OVERVIEW OF GNSS

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Contents

Objective

- To get an overview of the Global Navigation Satellite System (GNSS)

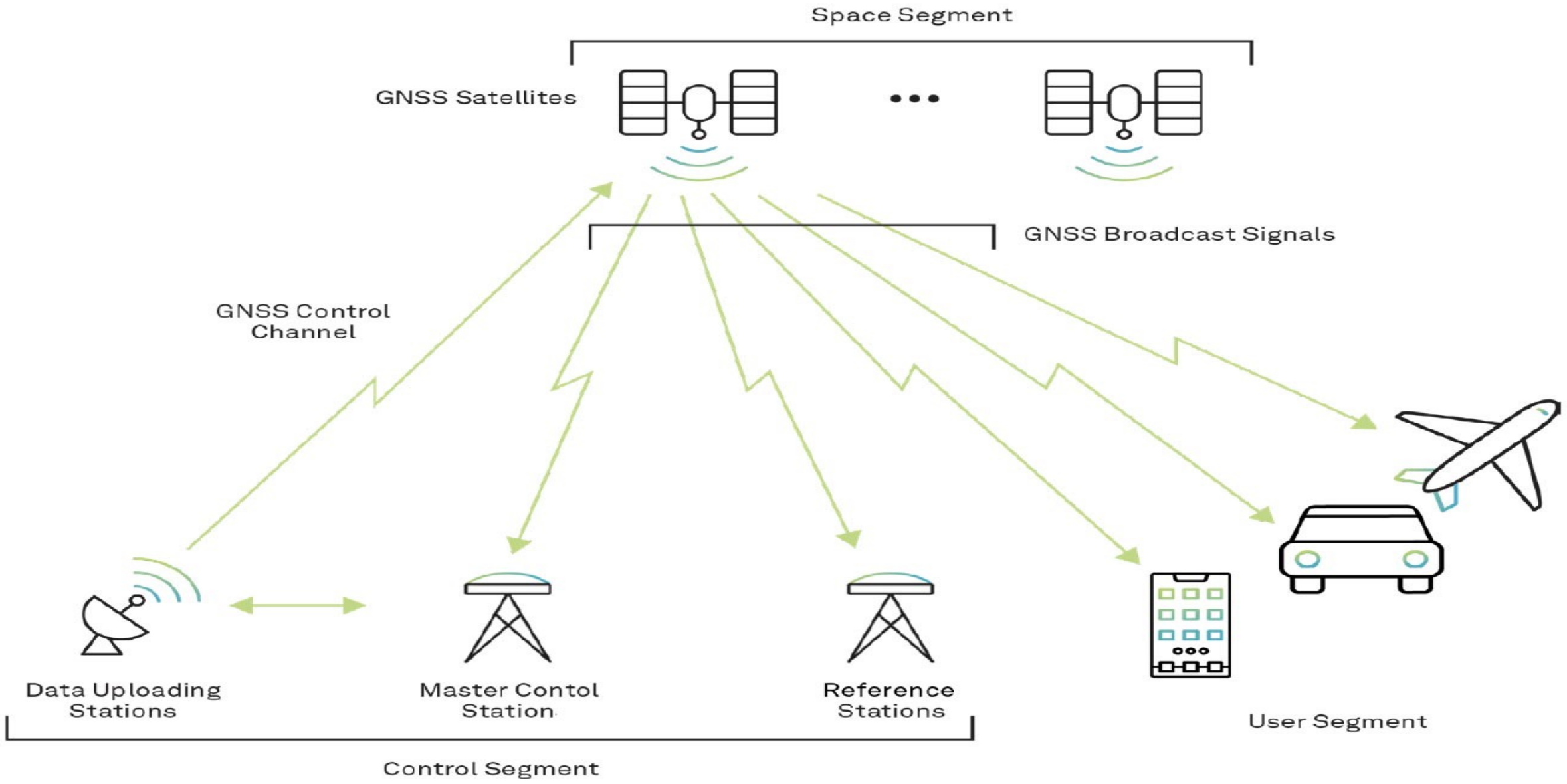
Introduction

- Navigation:Routes, Airways ,compass, Navaids and Satellite use
- Air navigation:determination of Aircraft position and direction.
- Separation: horizontal and vertical, Pilot and ATS situation awareness
- Traffic and Capacity balance- FANS , digitized and Satellite application
- Global Navigation Satellite System (GNSS): global coverage.
- GNSS1: First generation GPS and its augmentation systems
- GNSS2: Later constellations, GLONASS, Galileo etc

GNSS Bands

- GPS: L1 – 1575.42 MHz, L2 – 1227.60 MHz and L5 – 1176.45 MHz
- GLONASS:L1 – 1602.0 MHz, L2 – 1246.0 MHz and L3 – 1202.025 MHz
- Galileo:E1 – 1575.42 MHz, E5a – 1176.45 MHz, E5b – 1207.14 MHz and E6 – 1278.75 MHz
- BeiDou:E1 – 1575.42 MHz, E2 – 1561.098 MHz, E5B – 1207.14 MHz and E6 – 1268.52 MHz
- Varying (and sometimes overlapping) frequencies used by the different GNSS constellations, signal information modulated onto the carrier frequency in many different ways.

GNSS SUMMARY



GNSS Components

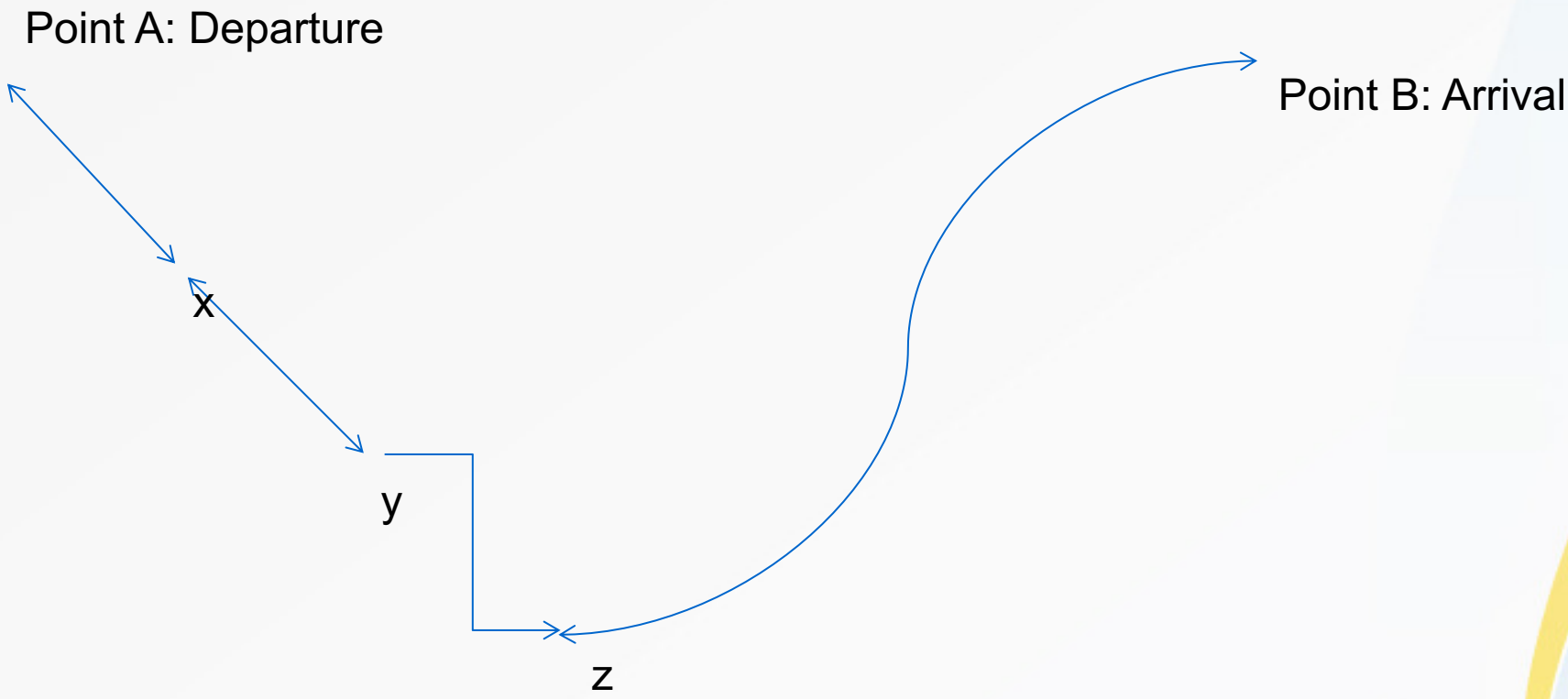
- Constellation of satellites dedicated to aviation using safety of life frequency bands initial plan but forced to use available ones.
- GNSS used for Positioning, Navigation, and Timing (PNT) and gets signals from GPS, GLONASS, GALILEO and BeiDou.
- Each GNSS constellation comprises a number of satellites transmitting signals from space to receivers globally.
- 18–30 Medium Earth orbit (MEO) satellites arranged in equally spaced planes, with at least four satellites available to every receiver at any time.
- Receiver calculates time to a high precision and stations around the equator control, monitor, track and maintain the satellites.

GNSS Performance

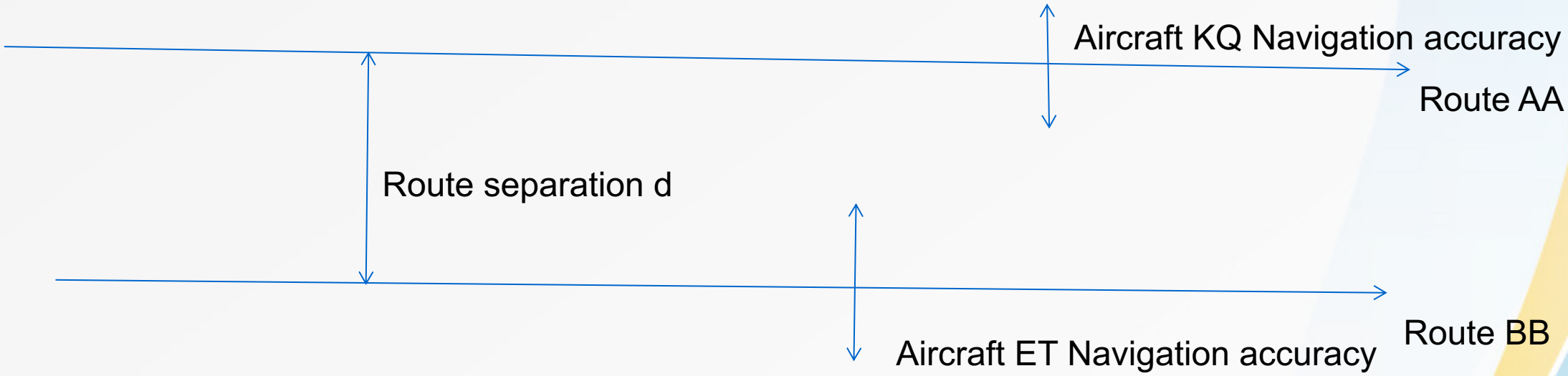
- Accuracy: Measures how factual the actual position, speed, or time are compared to that measured by the GNSS.
- Integrity: Describes the system’s ability to give confidence in the data it provides and to raise alarm when abnormal information is recorded.
- Continuity: GNSS’s capacity to provide continuous information without disruptions.
- Availability: % of how often the signals from that system fulfill the other three criteria
- Terrestrial Navigation systems require manual plotting of the intersection of signals on a map to determine an aircraft's location.
- Modern systems calculate the position automatically and display it to the flight crew on moving map displays and use WGS-84 coordinates as reference.

Routes and Airways

- Travel from point A to B: Departure, Enroute and Arrival phases
- Need coordinates, based on waypointsA, x, y ,z and B, whose coordinates are defined by either ground sensors or satellites.



PBN or Conventional Routes



ATS Routes

- GNSS based: Performance Based Navigation (PBN), separation narrower increasing Capacity (maximum number of Aircraft that can be accomodated at a time) in Airspace or Airport.
- PBN is a decision-making method based on accuracy, integrity and continuity, Avionics technology and ATS route or procedure designated independent of selected navigation means (GNSS or ground sensors) .
- Allow for narrower separation of adjacent routes designated RNAV X or RNP X e.g. RNAV 5, RNAV 1, RNP 1: “X” is the lateral navigation accuracy in NM, expected to be achieved, at least 95 % of the flight time by the operating Aircraft.
- Designation 1 requires Aircraft to be within 1 NM of vertically of the route centre line and includes all flight crew and airborne navigation system requirements.
- RNP requires monitorig and alarm system on Aircraft to alert Pilot in case of deviations.

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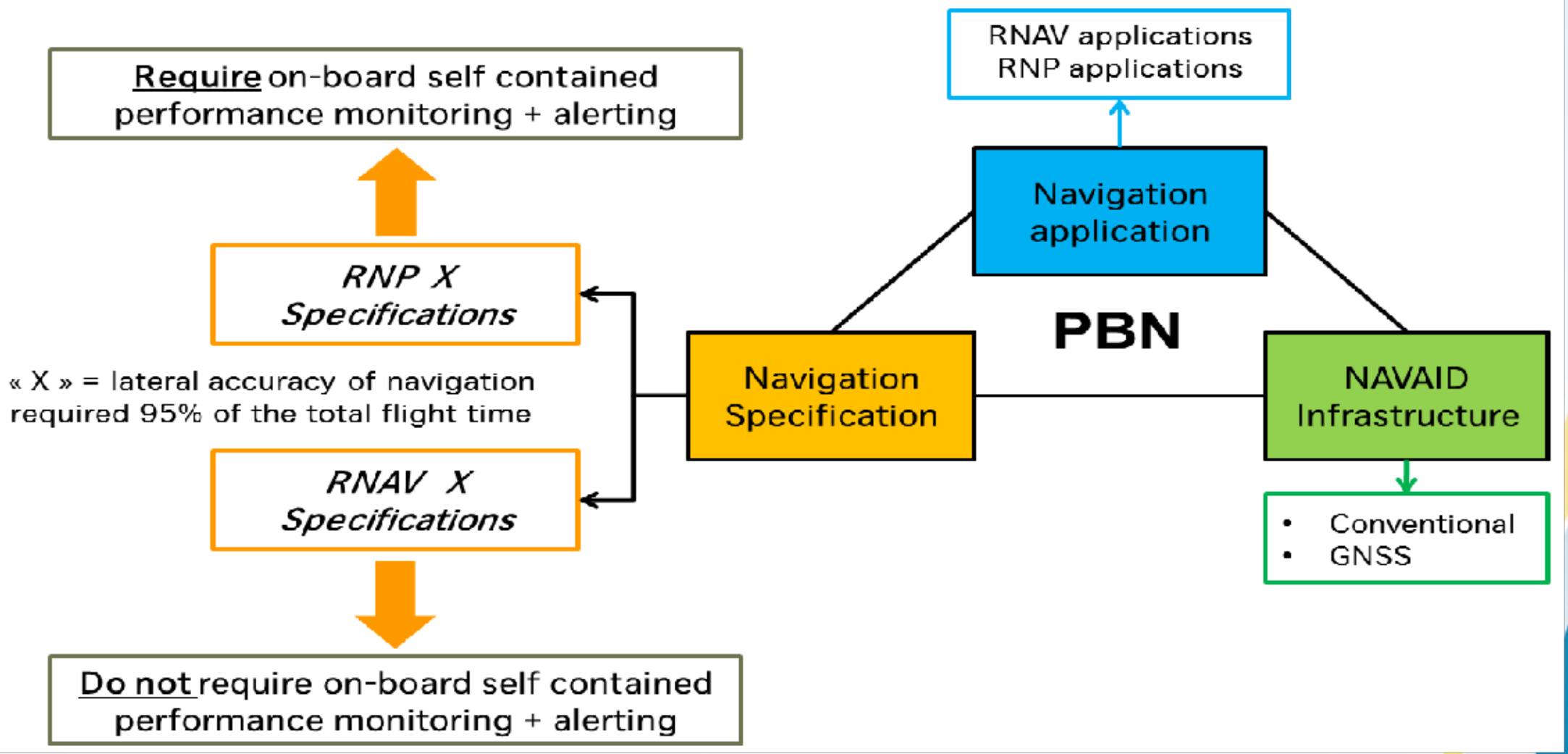
PBN, RNAV and RNP



Aircraft Based Augmentation System (ABAS)

- The discontinuation of use of GPS selective availability (SA) by USA resulted in an immediate improvement of GPS accuracy.
- Aircraft Autonomous Integrity Monitoring (AAIM) uses on-board sensors to provide GPS data integrity and Integration of GNSS with other sensors for improved aircraft navigation.
- Receiver Autonomous Integrity Monitoring (RAIM) requires a minimum of five visible satellites to perform fault detection of the presence of an unacceptably large position error for a given mode of flight.
- Fault Detection and exclusion (FDE) uses a minimum of six satellites to detect a faulty satellite and exclude it from the navigation solution so that navigation can continue uninterupted.
- A barometric altimeter reduces by one the ranging sources for RAIM and FDE when there are enough visible satellites for non precision approach operations.
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ABAS

- The average RAIM availability for 24-satellite GPS constellation is 99.99 per cent for en-route and 99.7 per cent non-precision approach operations for receivers that cannot take advantage of the SA discontinuation.
- Receivers that can take advantage of the SA discontinuation has availability of 100 per cent for en-route and 99.998 per cent for non-precision approach operations.
- FDE availability ranges from 99.8 per cent for en-route to 89.5 per cent for non-precision approach operations without SA factor and 99.92 per cent for en-route and 99.1 per cent for non-precision approach operations with SA discontinuation factor.

Satellite Based Augmentation System (SBAS)

- SBAS is a network of ground reference stations that provide satellite clock, ephemeris and signal propagation corrections via geostationary satellites, based on satellite observation from multiple reference locations.
- These data is relayed to a central processing facility, which assesses signal validity and computes corrections to the broadcast information and clock of each satellite and estimate the errors in the broadcast parameters and satellite clock, and then broadcasts the corrections.
- Integrity messages and corrections for each monitored ranging source are broadcast on the GPS frequency from SBAS satellites by providing ranging signals similar to GPS ;
- SBAS messages ensure integrity, improve availability, and provide the performance needed for Approach Procedures with vertical guidance (APV)-similar to ILS Cat 1.

SBAS

- The most widely used SBAS systems are the “wide area augmentation system” (WAAS) in the United States, the “European geostationary navigation overlay service” (EGNOS) in Europe, and the “Multi-functional Satellite Augmentation System” (MSAS) in Japan.
- The main limitation of SBAS is that the individual systems are not global but only cover specific areas. They provide precise differential corrections.
- A State may obtain SBAS service by either cooperating with an SBAS service provider whose coverage includes the State or by developing its own SBAS.

Ground Based Augmentation System (GBAS)

- GBAS will support Category I operations and the provision of GBAS positioning service in the terminal areas covered.
- It uses VHF data broadcast (VDB) to aircraft within the nominal range of 37 km (20 NM) in the approach area, when supporting Category I operations
- Single GBAS ground installation may provide guidance for up to 49 precision approaches within its VDB coverage, serving several runways and more than one aerodrome.
- It has the potential to support precision approach operations down to Categories II and III and some surface movement operations.
- The ground facility monitors GNSS signals at an aerodrome and broadcasts locally relevant integrity messages, pseudorange corrections and approach data within the range, depending upon intended operations, when providing positioning service.
- GBAS can also provide corrections for the SBAS ranging signal.

CONCLUSIONS

- GNSS provides Aviation with solutions to the Capacity and Traffic balance required by increasing capacity in airspace
- It enables use of Satellite based services for all phases of flight navigation besides marine and road transport.
- Augmentation by ABAS, SBAS and GBAS improves the signal's accuracy, integrity, continuity and availability to meet set ICAO SARPS for the relevant phase of flight.
- The only shortcoming is that for the moment non Aeronautical satellite systems are used for the provision of safety of life services.
- ICAO has a strategic vision of GNSS constellations operating on safety of life frequency bands.

References

- ICAO GNSS manual doc 9849
- ICAO Annex 10 Vol1 Aeronautical Telecommunications
- ICAO Doc 4444 Procedures for Air Traffic Management

Thank you.