



GREENER SKIES FOR BRAZIL: CONSIDERATION FOR EFFICIENT SIMULTANEOUS APPROACHES USING THE RNP ESTABLISHED CONCEPT

*Boeing Global ATM
& Airspace and Operations Efficiency*



SITRAER 2015
AIR TRANSPORTATION SYMPOSIUM
São José dos Campos, SP, Brazil
October 26 - 28, 2015

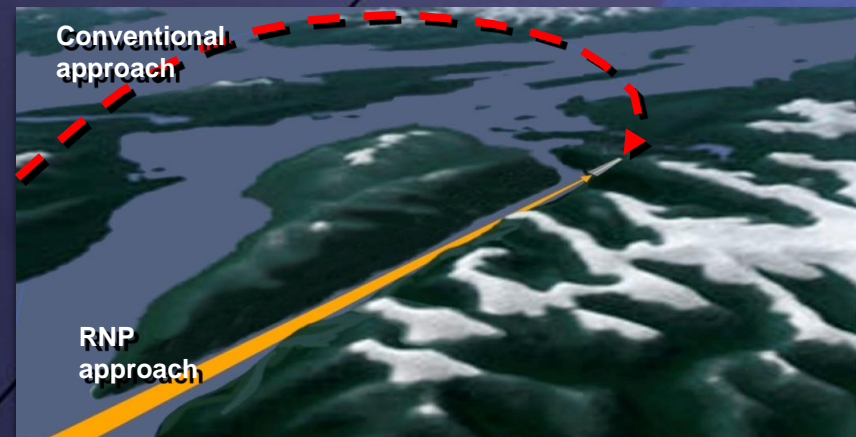
Export of this technology is controlled under the United States Export Administration Regulations (EAR) (15 CFR 730-774). An export license may be required before it is used for development, production or use by foreign persons from specific countries. The controller of this data has the individual responsibility to abide by all export laws. Controlled by ECCN: 9E991 Date: 09-15-12

Copyright © 2012 Boeing. All rights reserved.

Copyright © 2015 Boeing. All rights reserved.

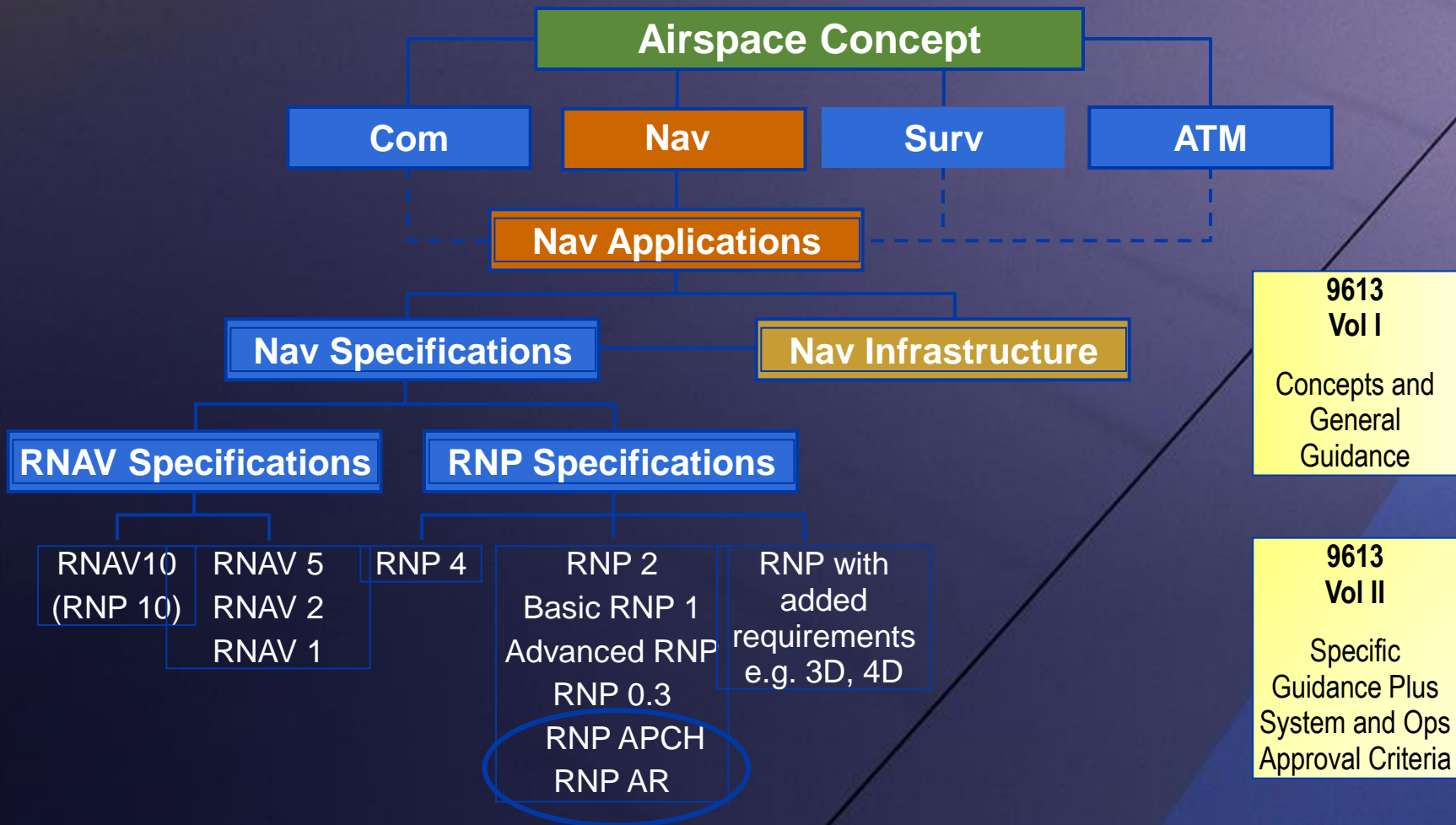
Performance-Based Navigation (PBN)

- Enables the airplane to navigate precisely along defined flight path
- Utilizes capabilities of the aircraft flight management avionics
- Uses GPS/GNSS navigation infrastructure
- Requirements for PBN operations formally defined as:
 - Accuracy
 - Integrity
 - Continuity
 - Availability
 - Functionality

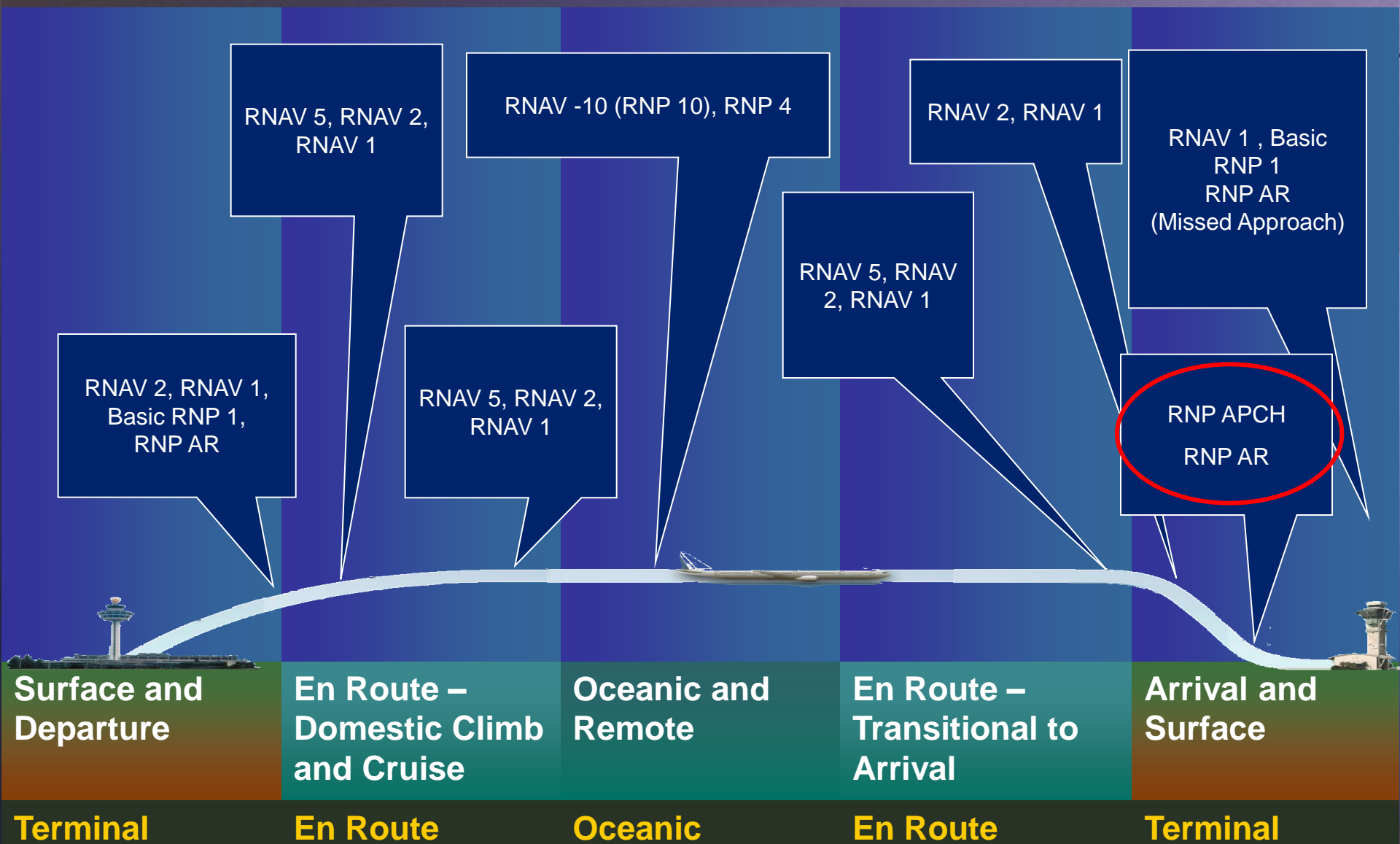


ICAO PBN Concept

Both RNAV and RNP are Performance Based Navigation

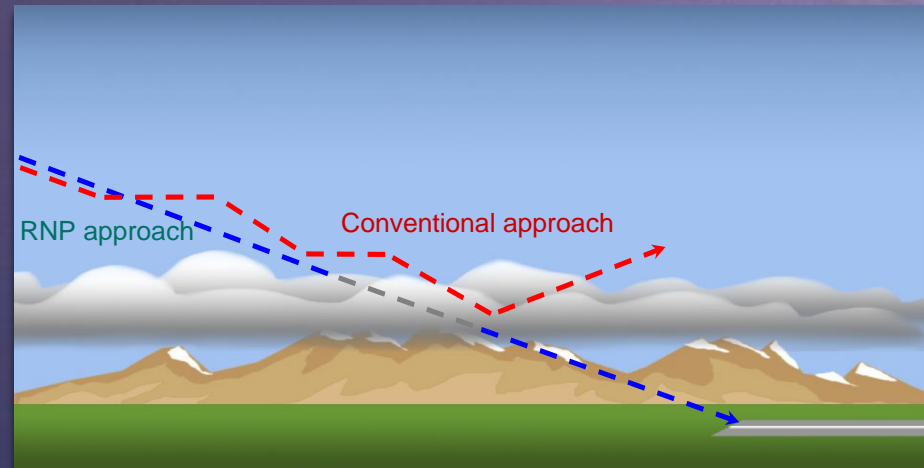
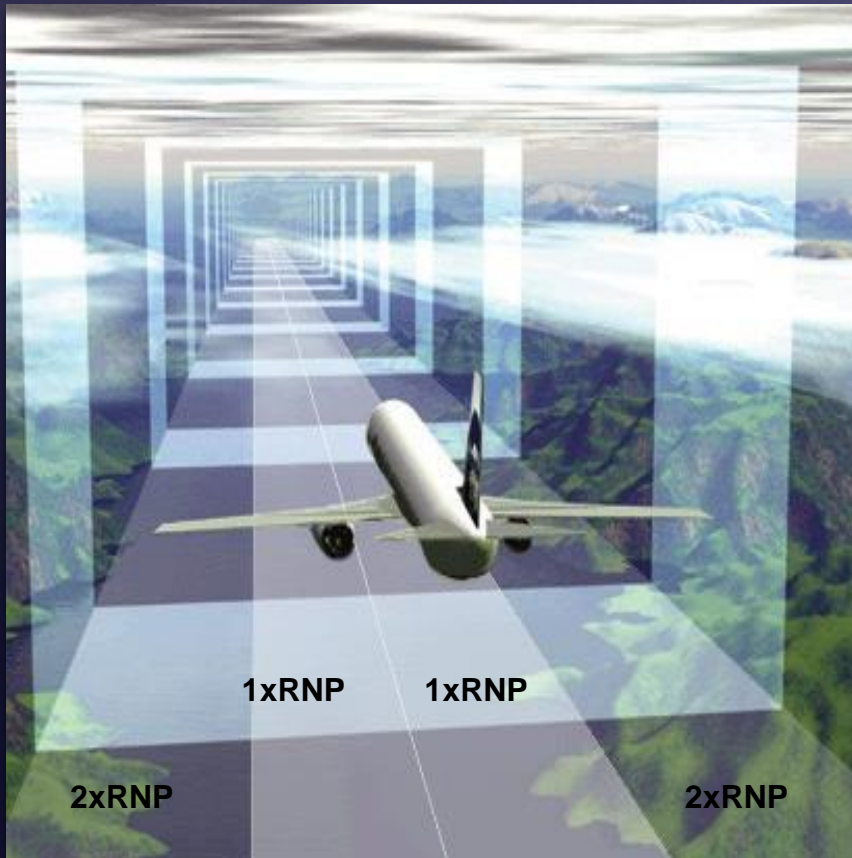


PBN in Phases of Flight



RNP uses the capability of modern aircraft to fly along tightly confined airspace corridors

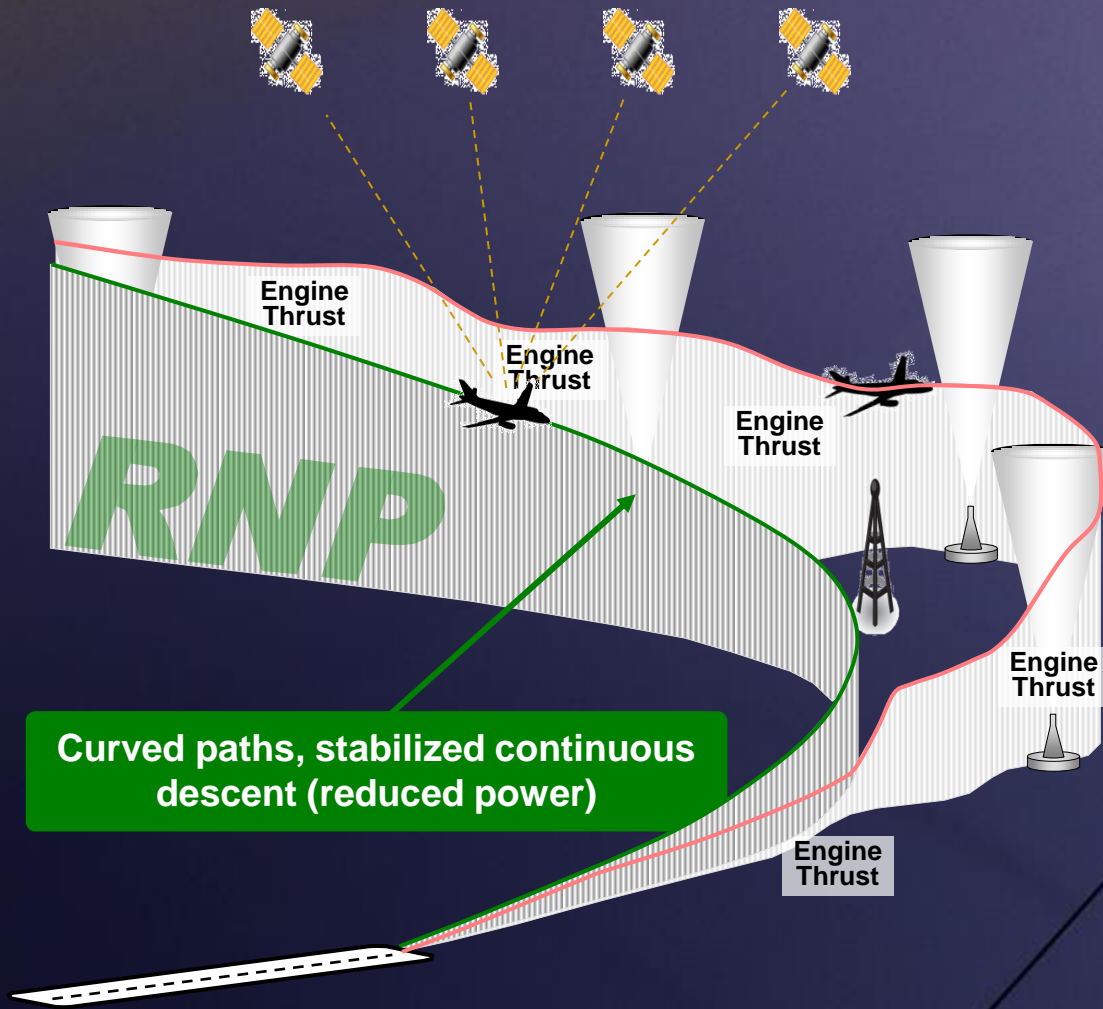
- RNP limit is 1xRNP,
- Containment Limit is 2xRNP



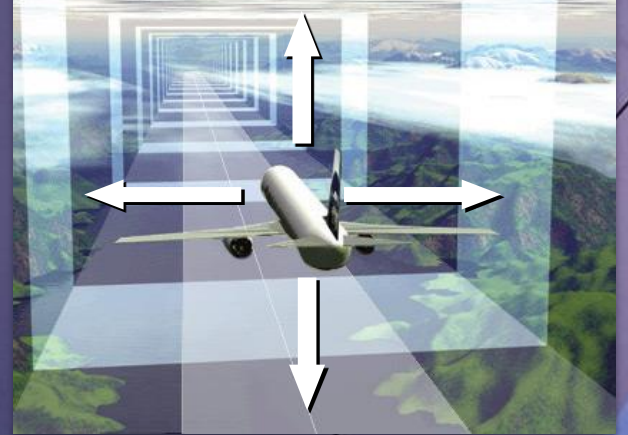
Enables stabilized continuous-descent approaches, no “dive & drive” circling NDB or back-course approaches



RNP provides precise, stabilized flight path to runway



Fly within containment corridor



Benefits

- **Safer** more **stabilized** approach
- **Access** to terrain challenged airports
- **Saves time and fuel**, optimized routing
- **Reduced emissions and noise**

RNP AR offers many benefits

- **Enhanced Safety**

- Enhanced safety in terrain-challenged environments
- Reduced controlled-flight-into-terrain (CFIT) accident risk
- Efficient, repeatable arrival & departure paths including missed approach

- **Better Access**

- Improved IFR access to airports with limited or no conventional approaches or ground nav aids
- Improved operation into terrain-challenged airports
- Lower minimums
- Reduced diversions

- **Increased Efficiency, Capacity**

- Increased schedule integrity in all weather conditions
- Reducing track miles, and trip time
- Increased efficiency and payload
- Higher takeoff weight with obstacles, less obstacle limited
- Priority to best equipped aircraft (Air Services Australia)

- **Reduced Environmental Impact**

- Reduced fuel consumption, takeoff fuel requirement
- Reduced noise footprint
- Reduced emissions

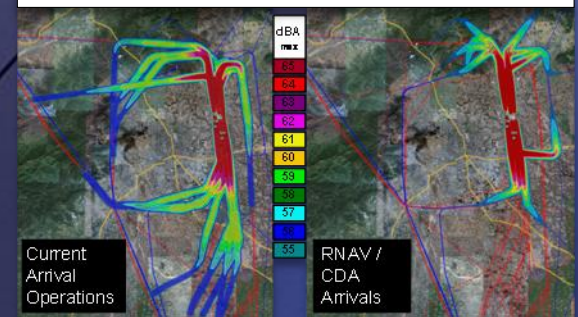
Safety



Access/Payload

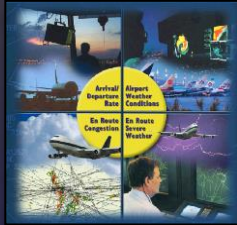


Environmental



Successful RNP AR implementation requires these elements be in place

Regulatory



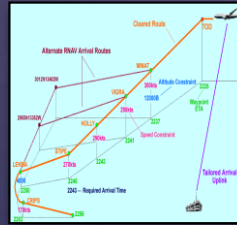
+

Airport and Facility



+

Air Traffic



+

Airline



+

Airplane



- Procedure criteria
- Operations requirements
- Approval process

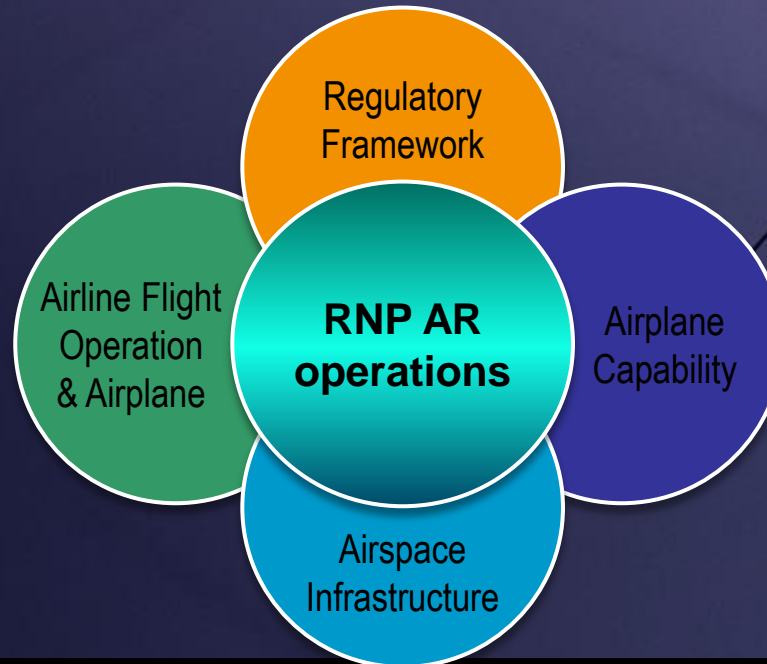
- RNP procedures
- WGS-84 airport survey

- Flight procedures
- ATC procedures
- Controller training

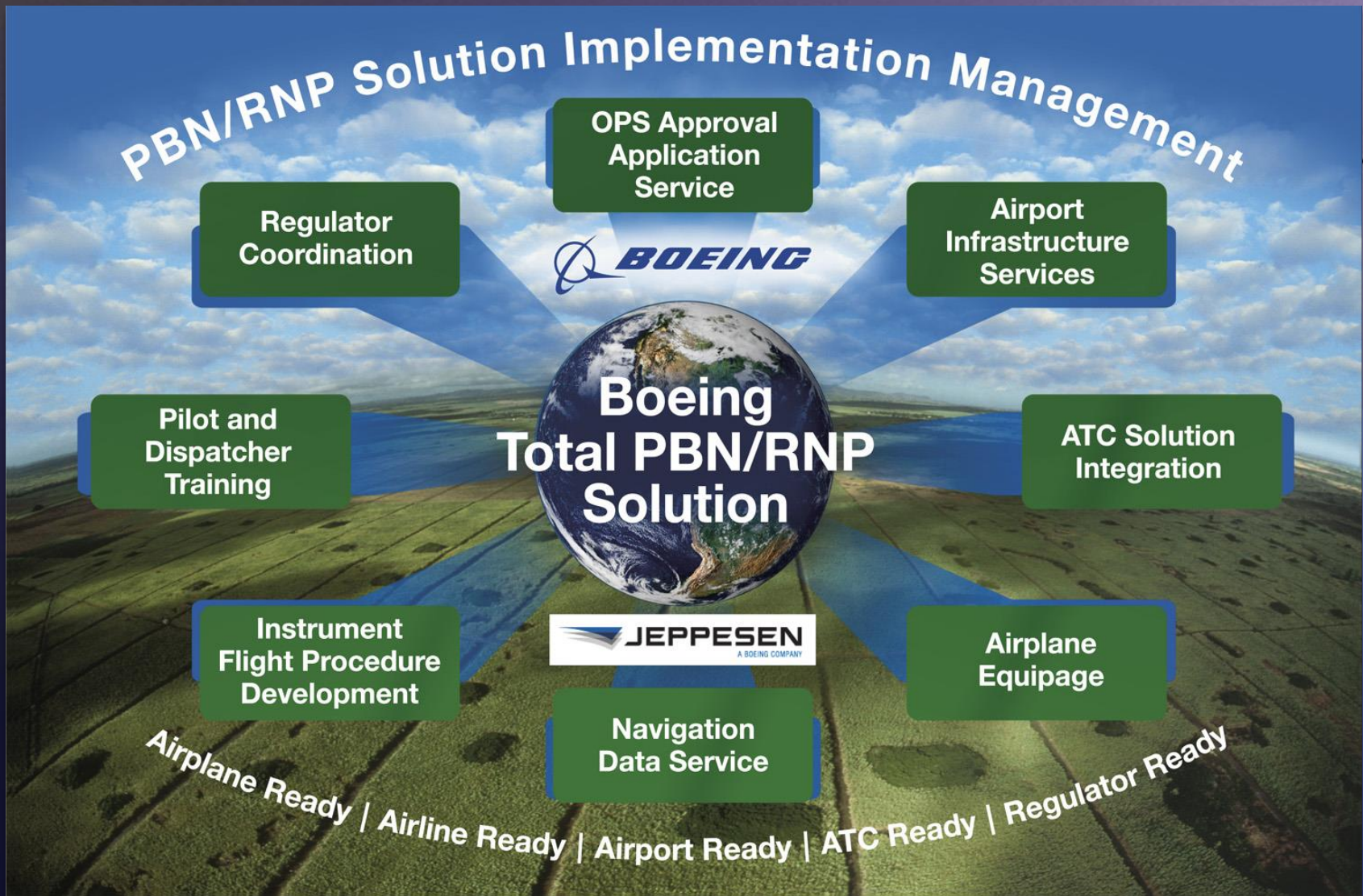
- Application package
- Crew ops procedures
- RNP AR training

- Application package
- Certified capability
- Proper equipment

=



Boeing offers complete RNP solution



Full-spectrum RNP services and support

- RNP Equipage Analysis support
- Procedure Design
- NDB Validation and Compare
- RNP AR Flight Crew and Dispatcher Training
- Application for Operational Approval support
- Demonstration/Validation Flight support



A new choice for RNP-AR...

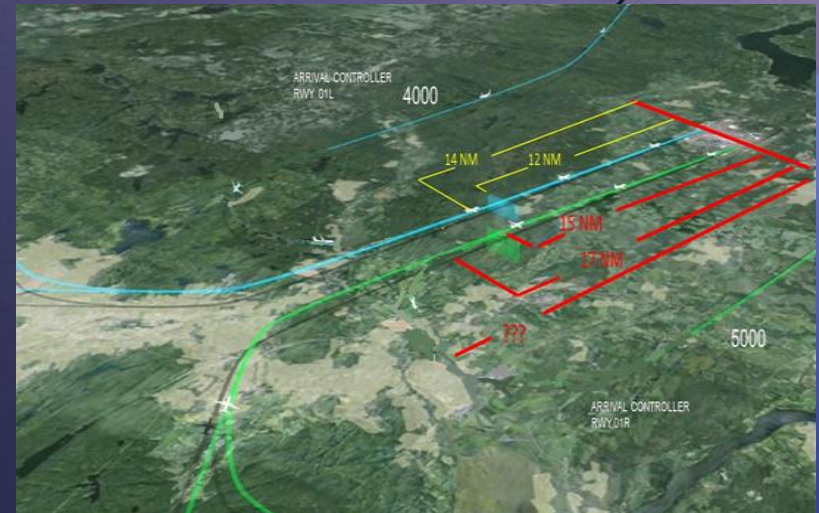
Simultaneous Runways Approach Operations

ICAO's Rules Today in the Manual on Simultaneous Operations on Parallel or Near Parallel Instrument Runways (SOIR, DOC 9643):

- ONLY ILS/MLS procedures allowed
- 1,000 ft vertical separation prior to Localizer intercept
- Uses High-side / Low-side for Course alignment
- Vectors to final (discontinuity in course)
- Independent Mode (1): 1035m min spacing
- Dependent Mode (2): 915m min spacing

Results in Noisier, Less Efficient Profiles, Particularly for Low Side:

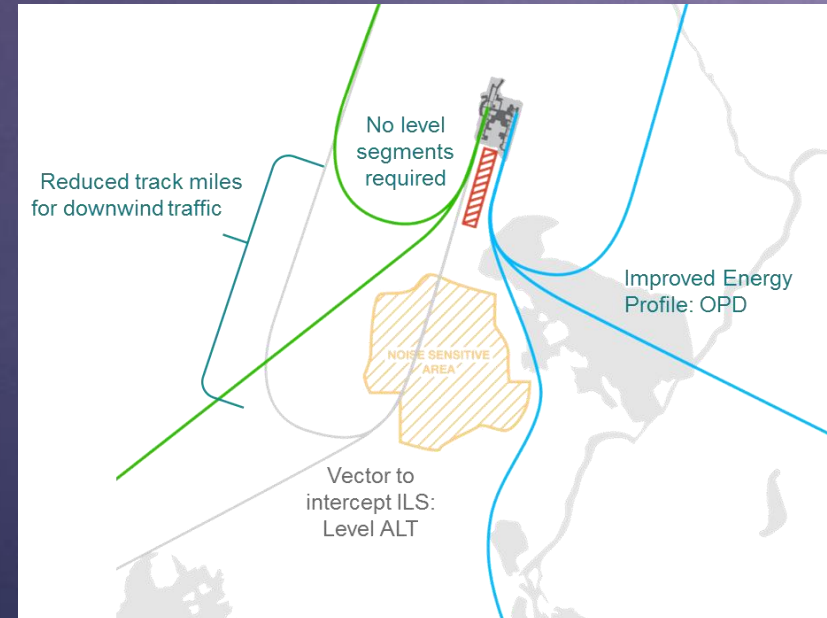
- Extended finals to build vertical separation
- Extended down-winds
- Excessive level flight, particularly low side
- Low/slow downwind and final > HIGH FUEL BURN
- Environmental Impact : COMMUNITY NOISE, CO2 EMISSIONS



Using RNP on approaches

RNP use at Major Airports enables:

- A complete and optimized descent path to the runway
- Flexible, curved paths – avoiding noise sensitive areas
- Reduced track miles flown, saving fuel and reducing emissions
- A single, efficient path that can be used in all weather, making traffic flow more predictable and safer
- Eliminate need to protect some ILS critical areas



How to improve even more Flexibility & Efficiency of operations ?

- Enabling RNP approaches in simultaneous operations
- Continue to allow access for ILS approaches (non RNP equipped)

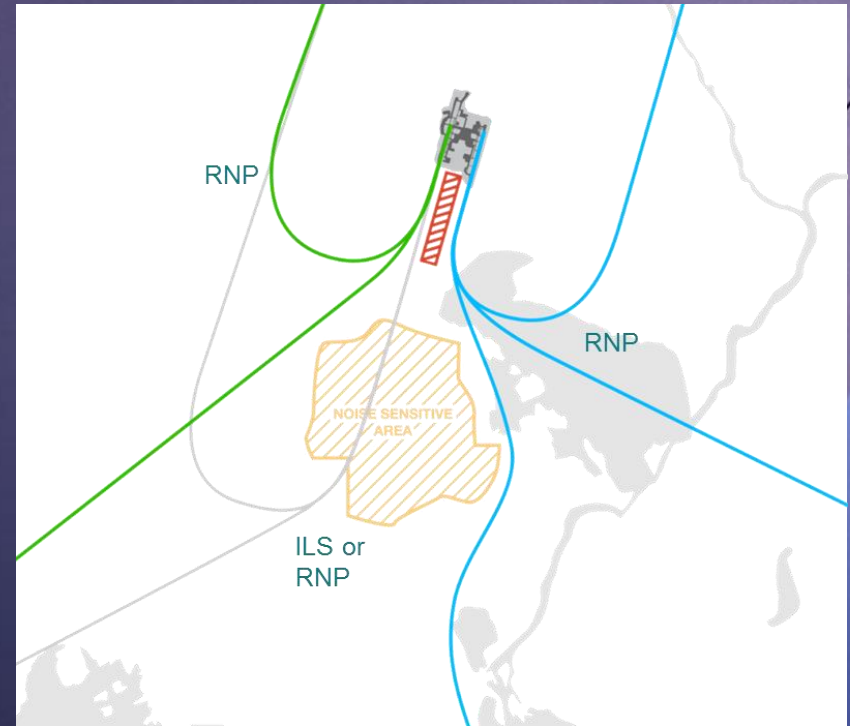
The RNPe (established) Concept

Operations Features

- Wake spacing maintained for each stream
- Can use both curved and straight transitions
- Manages both ILS and RNP traffic
- Replacing RADAR with technology-agnostic surveillance

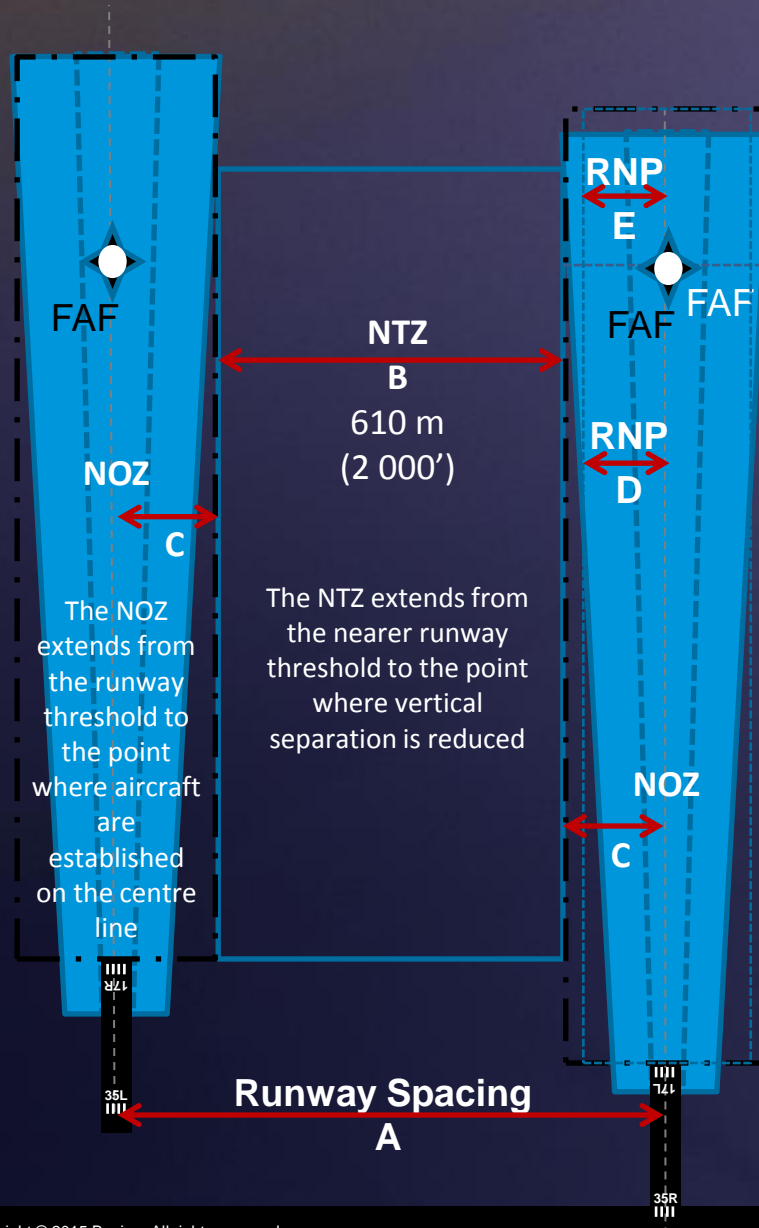
Safe by Design

- RNP values specified as to not interfere with other approaches
- Avoids TCAS issues with converging procedures
- Continuous vertical and lateral guidance to the runway
- No additional surveillance over traditional simultaneous operations
- Leverages proven, highly capable, certified technology



- FAA began ops Early 2015
- ICAO update : 2018 PANS ATM and SOIR (DOC 4444, 9643)

ICAO: Design Guidance for Simultaneous Use



any combination of instrument approaches including:

1) a precision approach

2) an RNP AR APCH procedure, if:

- the RNP (D and E) does not exceed $\frac{1}{4}$ of the distance between runway centerlines (A), and
- the RNP is equal to or less than $(A-B)/2$ [e.g. NOZ (C)]

3) an APV procedure with RNP segments that do not meet 2)a and b above, provided that

- the safety provided by the performance and operational error mitigation are satisfactorily demonstrated, and
- the designated APV is demonstrated to protect the NTZ from infringement during normal operations to avoid nuisance alerting

**Necessary
Safety Assessment**

RNPe Implementation in US

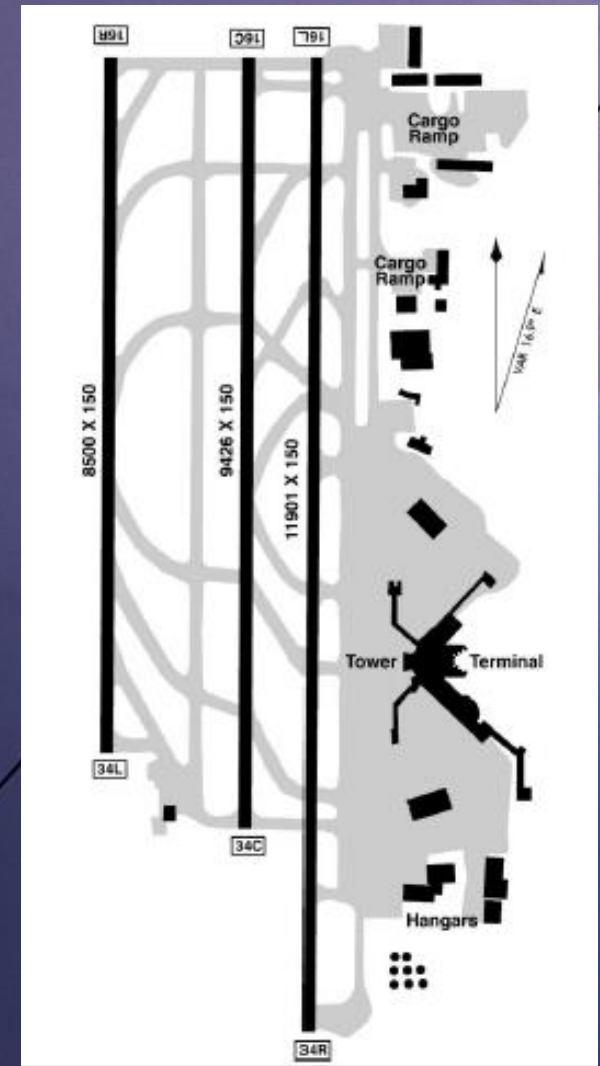
- FAA began dependent and widely-spaced operations 2Q2015 (Nextgen's "Greener Skies Program")
- Seattle –RNPe Dependent spacing - operational in April 2015.
- Independent and operations with TF turns (no RF capability) planned in ATL and other OEP airports in US
- ICAO: Drafting Operational Authority in 2018 revisions of PANS ATM (DOC 4444) and SOIR (DOC 9643)
- Boeing has provided safety assessment tools to assist with operational authorizations



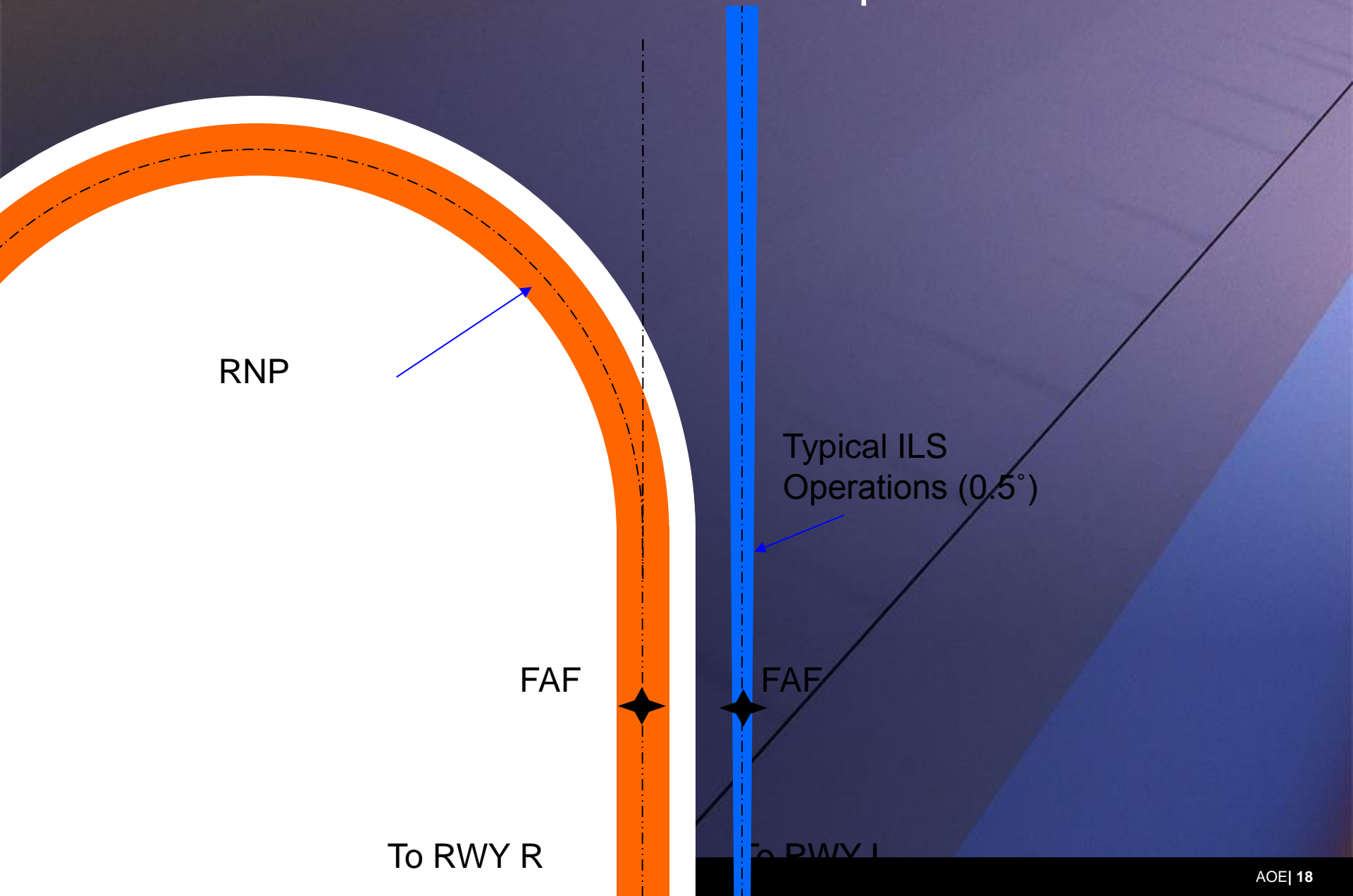
Seattle Tacoma Intl (KSEA)

Former operations under ICAO Doc. 9643 requirements:

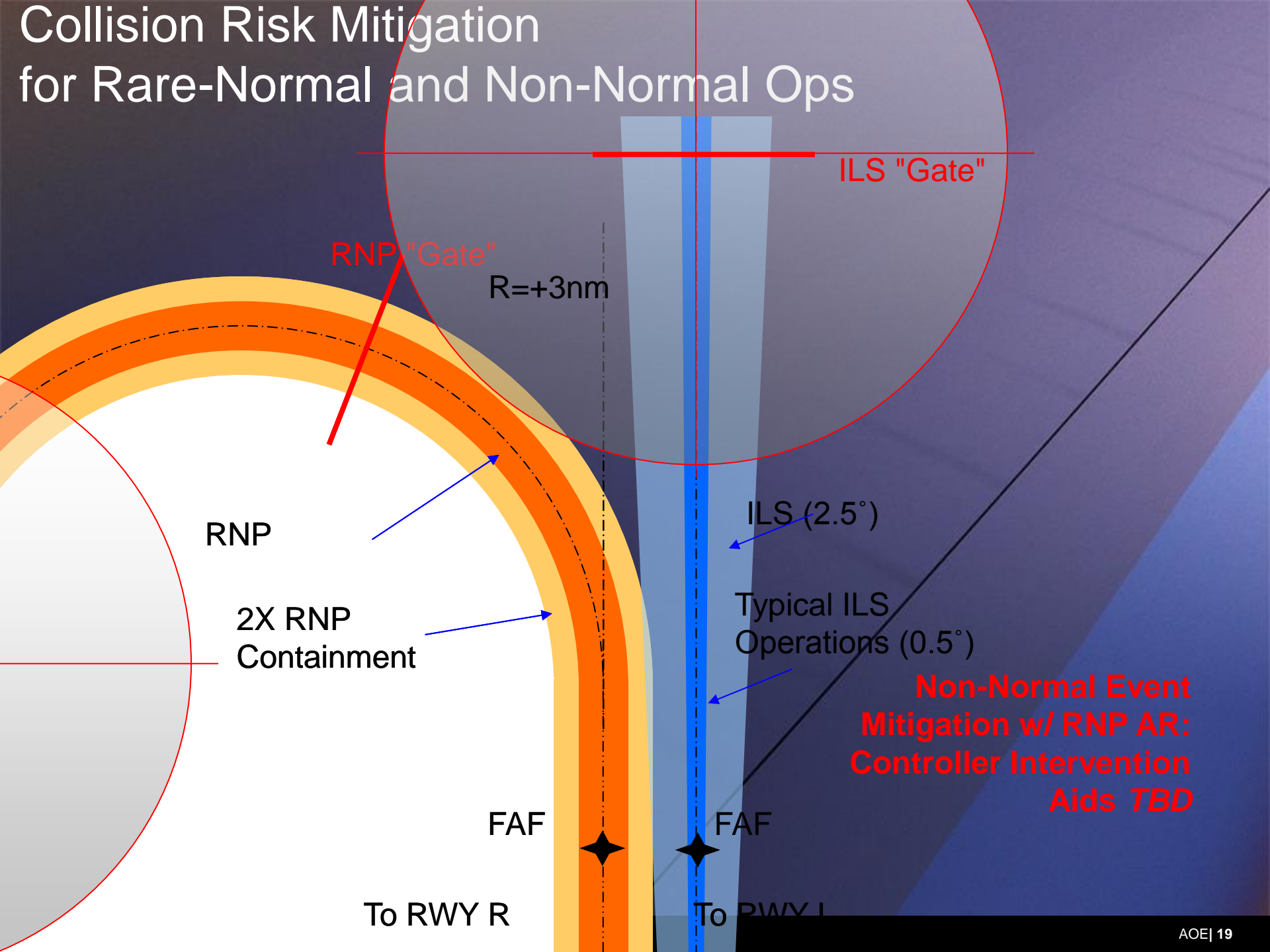
- IFR simultaneous operations allowed on 16L/34R - 16R/34L runways (1450m). IFR Capacity 78 mov/h.
- ILS approaches: 1,000 ft vertical separation prior to Localizer intercept.
- Parallel approaches on 16C/34C-16L/34R (480m) VMC only.
- Vectors to final (discontinuity in course)



Collision Risk Mitigation for Rare-Normal and Non-Normal Ops

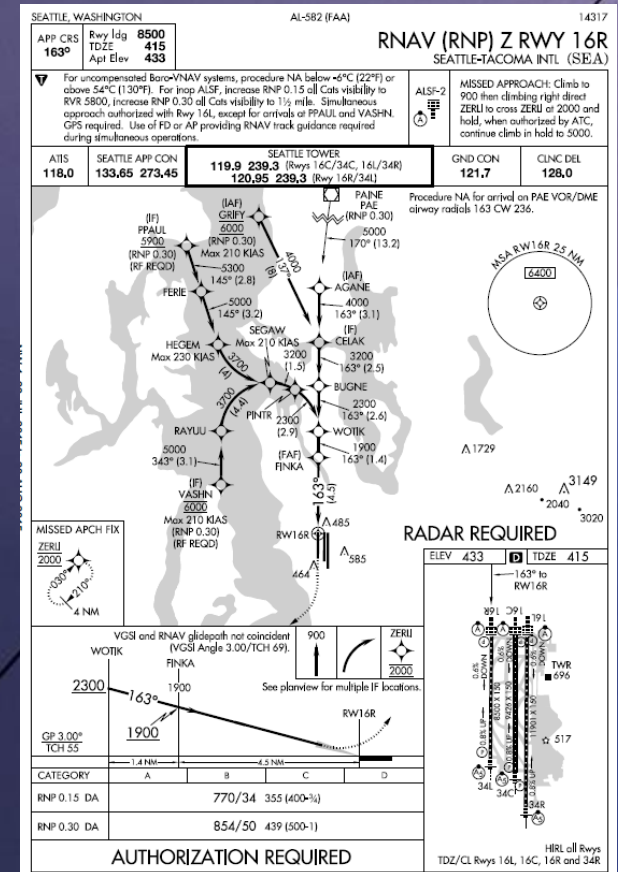
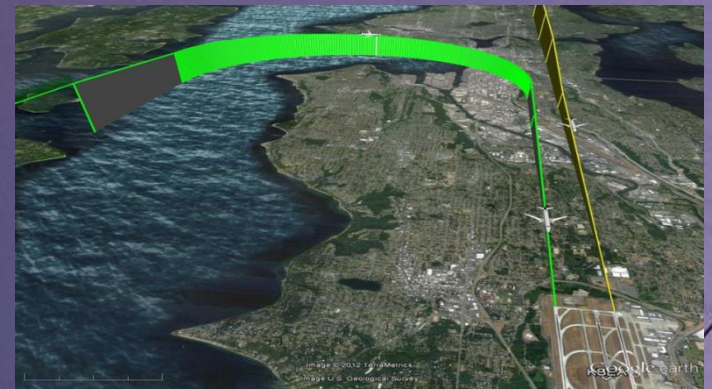


Collision Risk Mitigation for Rare-Normal and Non-Normal Ops



Seattle Tacoma Intl (KSEA)

- RNP-AR 16L simultaneous with ILS 16R
- FAA Controller Handbook updated (removed ILS/MLS limitation 7110.65U, 2012 for straight-in transitions).
- Waiver based on Boeing safety and operational assessment
- Direct noise over less inhabited areas reduces over flights in Seattle.
 - Higher longer idle descents
 - Population exposure count:
 - Typical Track = 239,000
 - Flown Track = 52,000
 - Reduced noise exposure: 187,000



Boeing Safety Assessment Tool

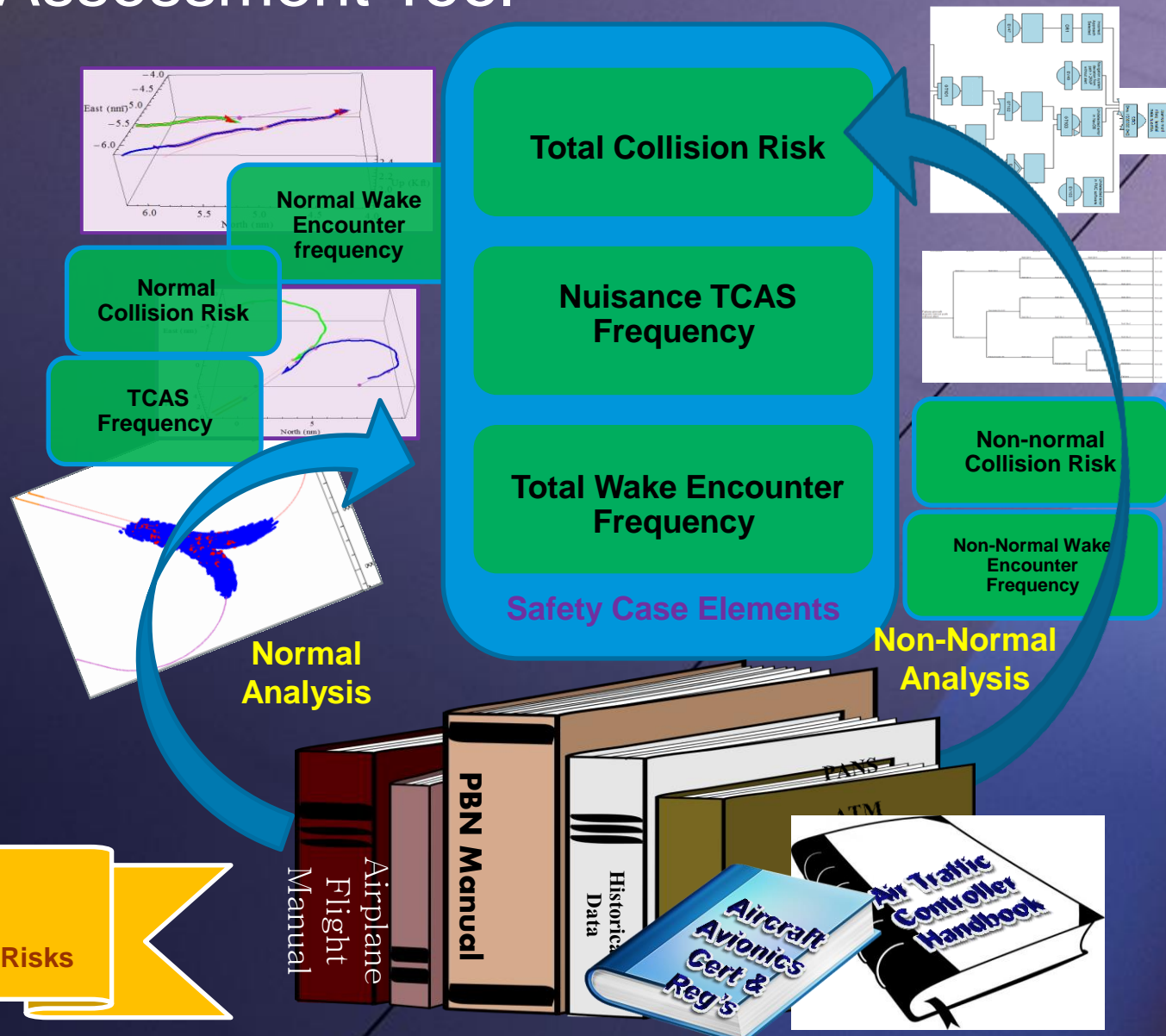
Modeling Based on PBN Specifications

- Collision Risk
- TCAS Nuisance Alerts
- Wake turbulence

Safety Resulting from Atypical Residual Risk

- Integrity
- Availability
- Failure mode Analyses

Safety Assessed from Normal and Non-Normal (Atypical) Risks



RNPe Demonstrated Benefits & Potential Expectations

Today's Operations

- Fewer Track Miles
- Lower Fuel Burn
- Less Emissions
- SeaTac overall fuel reduction could exceed 2.7 million gallons
- Emissions over Seattle could be lowered by 25,600 metric tons (like taking 5,400 cars off the road each year)



RNPe per approach
As much as 87 GAL
fuel
1 metric ton of
carbon emissions
Reducing

Reduced Noise Impact

- Aircraft are higher, and remain in Idle descent longer
- Reduces over-flights for Seattle, directing noise over less inhabited areas
- 180,000+ fewer residents exposed to noise



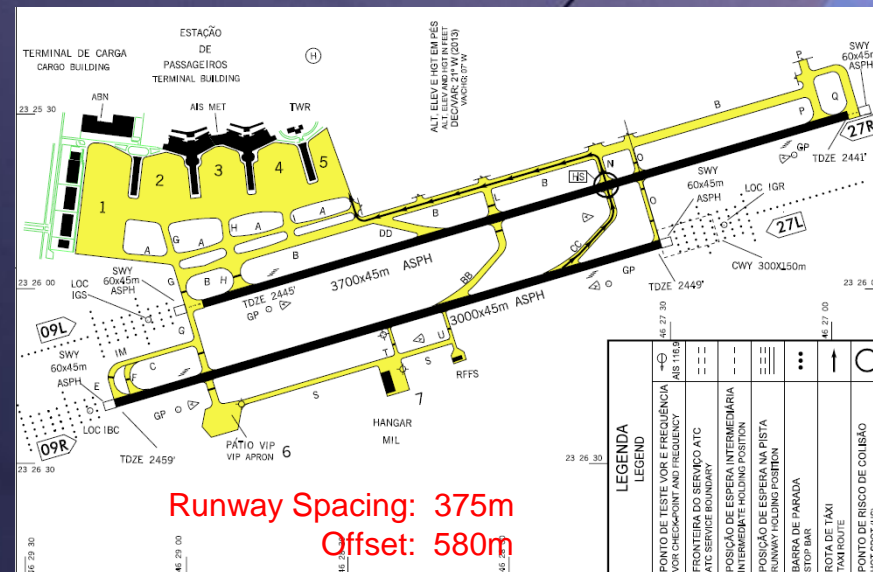
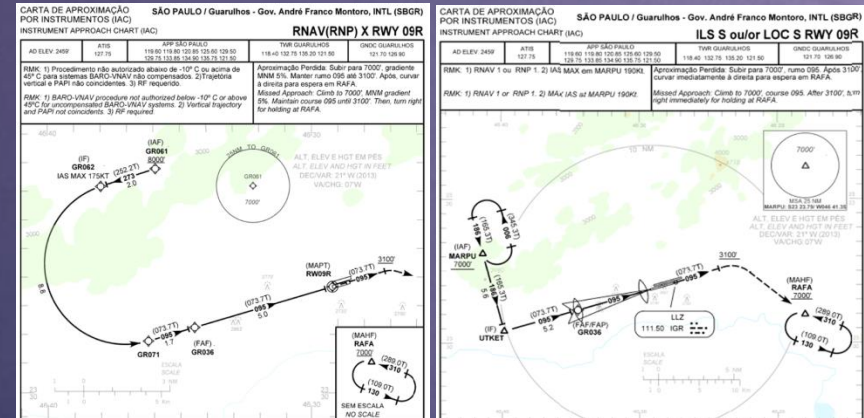
Some thoughts for Sao Paulo Intl (SBGR)

ICAO Requirements do not allow simultaneous operations

- Parallel operations not executed under conventional ILS approaches.
- Dependent operations: 09L/27R takeoffs and 09/27L for landings.
- Under study: parallel VMC approaches with less than 3NM diagonal separation.

Benefits Potentially from Close-in, Curved RNP-AR Transitions already designed

- Designed according to RNP 0.3 requirements. No difference on WX minima related to RNAV approaches. Runway 09R only.
- Design focus on fuel savings using RF-legs with shorter the trajectories than ILS.



Could RNP Operations be possible ?

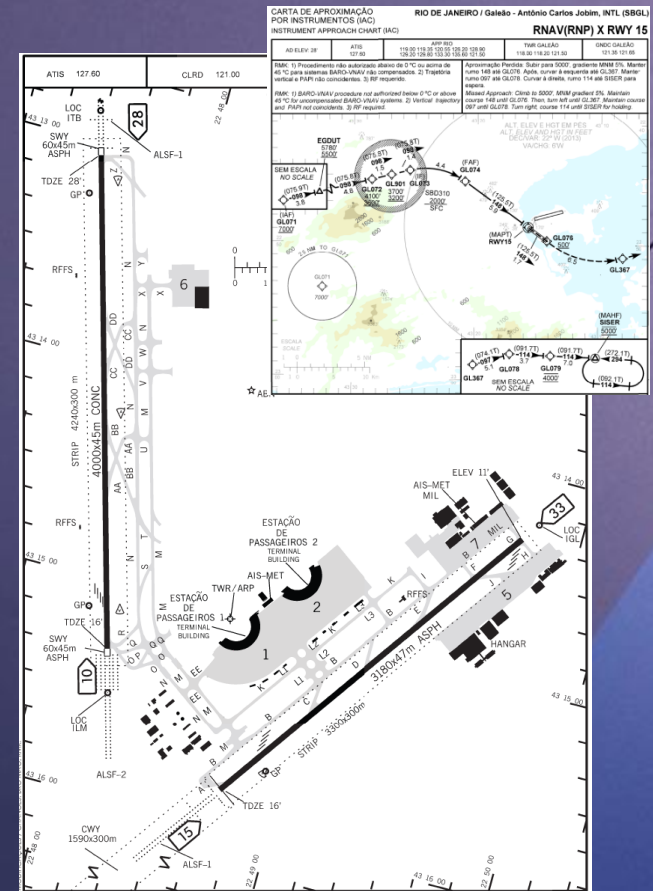
What about Rio de Janeiro Intl (SBGL) ?

Configuration

- Non-Parallel runways under conventional ILS approaches.
- Dependent operations: normally 10/28 takeoffs and 15/33 for landings.

Benefits Potentially from Close-in, Curved RNP-AR Transitions already designed

- Designed according to RNP 0.3 requirements. No difference on WX minima related to RNAV approaches. Runway 15 only.
- Design focus on fuel savings using RF-legs with shorter the trajectories than ILS.



Can RNP operations on non-parallel approaches be implemented ?

What about Brasilia Intl (SBBR) ?

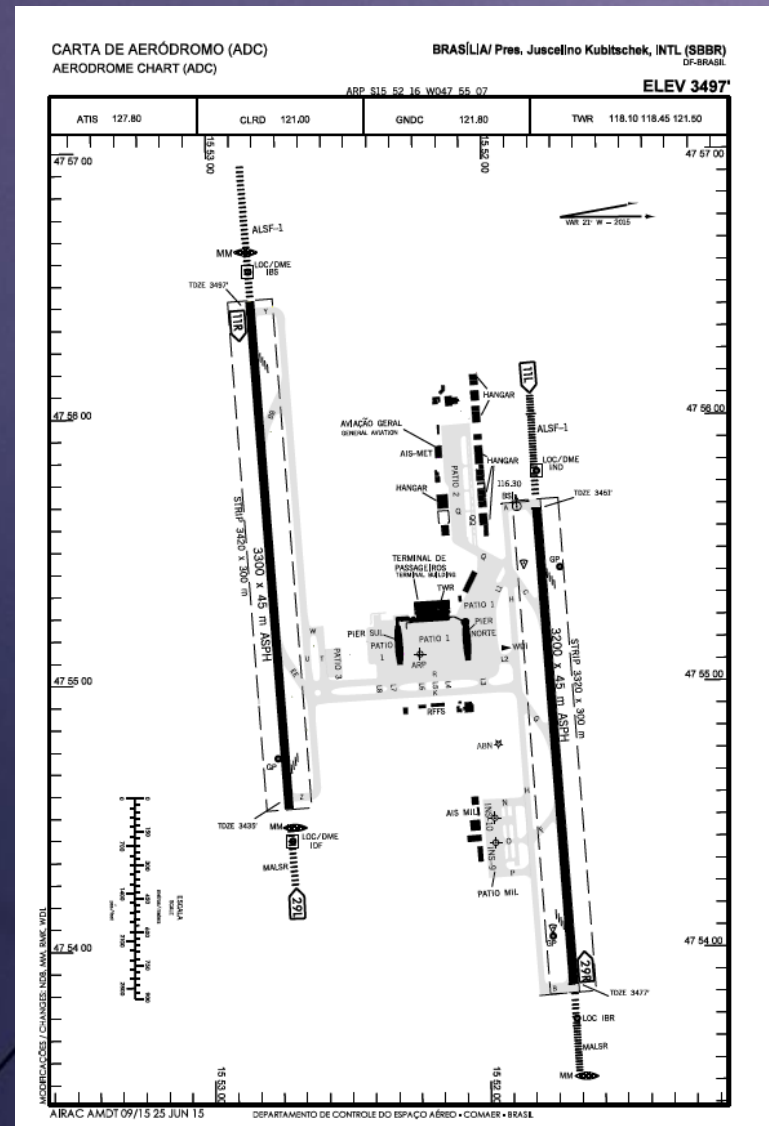
Configuration

- Parallel runways under conventional ILS approaches. Spaced by 1200m.
- Independent operations (80 mov / h)

RNAV procedures in place

- Designed according to RNP APCH 0.3 requirements.

Can RNP_e operations on non-parallel approaches be implemented ?



Final Comments

- The RNP_e concept has been gradually implemented as suitable solution as part of NextGen's "Greener skies" program.
- However the procedure may bring benefits to airport capacity improvement under IMC operations (under evaluation).
- Trials in KSEA have been mainly demonstrated environmental benefits on reduction on low level noise over surrounding communities and emissions.
- The special procedure design requires additional efforts on risk assessments. Boeing assisting stakeholders on this task.
- SBGR and SBGL operate two dependent runways with on RNP-AR chart already published, enabling opportunities for RNP_e implementation.



Michael Ulrey, PhD

Boeing Research & Technology, Seattle
e-mail: michael.i.ulrey@boeing.com

Sheila R. Conway, PhD

Boeing Commercial Airplanes, Seattle
e-mail: sheila.r.conway@boeing.com

Jeffery D. Musiak, PhD

Boeing Research & Technology, Seattle
e-mail: jeffery.d.musiak@boeing.com

José Alexandre T. G. Fregnani, MSc

Boeing Research & Technology, Brazil
e-mail: jose.a.fregnani@boeing.com

Thank you