Alternate Position, Navigation & Time
APNT for Civil Aviation

For Working Group B of the International GNSS Committee

Shanghai, May 2011

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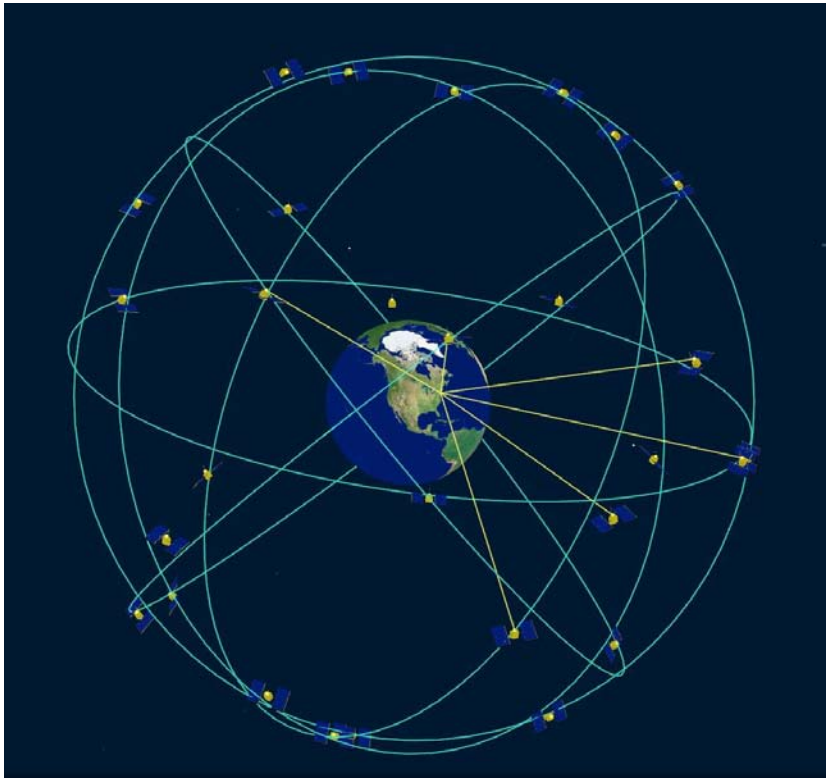
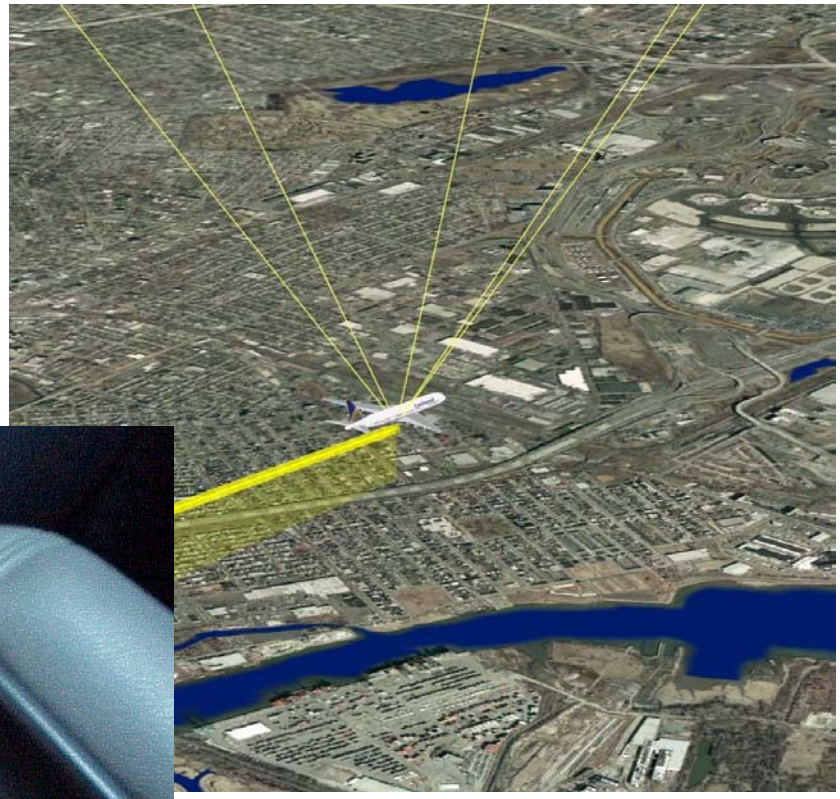
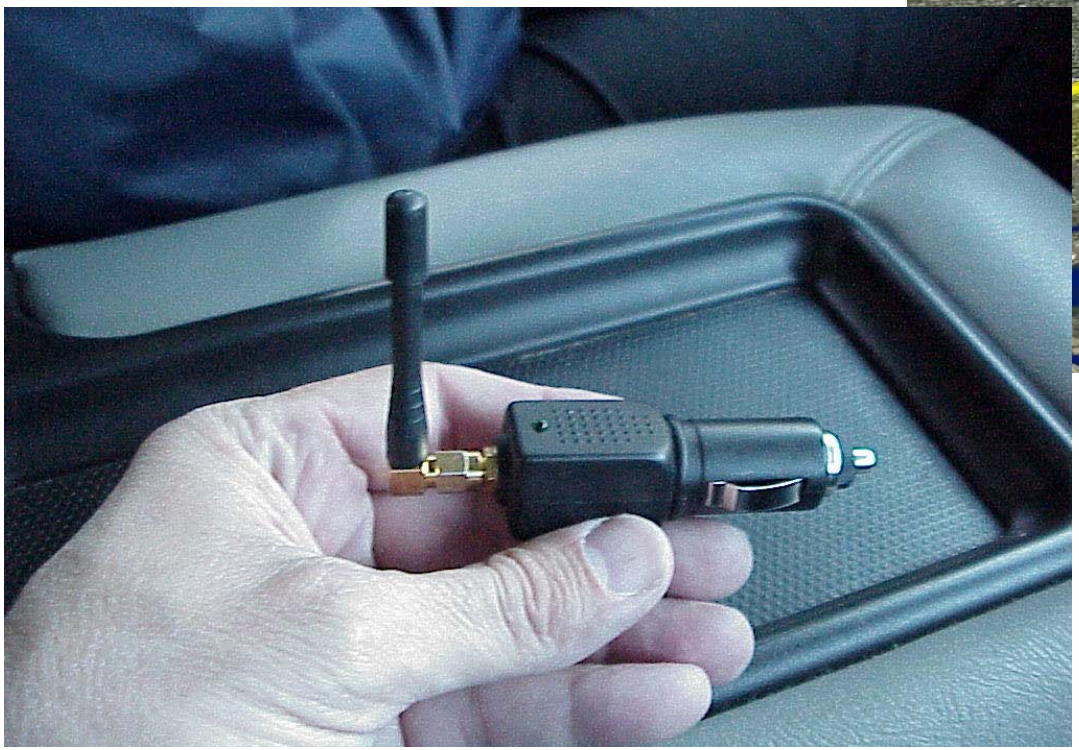
This briefing is NOT intended to convey a US Government position; rather, it is provided to facilitate a working-level discussion and exchange of ideas.

Danger of Radio Frequency Interference



Danger of Radio Frequency Interference





… and a few more “Personal Privacy Devices”

$110 Ebay

$335 Ebay

$92 Ebay

$40 GPS&GSM

$55 Ebay

$83 GPS&GSM

$152 Ebay

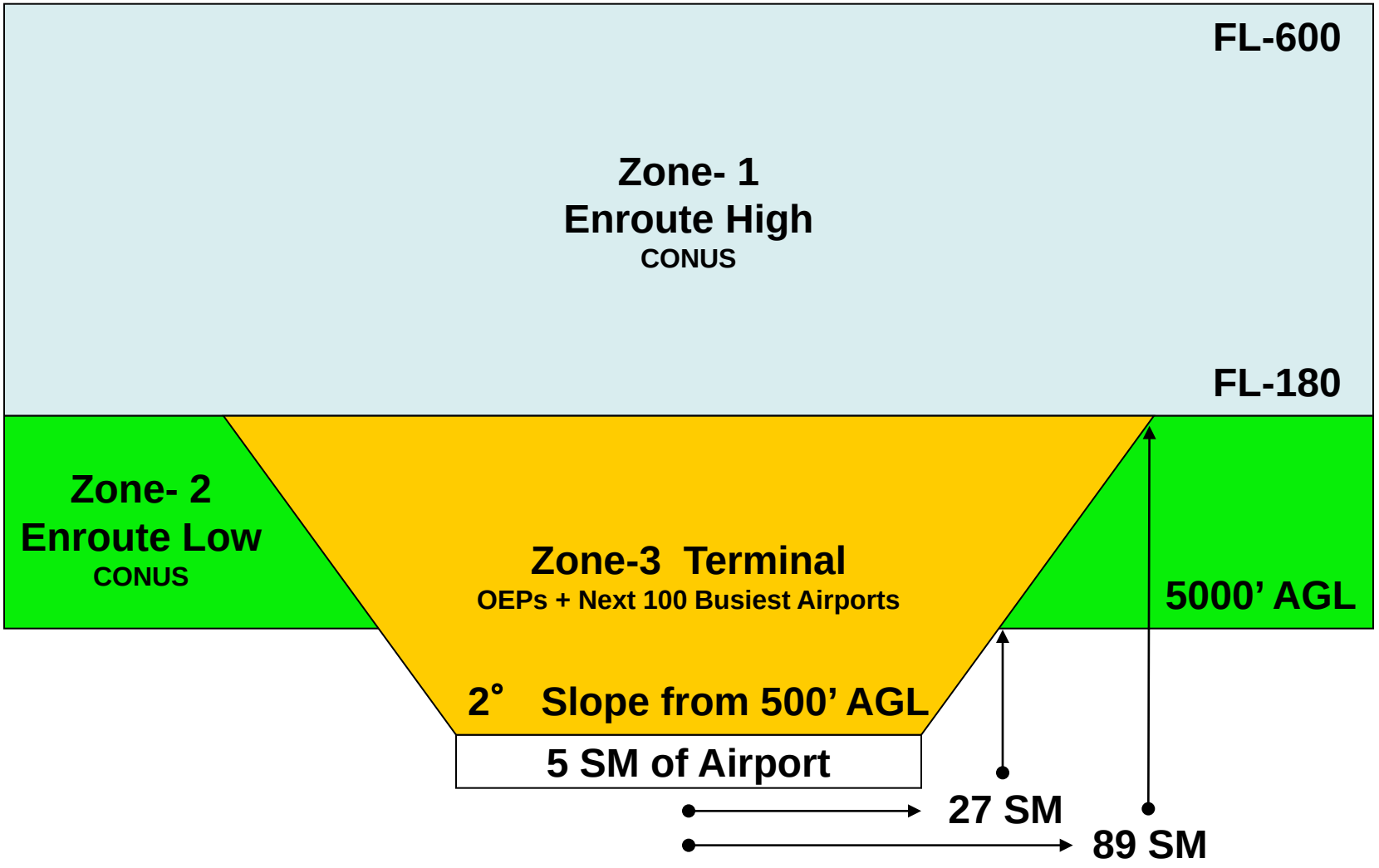
Why APNT?

- GPS radio frequency interference (RFI) requires mitigation
  - Waiting the interference source to be turned off is unacceptable
  - Continuity of operations must be assured at high density airports
- NextGen capabilities establish greater demand for precise PNT services, provided by GPS
  - 2X traffic is more than a controller can handle using radar vectors
  - Trajectory-based operations (TBO) will be used to improve capacity
  - Automation will sequence aircraft performing TBOs
  - 3 nm separation will be based on precise RNAV/RNP paths
  - Surveillance used for “conformance monitoring”
  - Controllers intercede to provide “control by exception”
  - DME/DME/IRU is not accurate enough to enable 3 nm separation
- FAA would like to avoid $1B cost to replace aging VORs
  - VORs are not compatible with RNAV and RNP

RFI Challenges without APNT

- Transitioning from 3-mile to 5-mile separation en route and on arrivals outside of 40 nm when a GPS RFI event occurs
- Shifting some aircraft to radar vectors – significant implications
- Rerouting aircraft around interference area to reduce demand
- Throttle back demand to compensate for loss of capabilities like parallel runway approaches
- Limit RNAV/RNP arrivals and departures and reduce options to handling arrivals

APNT Performance Zones

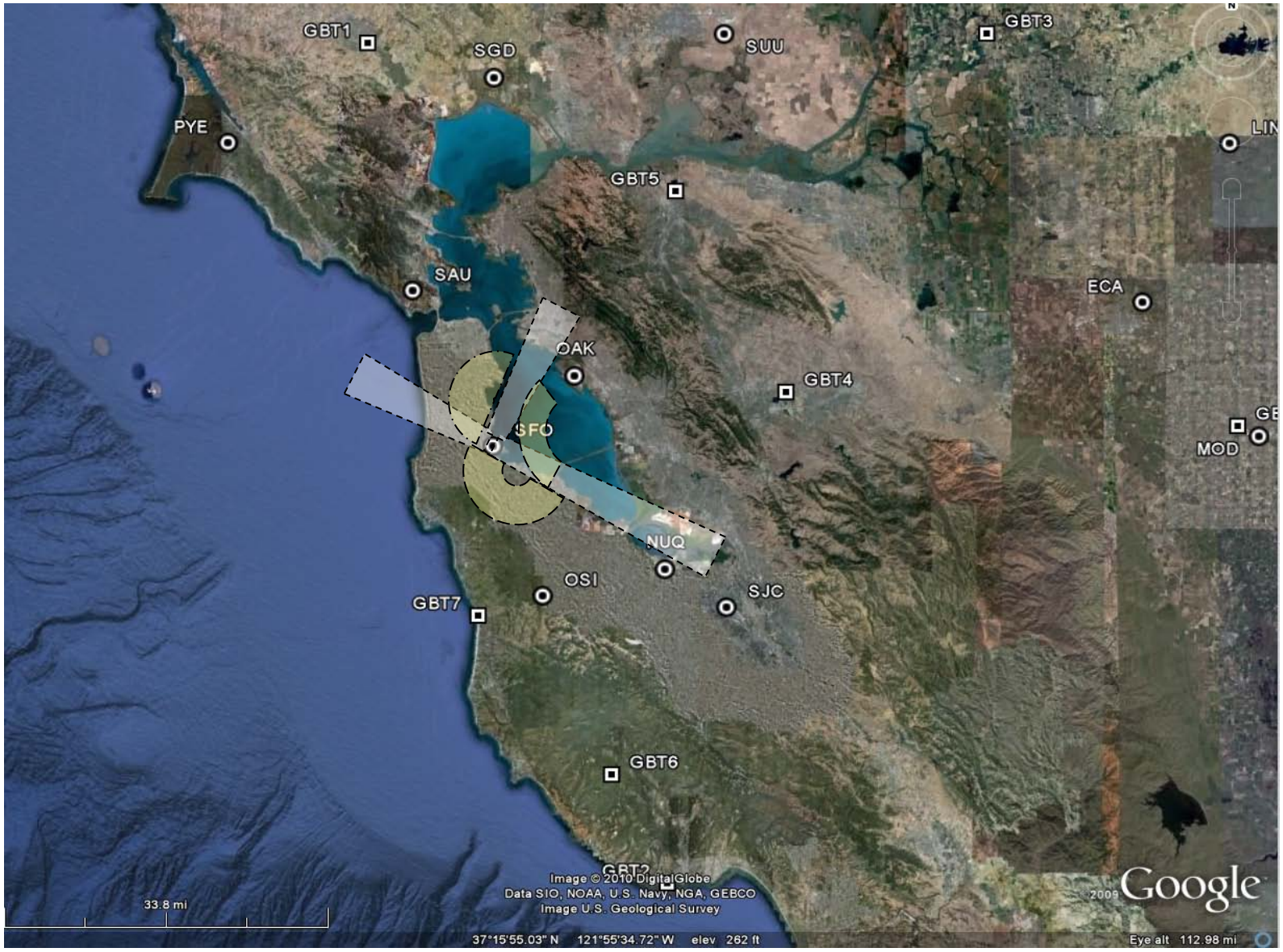


Combined Network of DMEs and GBTs

1090 DMEs

646 GBTs

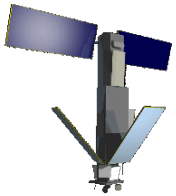
Bay Area Coverage from Terrestrial Radio



Ground-to-Ground Synchronization

GEO: WAAS L5

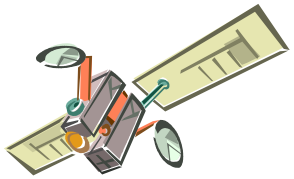
MEO: GPS

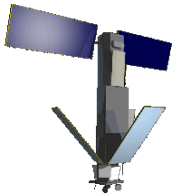


LEO: Iridium

DMEs + New Terminal Area DMEs + GBTs

Ground-to-Air Synchronization





one-way ranging
(aka pseudo-range)

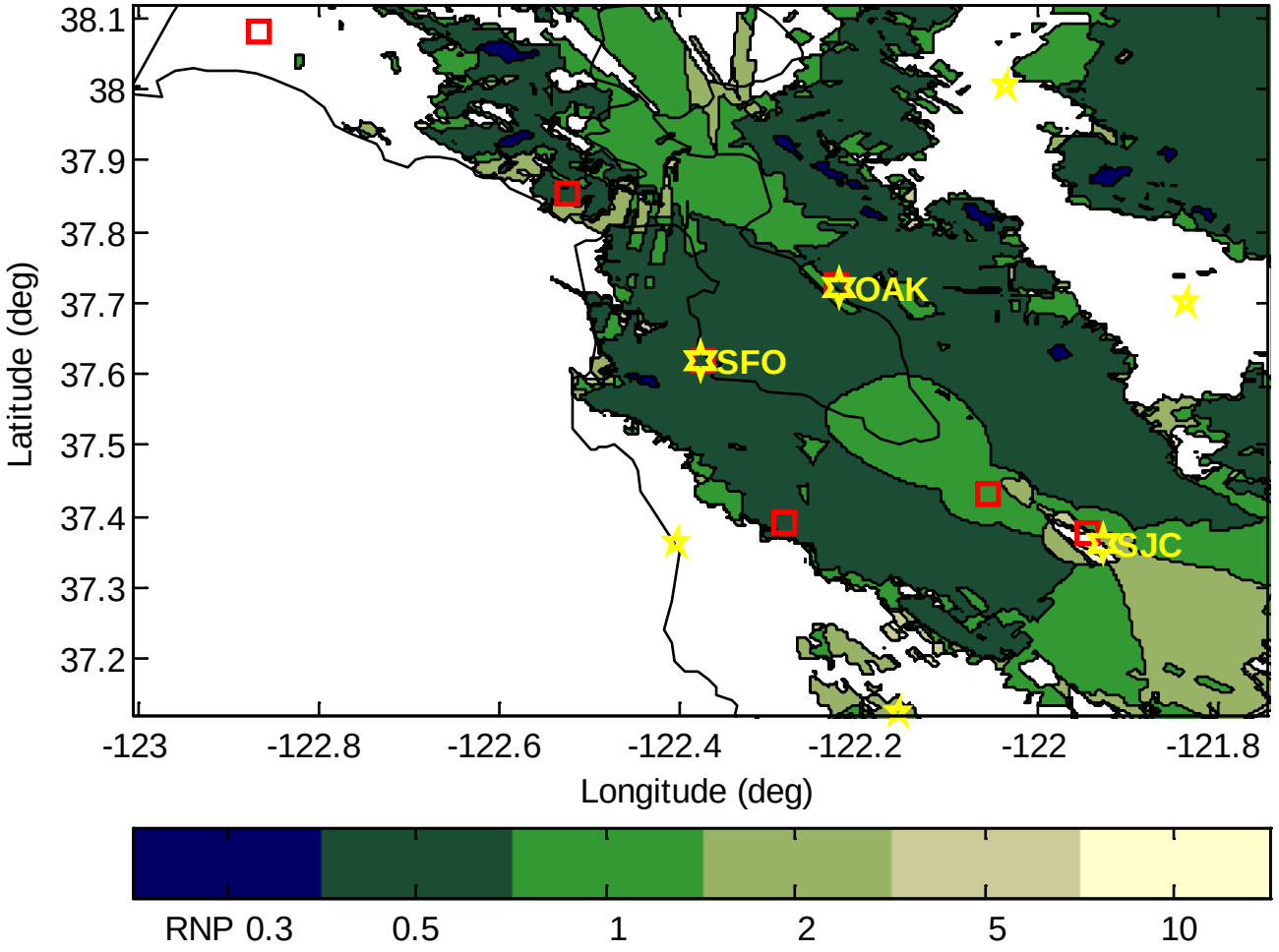
request/reply
(aka two-way ranging
or true range)

DMEs + Planned DMEs + GBTs

Coverage at 500’ AGL
True Ranging to DMEs + GBTs

from R. Niles
at Mitre & S. Lo

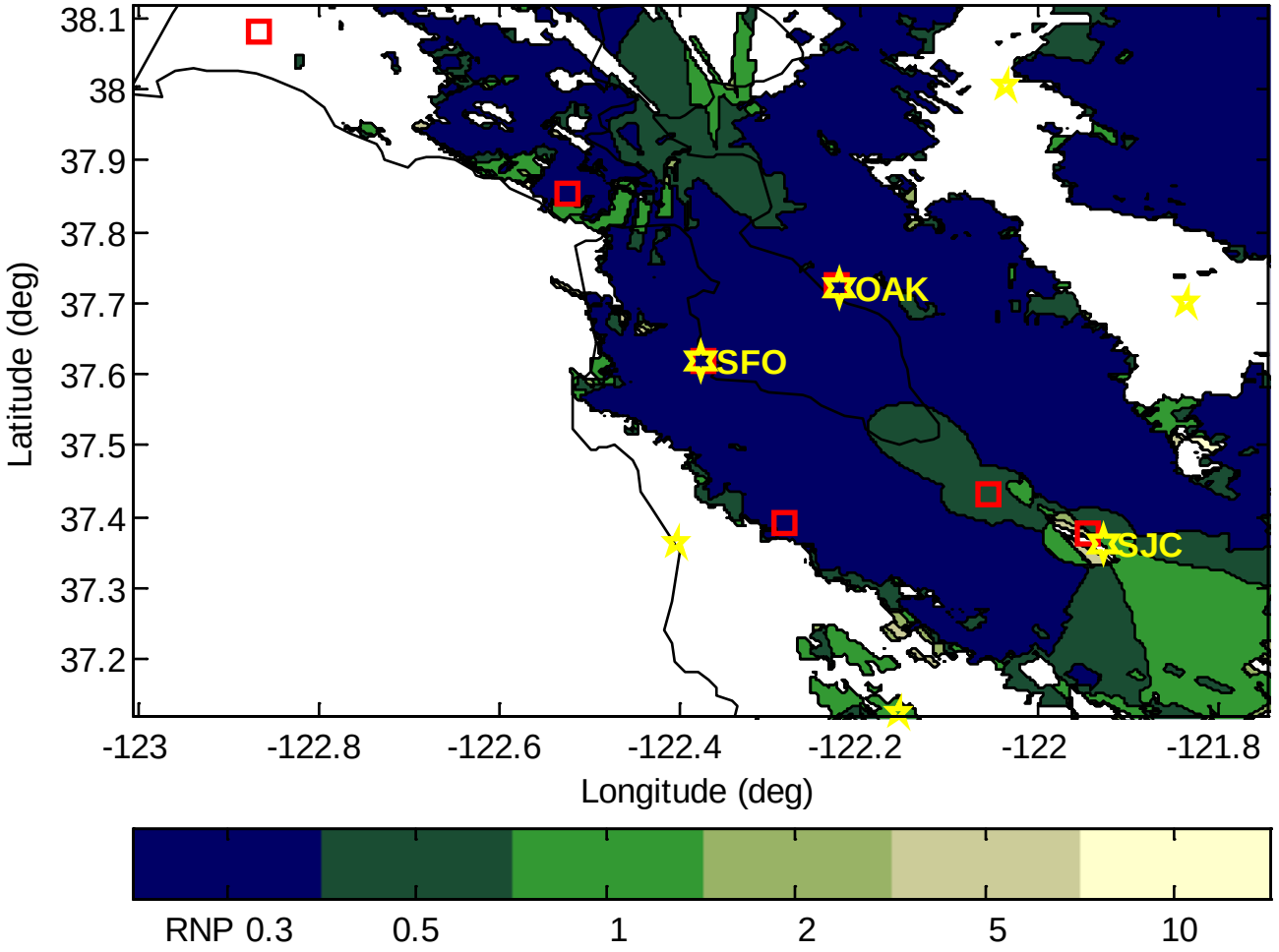
ε_{FTE} = .0625 NM
ε_{R} = 328 m



Coverage at 500’ AGL
True Ranging to DMEs + GBTs

from R. Niles
at Mitre & S. Lo

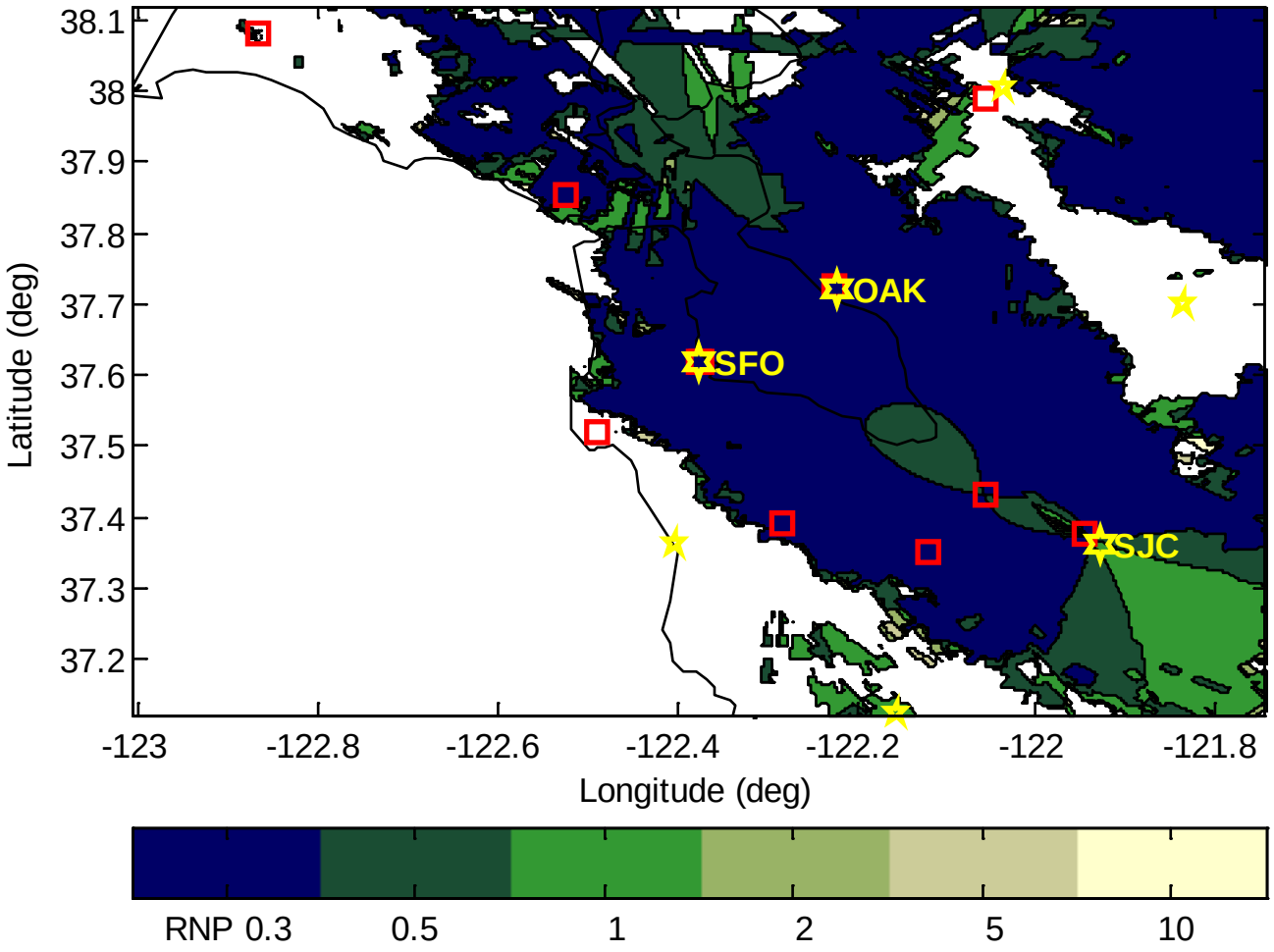
ε_{FTE} = .0625 NM
ε_R = 160 m



Coverage at 500’ AGL
True Ranging to DMEs + GBTs + New DMEs

from R. Niles
at Mitre & S. Lo

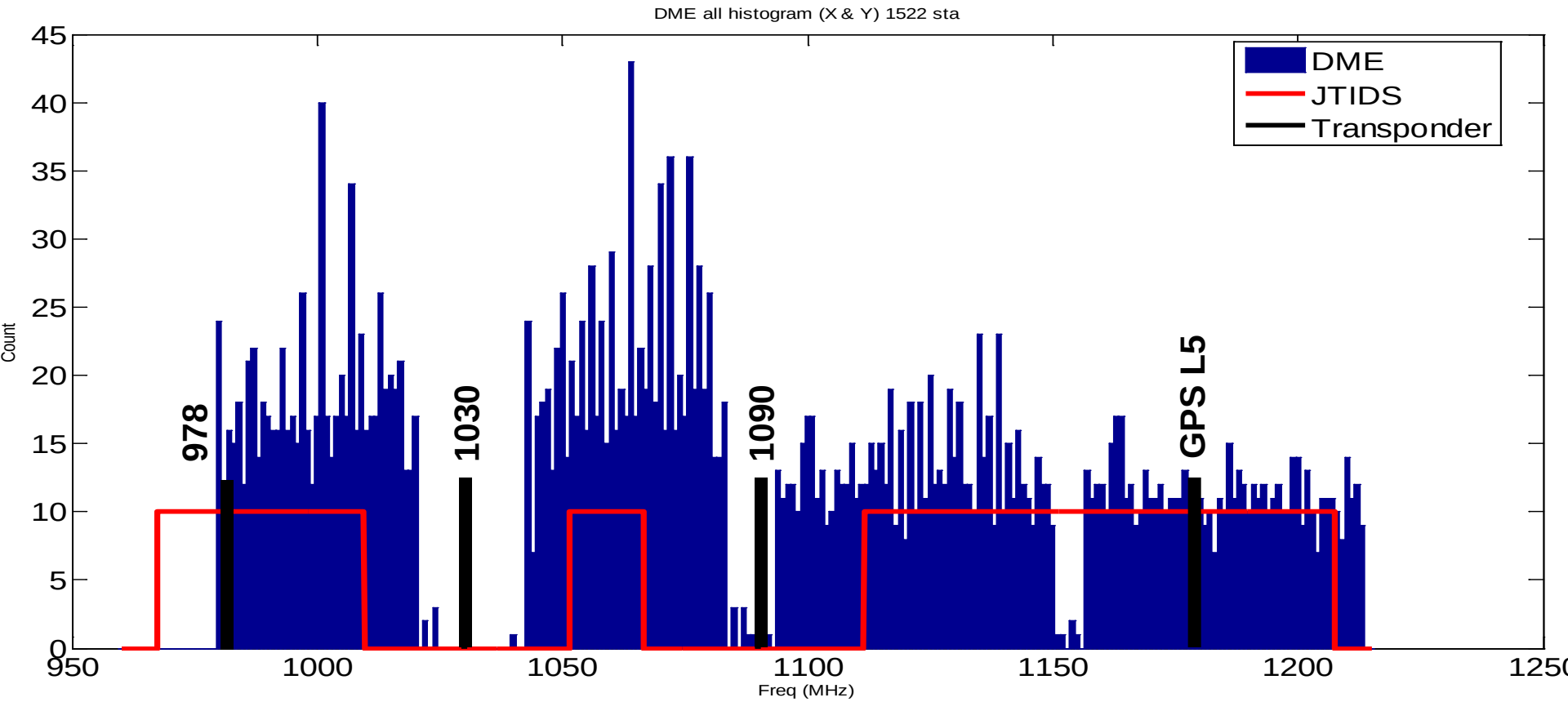
ε_{FTE} = .0625 NM
ε_{R} = 160 m



Signal Design Objectives

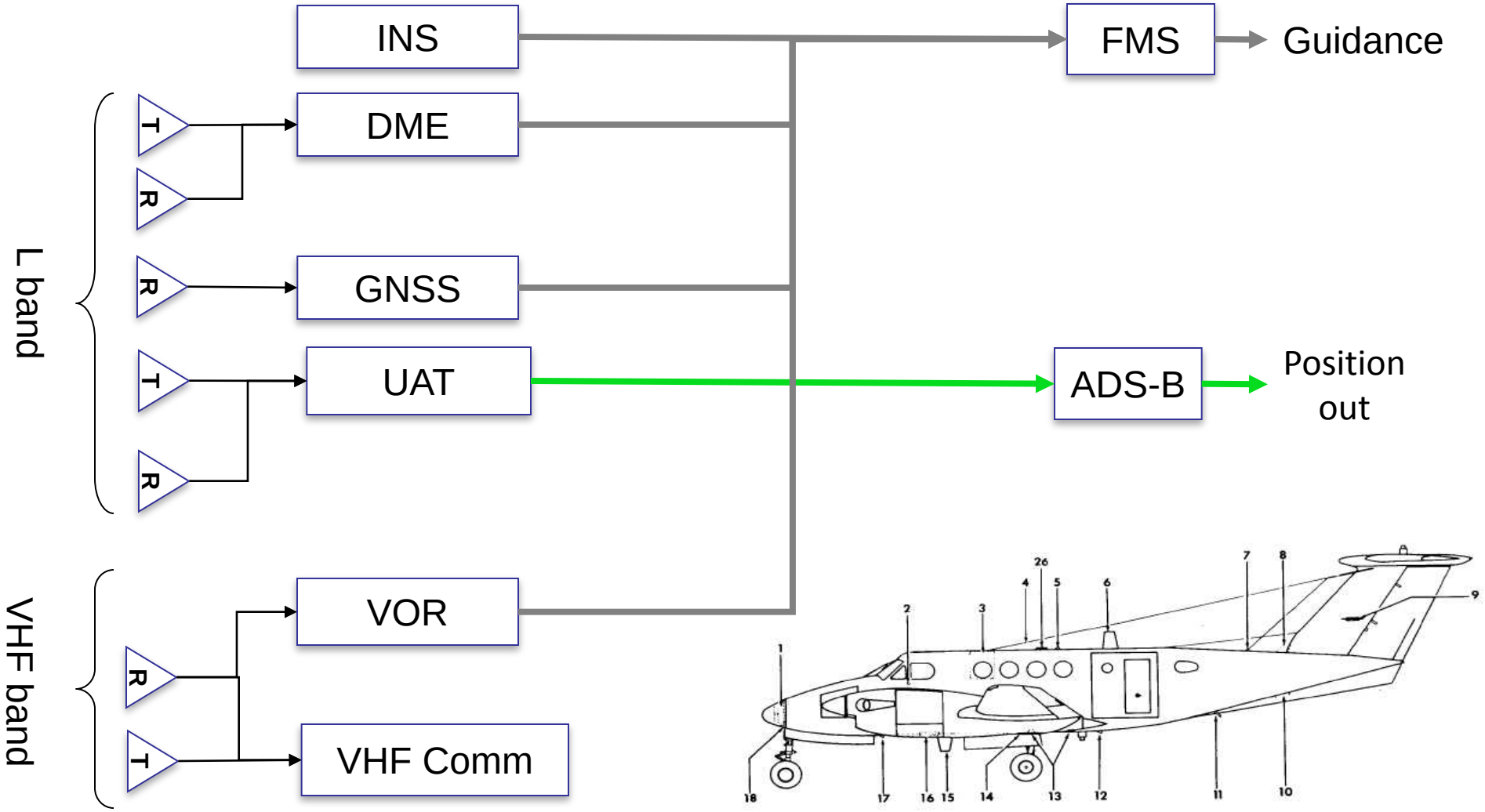
- Ranging accuracy !
  - Present DME is not precise enough for approach operations
  - Wider bandwidth than DME ?
- Better coverage ?
- New avionics would require new benefits
- Data capacity to support new benefits
  - Authentication, time, identification & location +
  - Wide area GBAS (ΔΦ) for Category II & III
  - AGPS for GPS anti-jam
  - WAAS & ISM for LPV
- Transportability to VHF ?

APNT Signals in the DME Band



- Any new signal in the DME band should be pulsed to minimize impact on legacy users.
- Bench tests needed to verify non-interference with 4 ms pulses.

Aviation Signals of Opportunity



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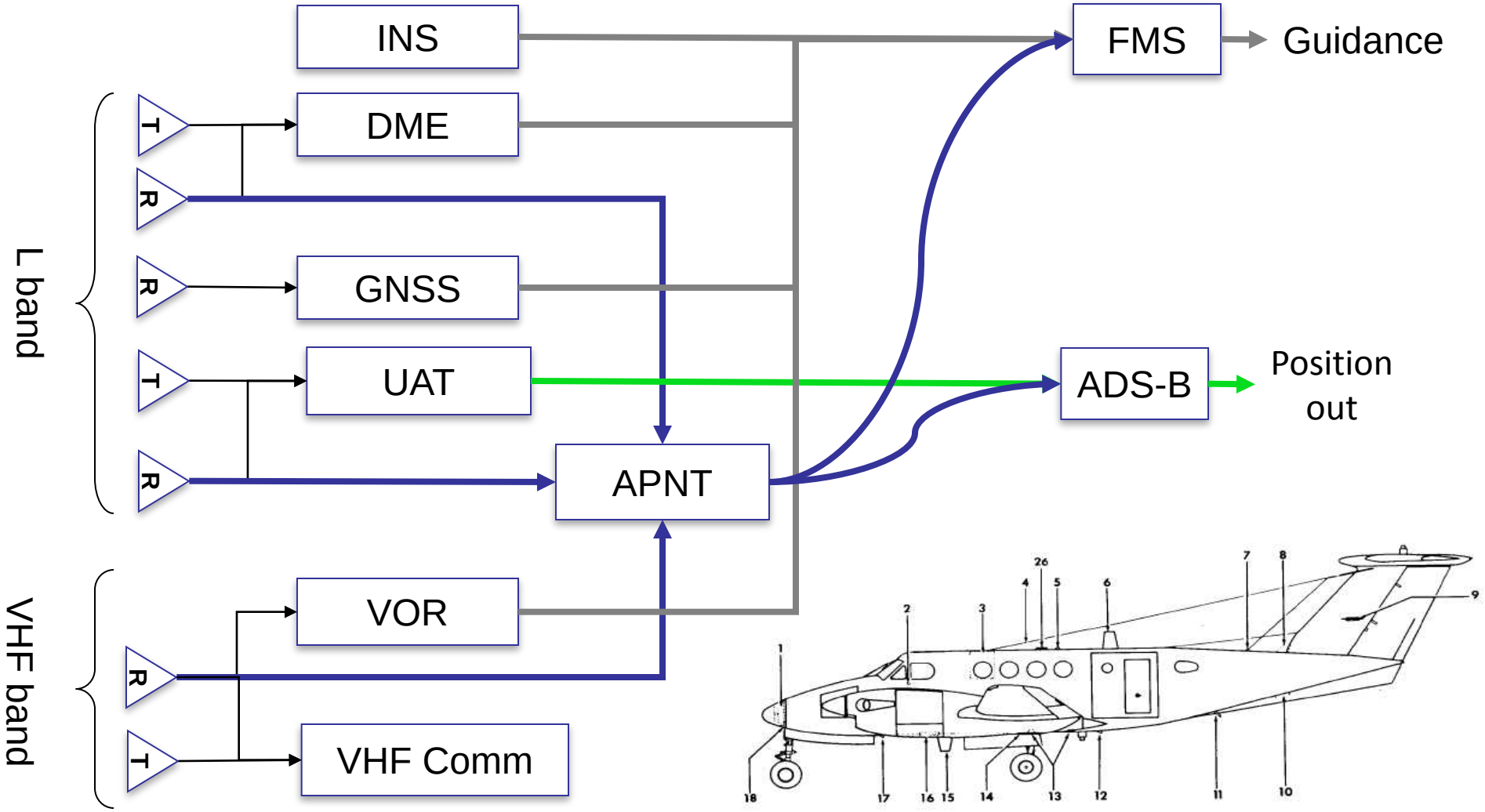
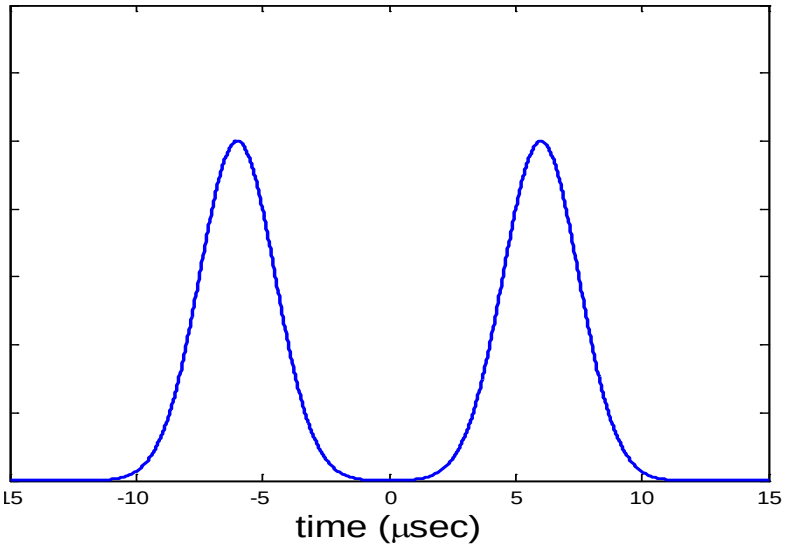
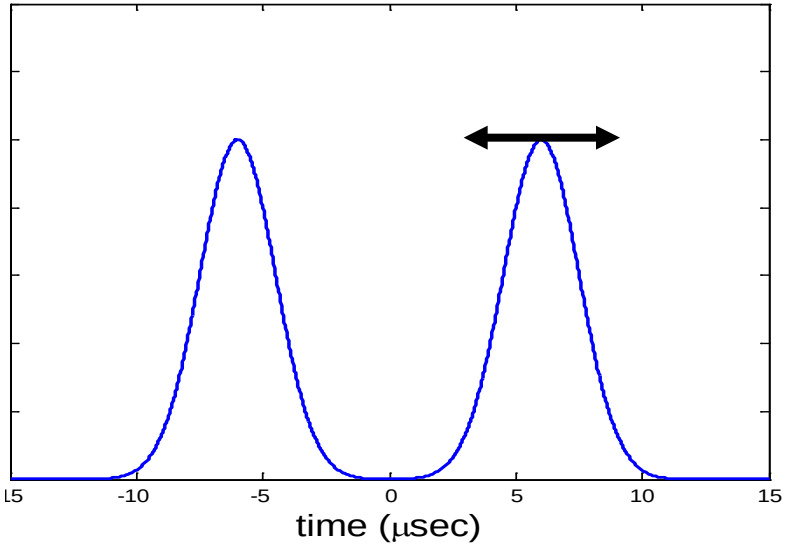
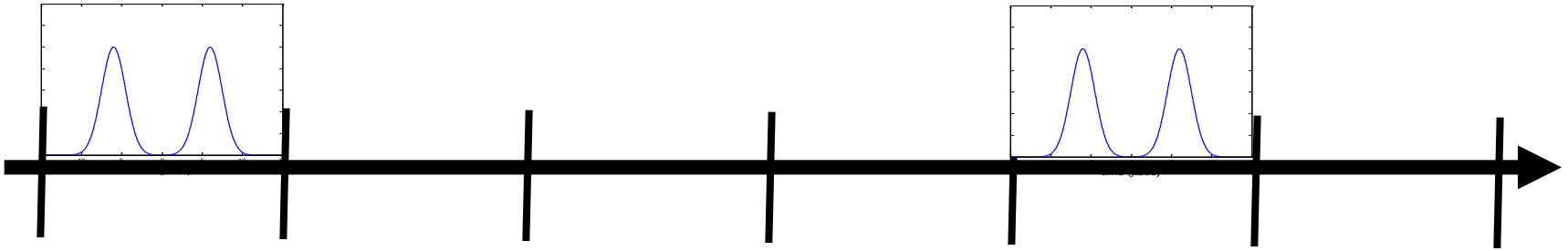


Pulse Position Modulation (PPM) or Pulse Pair Position Modulation (PPPM)

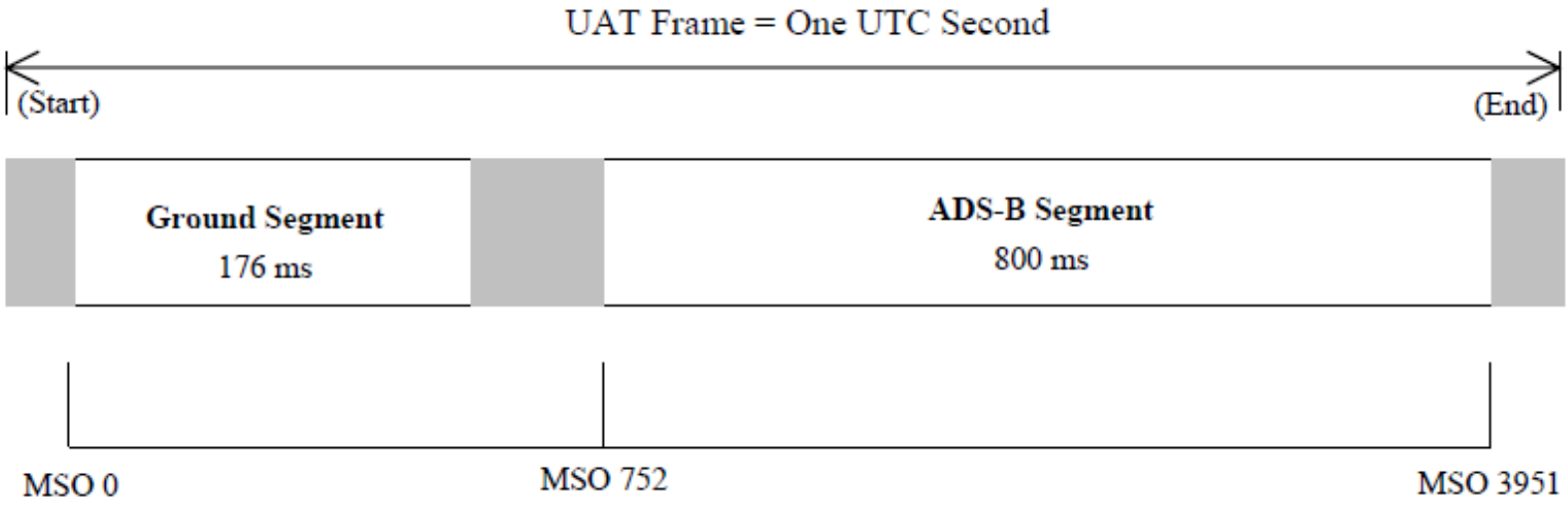




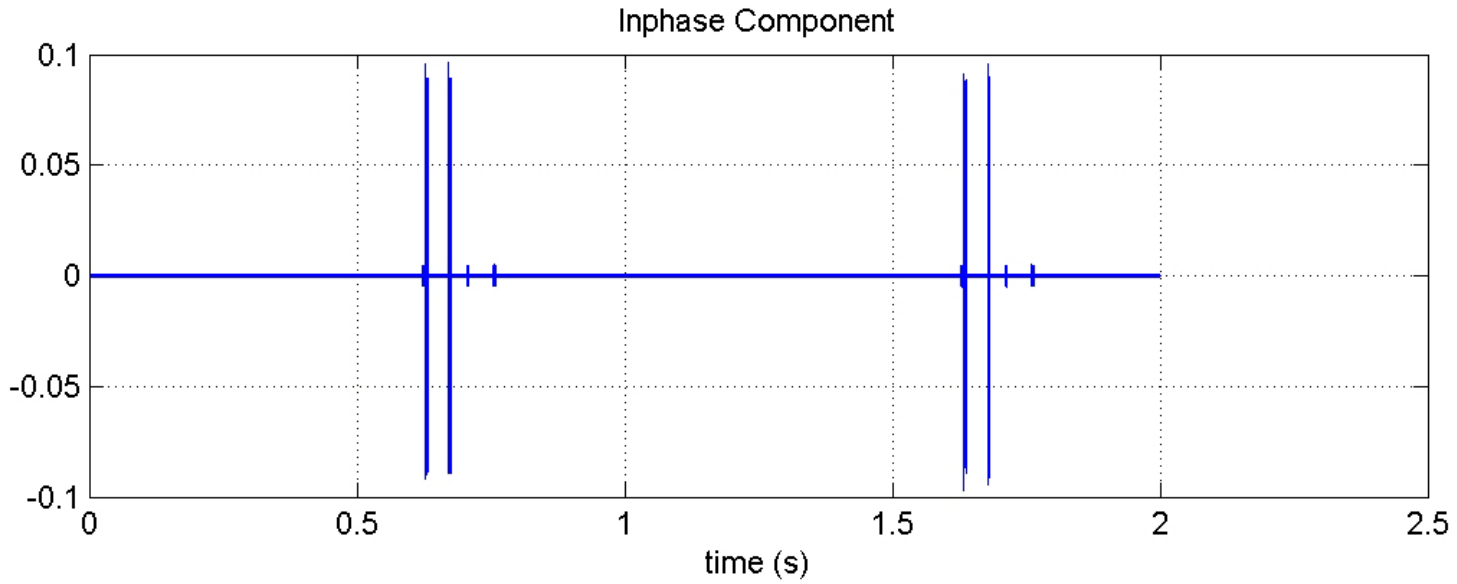


PPPM data capacity of 300 to 1200 bps

Universal Access Transceiver (UAT)



Message Start Opportunities (MSOs)



Summary

- 200,000 civil aircraft rely on GPS
- With NextGen, our reliance is increasing
- Consolidate & re-purpose ground navigation aids
- Backup GPS RNAV & RNP to ensure NextGen success