

# *Transportation Applications: Now and Future*

*Session 1:  
Overview: GNSS-Based Application Areas*

**United Nations/Zambia/ESA  
Regional Workshop on the Applications of  
Global Navigation Satellite System  
Technologies in Sub-Saharan Africa**

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# Augmentations Overview

- **GPS is an Open Architecture service**
  - Where GPS by itself does not fulfill user needs, it can be augmented
- **Public Augmentations**
  - Nationwide Differential GPS (Nationwide DGPS)
  - Space Based Augmentation Systems (e.g. WAAS)
  - Continuously Operating Reference Stations (CORS), International GNSS Service (IGS), Global Differential GPS (GDGPS)
- **Commercial Augmentations**
  - Differential GPS, Sensor Integration (e.g. inertial), Cellular, etc.
- **Distinct from Value-Added Services**
  - Integration of GPS with other data or services (e.g. Location-Based Services)

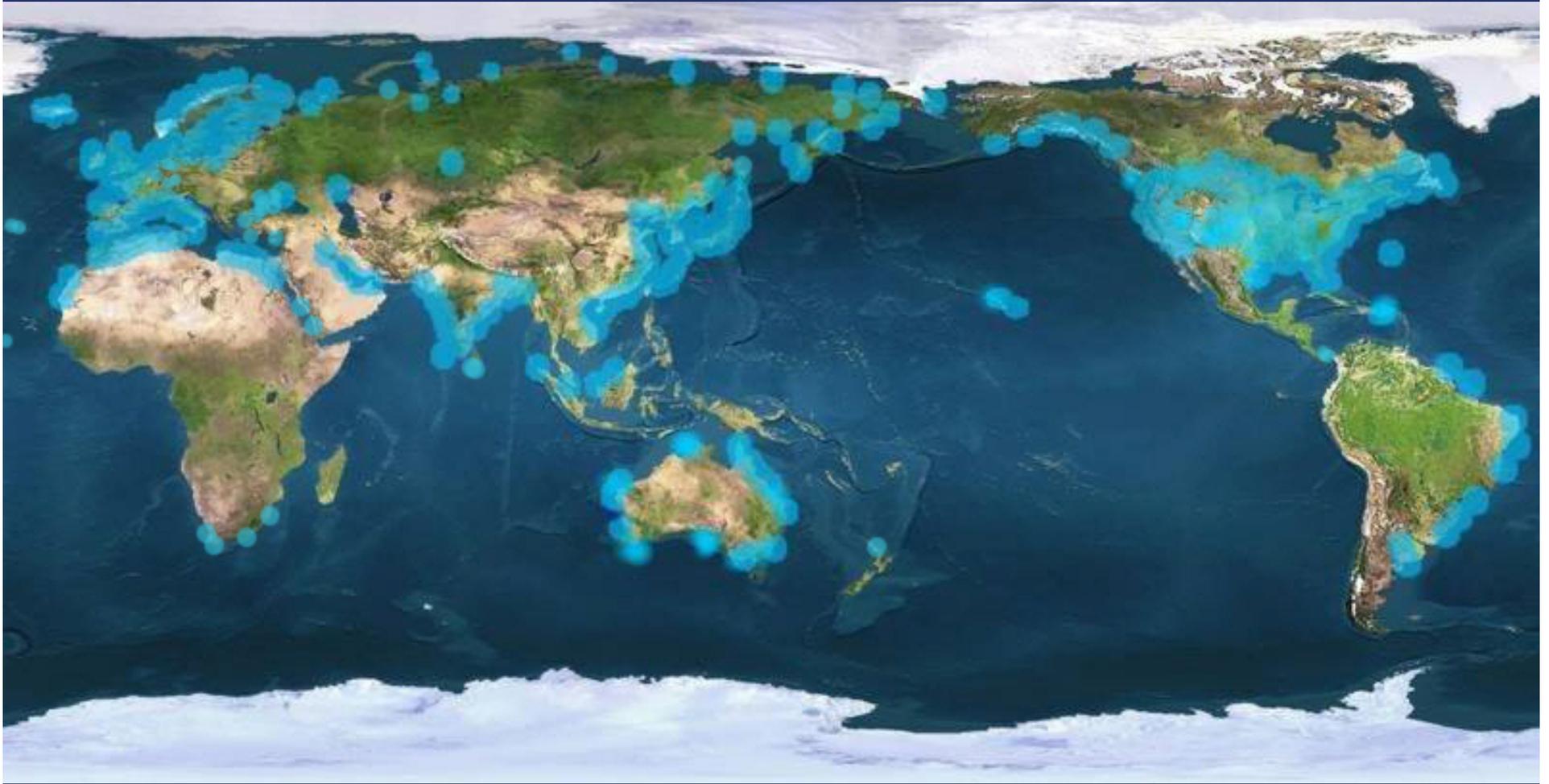


# Nationwide DGPS Status

- **Built upon Maritime Differential GPS network**
- **Operational Since March 1999**
- **Key Characteristics**
  - Local differential corrections
  - Low frequency correction broadcast (good for surface reception)
- **User Base**
  - Maritime, rail, survey, precision agriculture, weather forecasting, and resource management
- **International standard in over 50 countries**



# International Coverage



# GNSS Aviation Integrity

- **Availability of GNSS accuracy with continuity and integrity essential to International Civil Aviation Organization Modernization Planning**
- **Key to future implementation of required surveillance, communications as well as navigation performance**
- **GPS Aviation Use Approved for Over a Decade**
  - Aircraft Based Augmentation Systems (ABAS) – (e.g. RAIM)
- **Space Based Augmentation System (SBAS) since '03**
  - U.S. Wide Area Augmentation System (WAAS); Others soon
- **Increases air traffic while maintaining safety standards**
- **GPS type signals - requires no additional hardware**



# GPS (ABAS) Aviation Receivers

- **Aviation navigation services assured to Safety of Life integrity standards**
- **Over 16,000 \* commercial air carrier Instrument Flight Rated (IFR) GPS receivers sold (as of 2003)**
- **Additional 70,000 – 80,000 \* General Aviation IFR GPS receivers sold**

\* U.S. manufacturer sales only (does not include units limited to visual situational awareness)



# GPS Aviation Ops Approvals



# Space Based Augmentation System (e.g. WAAS/EGNOS/GAGAN)

- Provides integrity for all phases of flight
- Vertically guided approaches enhance safety
- Permits operations at airports without navigation aids
  - No ground hardware required at airport
- Operations to all runways at all airports\*
- Expanding Globally; Can augment multiple satellite navigation constellations
- Ranging and improved algorithm/mask angle increases availability for all applications
- Provides Safety of Life Integrity Services today
  - Must meet other instrument flight requirements



# WAAS Modernization

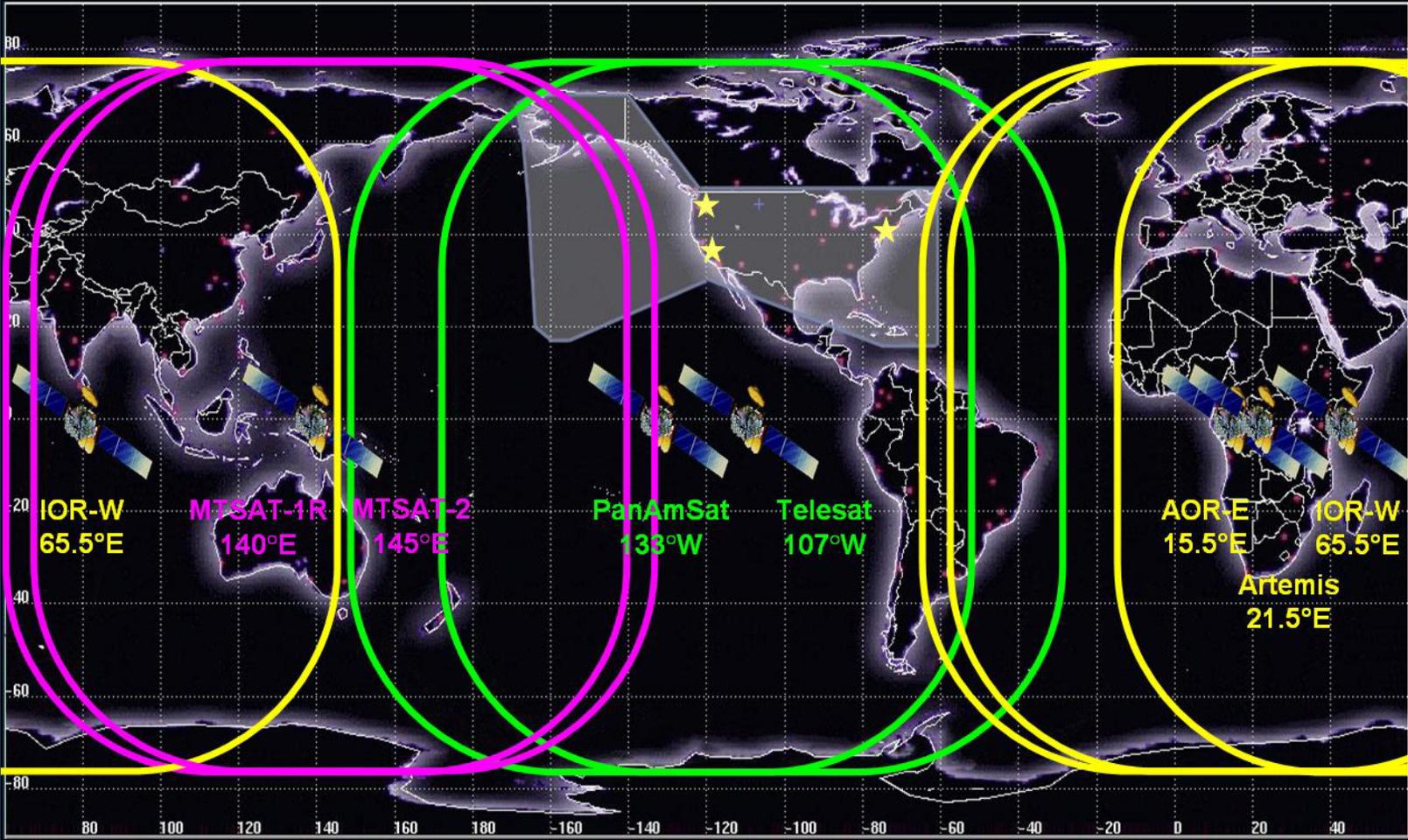
- **Expansion/Availability Improvements (through 2008)**
  - Two new geostationary satellites
    - On orbit (Telesat and PanAmSat)
    - L1 and L5 signals; Operational fall 2006
  - Ground network expansion in Alaska, Canada and Mexico
  - Software upgrades
- **Performance and Robustness Improvements**
  - Augment GPS L5 signals for redundant service
  - Improved accuracy and integrity
  - Better ops during periods of severe solar storm activity
  - Additional security against interference
  - Enables decommission of large number of ground-based aids
  - Possibility to monitor and augment Galileo Open Service



# SBAS (WAAS) Architecture



# International SBAS Coverage



Indian GAGAN

Japanese MSAS

U.S. WAAS

E.U. EGNOS



# WAAS APPROVED FOR NEW, LOWER MINIMUMS (March 2006)

- In 2007, WAAS procedures will provide precision approaches down to 200 feet above airport surface
  - Same as Category I Instrument Landing System (ILS)
- Since WAAS requires no equipment at the airport, it provides a cost-effective alternative to Category I ILS
- Increases capacity at thousands of airports without ILS

\* Many airports currently use ILS that is costly to install and maintain



# SBAS Equipment

- **Garmin GNS-480/CNX-80 - 4000 sold**
  - 430/530: 50,000 upgradeable units
- **Free Flight Aviation**
  - Panel Mount Receiver and sensor
- **Rockwell Collins Unit**
  - High end users
- **Others include: Avidyne, Chelton, CMC, Universal, Thales, and Honeywell**
- **No equipment changes required to get lower minima**
- **Non aviation receivers now provide SBAS at no additional cost**
  - Over 6 Million receivers (U.S. manufacturers)

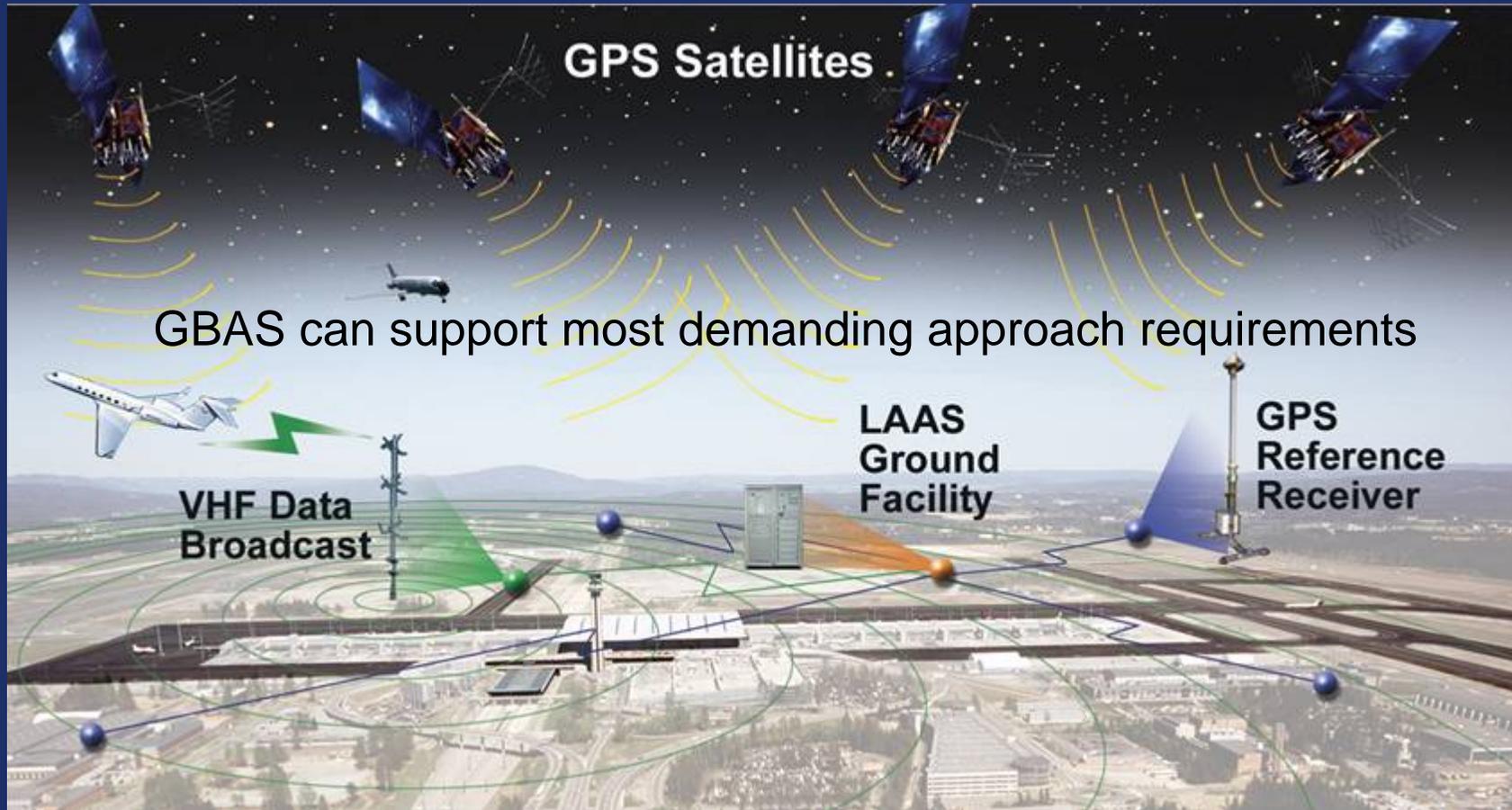


# Ground Based Augmentation System (GBAS)

- **Category-I through Category III (200 to zero foot Decision Height)**
  - U.S. implementation: Local Area Augmentation System (LAAS)
- **Boeing & Airbus Joined in Support of GBAS**
  - Boeing B-737NG certified GBAS avionics; Airbus A-380 in work
- **International GBAS Development Cooperation**
  - Airservices Australia cooperative agreement with FAA leverages U.S. technology investment for initial ops capability
  - DFS/Germany, AENA/Spain and other service providers interested



# GBAS (LAAS) Development

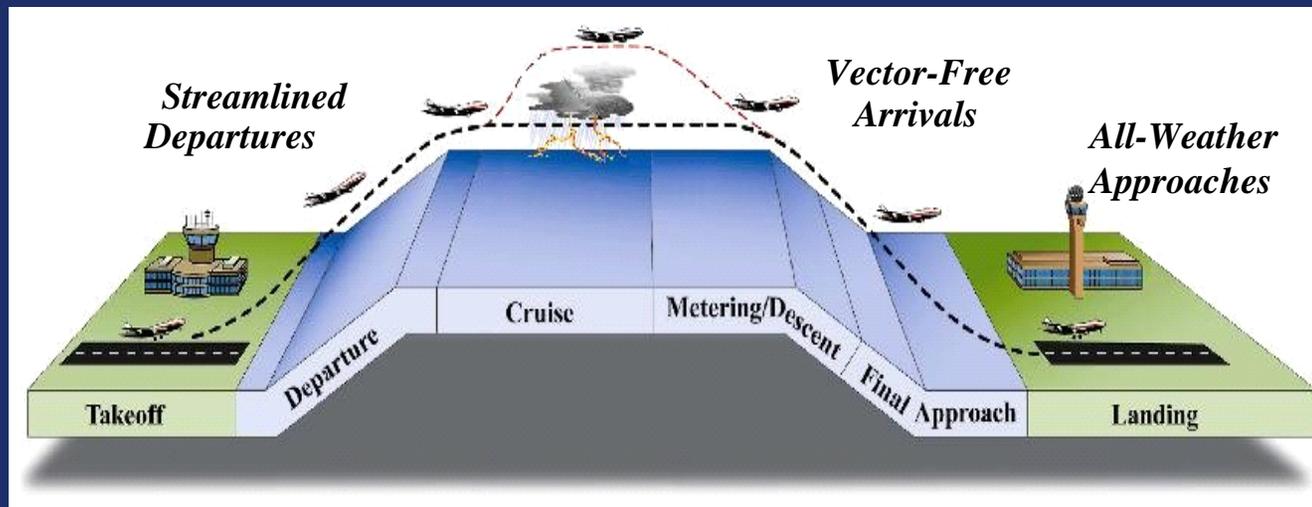


# Performance-Based Navigation

## Benefits:

- Enhanced Safety
- Increased Capacity
- Reduced Delays
- Increased Flight Efficiencies
- Increased Schedule Predictability
- Environmentally Beneficial Procedures

*Efficient, Flexible Routing*



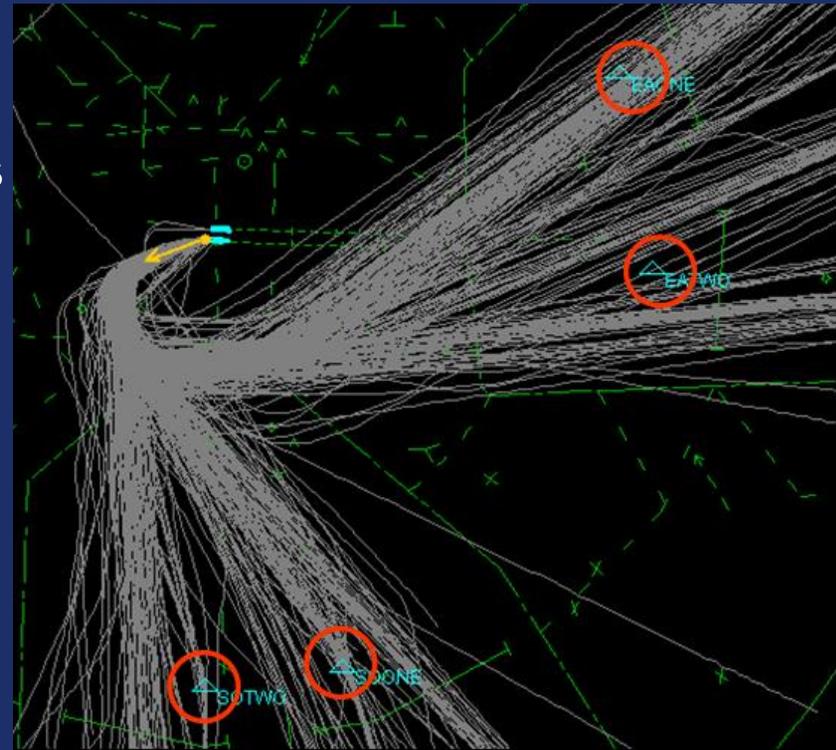
# Performance Based Navigation Implementation

- Existing Ground Based Navigation Aids
  - DME/DME with Inertial
- GNSS (GPS)
  - ABAS (RAIM)
    - Non Precision Approach
  - ABAS With Inertial
    - RNP .1
  - SBAS (WAAS)
    - Category I
  - GBAS (LAAS)
    - Category II/III



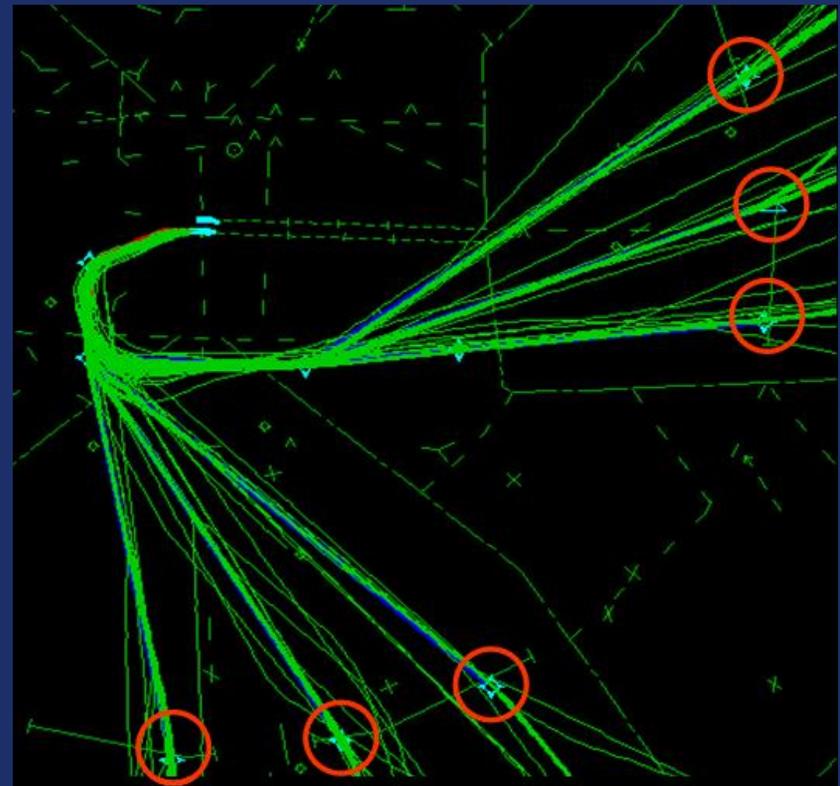
# Departure Procedures Before RNAV

- **Departures voice vectored**
  - Headings, altitudes and speeds issued by controllers
  - Large number of transmissions required
- **Significant dispersions**
  - Flight paths inconsistent and inefficient
- **Dispersions limit number of departure exit points**



# Departure Procedures After RNAV

- **Aircraft Fly RNAV tracks (not ATC vectors)**
  - Headings, altitudes and speeds automated (via avionics)
  - Voice transmissions reduced (30-50%)
- **Dispersions Reduced**
  - Tracks more consistent and more efficient
- **Additional Exit Points**



# Automatic Dependant Surveillance - Broadcast (ADS-B)

- **Automatic:** Periodically transmits information with no pilot or operator input required
- **Dependent:** Position and velocity derived from GNSS or Flight Management System (FMS)
- **Surveillance:** Method of determining position of aircraft, vehicles, or other assets
- **Broadcast:** Transmitted information available to anyone with appropriate receiving equipment
- **Other ADS-B services**
  - Traffic Information Service provides ADS-B equipped aircraft with position reports from surveillance radar on equipped aircraft
  - Flight Information Service transmits graphical weather, and airspace flight restrictions



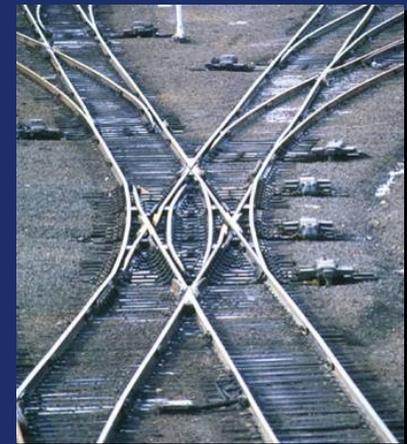
# GNSS Location Based Services

- **Cargo Fleet Tracking**
  - Improves safety and security
- **Fleet Control/Dispatch**
  - Fuel savings
  - Improves asset management
- **Emergency Operations**
  - Reduces response times
  - Reduces injury & property loss
- **Road Maintenance**
- **In Vehicle Navigation**
  - Accurate position determination
  - Reduces air pollution



# GNSS Positive Train Control

- Situational Awareness
- Enhances safety
  - Reduces accidents
- Increases capacity and efficiency
  - Closer train spacing reduces investments
  - Reduces fuel consumption
- Rapid rail structure and condition mapping
  - Improves maintenance capability



# GNSS Maritime Applications

- Large ships, fishing & recreation boats
- Harbor entrance and approach
  - Regardless of visibility
- Hydrographic Survey
- Buoy Positioning, etc.





# Summary

- **GPS - Robust and operating above standards**
- **Augmentations (user equipment or infrastructure based) provide additional capabilities**
- **WAAS (SBAS) in operation today for instrument use; adding 200' decision height in 2007**
  - Benefits all users - even those not within Geo footprint
- **Surface, Rail, and Maritime GNSS Services improve safety, security, and efficiency**
- **Performance based requirements**
  - Support use of one or more GNSS solutions
  - Interoperability provides greater capability than from a single solution
- **New constellations and augmentations on the way**



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