Session 10

Resilience by Design: NAV MON/RON

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Agree or disagree?



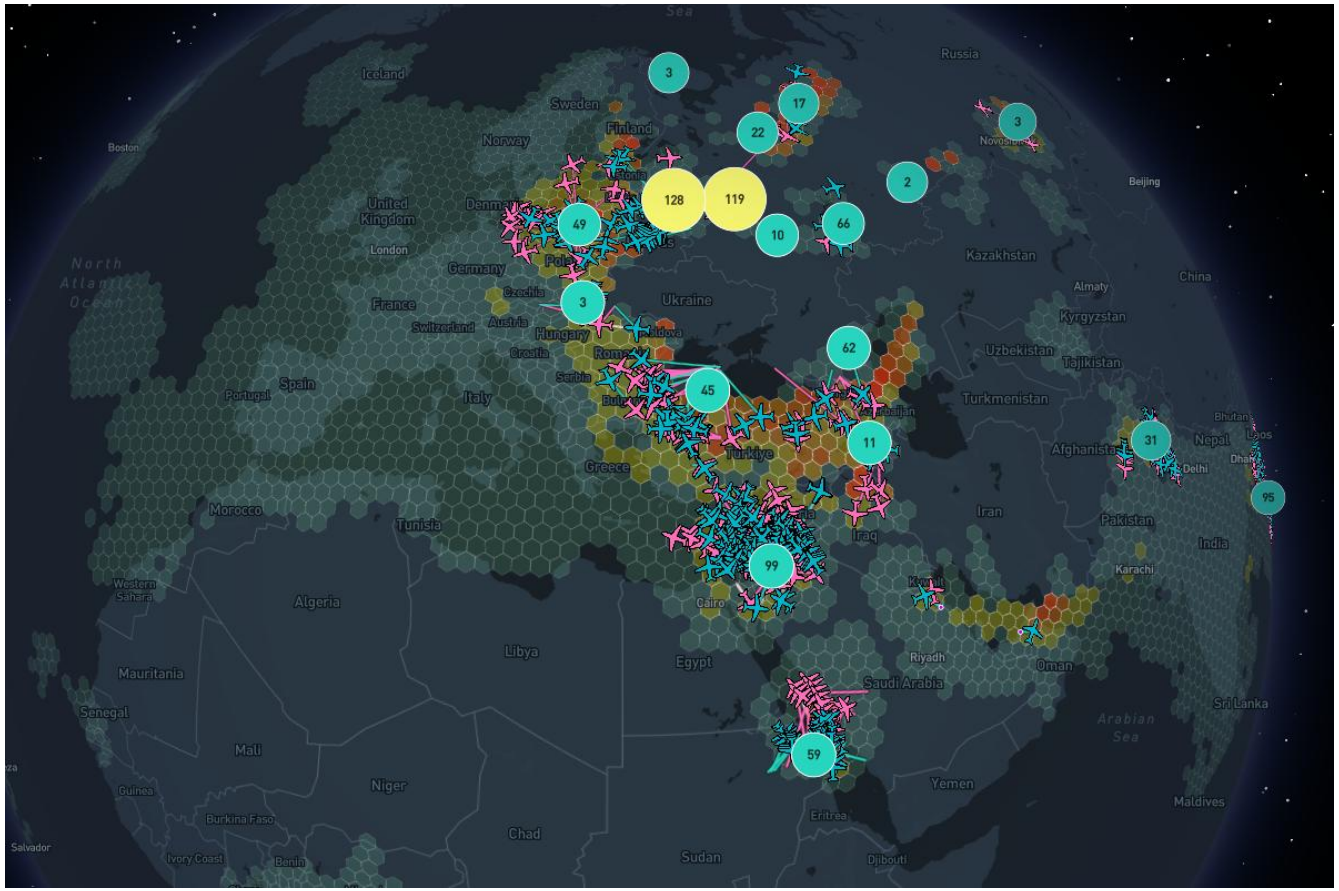
The future of navigation resilience depends on maintaining terrestrial navigation infrastructure alongside GNSS

Terrestrial CPNT for a Resilient RNP

Okuary Osechas; ZHAW



GNSS interference accompanies geopolitical conflict …



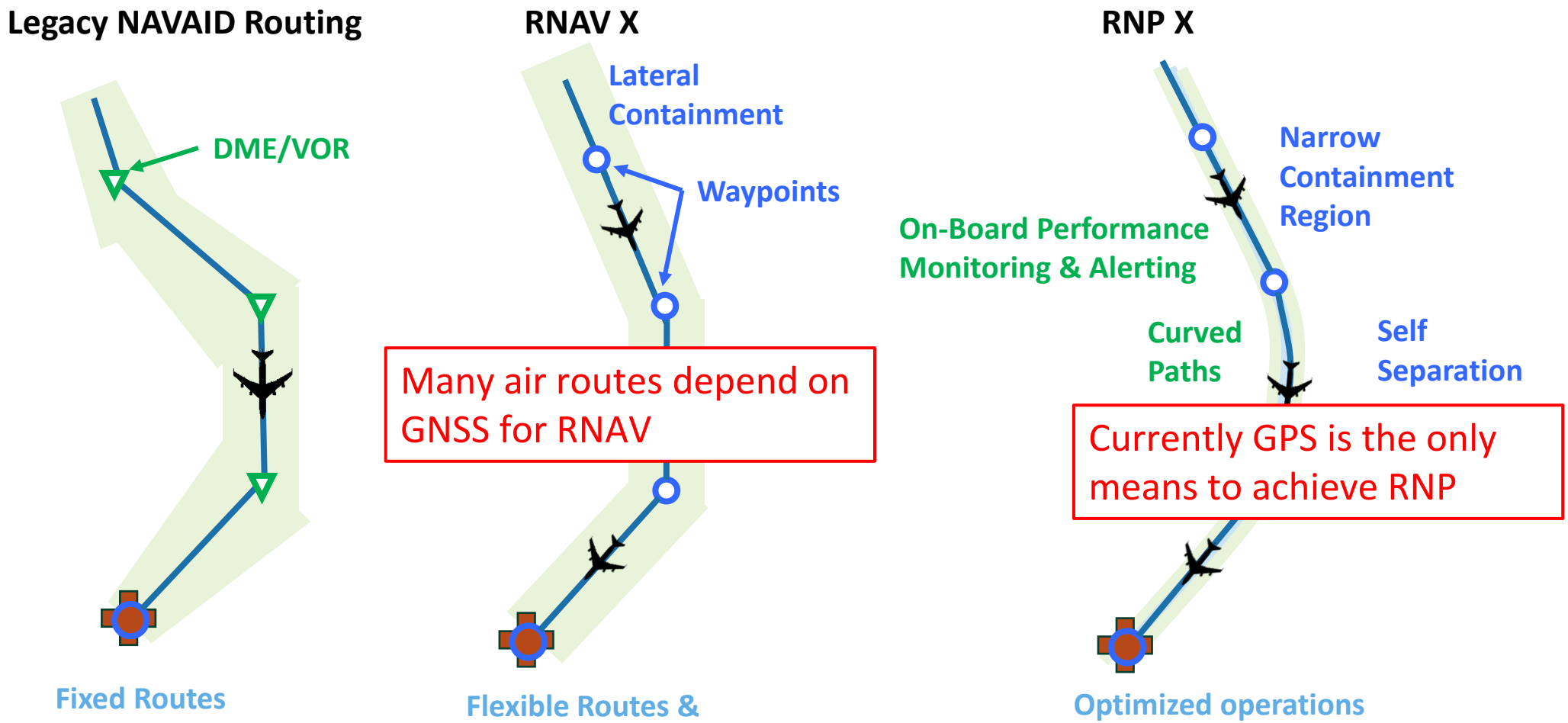
https://gpswise.aero/map

… and it's killing Performance Based Navigation (PBN)

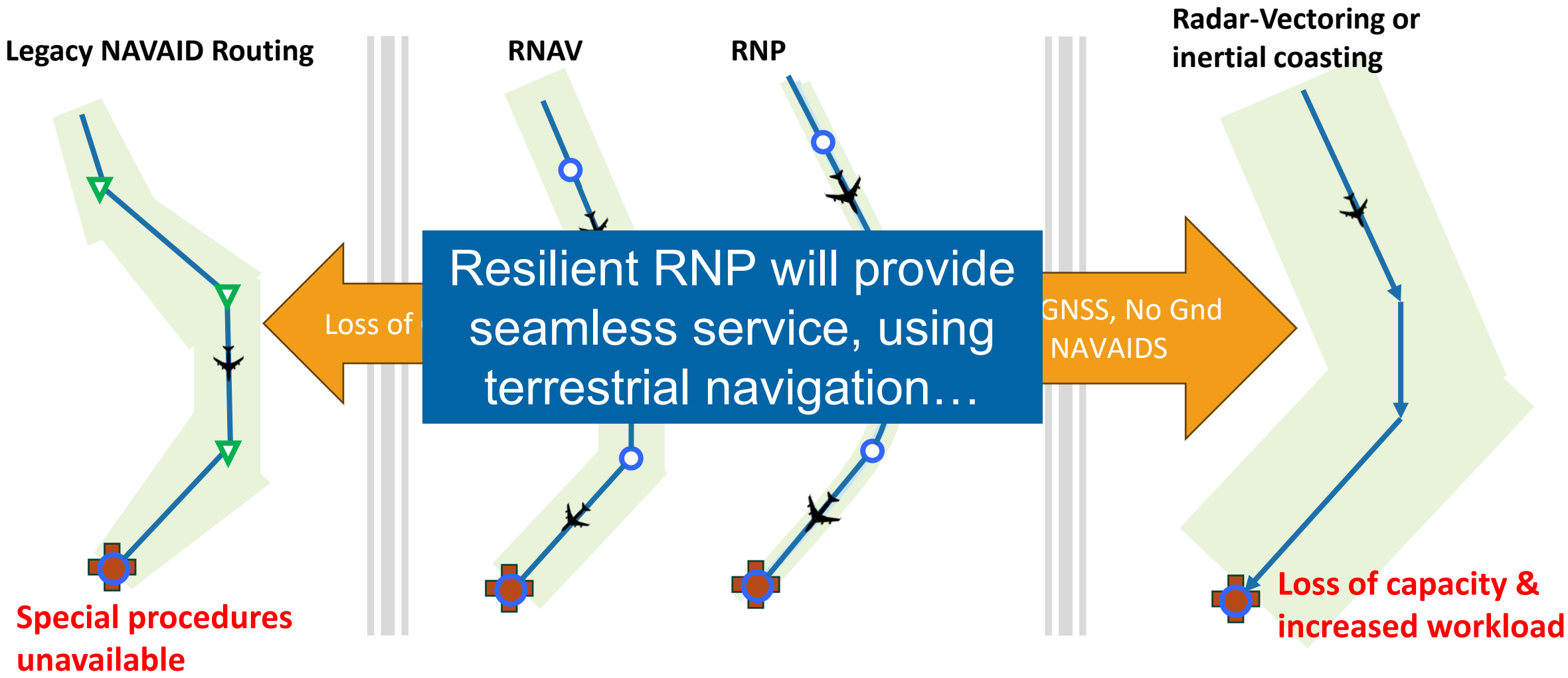


Okuary Osechas Friederike Fohlmeister Thomas Dautermann, and Michael Felux NAVIGATION: Journal of the Institute of Navigation June 2022, 69 (2) navi.516; DOI: https://doi.org/10.33012/navi.516

PBN improves efficiency, flexibility and increases capacity



Loss of GNSS disrupts operations



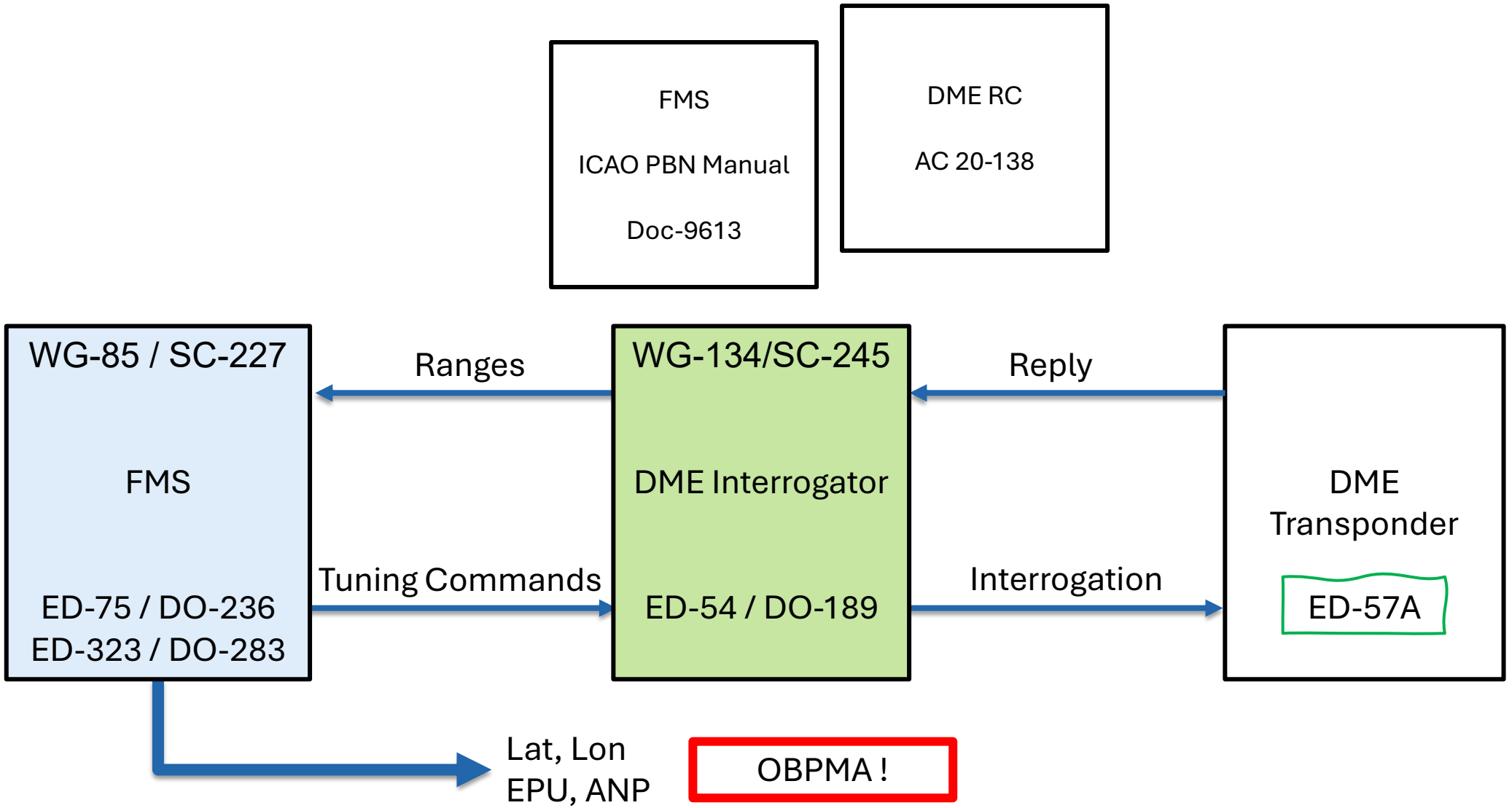
… Distance Measuring Equipment (DME)

There is a lot of on-going activity to make RNP Resilient

WG	ED	Draft Title	Target Date
WG-85 / SC-227	ED-75G / ED-236F	Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation	2027
WG-85 / SC-227	ED-323A / ED-283D	Minimum Operational Performance Standards: Required Navigation Performance for Area Navigation	2027
WG-134 / SC-245	ED-54A / DO-189A	MOPS for DME Interrogator (DME/N and DME/P) Operating Within the Radio Frequency Range 960 to 1215 MHz	2027

DME and RNP standards are spread over several documents

Many are being updated



Two active WG/SC

Required Navigation Performance (RNP) and Distance Measuring Equipment (DME)

Zurich University of Applied Sciences
zh aw School of Engineering

WG-85 / SC-227:

MASPS and MOPS for RNP

Recent tasks:

- Removed language for GNSS dependence
- Introduced DME Navigation (aka Multi-DME)

Next goals:

- RNP with DME!!
- Updates to Time of Arrival Control (TOAC)

WG-134 / SC-245:

Airborne DME Interrogators

Short term:

- Quantitative error model of DME
- Tuning behavior of interrogator

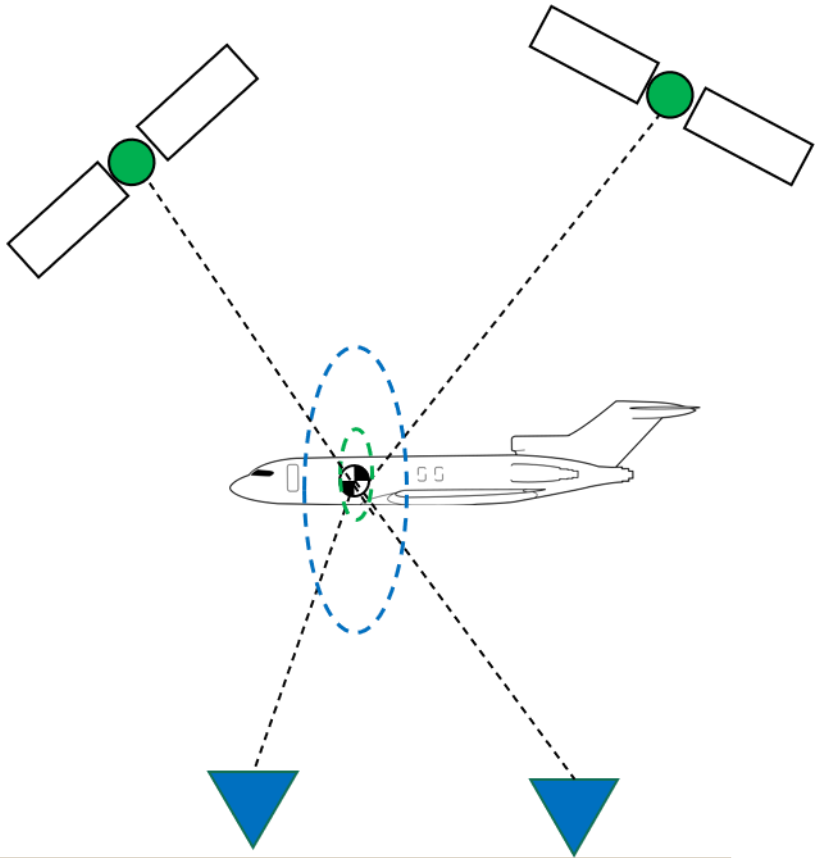
Long term:

- Interference Tolerance Mask (ITM)
- Enhanced DME (eDME)

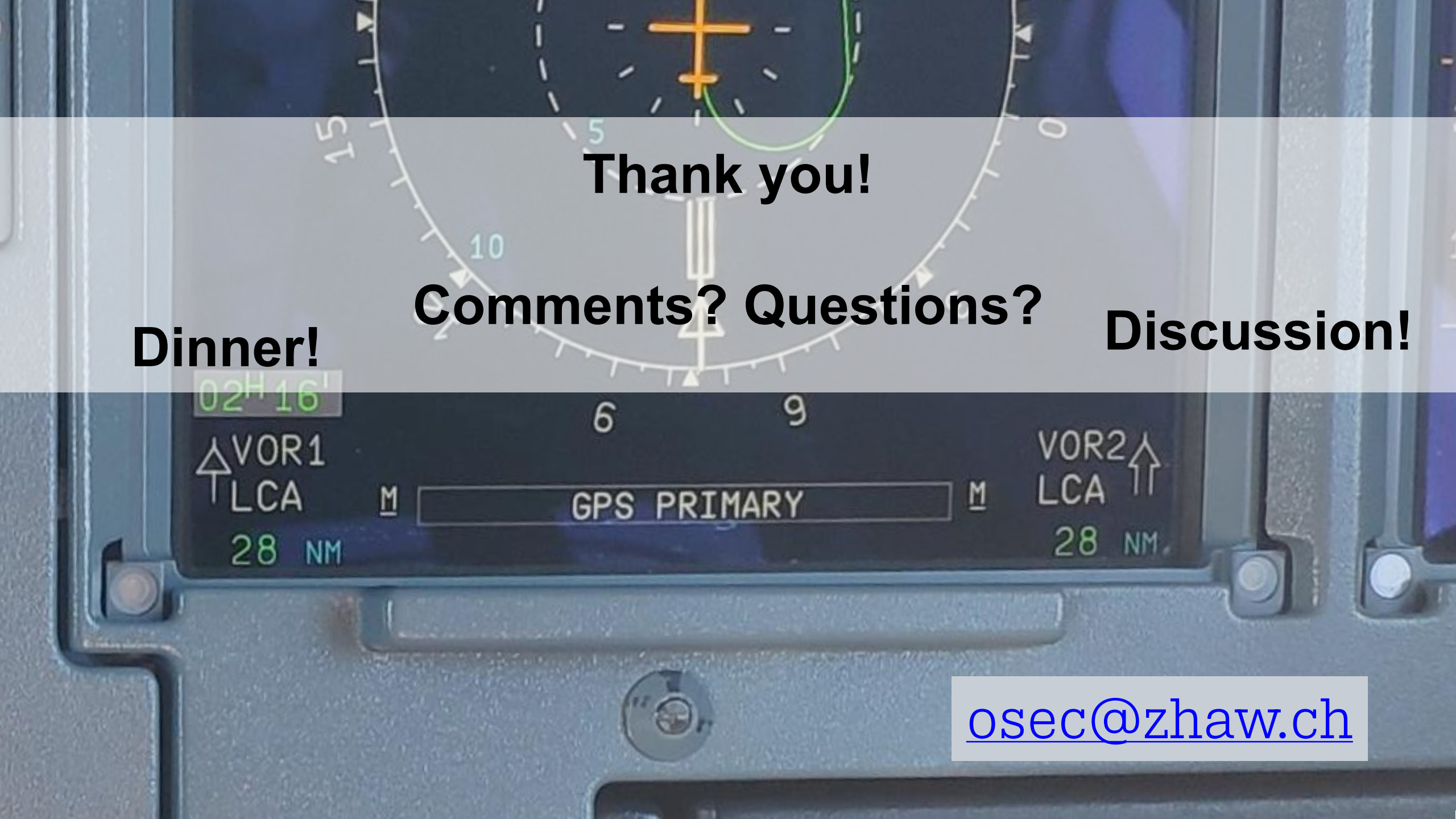
Complementary PNT: a modular approach to navigation

- Integrate:
  - GNSS
  - DME
- Later:
  - eDME
  - LDACS

Inertial Fusion?



… to deliver Resilient RNP on a wide scale.

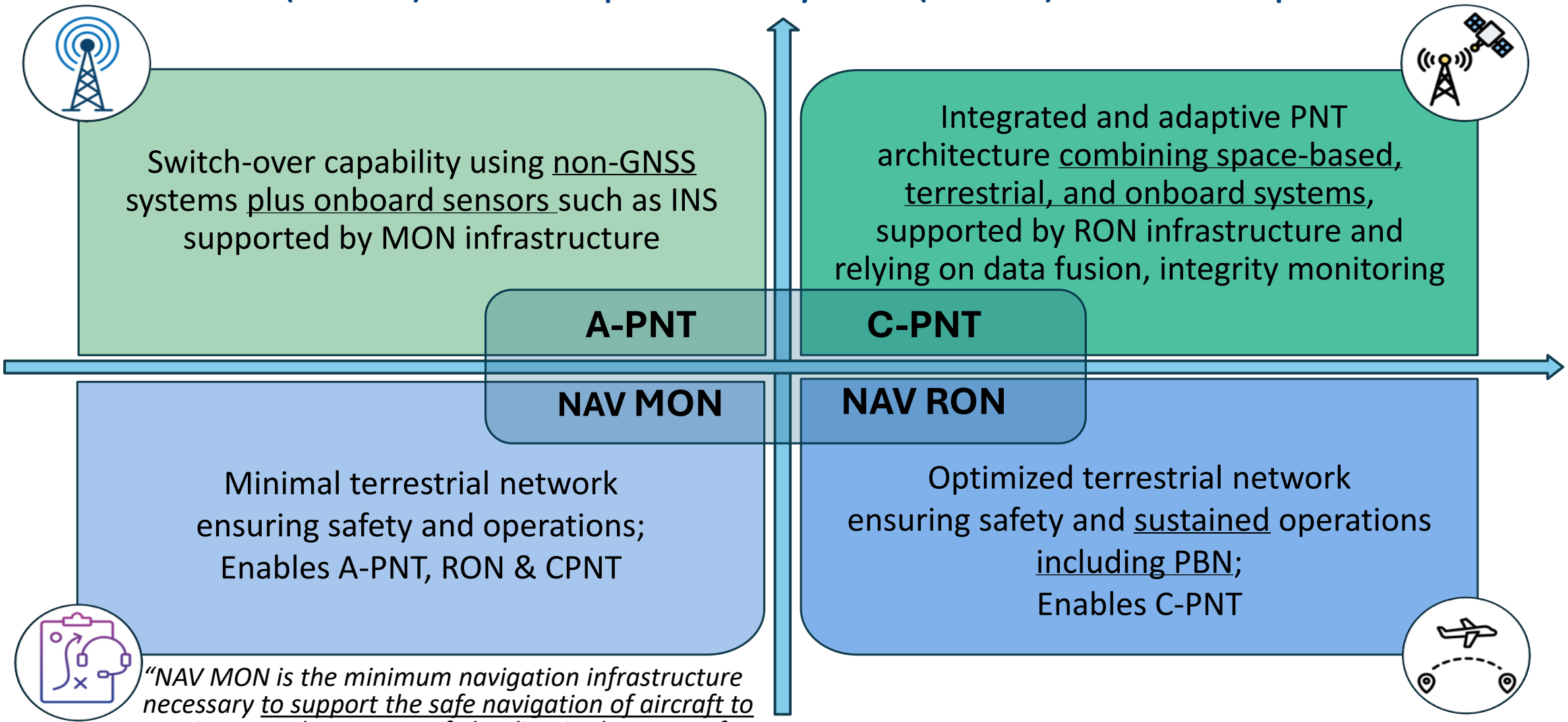

Thank you!
Comments? Questions?
Dinner!
Discussion!
02H 16'
VOR1
LCA
28 NM
M
GPS PRIMARY
M
VOR2
LCA
28 NM
osec@zhaw.ch

Session 10 - Resilience by Design: NAV MON/RON

Ken Alexander

Chair, ICAO Navigation Systems Panel

Minimum Operational Network (MON), Resilient Operational Network (RON), Alternative PNT (A-PNT) and Complementary PNT (C-PNT) Relationships



"NAV MON is the minimum navigation infrastructure necessary to support the safe navigation of aircraft to an airport and ensure a safe landing in the event of navigation service degradations"

Complementary PNT Requires Capabilities Independent of GNSS

Complementary PNT sustains operations when GNSS is unusable and provides a reference source for “reasonableness check”

Sensor diversity must provide independence from GNSS interference

Shared Vulnerability

- Multiple GNSS receivers share common frequencies/interference exposure
- Common frequencies create common vulnerabilities

Complementary Capability

- DME & Inertial systems can complement GNSS
- Coverage, equipage and performance must meet area navigation (RNAV) and/or required navigation performance (RNP) requirements

The Operational Test

Can the combined capability maintain the RNP when GNSS is degraded and cannot be used, without sharing its failure dependencies?



ICAO's Work Plan Enables State Resilient Operational Network Design and Progresses A-PNT and continues assessing C-PNT Q4 2032

Job Card NSP.010.01 takes a holistic perspective to provide States information they need to design their networks of terrestrial navigation infrastructure to be complementary **and** resilient







Operations and CONOPS

Operational guidance –Q4 2030

Maintain **safe and efficient** operations during GNSS degradation

RON CONOPS – Q4 2030

Define RON operations and relationship between MON and RON

C-PNT Report – Q4 2027

Evaluates Technical Options for improved, backward compatible DME

Charts, routes and data

Aeronautical charts – Q4 2027

Add or restore annotations for VOR/DME cross-checks and ILS intercept

Route spacing – Q4 2027

Preserve spacing for mixed conventional & PBN procedures during GNSS reversion

Digital infrastructure data – Q4 2027

Enables aircraft and aircrew to understand of PBN infrastructure level; Avoid GNSS-only specifications where appropriate

DME network performance

DME selection/tuning – Q4 2027

Clarify PBN criteria so aircraft use available DME facilities during GNSS reversion

Network pulse load Assessment – Q4 2027

Develop pulse load method; Optimize DME density for traffic and satisfactory service

Note: Above Job Card Activities are representative & not all inclusive of work done and to do!



Join SLIDO