aircraft using FAA ground stations.

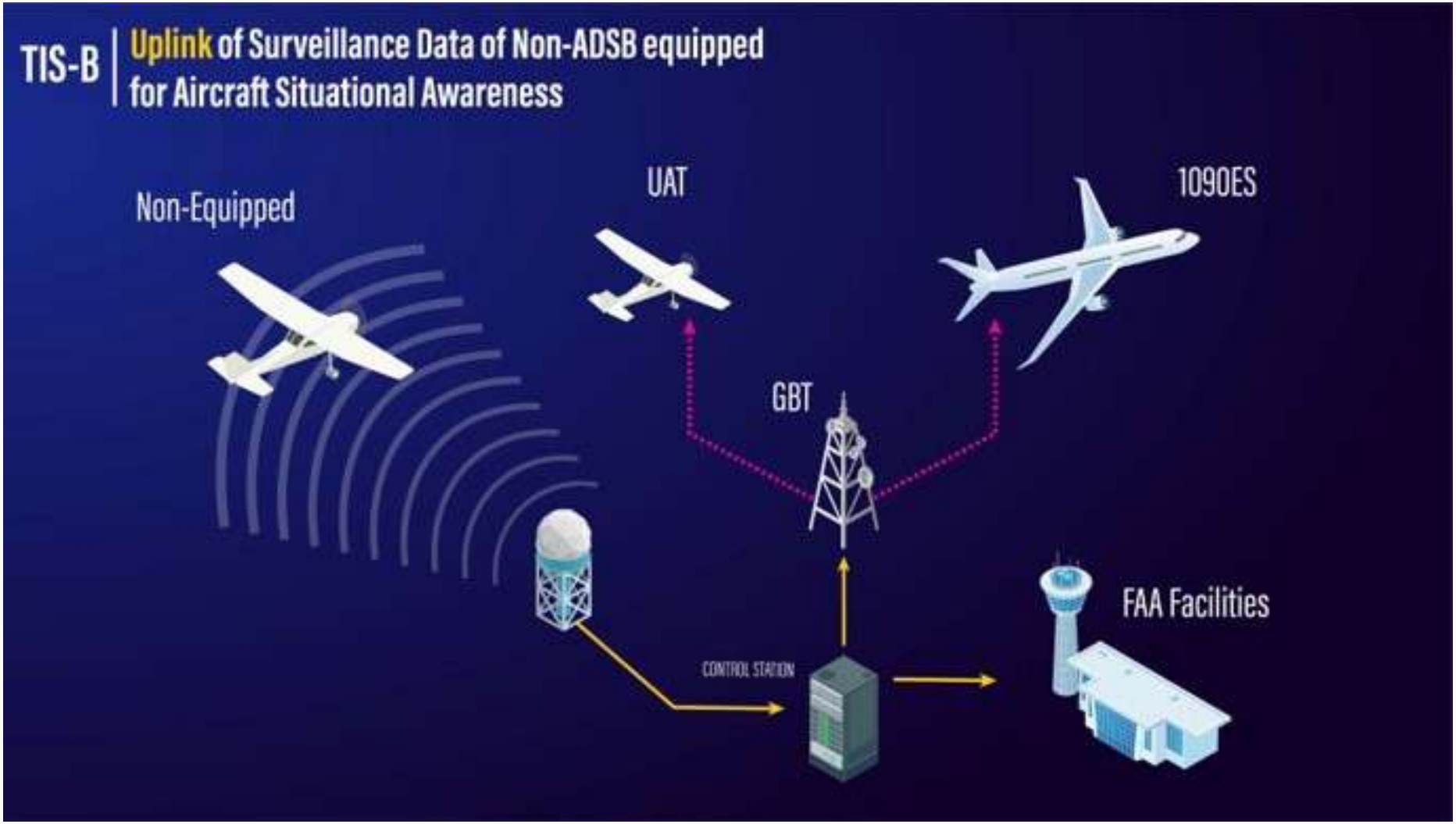
- This service allows aircraft with ADS-B In on 1090 MHz to see UAT aircraft, and vice versa. ADS-R increases pilots' situational awareness by displaying traffic information in the cockpit.

Automatic Dependent Surveillance – Rebroadcast

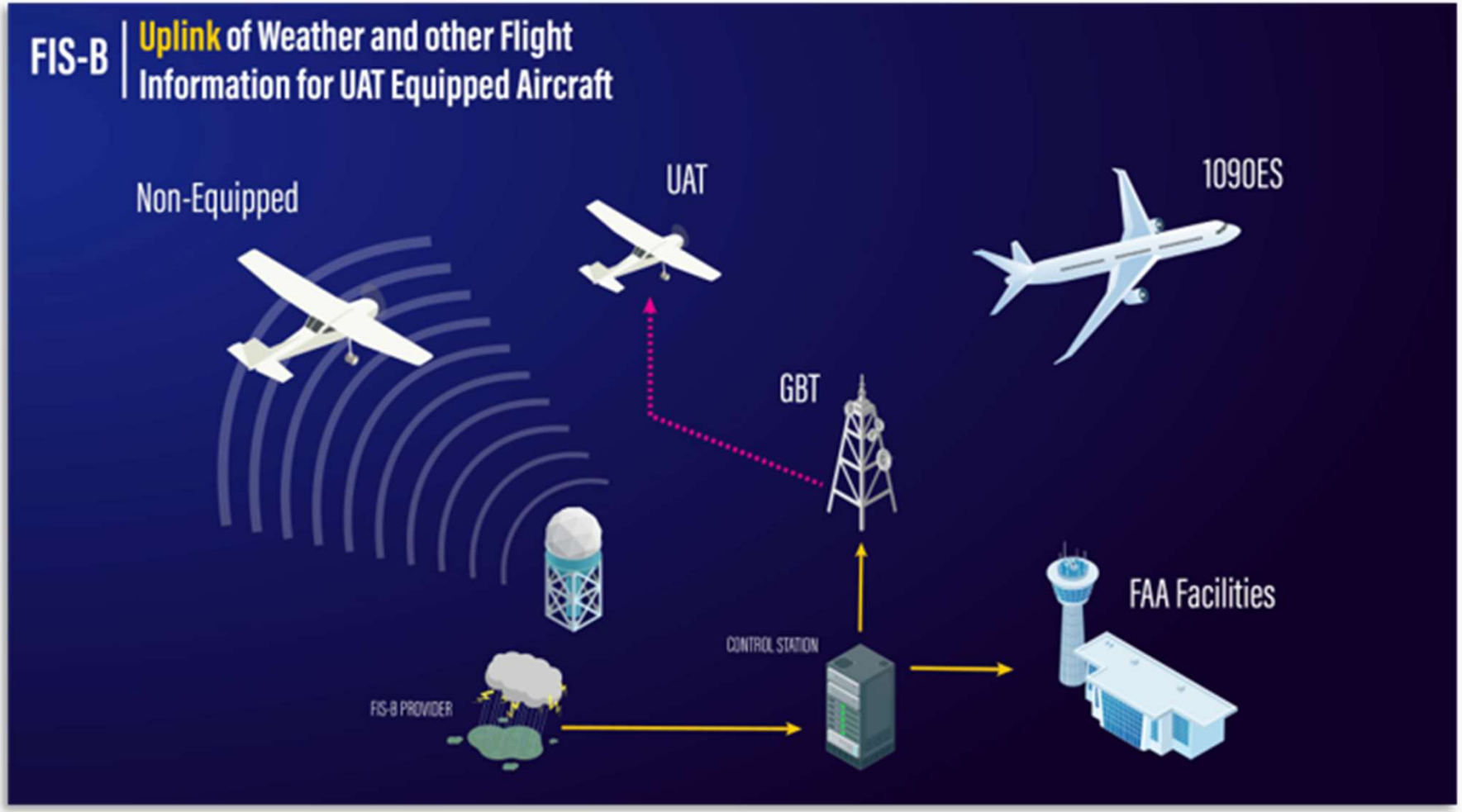


ADS-B (Air-to-Air Broadcast): Information is directly received from an ADS-B Out-equipped aircraft via an air-to-air broadcast.
ADS-R (ADS-B Rebroadcast): The ground station rebroadcasts ADS-B messages it receives on one ADS-B frequency to the other ADS-B frequency

Traffic Information Services – Broadcast



Flight Information Services – Broadcast



Air Traffic Control Tower (ATCT)

Operations Room

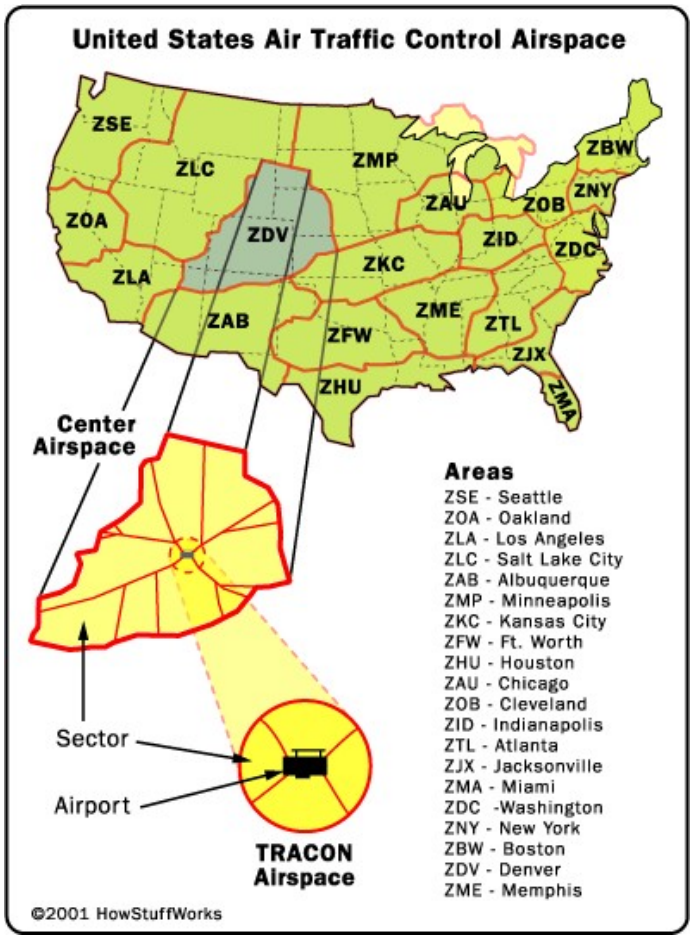
Air Traffic Control (ATC)

- **Air Traffic Control System Command Center**

- **Air Route Traffic Control Centers (ARTCC)**
  One per zone managing all air traffic except for TRACON and local-airport airspace.

- **Terminal Radar Approach Control (TRACON)**
  Controls departing and approaching aircraft within its airspace.

- **Air Traffic Control Tower (ATCT)**
  Controls all takeoff, landing, and ground traffic from a specific airport

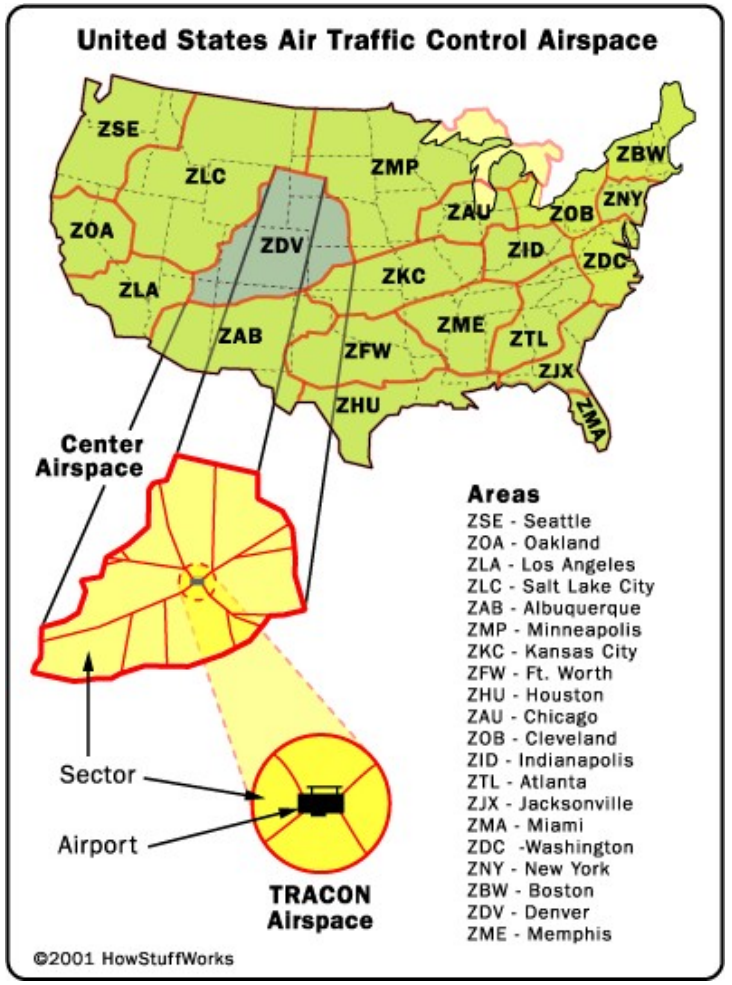


Air Traffic Control (ATC)

Air Route Traffic Control Centers (ARTCC) Centers - Zones

• The United States airspace is divided into 21 zones (centers), and each zone is divided into sectors.

• The shape and size of zones is largely determined by the volume of air traffic within a given geographic area. For example, the air traffic control zone that covers New York City is significantly smaller, from a geographic perspective than that of the sector that covers Montana and Idaho.
• Low and high altitude sectors 18,000 – 24,000 ft MSL
• IFR lateral and vertical separation

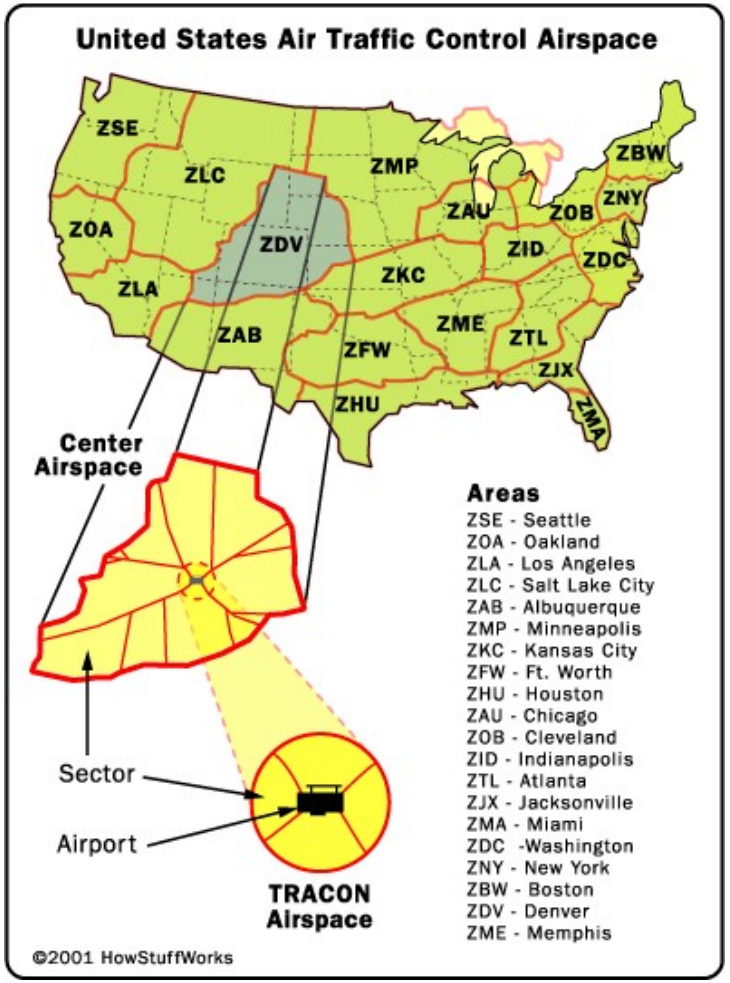


Air Traffic Control (ATC)

Sectors and **TRACON - T**erminal **R**adar **A**pproach **CON**trol)

• Within each zone are portions of airspace, about 50 miles in diameter, called **TRACON** (**T**erminal **R**adar **A**pproach **CON**trol) airspaces.

• Within each TRACON airspace are a number of airports, each of which has its own airspace with a 5-mile (8-km) radius. Class D airspace - KBED



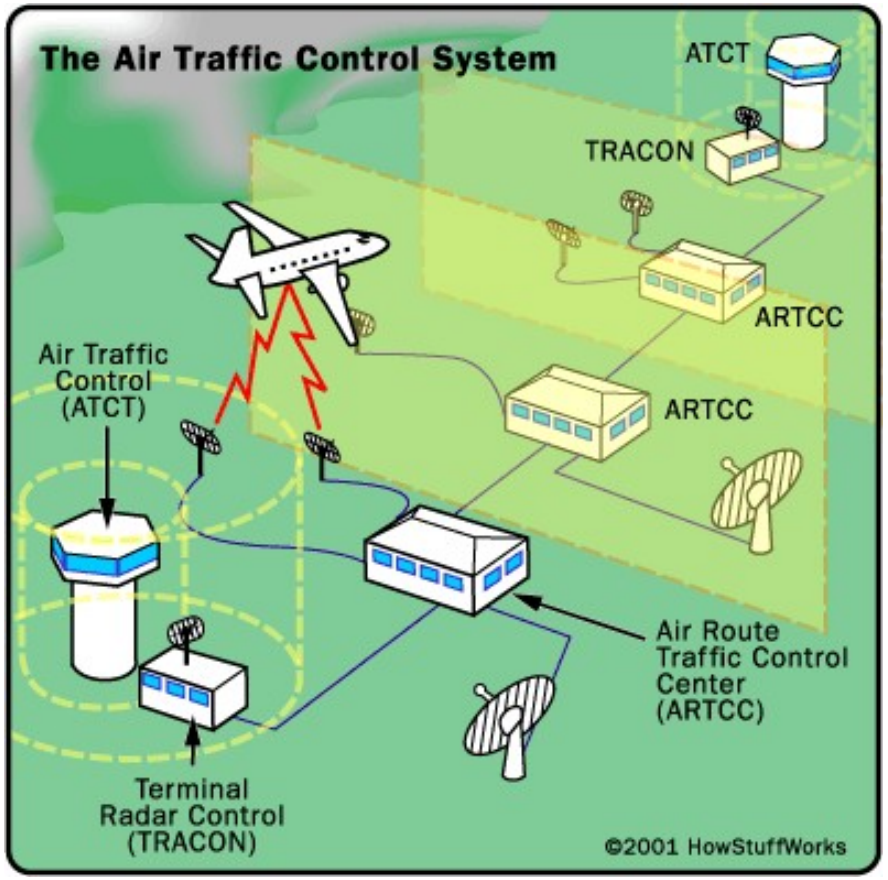
Air Traffic Control (ATC)

- So how does it all work together?
- Let's follow a flight from takeoff to landing

En route: ARTCC

Ground: ATCT
Takeoff: TRACON

Landing: TRACON
Ground: ATCT



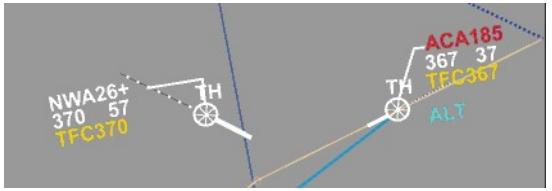
ARTCC Information

ARTCC Traffic Separation

- Separation of IFR traffic and Safety Alerts
- VFR separation is work-load permitting only
- Flow control restrictions help regulate traffic at busy airports (based on arrival rates)
- Free flight is operational in Alaska, Hawaii with 2000 aircraft
- Enroute IFR Traffic Separation – speed reduction, route change, radar vectoring, etc.
- Pilot Responsibilities – must file IFR is WX are below minimums

Additional ARTCC Services

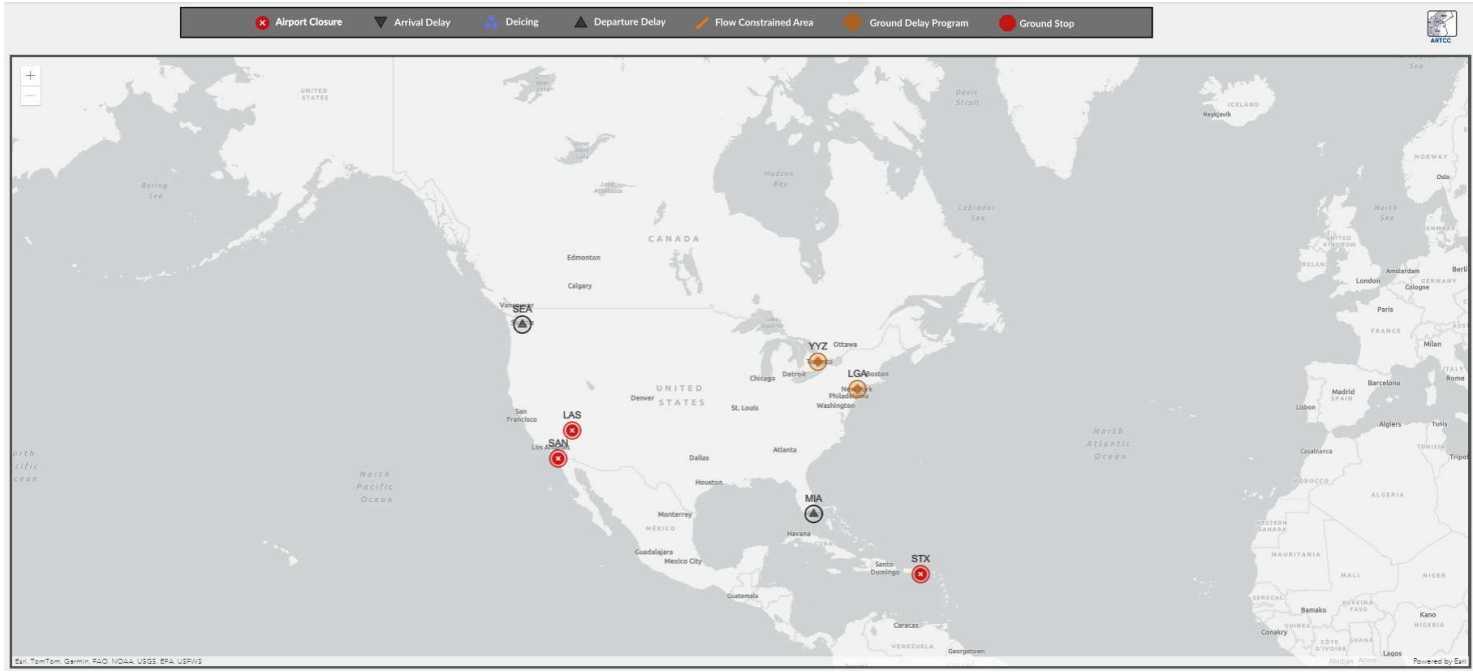
- Separation from other traffic – IFR in VMC is see and avoid
- Weather Information – significant WX and CWA – Center Weather Advisories
- Safety Alerts
  - Terrain and obstruction alerts
  - Aircraft Conflict Alerts



- Emergency Assistance
  - On IFR flights you are always in communication with ATC

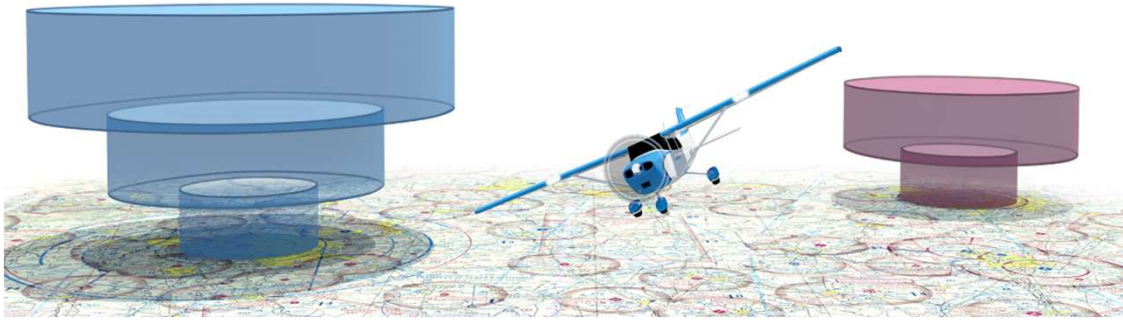
Flow Control

- Dependent on Airport Arrival Rates (AAR)
    - The number of aircraft an airport can handle per hour
- Ground Delay Programs
- Airspace Flow Programs
- Ground Stops
- Expect Departure Clearance Times (EDCTs)
- https://nasstatus.faa.gov/



Pilot Responsibilities

- Even when operating on an IFR flight plan - When flying in VMC Pilots still must see and avoid
- Minimum Vectoring Altitude vs Minimum Safe Altitudes
    - https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/mva_mia/mva/
- Maintain situational awareness
- Question any clearances which may jeopardize safety of flight
- Question any clearances of aircraft around you which may create a hazard
- As a pilot - you are a line of defense in ensuring the safety of the National Airspace System



Terminal Facilities

ATIS – Automatic Terminal Information Services (124.6 MHz)

- Continuous recorded WX and airport information
- For example on frequency 124.6 MHz, Hanscom Information “Charlie”

Clearance Delivery (121.85 MHz)

- Provides IFR clearance before taxi and contacting Ground

Ground (121.7 MHz) and Control Tower (118.5 MHz)

- Provides safe flow of traffic on ground (movement areas) and in vicinity of airport
- Clearance required when tower is operational

Approach and Departure (124.4 MHz)

- Provides coordination with ARTCC, transition from terminal to enroute, Class D, C, B

Radar Services for VFR and FSS

Flight Service Station (FSS)

Provides information (weather, route, terrain, flight plan) for pilots flying into and out of small airports and rural areas. It assists pilots in emergencies and coordinates search-and-rescue operations for missing or overdue aircraft.

Class C

Radar service mandatory for VFR and IFR traffic separation, must establish two-way radio communications, sequencing of all arrivals

Class B

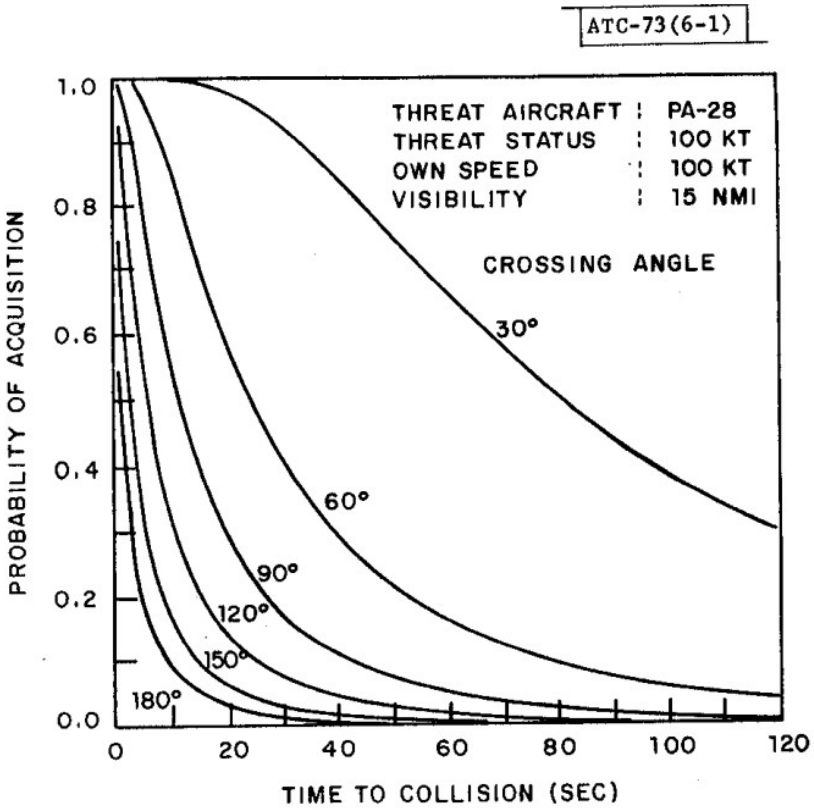
Requires specific ATC clearance, radar service mandatory for VFR and IFR traffic separation, Mode C transponder, sequencing of traffic provided

VFR Traffic Advisories

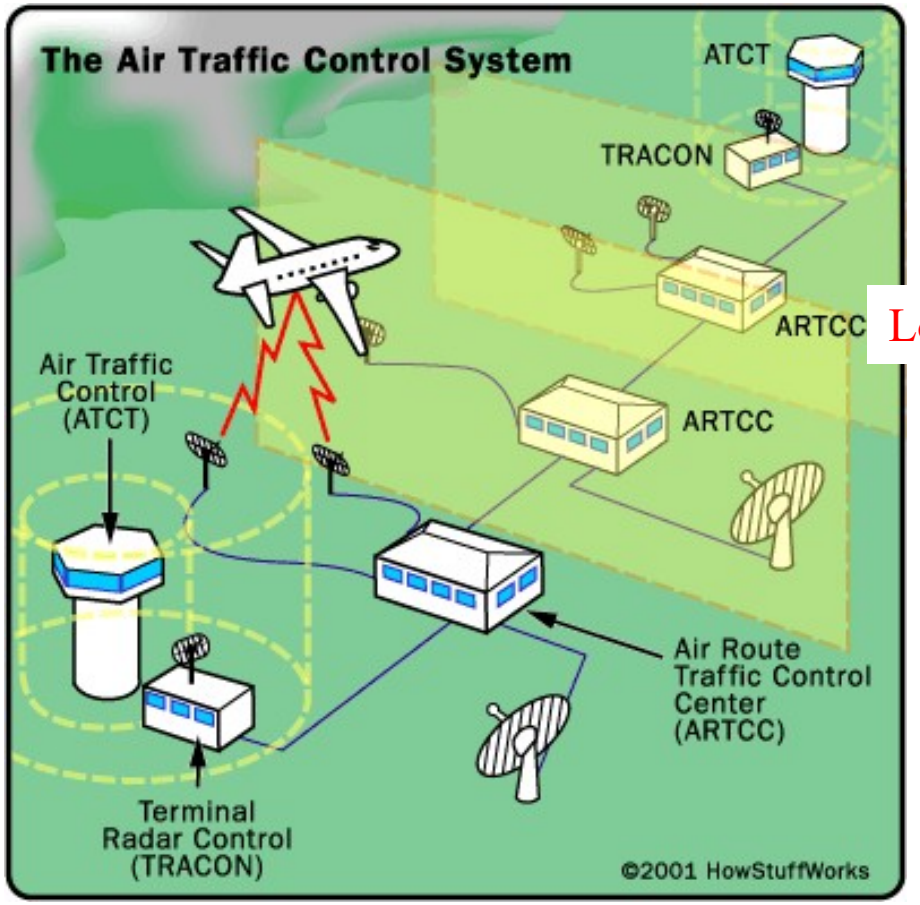
ATC provides azimuth and altitude advisories of traffic in vicinity of your aircraft

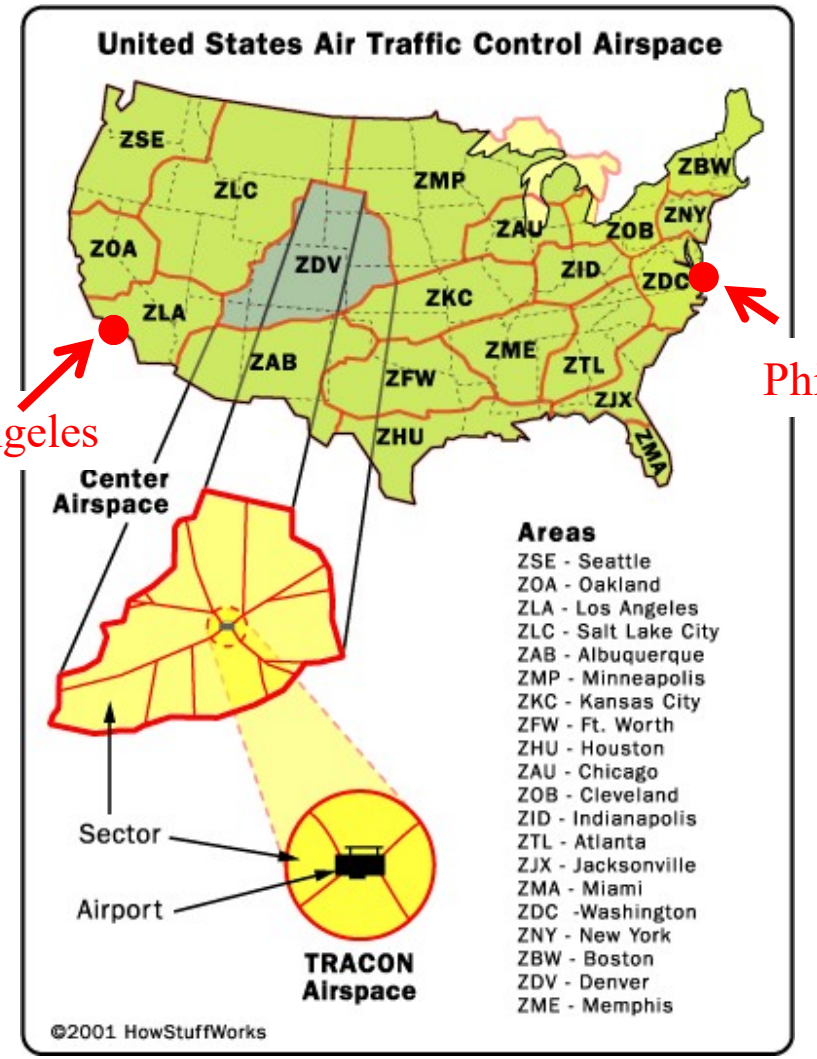
Human Performance Limitations

- Humans tend to see moving targets very well
- Aircraft on a collision course tend to stay in a fixed field of view
- https://www.ll.mit.edu/sites/default/files/publication/doc/2018-12/Andrews_1977_ATC-73_WW-15318.pdf
    - 1977 MIT LL paper from John W. Andrews covers pilot performance limitations



Air Traffic Control Worksheet





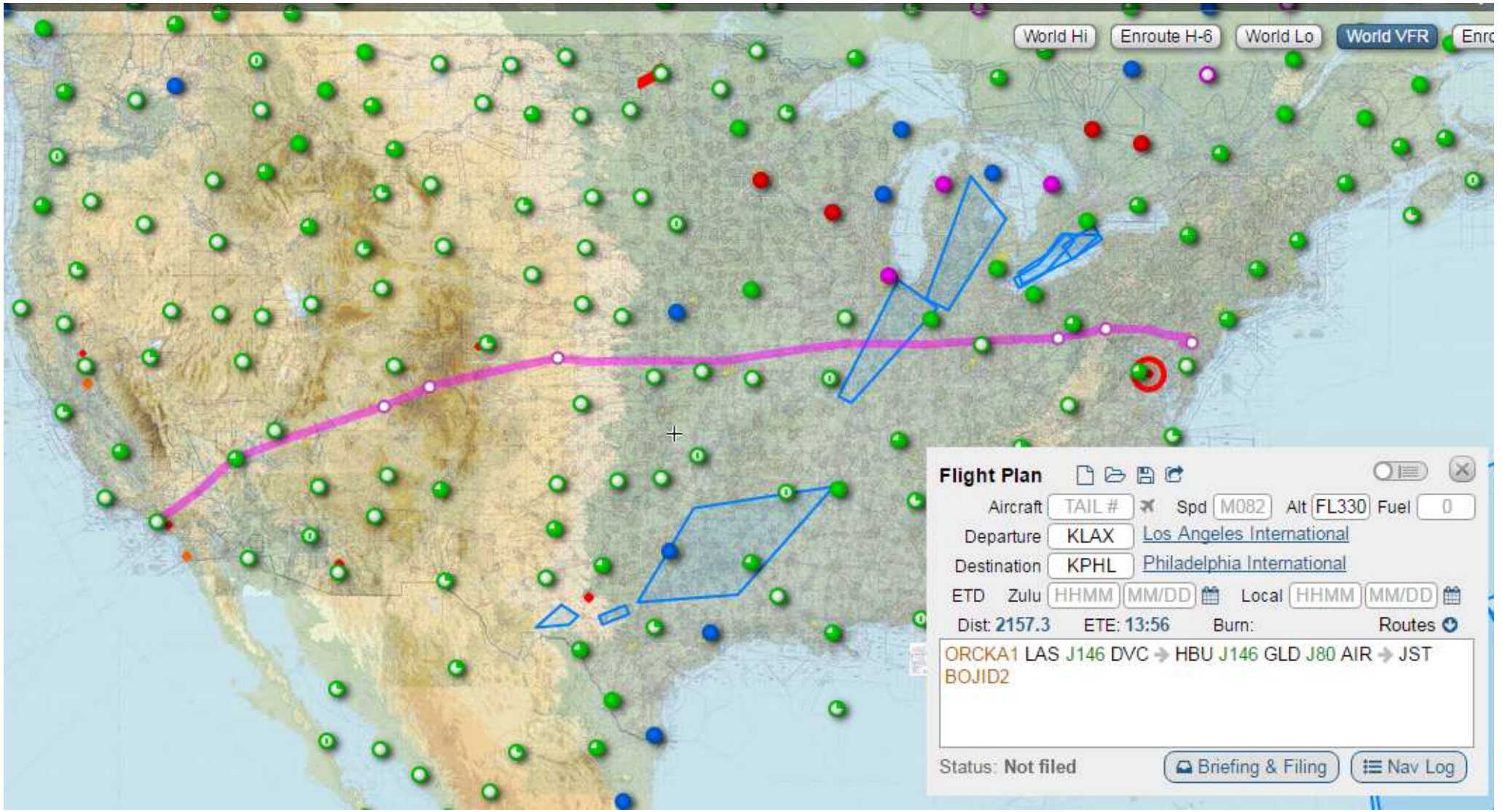
Los Angeles

Philadelphia

KLAX ORCKA1 LAS J146 DVC HBU J146 GLD J80 AIR JST BOJID2 KPHL

ARTCC – ZLA ZLC ZDV ZMP ZAU ZOB ZDC

Air Traffic Control Worksheet



KLAX ORCKA1 LAS J146 DVC HBU J146 GLD J80 AIR JST BOJID2 KPHL

ARTCC – ZLA ZLC ZDV ZMP ZAU ZOB ZDC

FAA Questions

A. What service is provided by departure control to IFR flights when operating within the outer area of Class C airspace?
    1. Separation from all aircraft
    2. Position and altitude of all traffic within 2 miles of the IFR pilot
    3. Separation from all IFR aircraft and participating VFR aircraft

B. During takeoff into IFR conditions with low ceilings, when should the pilot contact departure control?
    1. Before penetrating the clouds
    2. When advised by ATC
    3. Upon completing the first turn after takeoff on upon establishing cruise climb

C. Which service is provided for IFR arrivals by FSS located on an airport without a control tower?
    1. Automatic closing of IFR flight plans
    2. Airport advisories
    3. All functions of approach control

ATC Video Tutorials

Air Traffic Control Videos and Tutorials

What is ATC?
https://www.youtube.com/watch?v=m5KOgETF78o

Inside Air Traffic Control Towers
https://www.youtube.com/watch?v=e6BoOqwJ57w

Matt Lauer Worked In An Air Traffic Control Tower
https://www.youtube.com/watch?v=vPXKJ_9x6aU

Disclaimer

Please note that information within this presentation comes from various sources which may or may not have been validated.

Always use official FAA materials and documents for current FARs and publications.

Refer to Certified Flight Instructors for clarification and questions, as needed.