Tishk International University
Faculty of Engineering
Aviation Engineering Department

Aircraft Navigation Systems

Topic: Introduction to Aircraft Navigation Systems II

Week1 _Lecture1

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Purpose and Importance of Aircraft Navigation Systems

1. Purpose:
   1. To ensure safe and accurate aircraft positioning.
   2. To guide the aircraft along predefined routes and avoid obstacles.
   3. To assist in approach, landing, and departure phases.
2. Importance:
   1. **Safety:** Prevent collisions and maintain flight paths.
   2. **Efficiency:** Minimize fuel consumption and optimize routes.
   3. **Precision:** Enable accurate approach and landing even in poor visibility.
   4. **Situational Awareness:** Enhance pilot awareness using navigation aids.

- **Illustration Idea:** Diagram showing an aircraft in flight with GPS, radar, and other navigation systems tracking its location.

Types of Navigation Systems

1. Dead Reckoning Navigation:

1. Based on known position, speed, heading, and elapsed time.
2. Calculations assume a straight-line path but are prone to cumulative errors.

2. Radio Navigation:

1. Utilizes ground-based systems like VOR, DME, and ADF.
2. Provides accurate bearing and distance information.
3. Coverage limited by line-of-sight and terrain.

3. Satellite-Based Navigation (GNSS):

1. Global Navigation Satellite Systems like GPS, Galileo, and GLONASS.
2. Provides high accuracy, global coverage, and real-time updates.
3. Augmented by systems like WAAS for additional precision.

Illustration Idea: A flowchart showing the relationship between different navigation types.

Comparison of Navigation Types

Navigation Type	Advantages	Limitations
Dead Reckoning	Simple and independent	Cumulative errors over time
Radio Navigation	Reliable within coverage areas	Line-of-sight limitations
Satellite Navigation	Global coverage, high accuracy	Dependent on satellite signals

Discussion of Results (Based on Plot):

1.Radio Navigation:

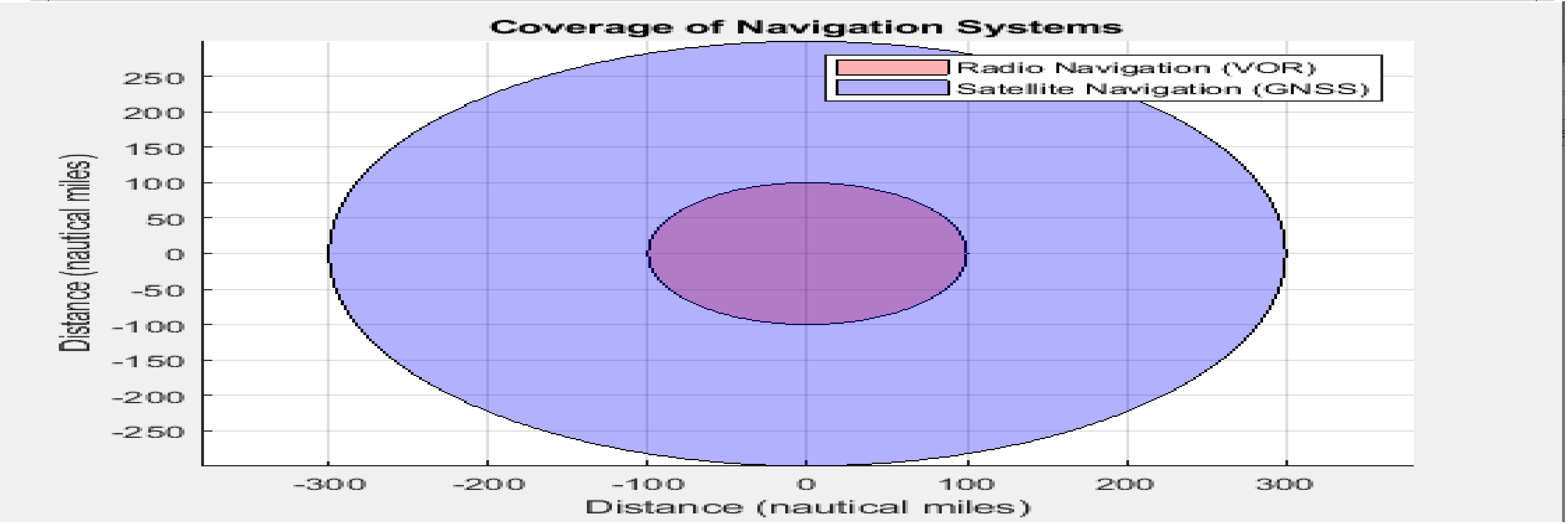
1. Smaller coverage area limited to approximately 100 nautical miles.
2. Effective for short-range navigation but relies on line-of-sight.

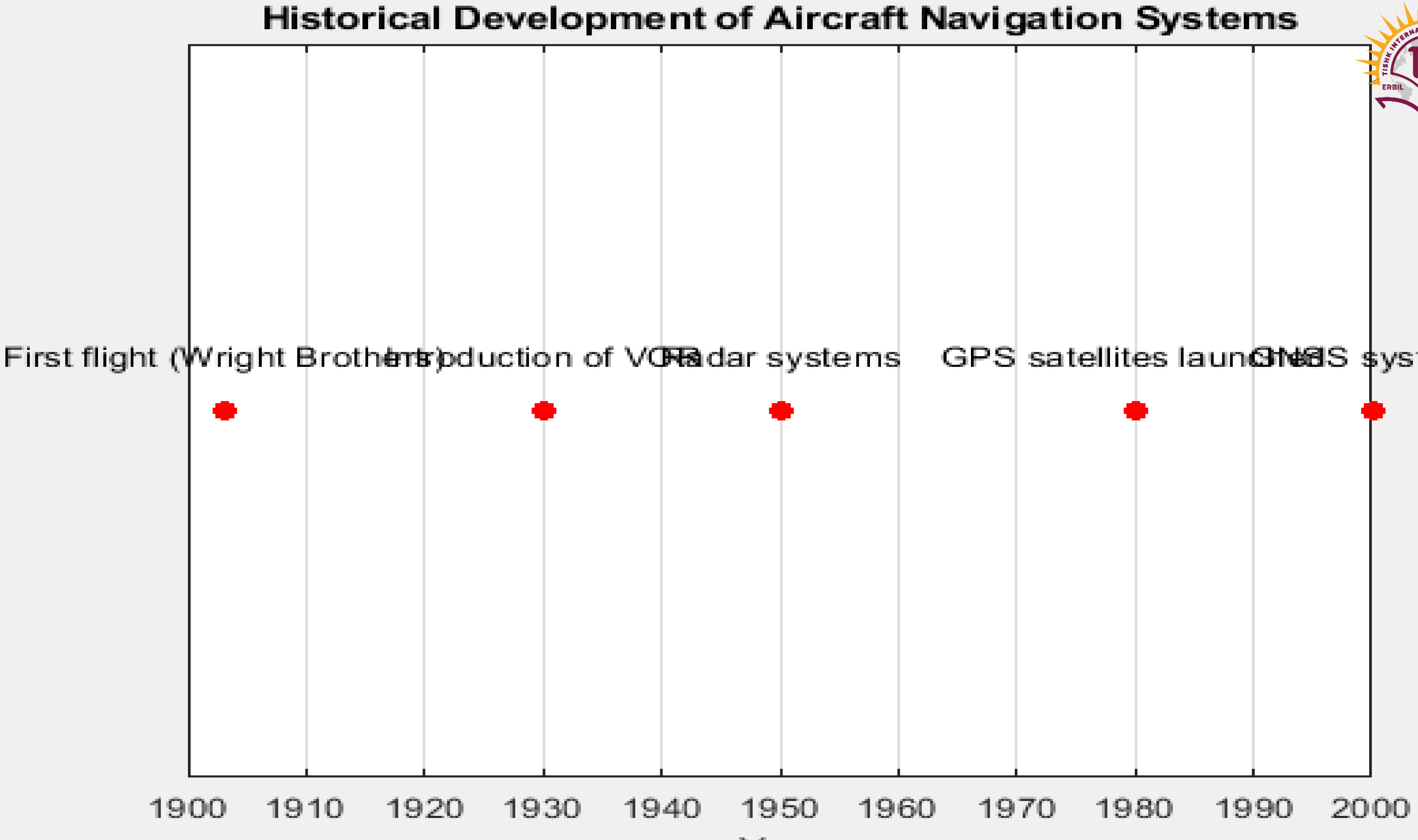
2.Satellite Navigation:

1. Larger coverage area due to the global reach of satellites.
2. Suitable for long-range flights and remote regions.

3.Conclusion:

1. Each navigation system has unique strengths, making them complementary for modern aviation.




Historical Development of Aircraft Navigation Systems
First flight (Wright Brothers)
Introduction of VOR
Radar systems
GPS satellites launched
GNSS systems
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

Key Discussion Points for the Class:

1. Historical Importance of Navigation Systems:

1. Early aircraft navigation was heavily reliant on visual cues and compass heading, which were often unreliable in poor visibility conditions.
2. The advent of radio navigation systems (like VOR and DME) in the mid-20th century revolutionized air navigation, allowing aircraft to fly more safely and accurately, even in adverse conditions.

2. Advancements in Technology:

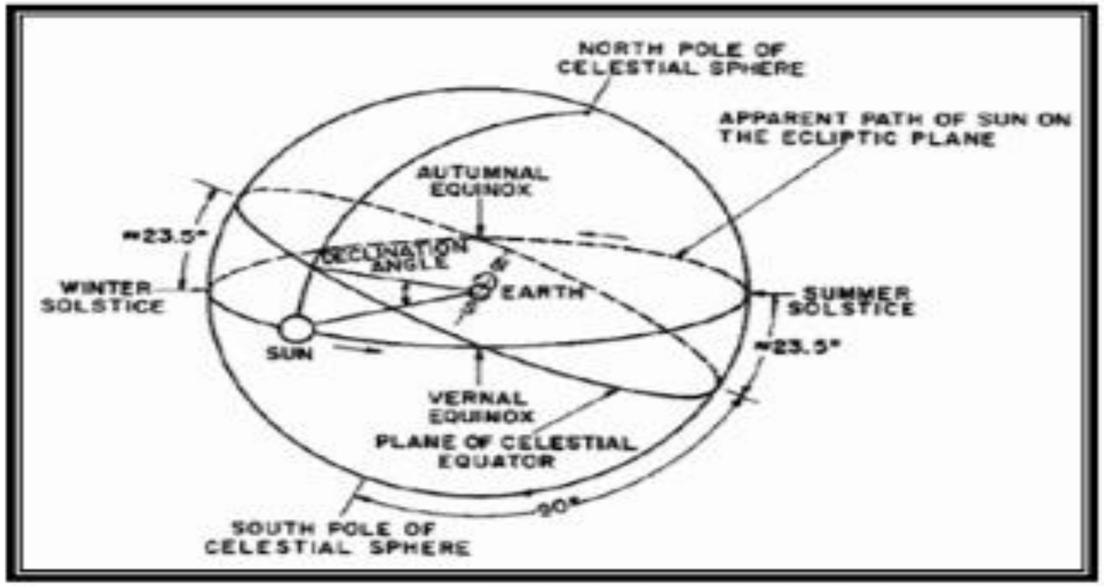
1. GPS and GNSS technologies have transformed the aviation industry, enabling aircraft to navigate with high accuracy anywhere in the world.
2. The integration of various navigation systems (GPS, INS, Radar) helps ensure redundant and accurate positioning, especially during challenging conditions such as poor weather or GPS signal loss.

3. Why Multiple Navigation Systems are Important:

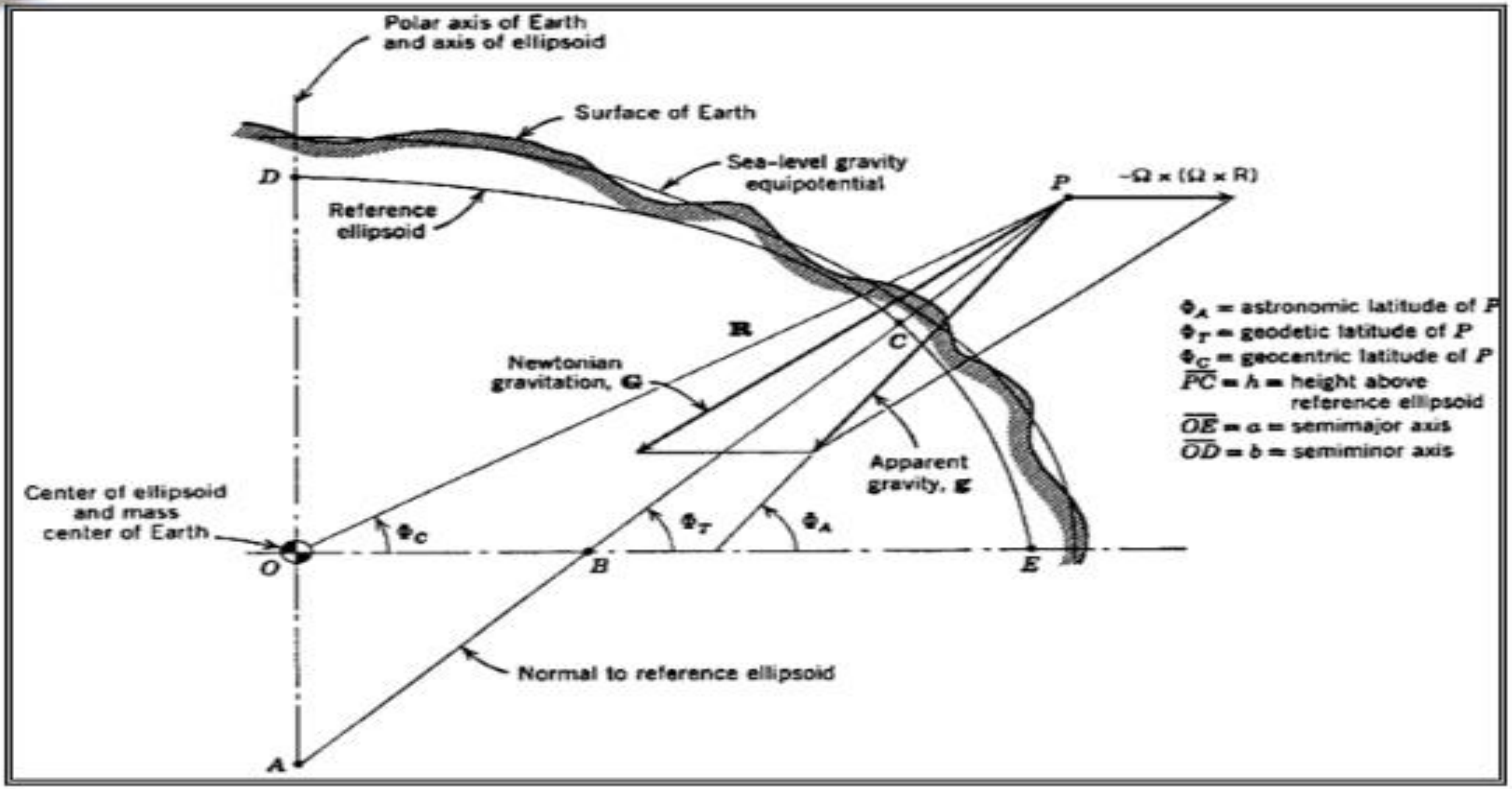
1. Modern aircraft often use a combination of systems (GPS, INS, VOR, Radar) to ensure continuous and reliable navigation.
2. Each system has strengths and weaknesses, which is why redundancy is essential in aviation safety.

Navigation: Geometry of The Earth

- For navigational purposes, the earth's surface can be represented by an ellipsoid of rotation around the Earth's spin axis
- The size & shape of the best-fitting ellipsoid is chosen to match the sea-level equal-potential surface.



Geometry of The Earth

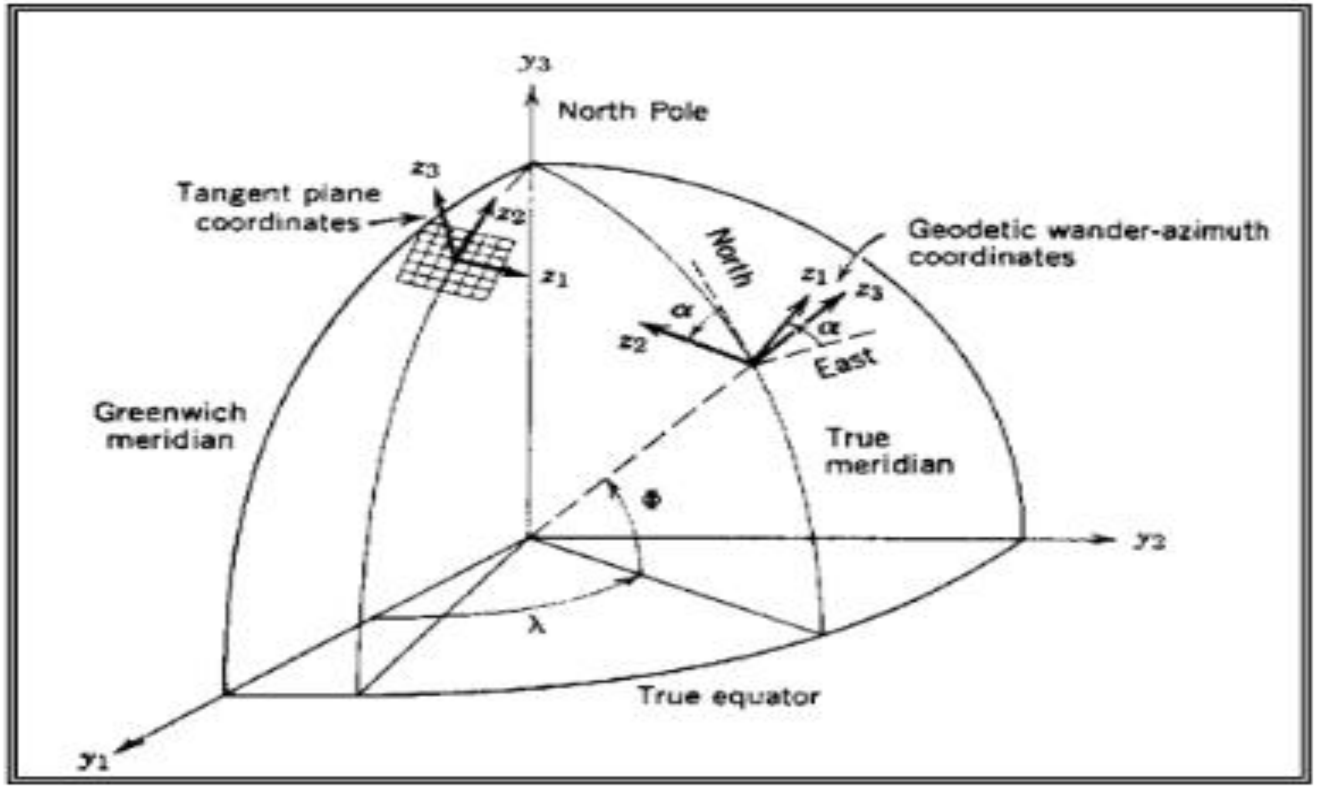


Median section of the earth, showing the reference ellipsoid & gravity field

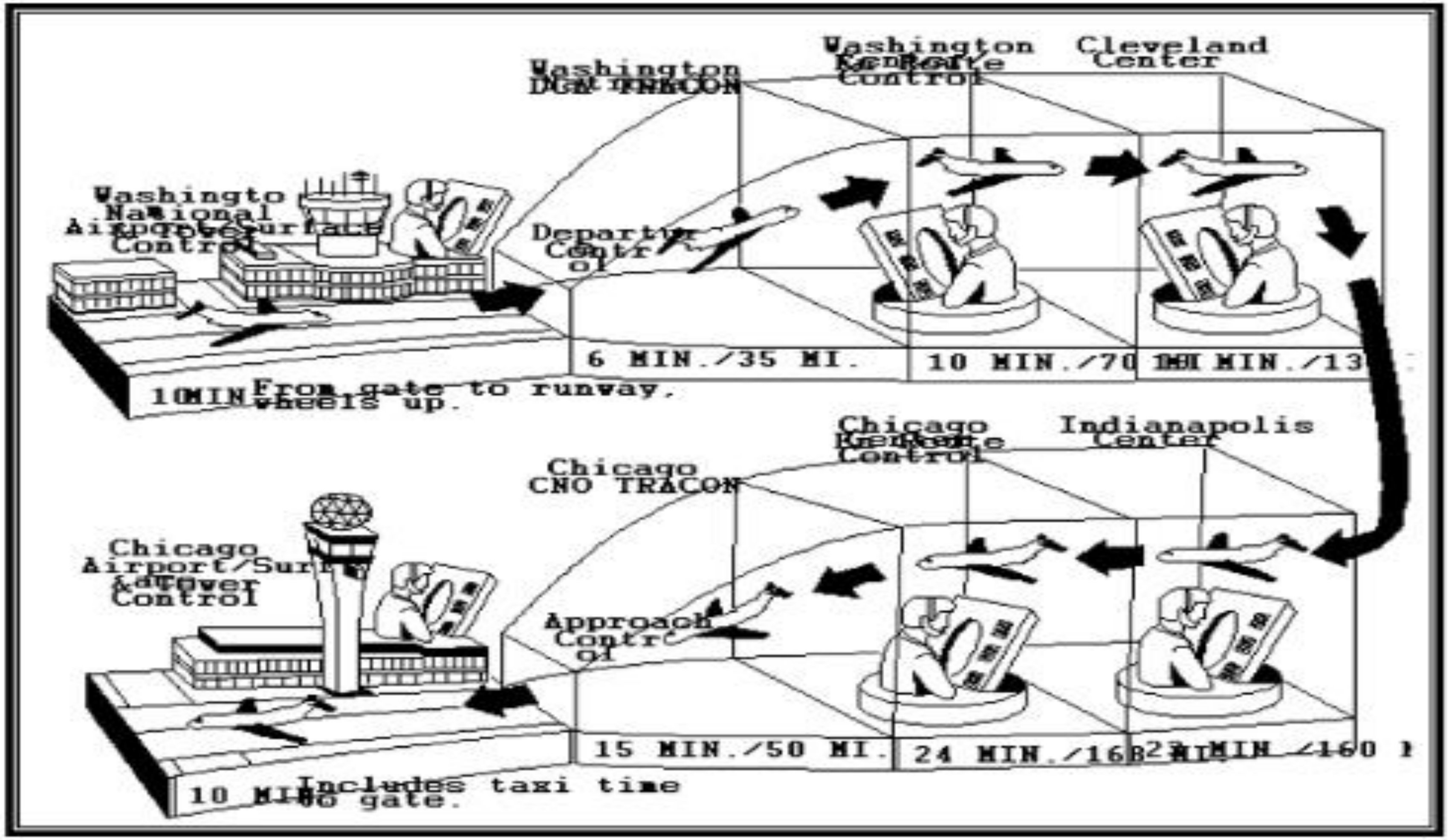
Coordinate Frames

- The position, velocity and attitude of the aircraft must be expressed in a coordinate frame: WGS-84

Navigation coordinate frame

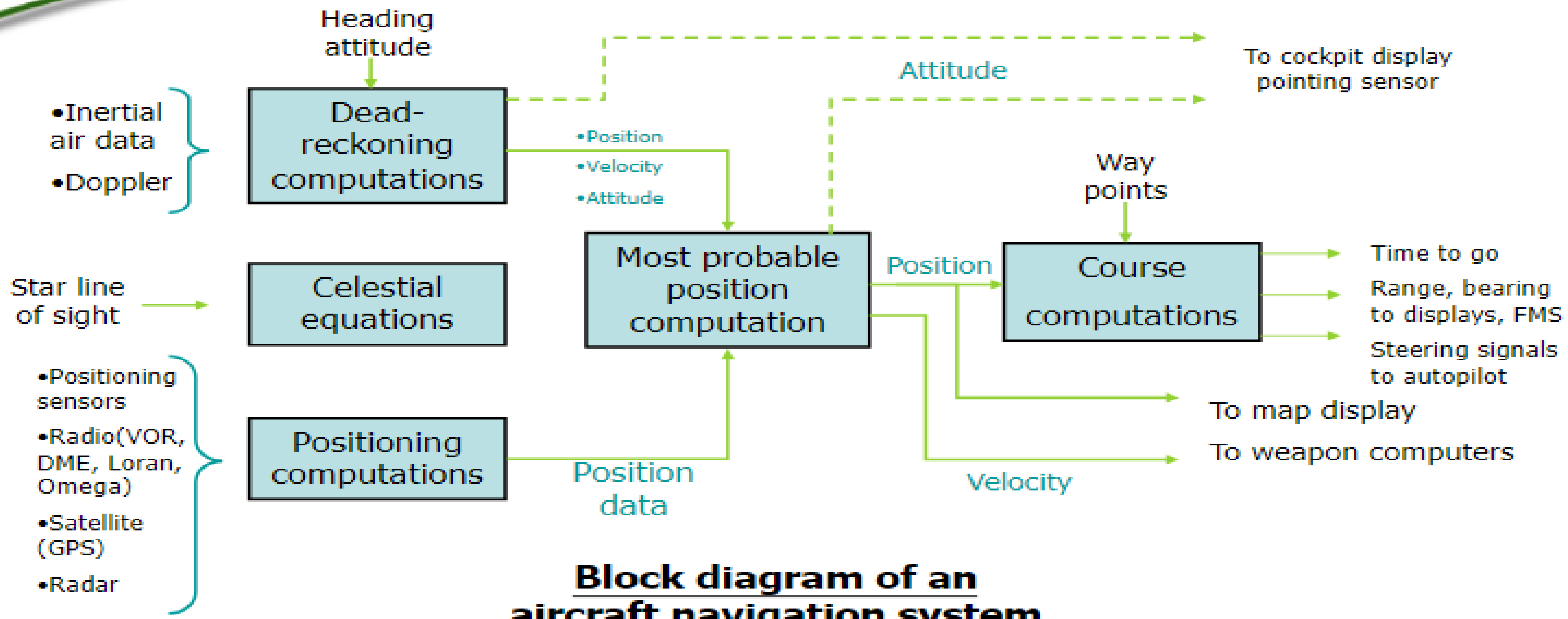


Navigation Phases



Picture courtesy of MITRE Corporation

Aircraft System Hierarchy



Block diagram of an aircraft navigation system

Terminal Area Navigation

1. *Departure:* begins from maneuvering out the runway, ends when acft leaves the terminal-control area
2. *Approach:* acft enters the terminal area, ends when it intercepts the landing aid at an approach fix

- Standard Instrument Departure (SIDs) & Standard Terminal Approach Route (STARs)
- Vertical navigation→ Barometric sensors
- Heading vectors → Assigned by traffic controller

En Route Navigation

- Leads from the origin to the destination and alternate destinations
- Airways are defined by navaids over the land and by lat/long over water fixes
- The width of airways and their lateral separation depends on the quality of the navigation system
- From 1990s use of GPS has allowed precise navigation
- In the US en-route navigation error must be less than 2.8 nm over land & 12 nm over ocean

Approach Navigation

- Begins at acquisition of the landing aid until the airport is in sight or the acrft is on the runway, depending on the capabilities of the landing aid
- *Decision height (DH):* altitude above the runway at which the approach must be aborted if the runway is not in sight
  - The better the landing aids, the lower the the DH
  - DHs are published for each runway at each airport
  - An acrft executing a non precision approach must abort if the runway is not visible at the minimum descent altitude (typically=700 ft above the runway)

Landing Navigation

- Begins at the DH ends when the acrf exits the runway
- Navigation may be visual or navigational set's may be coupled to a autopilot
- A radio altimeter measures the height of the main landing gear above the runway for guiding the flare
- The rollout is guided by the landing aid (e.g. the ILS localizer)

Missed Approach

- Is initiated at the pilot's option or at the traffic controller's request, typically because of poor visibility. And alignment with the runway
- The flight path and altitude profile are published
- Consists of a climb to a predetermined holding fix at which the acrf awaits further instructions
- Terminal area navaids are used


Thank You!