Alternative Positioning, Navigation, and Timing (APNT)

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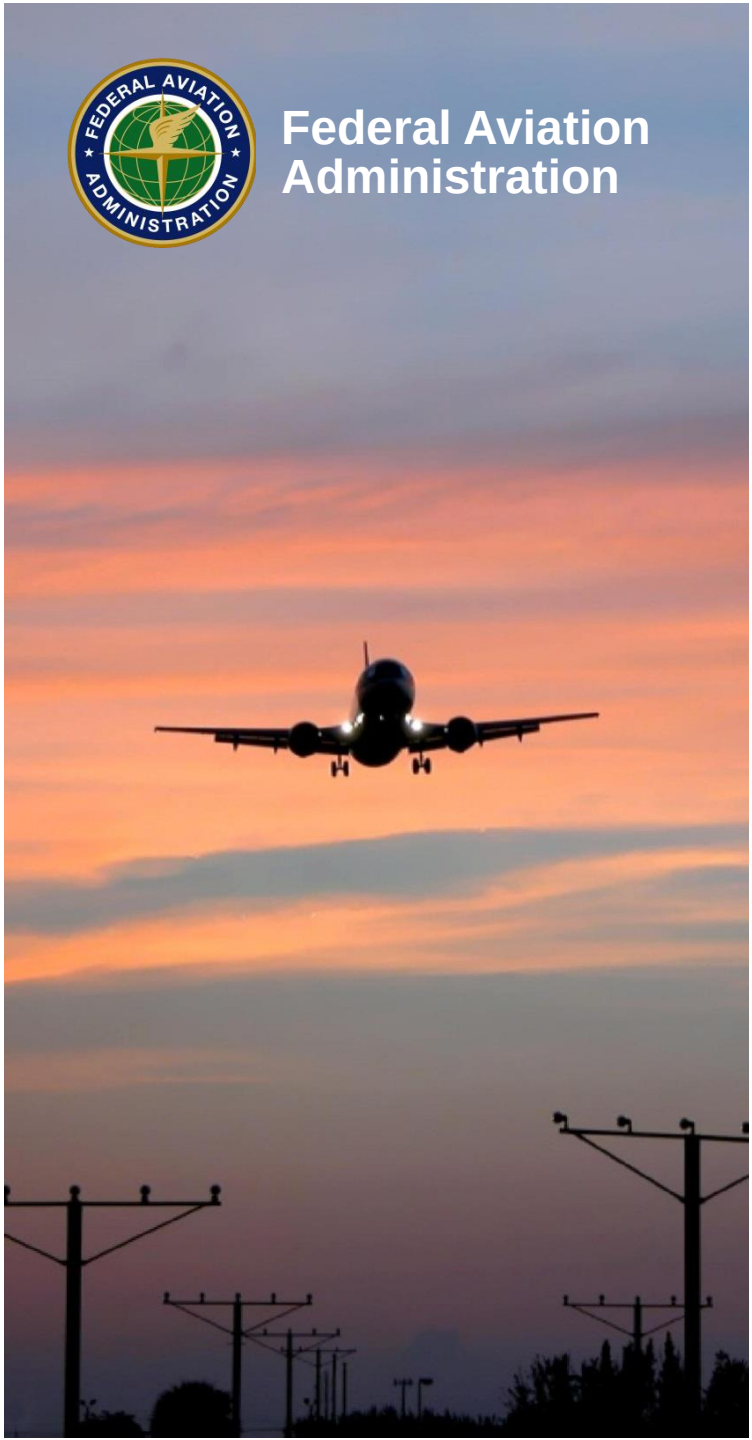


Why Alternate PNT?

- **Presidential Policy Directive 21 (PPD-21), *Critical Infrastructure Security and Resilience***
  - advances a national unity of effort to strengthen and maintain secure, functioning and resilient critical infrastructure
- **FAA needs to maintain aviation operations in the event of a Global Navigation Satellite System (GNSS) interference event or outage**
  - Maintain safety and security
  - Maintain a reasonable level of capacity and efficiency
  - Minimize economic impact
- ***Waiting for the source of the interference to be located and turned off is not an acceptable alternative!***

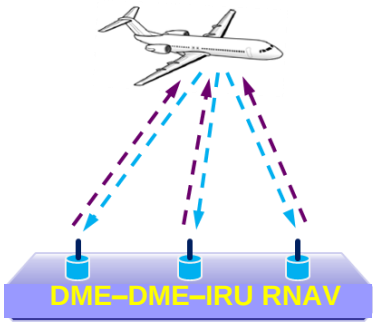
What are “Disruptions”?

- **For GNSS “Disruptions” = “Interference”**
- **GNSS Interference can be:**
  - Intentional/Unintentional
  - Predictable/Unpredictable
  - Manmade/Environmental
  - Crude/Sophisticated (Jamming/Spoofing)
  - Widespread/Localized
- **Applies to all GNSS provided services**
  - Position
  - Navigation
  - Timing

Today's Alternate PNT

- The FAA currently relies on existing legacy systems for GPS alternative navigation which does not fully support RNAV, RNP, or TBO.
- Today's ATC system cannot simply be scaled up to handle twice the traffic
- Today's Legacy PNT services cannot support many NextGen Operational Improvements (OIs) or meet performance requirements necessary to maintain adequate capacity and efficiency
  - Continued reliance on current APNT infrastructure will significantly impact:
    - NAS capabilities and capacities
    - Pilot and controller workload
    - Economic and environmental benefits (fuel, carbon footprint, etc.)
    - Capital budget (Continuation of Current State Requires Recapitalization of VORs: a very large investment for a non-PBN solution)

Legacy Case – DDI and VOR

Alternative	Description	Strengths	Weaknesses	Risk / Rationale
	• Sustain the current DME infrastructure • Sustains the VOR Network • Users must equip with DME/DME/IRU to fly RNAV procedures without GNSS	• No new MOPS/TSO/ICD required • 97% of air carriers already have DDI or DD avionics • Rulemaking not required • Meets minimum RNAV coverage for Air Carrier Operations	• 30% of air carriers (Regional Jets) do not have IRU • Accuracy limited to RNAV-1.0 • No RNP backup, RNP IFPs will be GNSS only • Loss of GNSS may cause unacceptable workload for pilots and controllers as they revert to VOR and radar vectors • Will require retention of additional SSRs • No RNAV backup for GA	**Technical -Low** **Cost – Low** **Schedule – Low**

Performance Summary		Aircraft Equipage Capability			
RNP-0.3	ADS-B-0.05 nm	Air Carrier	Regionals & Business	General Aviation	MOPS Changes
No	No	RNAV-1.0/2.0 Backup	No PBN Backup	No PBN Backup	No

NextGen Alternate PNT

- The Alternative Positioning, Navigation, and Timing (APNT) project is investigating alternatives for providing higher precision back-up for Global Positioning System (GPS)-based position, navigation, and timing (PNT) services.

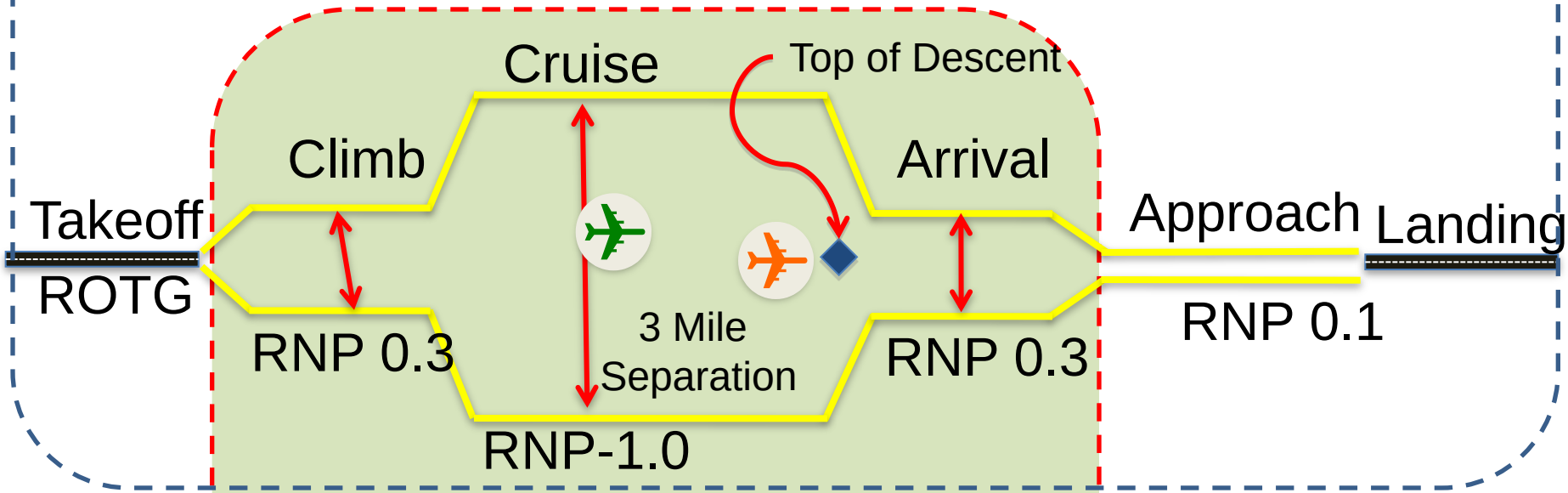
- GPS PNT services are the enablers of performance-based navigation (PBN) and Automatic Dependent Surveillance Broadcast (ADS-B) services that, in turn, enable Trajectory-Based Operations (TBO), area navigation (RNAV), Required Navigation Performance (RNP), and other NextGen improvements.

- NextGen APNT will provide a means for users to seamlessly continue RNAV and RNP operations.

CONOPS Overview – Backup to GPS

Primary PNT Service

GNSS meets all PBN levels and ADS-B performance throughout the NAS and TBO requirements

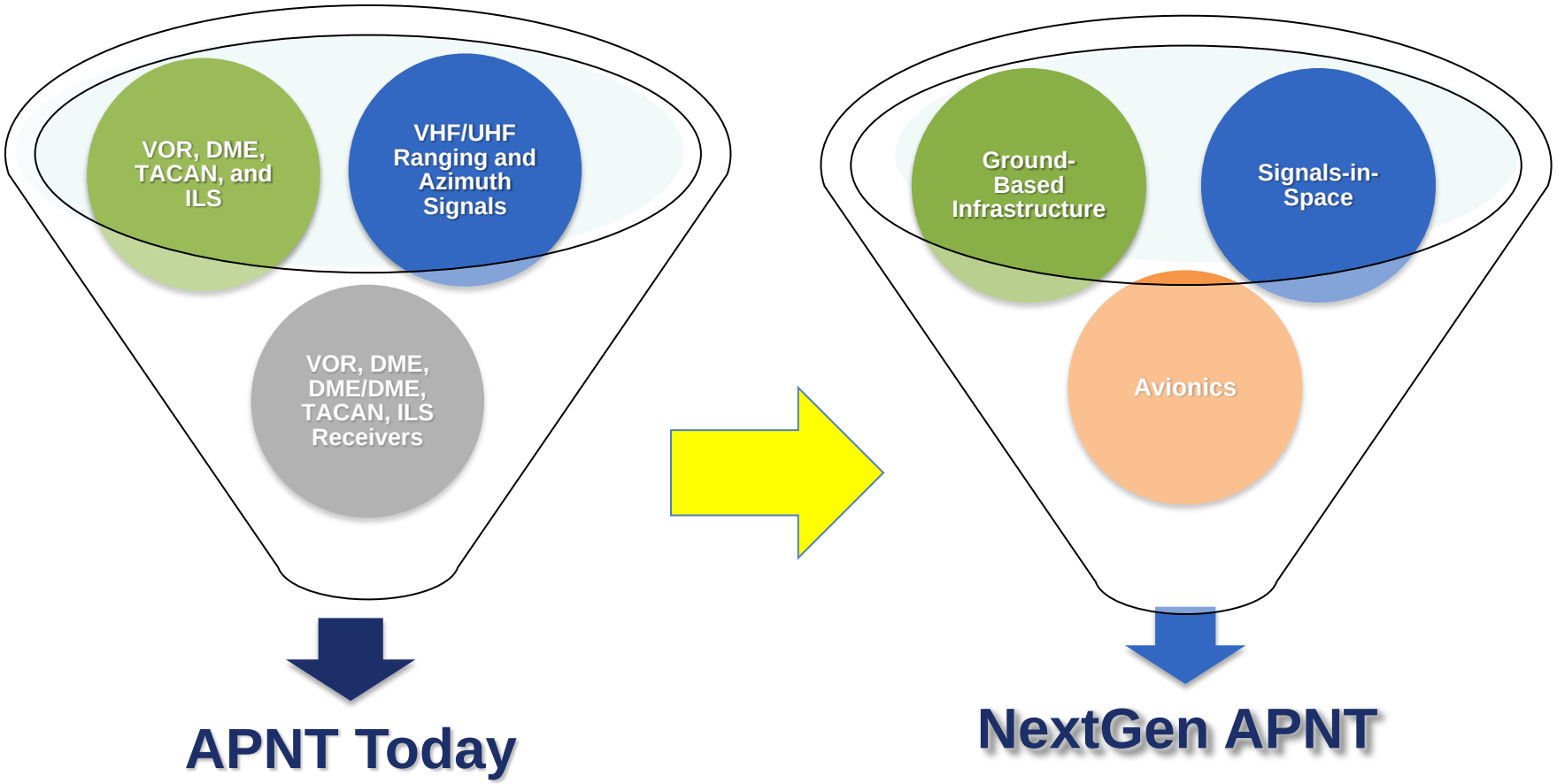


Alternate PNT Service:

Enables RNAV & RNP for enroute and terminal, excluding approach & landing. Provides positioning information for ADS-B

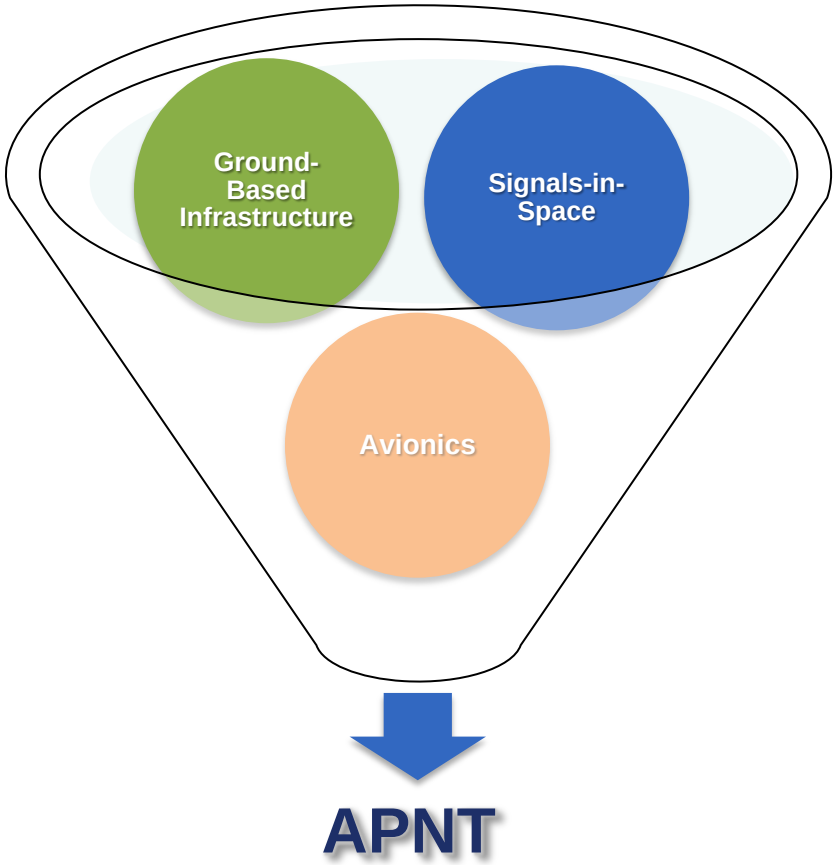
ROTG – RNAV off the ground
RNP – Required Navigation Performance
TBO – Trajectory Based Operations
ADS-B – Automatic Dependent Surveillance Broadcast
PBN – Performance Based Navigation
NAS – National Airspace System

The Road to APNT

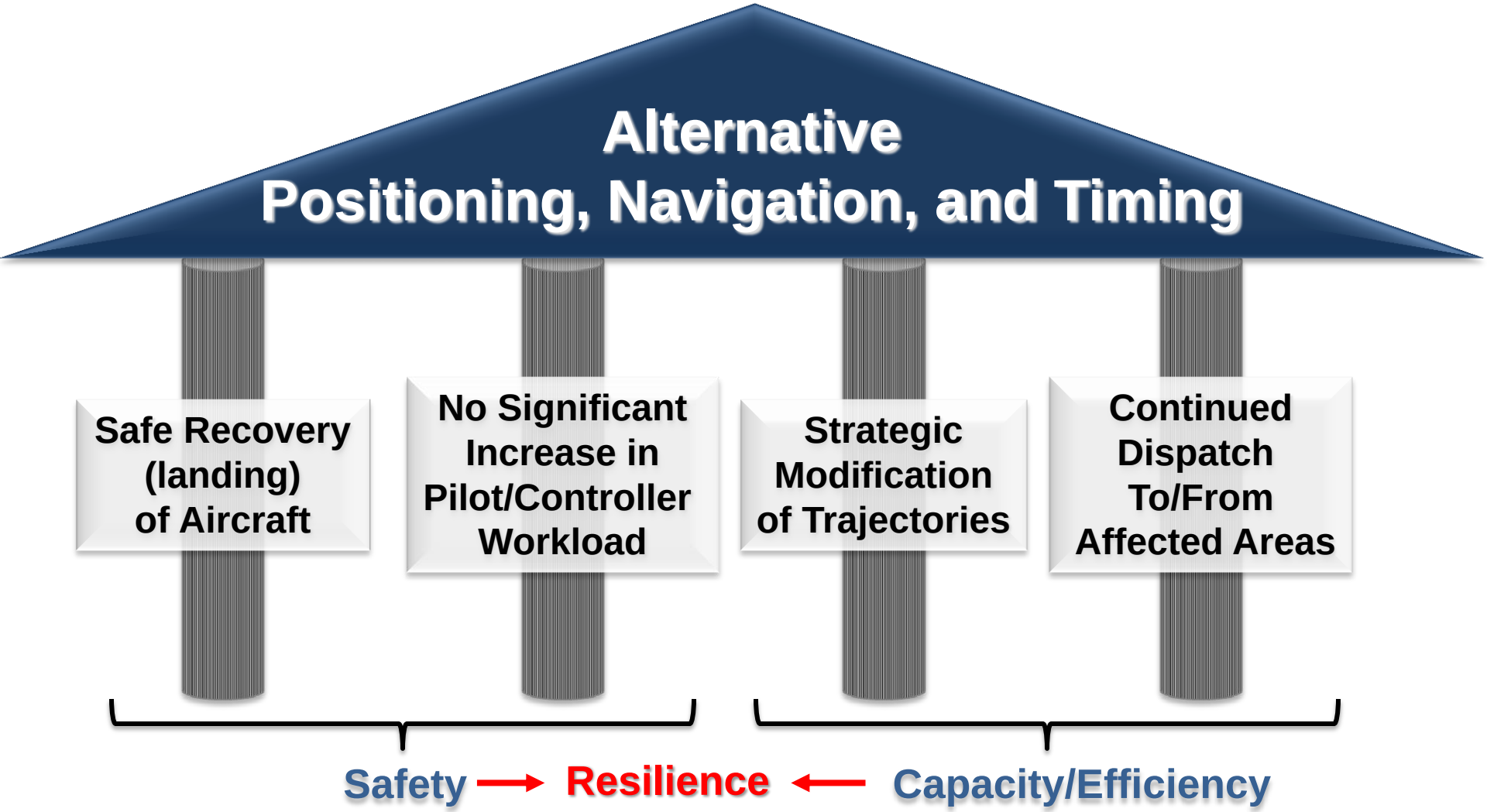


The Road to APNT con't

- The development of APNT requires the identification of multiple solution sets that can serve diverse NAS users
- APNT solution sets will be comprised of ground-based infrastructure transmitting non-GNSS signals-in-space to avionics that may vary by user
- The signals-in-space must support legacy users as well as emerging user communities (e.g., UAS)
- Robustness/resilience is paramount, i.e., safety of operations must be maintained and operations must continue at or near nominal levels



APNT Objectives

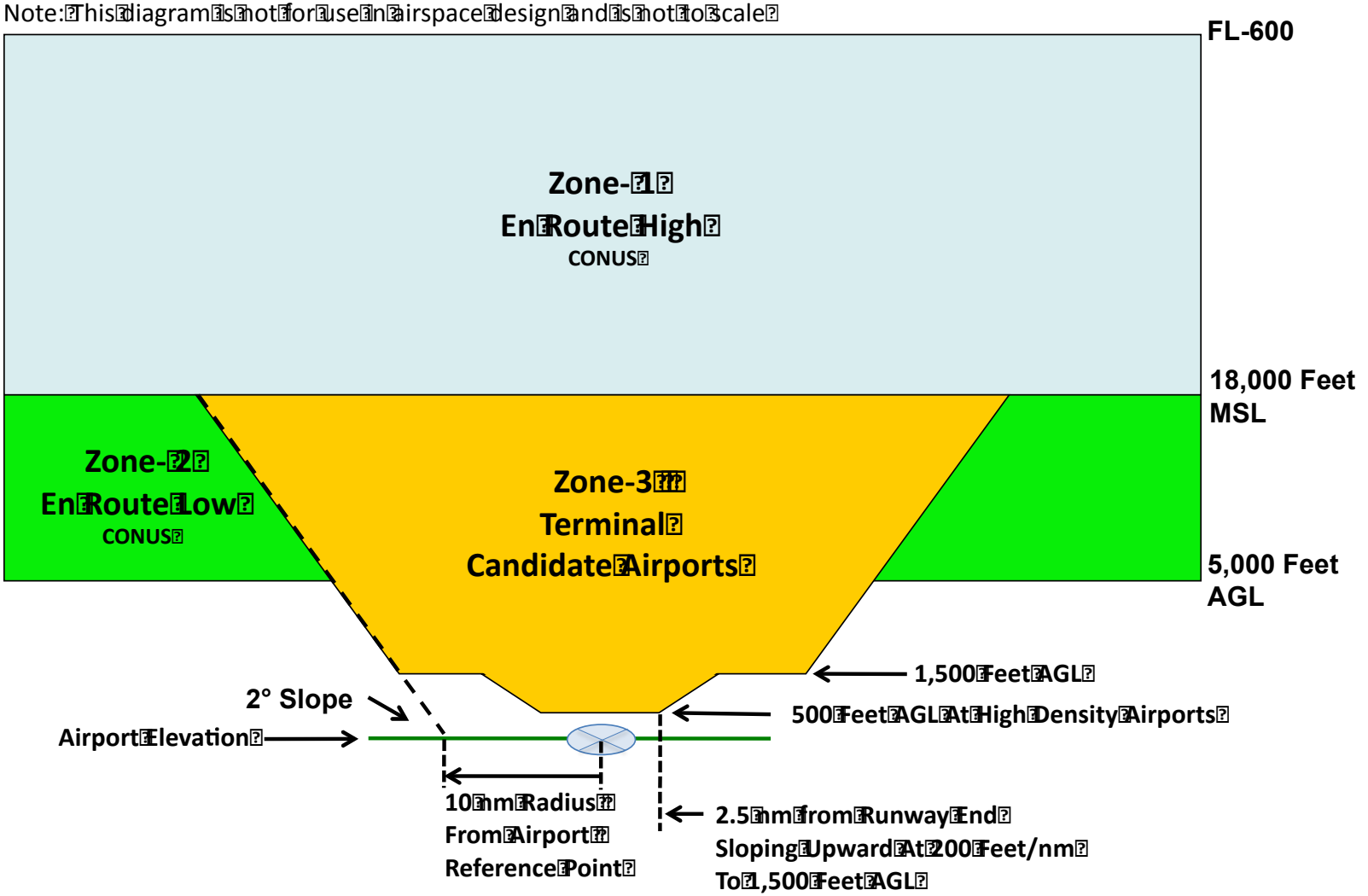


Benefits

NET Benefits: FAA		
Efficiency/Productivity	Yes	Sustains RNAV/RNP – TBO during GPS outages
NET Benefits: User		
Safety	Yes	Users avoid disruptions for transitions from 3nm separation to 5nm during GPS outage
Operator Cost	Yes	Avoid impacts to fuel burn during GPS outage transition
Passenger Value of Time (PVT)	Yes	Minimizes time lost during GPS outages and limits discomfort and cost people experience when traveling
Capacity	Yes	Sustains departure and arrival traffic flow to the Core 30 (minus Hawaii) airports plus the next ~*100 busiest airports in CONUS (*Depending on the business case)

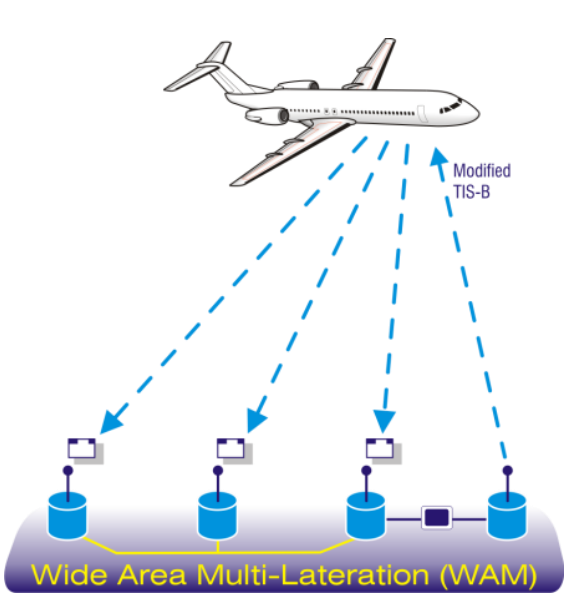
Notional APNT Coverage

Note: This diagram is not for use in airspace design and is not to scale

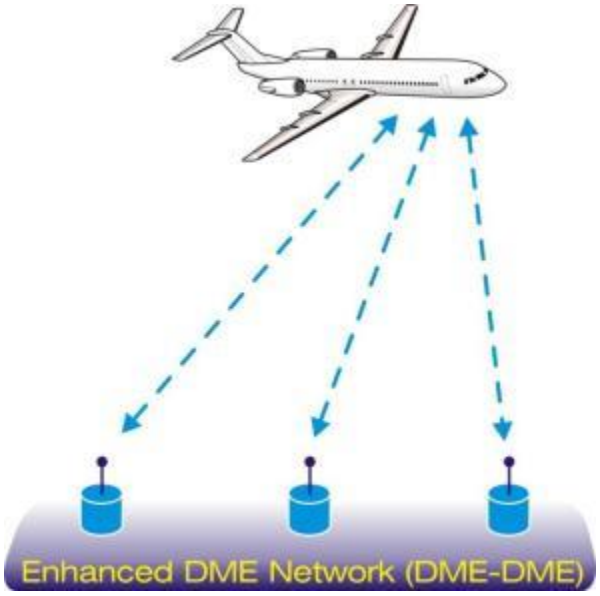


Note: 1,500 foot AGL floor covers arrivals while the 500 foot AGL floor is for departures. The departure coverage starts at 2.5 nm from the runway end and extends upward to cover the climb out and may not be a conical surface around the airport.

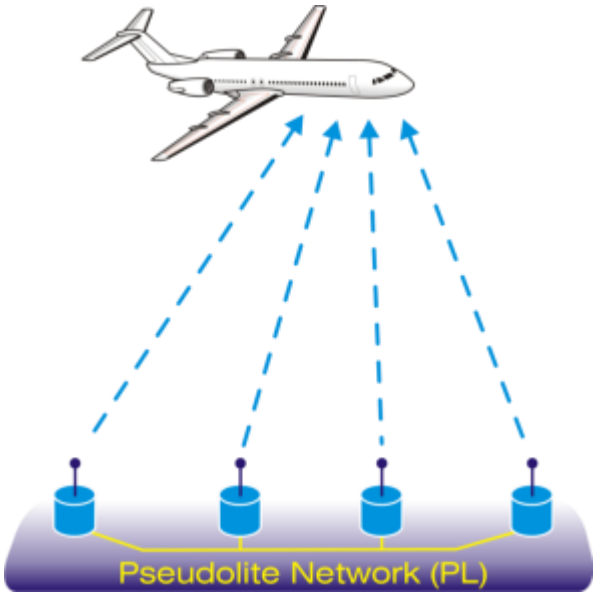
Initial Alternatives Evaluated



- Time-difference of arrival (TDOA) of a signal between several known and carefully surveyed observation points
- Uses TIS-B as a data link for navigation
- Precise synchronization of the ground stations

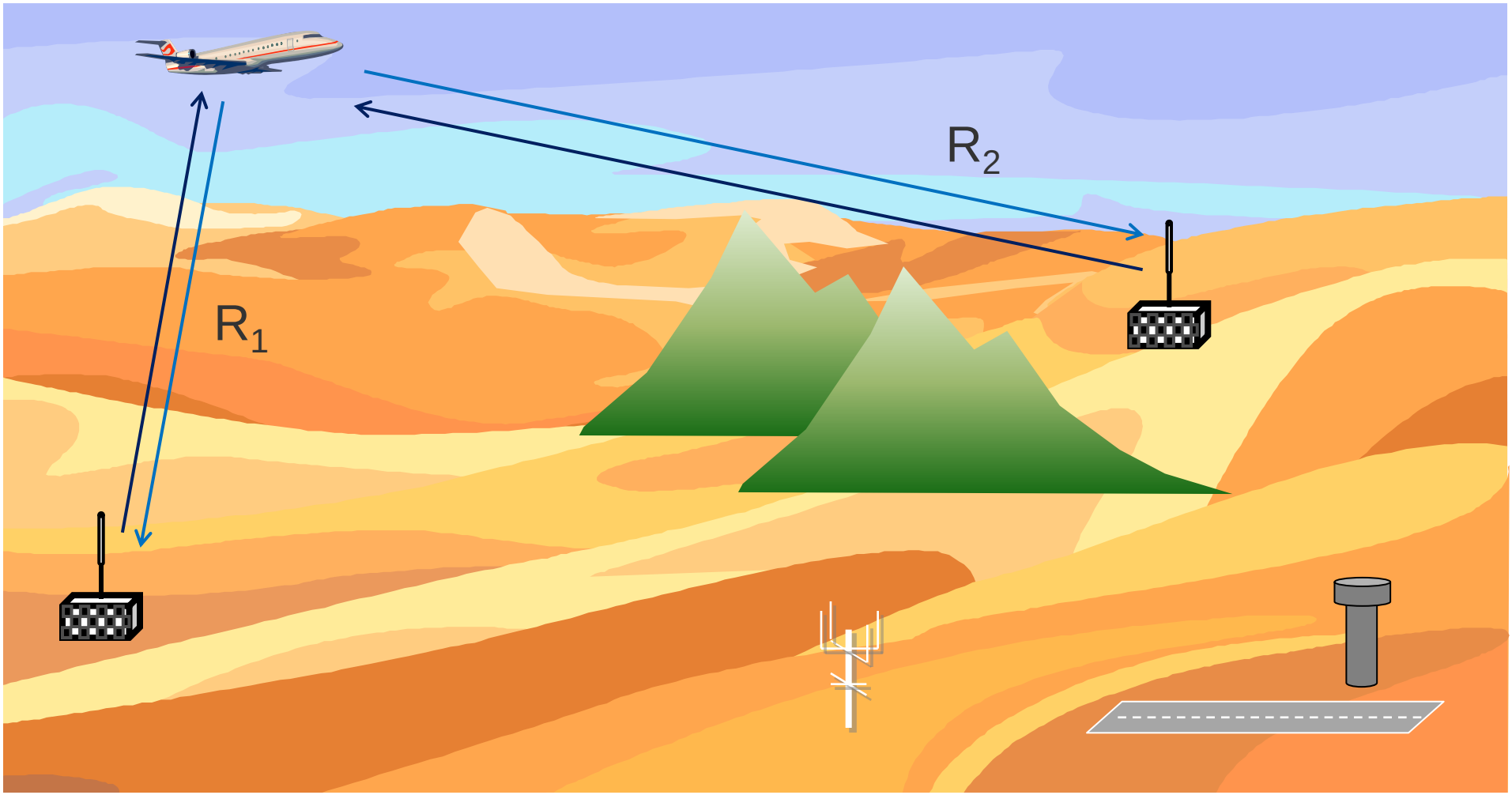


- Leverages Existing DME/DME Technology
- RNAV Today; Impacts to Avionics to realize RNP
- Evaluating means to support both IRU and non-IRU aircraft

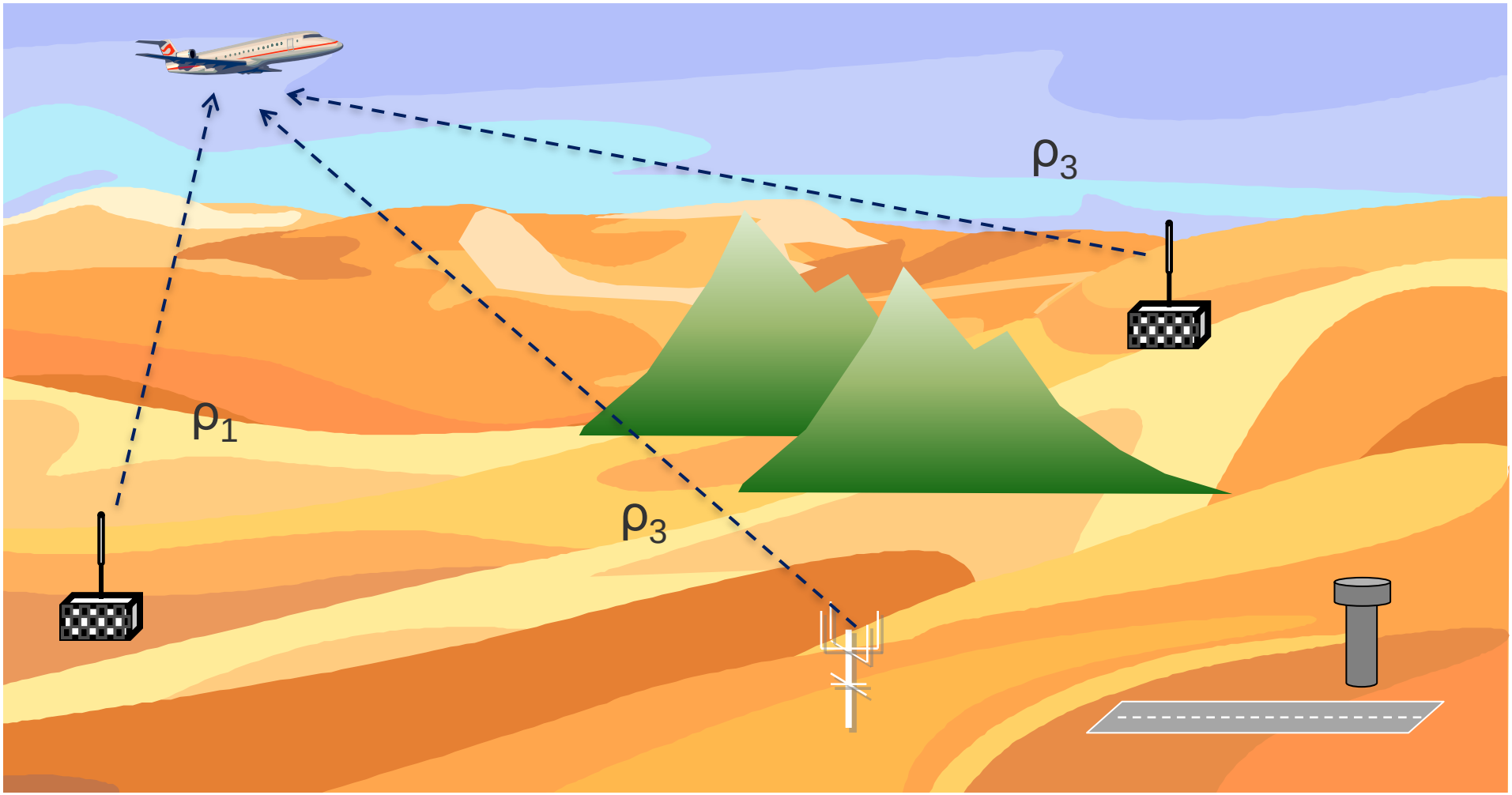


- New Concept
- Leverages DME/GBT Infrastructure
- Provides precise time to aircraft
- Impact to Avionics

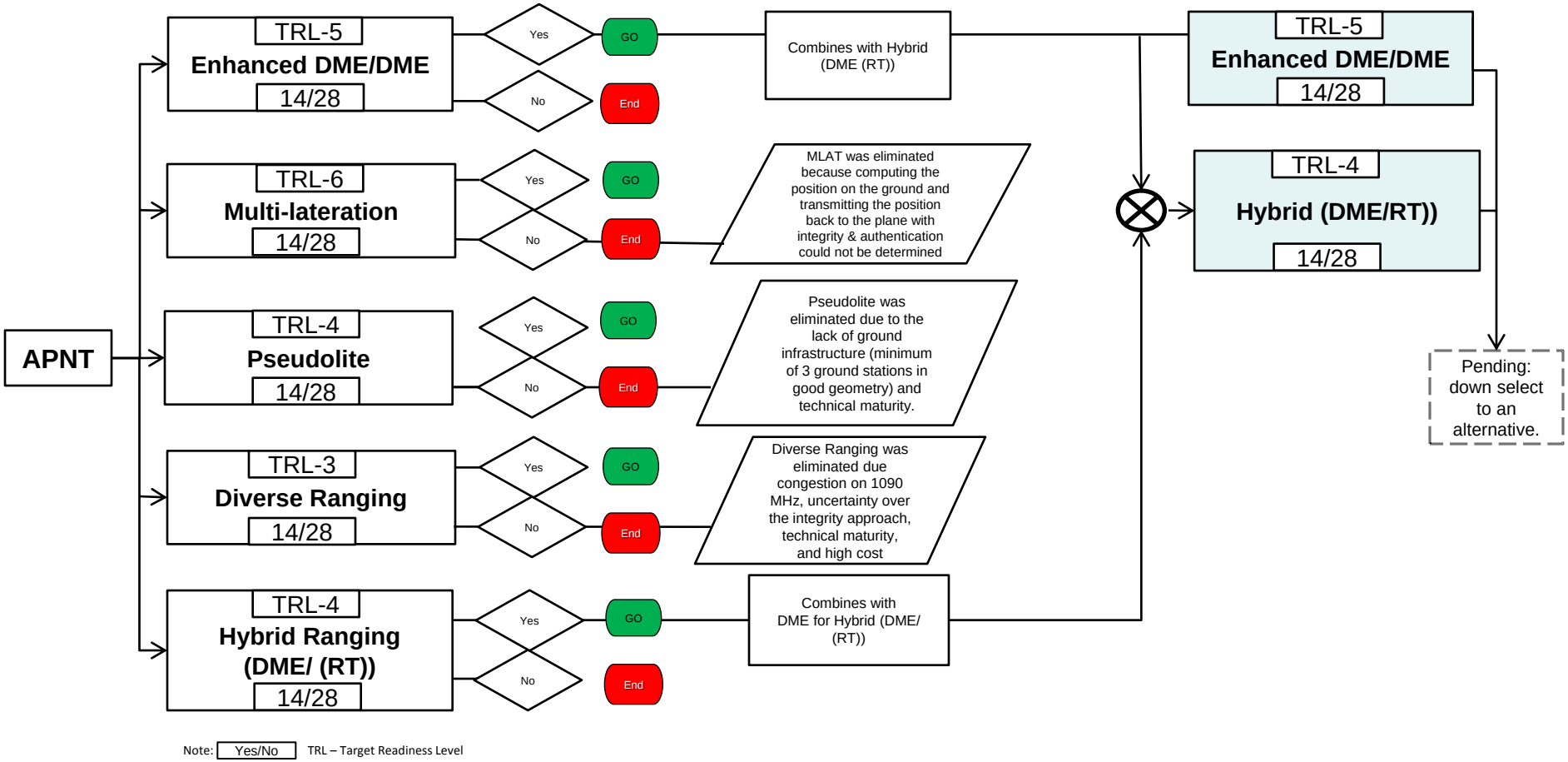
Hybrid APNT Includes DME (two way ranging)



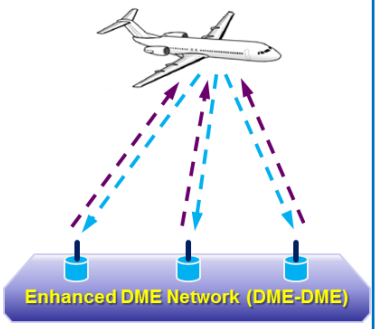
Hybrid APNT Includes GBTs (one way ranging)



Decision Tree

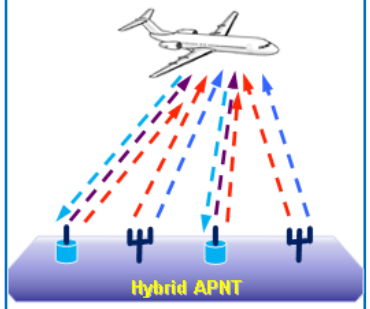


Enhanced DME (eDME)

Alternative	Description	Strengths	Weaknesses	Risk / Rationale
	• Modify DME facilities to enable RNP with Monitoring & Alerting • Modify DME facilities to Improve ranging accuracy to achieve RNP-0.3 • Modify DME avionics to enable Monitoring & Alerting and improved accuracy • Assumes NextGen DME will eliminate critical facilities and fill coverage gaps for DD-only users	• Air carriers are equipped with DDI • MOPS/TSO already exist (RTCA/SC-227) • Global Air Navigation Plan compatible	• MOPS Changes will be needed to enable RNP accuracy and monitoring & alerting • RTCA/SC-227 does not support • GA does not have DME • Performance may be limited to RNAV-0.6 at best. • Does not meet ADS-B positioning requirements (SSRs still needed) • Will need to retain more VORs	**Technical - High** • Enabling RNP Monitoring & Alerting - High Risk • RNP-0.3 accuracy - High Risk **Cost – Medium** • Aircraft – High • GND system – Low **Schedule – Medium** • Aircraft – High • GND System - Low

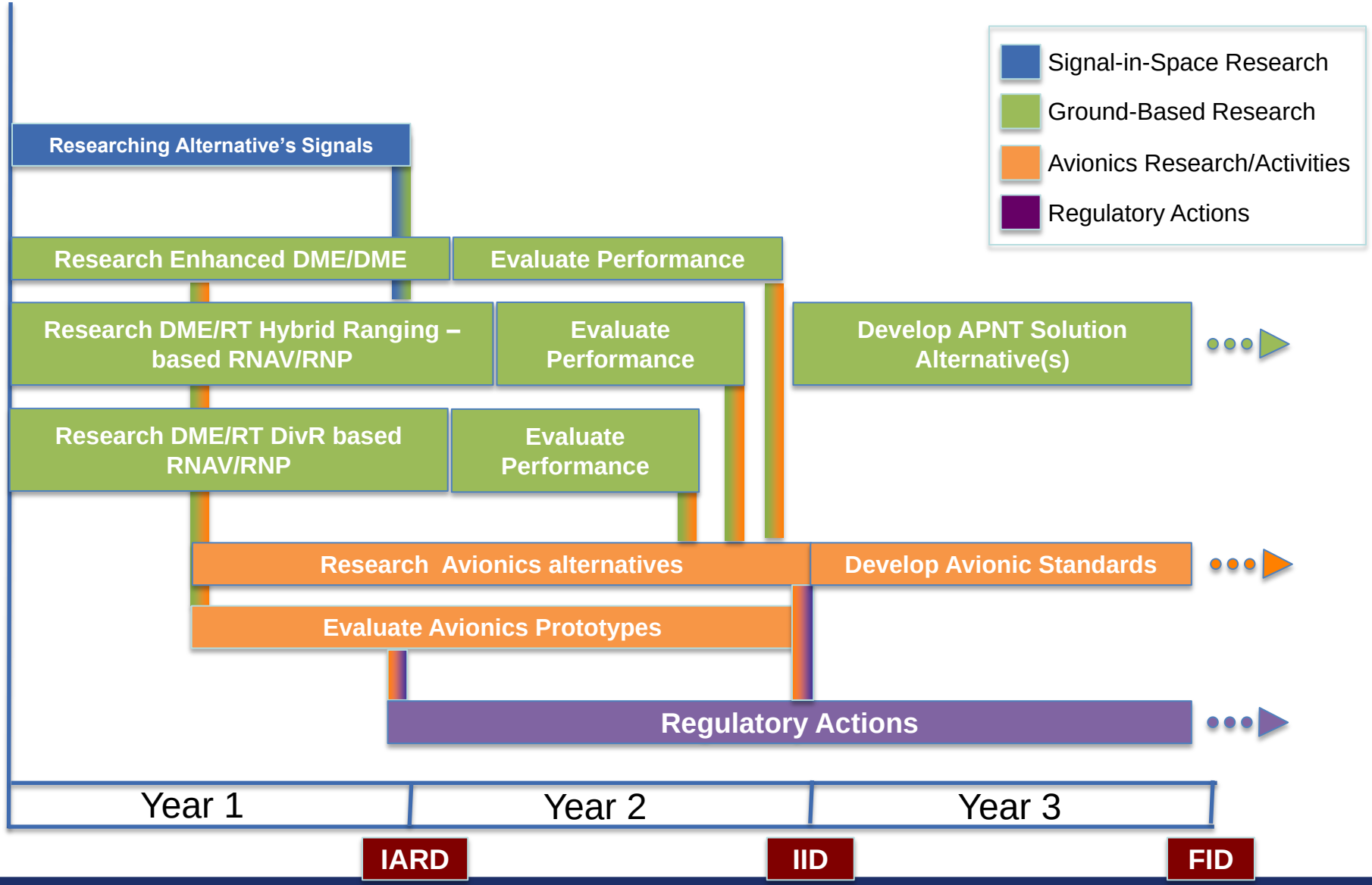
Performance Summary		Aircraft Equipage			
RNP-0.3	ADS-B 0.05 NM	Air Carrier	Regionals & Business	Genaral Aviation	MOPS Changes
TBD	No	RNP-0.3 Backup	RNP-0.3 Backup	No PBN Backup	Yes

Hybrid Ranging

Alternative	Description	Strengths	Weaknesses	Risk / Rationale
	• Modify DMEs to add a pseudolite ranging signal • Modify ADS-B RTs to enable 1090/UAT ranging • New Avionics to compute position solution • Provide backup positioning for PBN and ADS-B • Assumes NextGen DME will eliminate critical DMEs and fill coverage gaps.	• Achieves the accuracy required for RNP-0.3 • Provides RNP Monitoring & Alerting • Signal and site diversity	• Requires new MOPS/TSO/ICD • No user equipage base • Long term solution • Most costly alternative	**Technical -Medium** • Achieving RNP Monitoring & Alerting – Medium Risk • Meeting accuracy for RNP-0.3 – Low Risk • User acceptance – Medium Risk **Cost – High** **Schedule - High**

Performance Summary		Aircraft Equipage Capability			
RNP-0.3	ADS-B 0.05 NM	Air Carrier	Regionals & Business	General Aviation	MOPS Changes
Yes	Yes	RNP-0.3 Backup	RNP-0.3 Backup	RNP-0.3 Backup	Yes

Nominal APNT Development Activities



Summary

- ***GNSS is vulnerable!***
- Today's status quo may not be an acceptable alternative in the future as GNSS services continue to proliferate and support more and more critical operations
- There are robust and resilient alternatives – but there is a need to identify and incorporate them into operations that ensure safety and security and to mitigate significant economic impact
- NextGen is addressing the need for robust and resilient alternative position, navigation, and timing services

Questions

Back Up

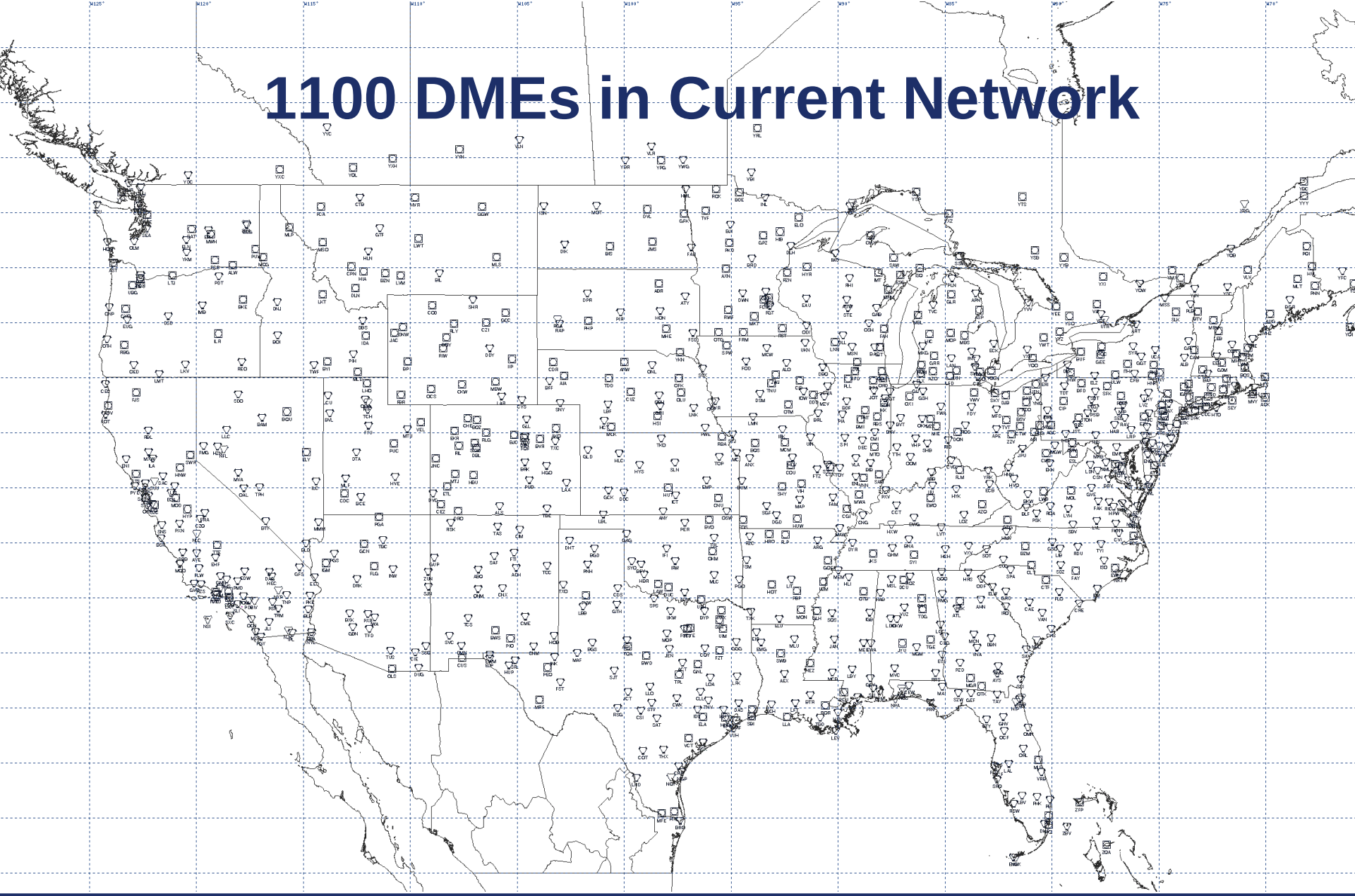
Legacy Infrastructure Description

- **VOR MON ~ 500 VORs**
  - 30 to 40 years old
- **DME Service**
  - DME ~400
    - 30 to 40 years old
  - TACAN ~537
    - 40 to 50 years old
- **Aging infrastructure will require sustainment activities**
  - Technical refresh required

Legacy Case

	Capabilities	Navigation Enablers	
Description	**Current**	**Primary**	**GNSS Backup**
Class A Airspace FL180-FL600 (with gaps)	VOR Airways Q/T Routes (RNAV-2.0)	GNSS or VOR	70 % of air carriers can use DDI for en route above FL240 and terminal RNAV at approximately 135 Airports All others revert to VOR/DME for en route & terminal Navigation VOR/DME/ILS for approach & landing
Class B - 36 Airports 1000' AGL up to 10,000 AGL	Conventional SID/STAR RNAV SID/STAR (RNAV-1.0) RNAV Approach Conventional Approach	GNSS or VOR/ILS	
Class C – ~99 Civil Airports 1000' AGL up to 4000 AGL			
Class E Airspace 5000 AGL up to FL180	VOR Airways Q/T Routes (RNAV-2.0)	GNSS or VOR	VOR navigation for en route & terminal VOR/ILS for approach & landing

1100 DMEs in Current Network



Combined Network of DMEs and GBTs