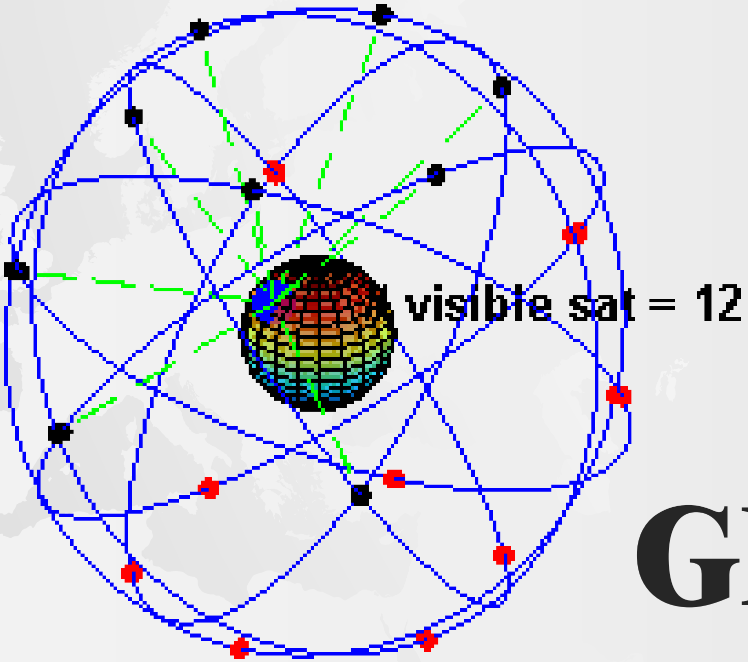

GBAS FOR ATCO

June 2017

民航處
Civil Aviation Department

Disclaimer

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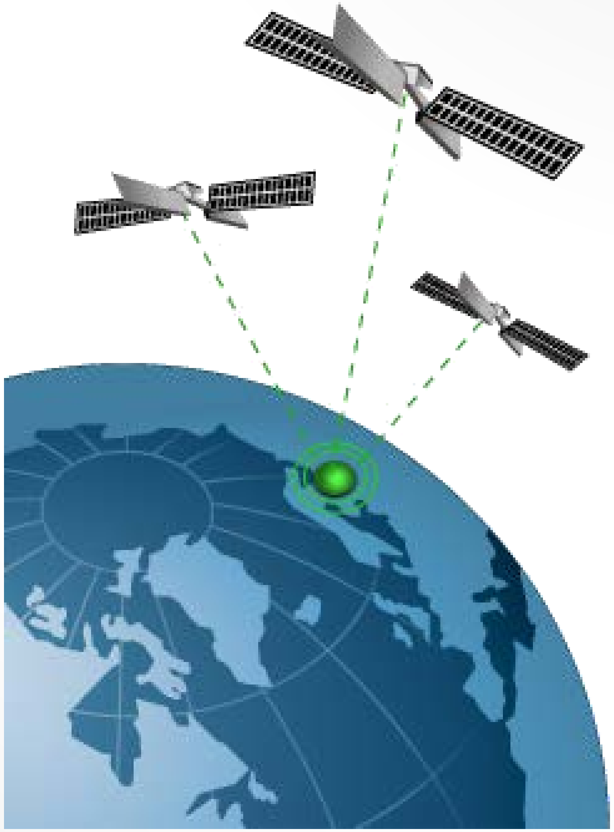
CONTENT

- Review the Basis of GNSS
- GBAS Operational Overview
- Advantages of GBAS
- Info for ATCO
- Q&A

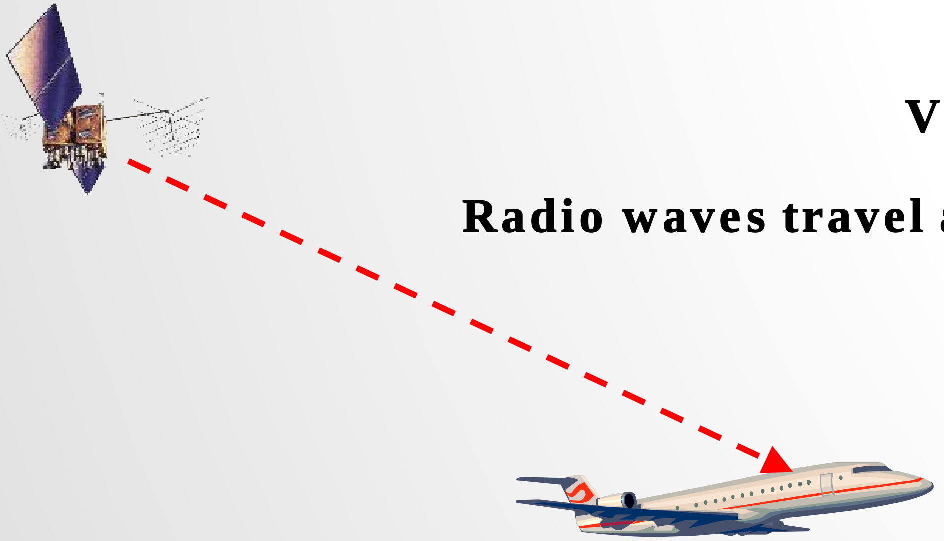
BASIS OF GNSS - 1

Time Difference

The GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is.

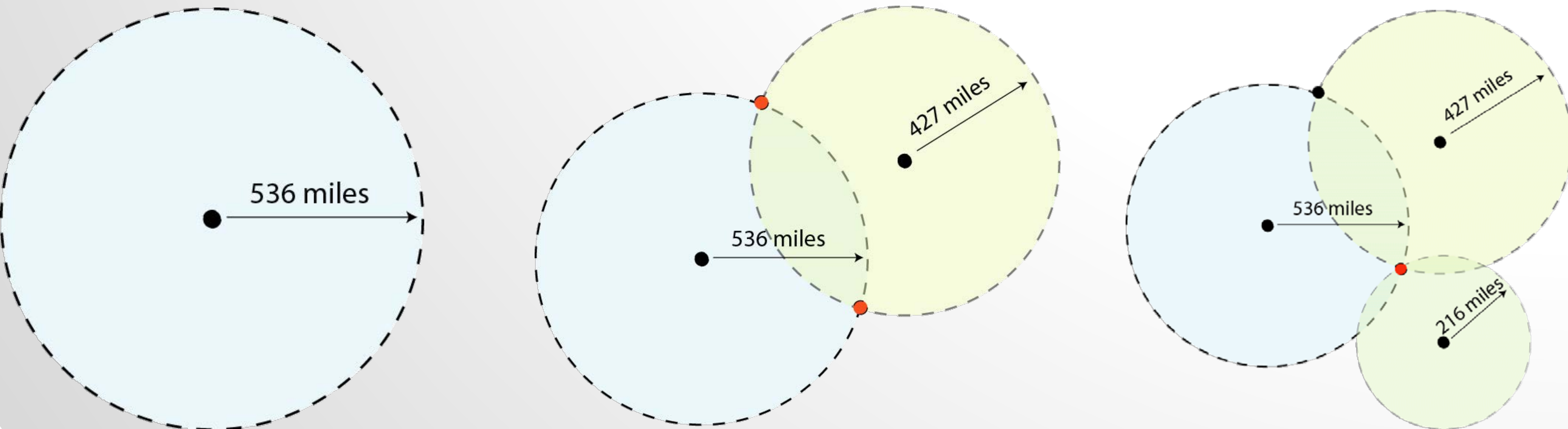


BASIS OF GNSS - 2



Velocity x Time = Distance

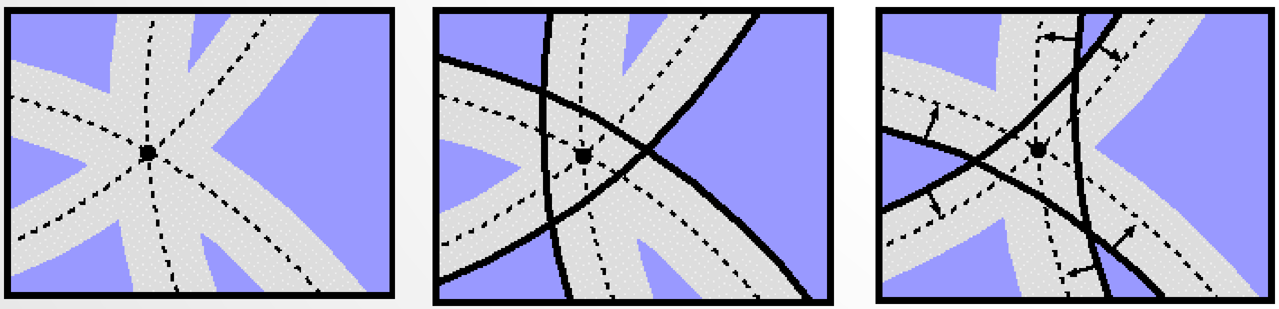
Radio waves travel at the speed of light, roughly 186,000 miles per second (mps)



BASIS OF GNSS - 2

ATOMIC CLOCKS

GPS satellites use Atomic Clocks for accuracy, but because of the expense, most GPS receivers do not.



Solution: GPS software uses a fourth satellite to provide a cross check in the trilateration process and update the internal clock simultaneously.

BASIS OF GNSS - 3

- Satellite navigation system or satellite constellation support GNSS

  - **GPS (United States):** GPS was the first GNSS system. GPS was launched in the late 1970s by the United States Department of Defense. As of Feb., 2016 there are 32 satellites in the GPS constellation.

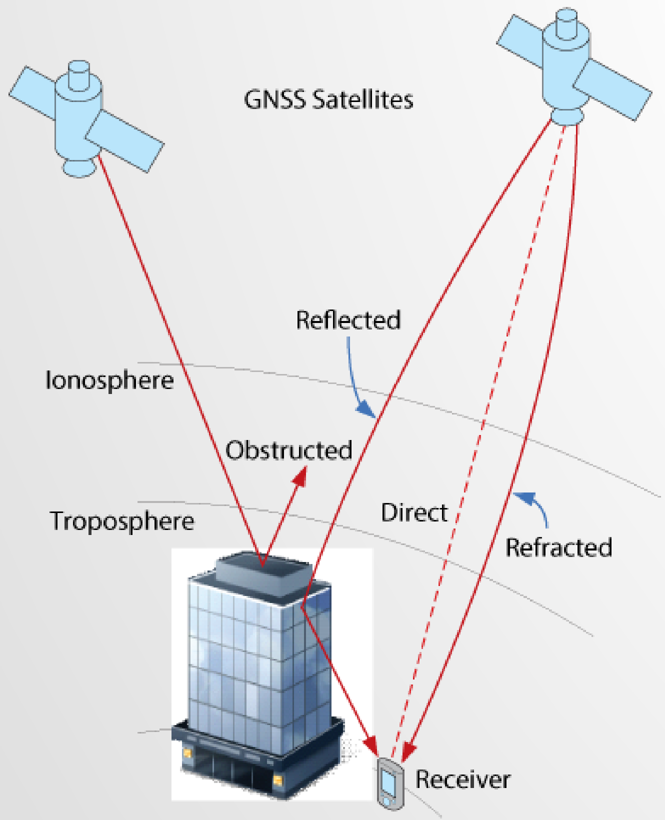
  - **GLONASS (Russia):** GLONASS is operated by the Russian government. The GLONASS constellation is officially completed in 2015 (since 1996) which consists of 24 satellites and provides global coverage.

  - **Galileo (European Union):** Galileo is a civil GNSS system operated by the European Global Navigation Satellite Systems Agency (GSA). As of December 2016 the system has 18 of 30 satellites in orbit. Galileo started offering Early Operational Capability (EOC) on 15 December 2016 and is expected to reach Full Operational Capability (FOC) in 2019. The complete 30-satellite Galileo system (24 operational and 6 active spares) is expected by 2020.

  - **BeiDou (China)**: BeiDou is the Chinese navigation satellite system. The system will consist of 35 satellites. A regional service became operational in December of 2012. As of 2016, 23 satellites were launched. BeiDou is expected to provide global coverage by end of 2020.

BASIS OF GNSS – 4

GNSS ERROR SOURCES



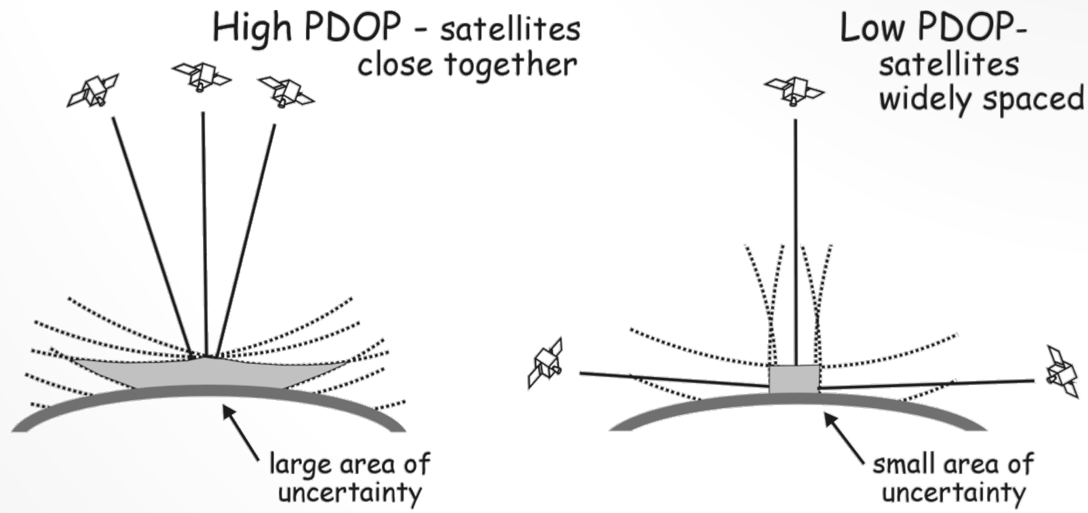


Image courtesy of www.novatel.com

BASIS OF GNSS – 4

GNSS ERROR SOURCES

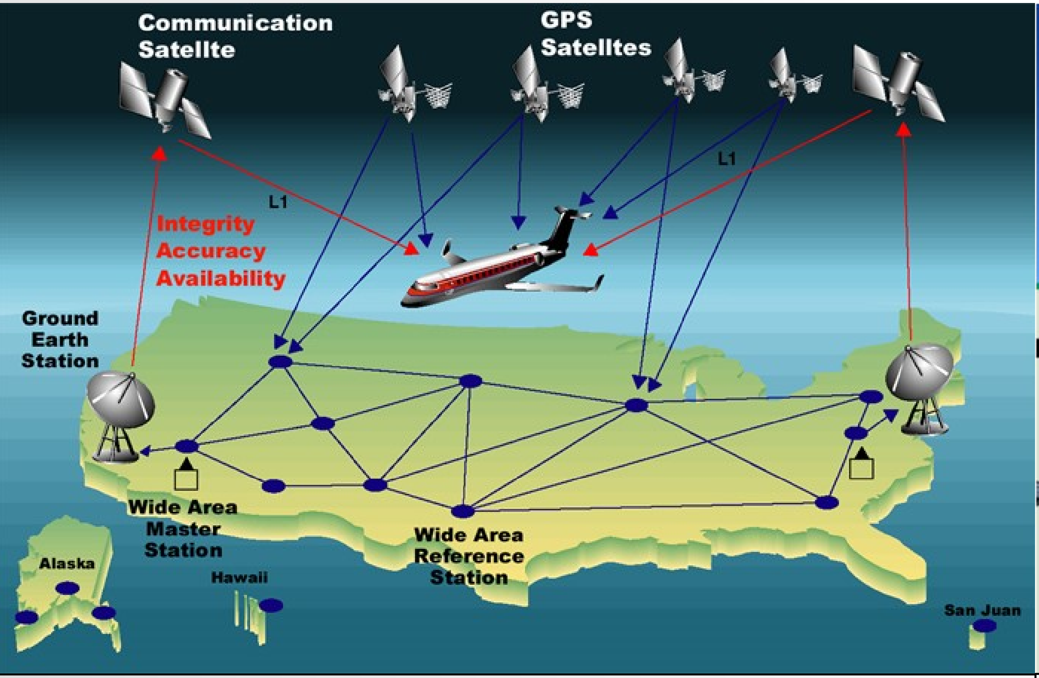
Contributing Source	Error Range
Satellite Clocks	±2 m
Orbit Errors	±2.5 m
Inospheric Delays	±5 m
Tropospheric Delays	±0.5 m
Receiver Noise	±0.3 m
Multipath	±1 m

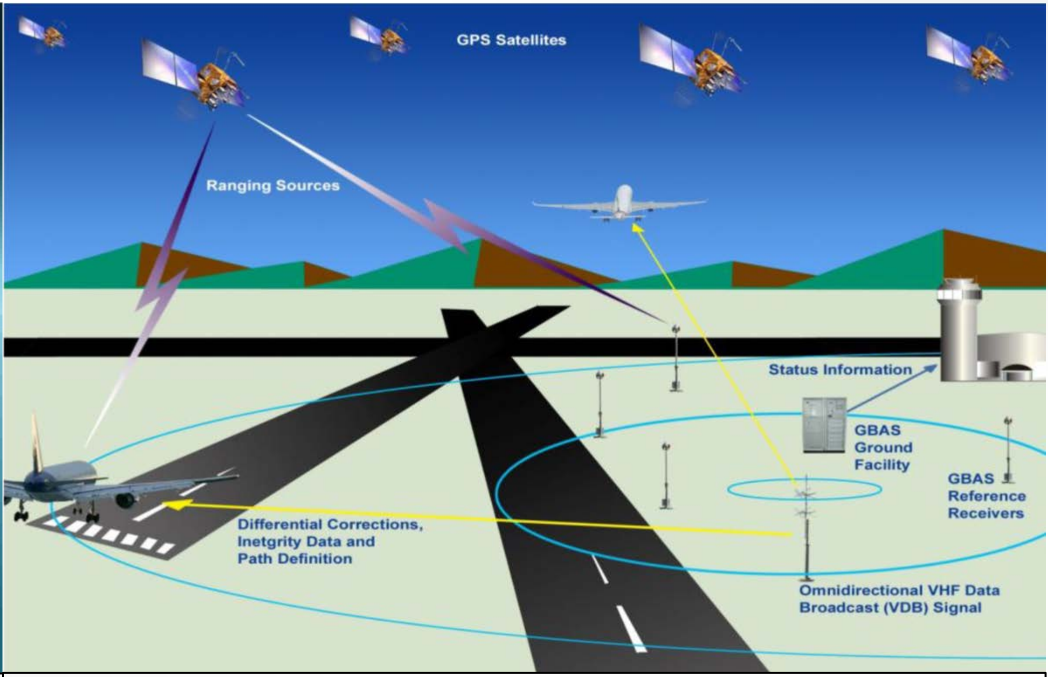
Data courtesy of www.novatel.com

BASIS OF GNSS – 5

RESOLVING THE PROBLEM

Image courtesy of FAA





Satellite Based Augmentation Systems (SBAS)

FAA-Wide Area Augmentation System (WAAS); EASA-European Geostationary Navigation Overlay Service (EGNOS); JCAB-MTSAT Satellite Based Augmentation Navigation System (MSAS); India-GPS-Aided GEO Augmented Navigation System (GAGAN); Russia-System for Differential Corrections and Monitoring (SDCM); China-SNAS (Satellite Navigation Augmentation System)

Ground Based Augmentation Systems (GBAS)

FAA-Local Area Augmentation System (LAAS); ICAO-GBAS Landing System (GLS)

BASIS OF GNSS – 5

RESOLVING THE PROBLEM

Contributing Source	Error Range
Satellite Clocks	±2 m
Orbit Errors	±2.5 m
Inospheric Delays	±5 m
Tropospheric Delays	±0.5 m
Receiver Noise	±0.3 m
Multipath	±1 m

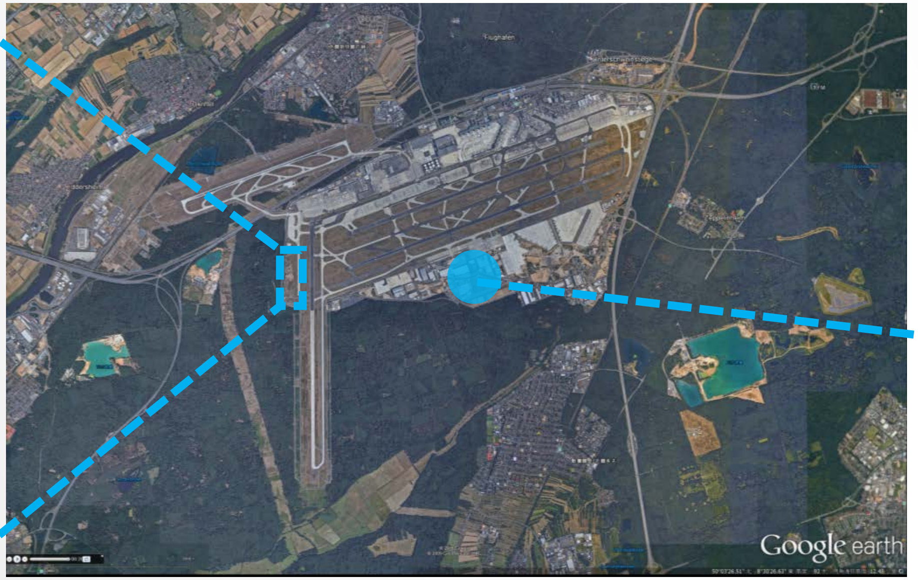
Typical error budget (in metres)

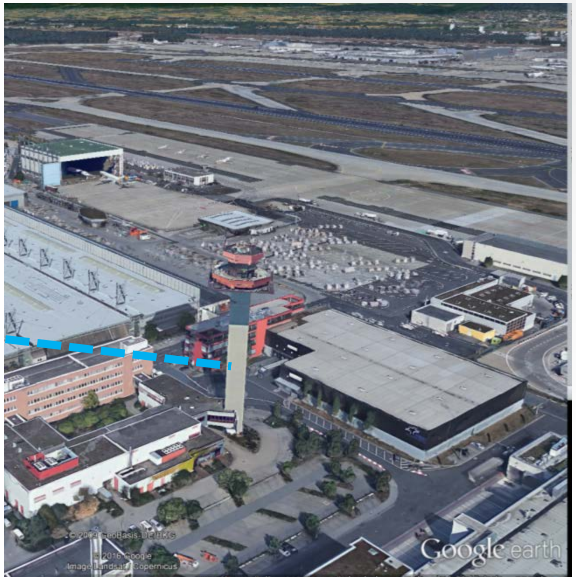
Per satellite accuracy	Standard GPS	Differential GPS
Satellite clocks	1.5	0
Orbit errors	2.5	0
Ionosphere	5.0	0.4
Troposphere	0.5	0.2
Selective availability*	30.0	0
Receiver noise	0.3	0.3
Multi-path (reflections)	0.6	0.6
Typical positioning accuracy		
Horizontal	50.0	1.3
Vertical	78.0	2.0
3D	93.0	2.8

**Note*: Selective Availability error is shown to demonstrate the effectiveness of the DGPS technique, although the Selective Availability restriction has now been removed.

Data courtesy of www.novatel.com

GBAS - OPERATIONAL OVERVIEW
LAND SECTION





Ground Facilities:

- GPS Reference Receivers (RR)
- Very High Frequency (VHF) Data Broadcast (VDB) Transmitter
- Equipment Room
- ATC Status Display

Image courtesy of Honeywell

GBAS - OPERATIONAL OVERVIEW
ONBOARD EQUIPMENT SECTION

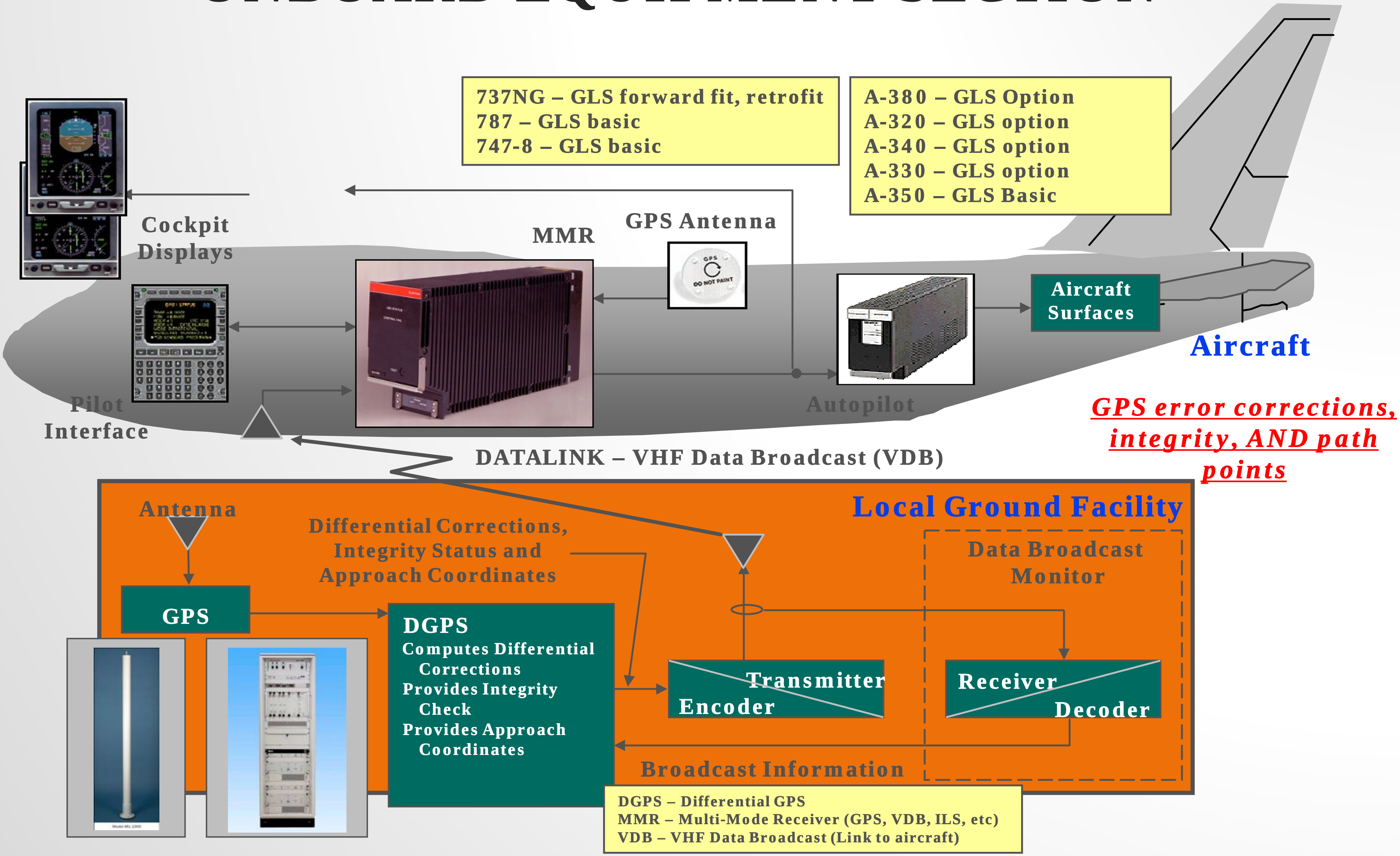


Image courtesy of Honeywell

GBAS - OPERATIONAL OVERVIEW ONBOARD EQUIPMENT SECTION

- ILS look alike
  - Glideslope
  - Localizer

737-07-XX July XX, 2007

GLOBAL POSITIONING LANDING SYSTEM (GLS) PROCEDURES

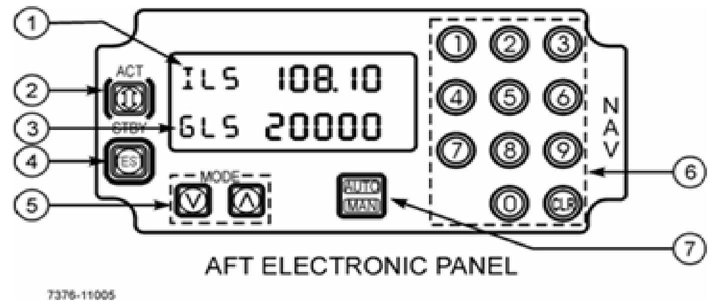
This bulletin describes aircraft systems and procedures for GLS approaches.

The initial aircraft to obtain this system will be the Continental Micronesia 737-800's. Installation will commence at the end of June, with flight procedures to begin in the fall timeframe.

The aircraft will have the following physical differences on the flight deck:

1. Multi-Mode Navigation Control Panel. This is visually identical to the panel currently installed in the 500's. The difference is the ability to select GLS frequencies.

Multi – Mode Navigation Control (If Installed)



AFT ELECTRONIC PANEL

7376-11005

- Active (ACT) Mode and Frequency Indicator

  Indicates the active mode and frequency.

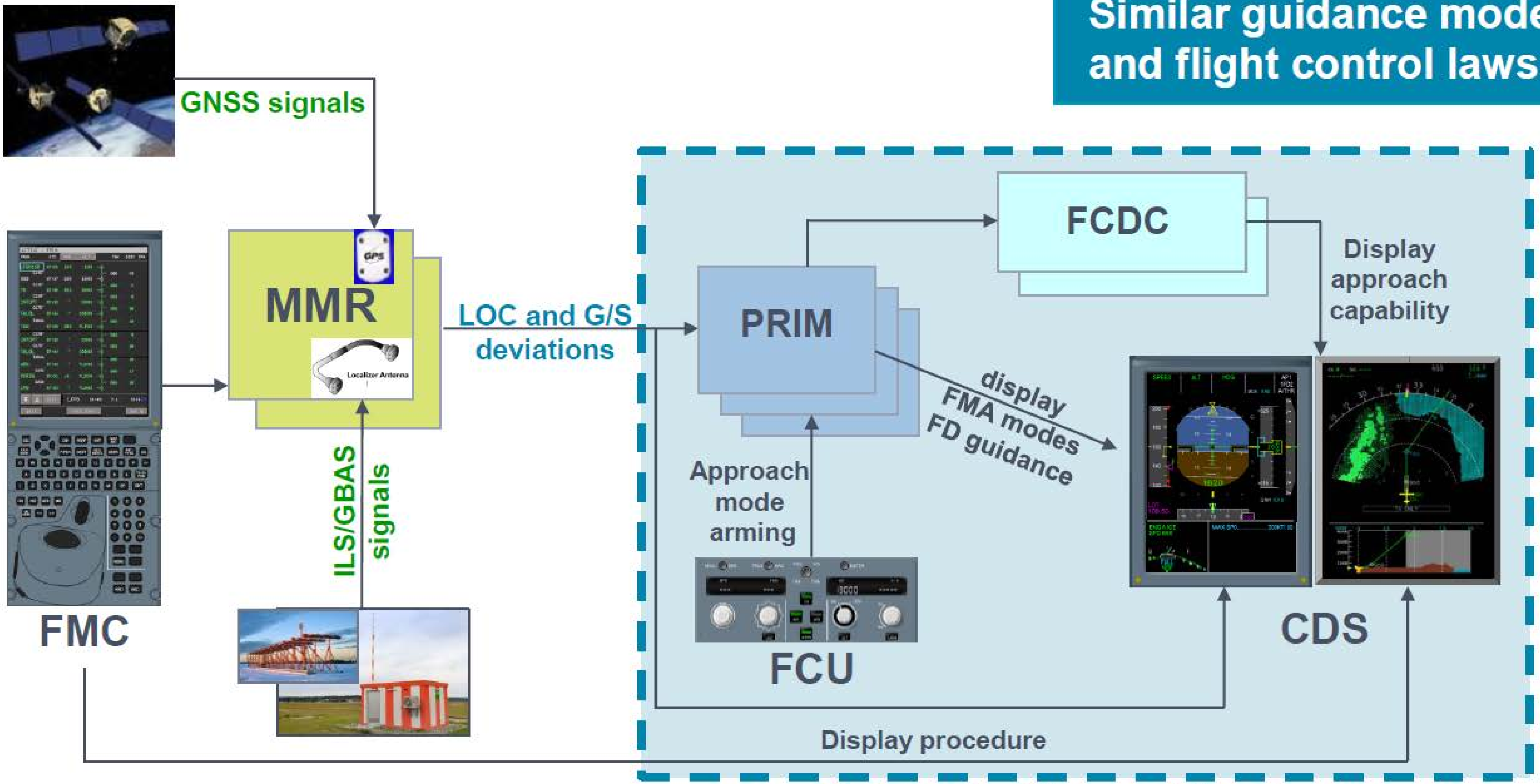
- Transfer Switch

GLS – GPS Landing System
ILS – Instrument Landing System

Image courtesy of Honeywell

GBAS - OPERATIONAL OVERVIEW
ONBOARD EQUIPMENT SECTION

ILS look-alike architecture
–
Similar guidance mode and flight control laws



ILS look-alike architecture

Image courtesy of Airbus

GBAS - OPERATIONAL OVERVIEW
ONBOARD EQUIPMENT SECTION

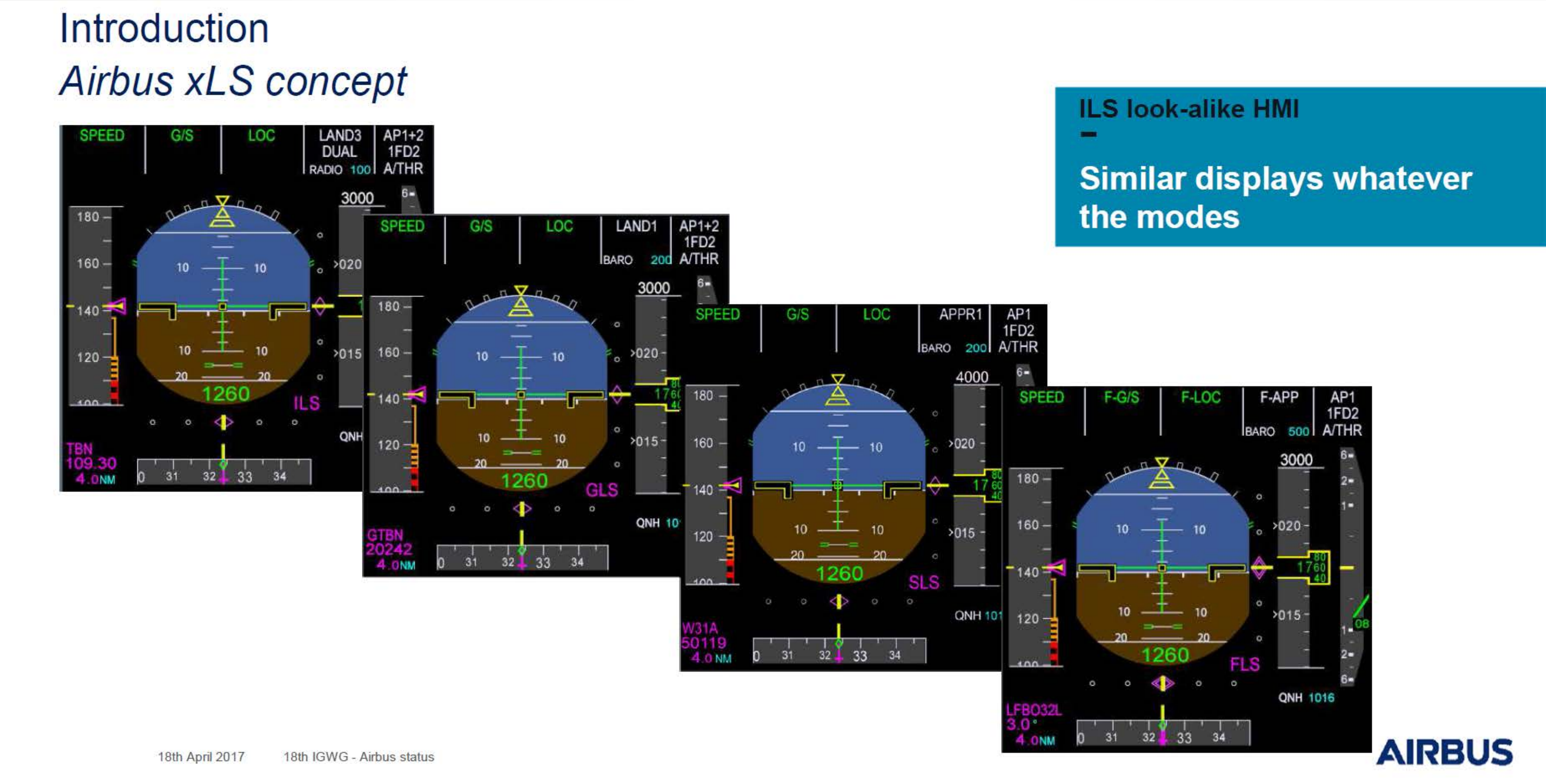


Image courtesy of Airbus

ADVANTAGES OF GBAS - GENERAL

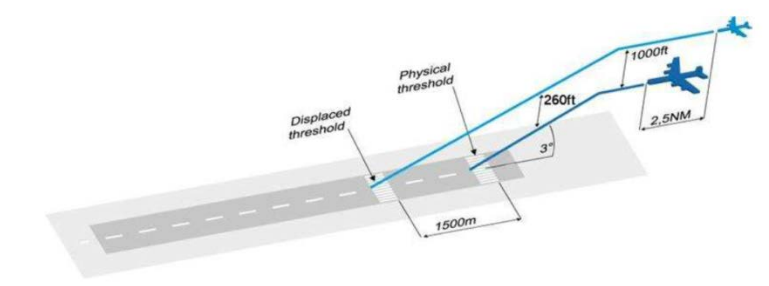
- **Increased airport capacity:** GBAS unlocks capacity constraints
  - Offers precision approach where ILS cannot due to geography
  - Relatively more flexible design criteria on approach and potentially for departure
  - Eliminates ILS sensitive/ critical area
- **Lower life-cycle cost:** GBAS is more cost efficient than ILS
  - For multiple runway, One GBAS system serves all runway ends, initial acquisition cost is lower
  - Lower maintenance cost
  - Lower flight inspection cost
- **Safety:** GBAS improves safety
  - Offers precision approach where ILS cannot due to geography
  - Signal stability (immune to signal interference inherent in ILS)
- **Reduced noise/shorter routes:** Variable glide slopes, RNAV/RNP to GLS finals
  - Airlines benefit: fuel and emission savings, increased schedule flexibility, avoid noise violations
  - Airports benefit: increased capacity and schedule flexibility, improved community relations

ADVANTAGES OF GBAS - ATC

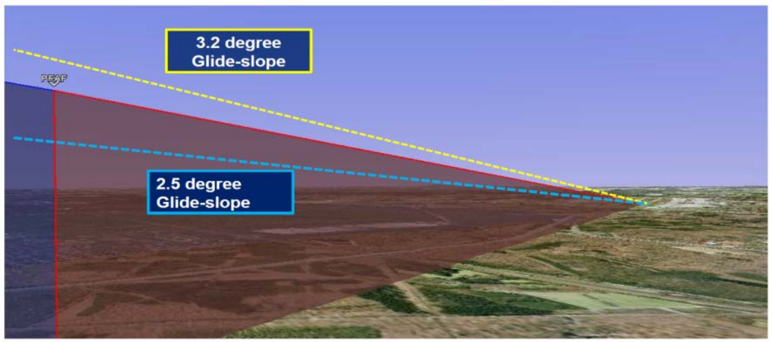
Image courtesy of Honeywell

GBAS: Programmable Touchdown Points and Path

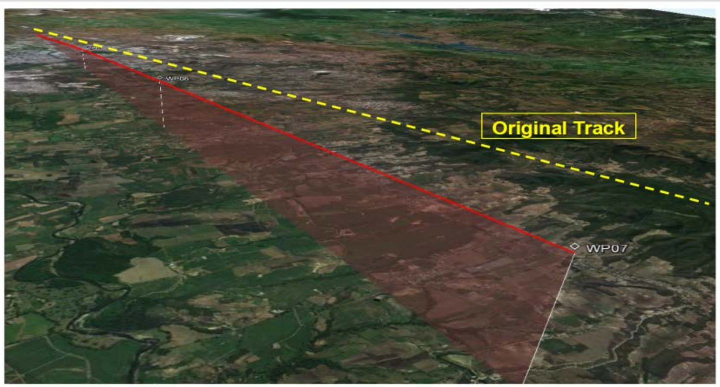
- ILS: single defined vertical path, same touchdown point on runway
- SmartPath GBAS: multiple touchdown points and glide slope combinations



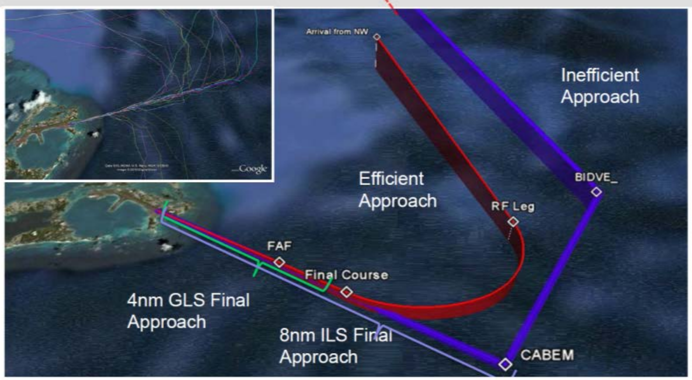
GBAS: Programmable Touchdown Points and Path



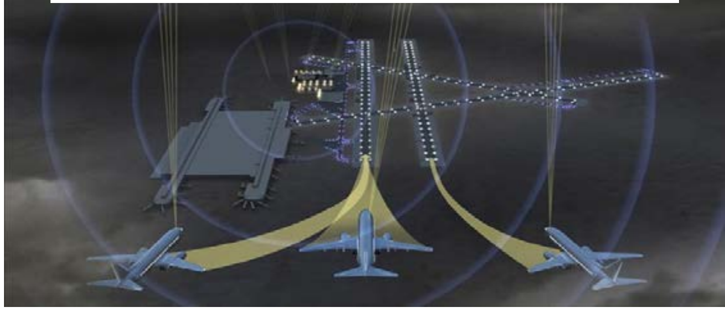
GBAS Offset Approaches



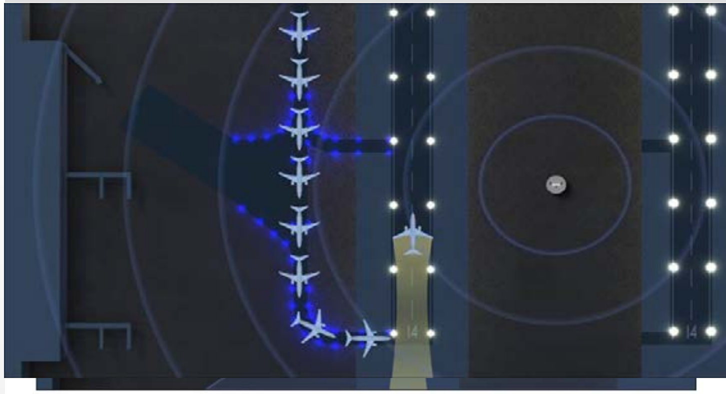
RNP + GBAS GLS: Enabling Maximum Efficiency



Multiple Concurrent Operations



ILS Clear Zones



INFO FOR ATCO CHART

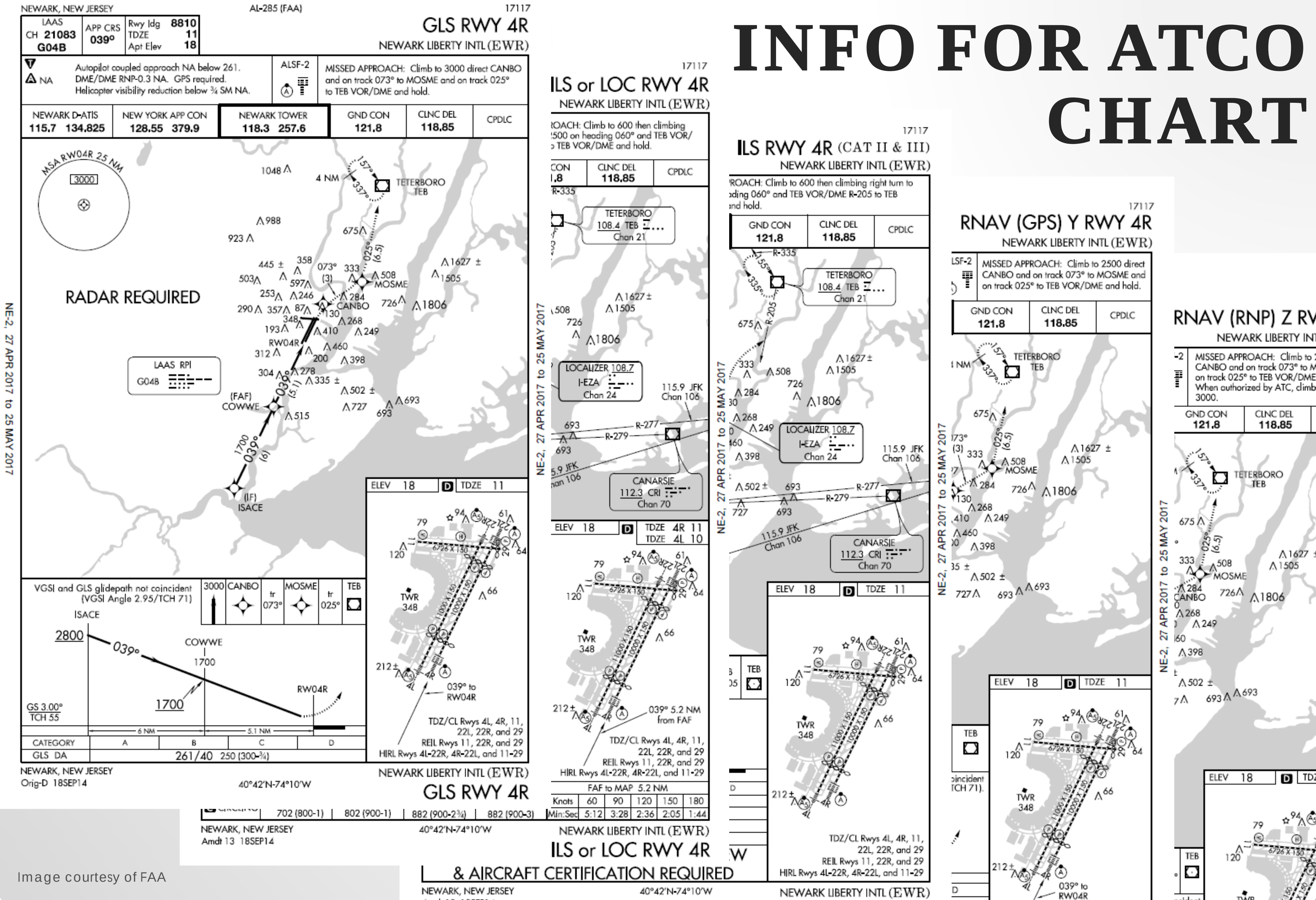
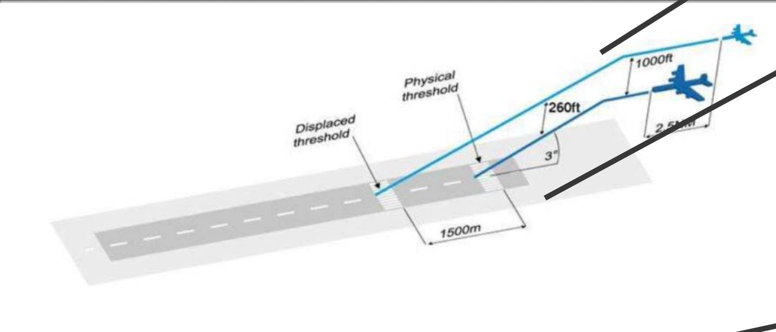


Image courtesy of FAA

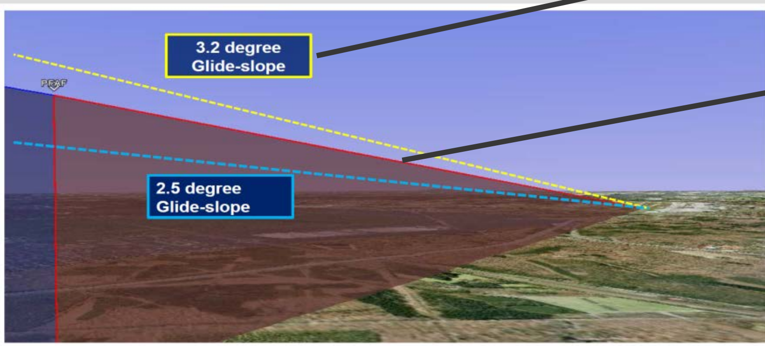
INFO FOR ATCO-OTHER ISSUES

GBAS: Programmable Touchdown Points and Path

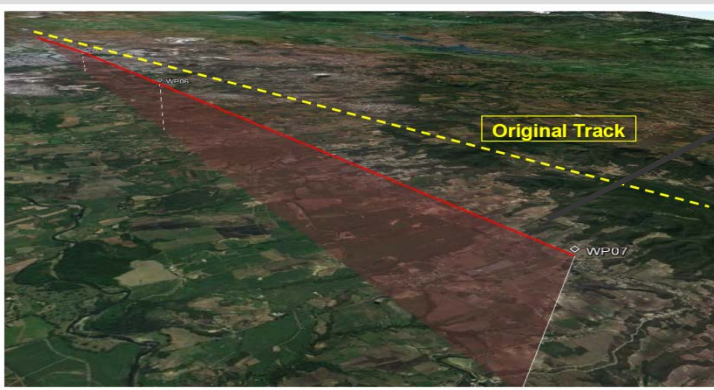
- ILS: single defined vertical path, same touchdown point on runway
- SmartPath GBAS: multiple touchdown points and glide slope combinations



GBAS: Programmable Touchdown Points and Path



GBAS Offset Approaches



Wake?

RWY Marking? Lighting?

Spacing? Integration?

PAPI?

GLS 3.2^{0} vs ILS 3^{0} spacing?

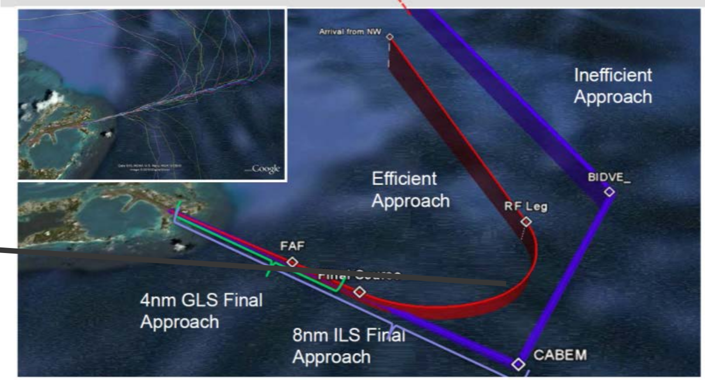
Service Volume?

GBAS VDB vs other NAVAIDs VHF ?

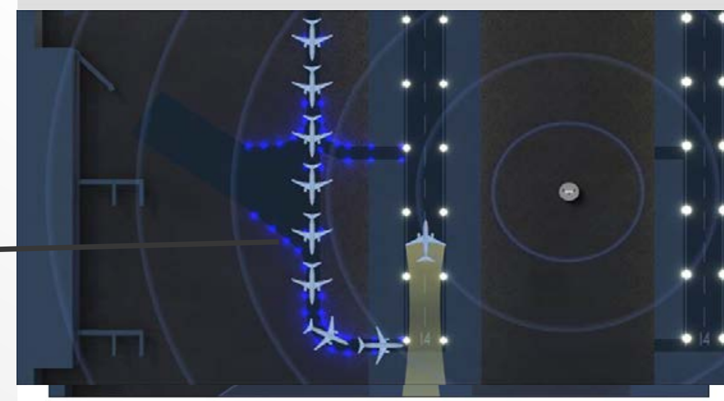
Offset for Noise?

Spacing reduction? How much?

RNP + GBAS GLS: Enabling Maximum Efficiency



ILS Clear Zones



THANK YOU!

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