C/AFT
Advanced Navigation
Focus Group

Toulouse, France
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Overview

- Advanced Navigation Focus Group Goals
- Definition of Near-Term Focus
- Cost/Benefit Model Assumptions
- Issues
- First Run Model Results
- Next Steps

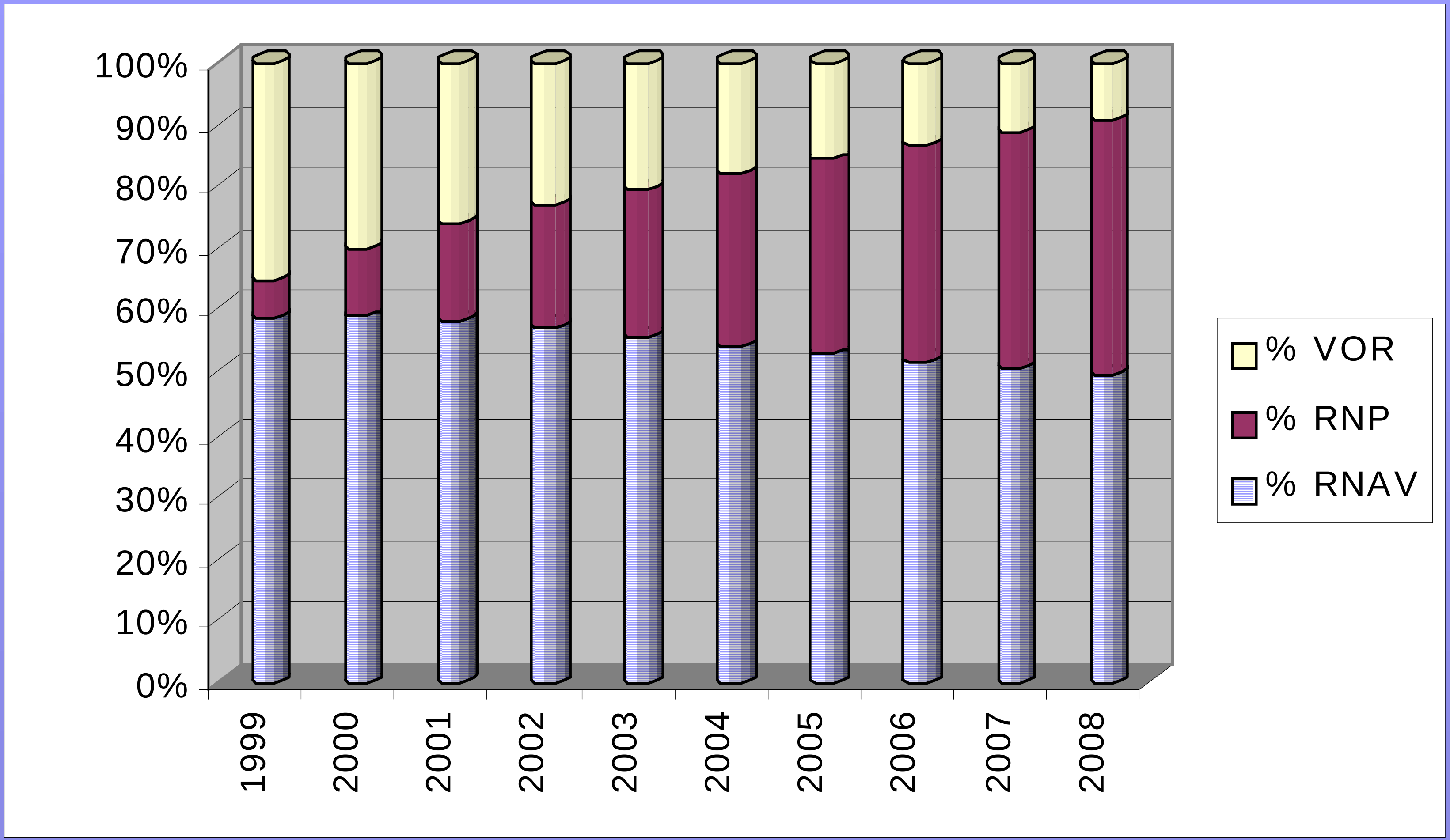
Advanced Navigation Focus Group Goals

- To demonstrate the value of existing navigation technology
  - airplanes have navigation capabilities that aren't being used
  - new procedures are required
  - no additional technology enablers required
- C/AFT Current Analysis: To evaluate the value of operational enhancements associated with existing navigation capabilities. To present preliminary results of economic value of existing capability.
- RNAV
- C/AFT Next Steps
  - RNAV --> RNP 0.3
  - RNAV --> RNP 0.3 + Vertical Navigation

Area Navigation (RNAV)

- RNAV is a method of navigation that permits aircraft operations on any desired course within the coverage of station referenced navigation signals or within the limits of a self-contained system capability or combination of these.

Air Transport System Capability to Enable Capacity



Availability of Navigation Capabilities

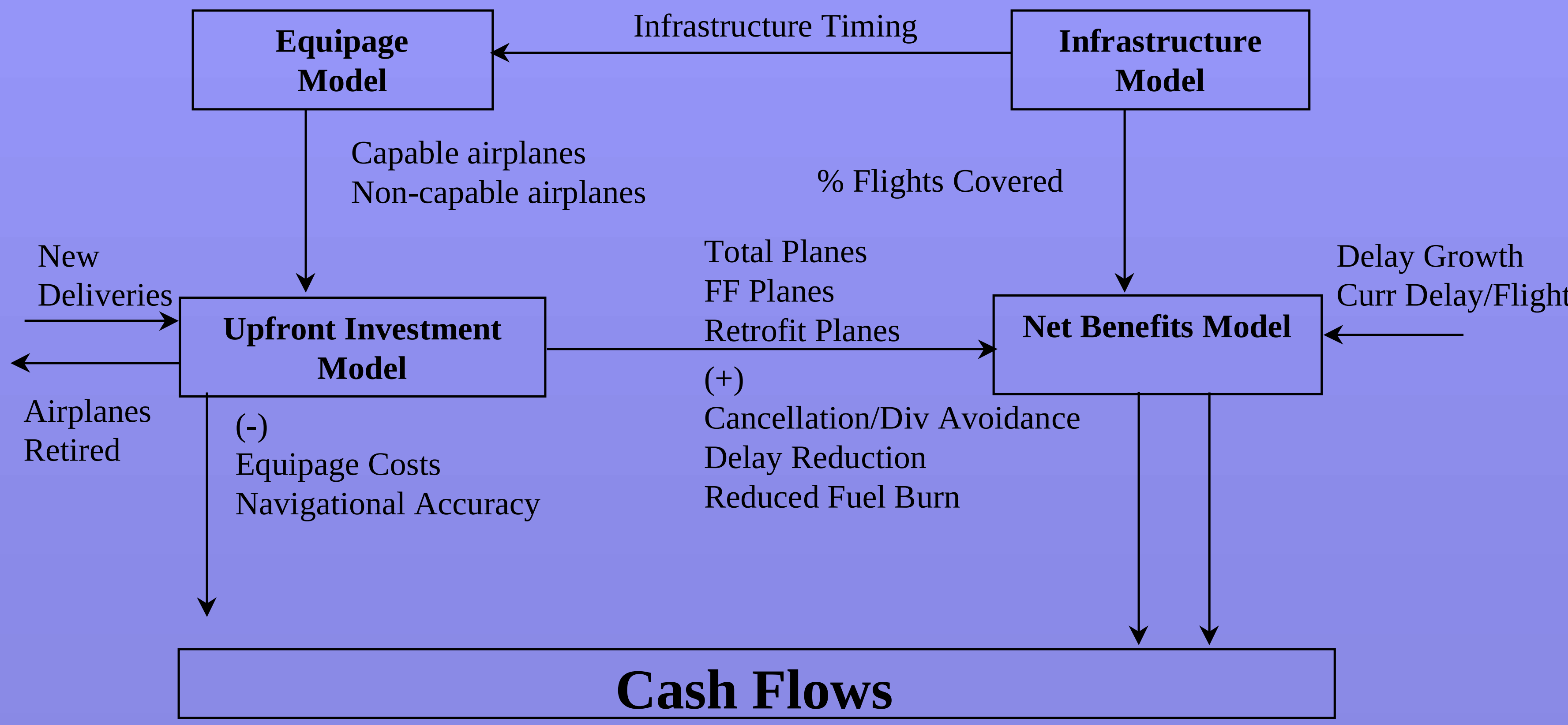
Terminology

- Capability
  - Specific navigation enabler, e.g. RNAV
- Operational Enhancement
  - An operational change leading to benefit.
- Benefit
  - Increased capacity, efficiency, or other cost savings (e.g. training)

RNAV Cost/Benefit Model Assumptions

- This is not an alternatives analysis. We are looking at incremental navigation capability levels only.
- Analysis is from airline point of view (airline as an industry, not single airline)
- Model will be built to accommodate any region -- first run will be for US for RNAV capability.
- Analysis will be from 2000 - 2015 for equipage / procedures, and 2000 - 2020 for other costs and benefits
- Total # of planes and traffic / delay growth will be same as in C/AFT U.S. datalink analysis
- Differential infrastructure costs included for regions with route charges

RNAV Investment Model



RNAV Benefit Model Definitions

- Capacity
  - Cancellation / Diversion Avoidance
    - used to quantify improved access to airports/runways
  - Delay Reduction
    - quantified using Direct Operating Cost (DOC) for each minute of delay saved, with higher costs assigned to higher values of predictable delay savings.
    - Revenue enhancement not modeled, although an airline could convert delay savings to increased number of flights, or avoidance of missed connections (this is airline/location dependent).
    - Efficiency
  - If unpredictable, Reduced Fuel Burned
  - If predictable, Reduced Block Fuel
    - this could be taken as increased payload
  - If predictable, Reduced Block Time
    - improved utilization

RNAV Intangible Benefits

- Environmental
- Safety
- Repeatability

RNAV Benefit Model Operational Enhancements

- Enhanced Route Structure
  - Delay Reduction / Cancellation Avoidance. More routes available when some routes closed or congested
  - Reduced Block Fuel / Time. Routes that support more efficient operations (e.g. deconflicting airspace)
- Better Approach Transitions
  - Delay Reduction. More laterally efficient approach /departure transitions reduces controller communication overhead
  - Reduced Block Fuel / Time. Routes that support more laterally efficient paths

RNAV Infrastructure Model Assumptions

- Procedures are the only infrastructure required.
- Procedure development will occur in three stages:
  - Stage 1. Specials developed by airlines and Air Traffic Service Provider.
  - Stage 2. Air Traffic Service Provider developing public procedures in low-density areas.
  - Stage 3. Air Traffic Service Provider developing public procedures in high-density areas.

RNAV Equipage Rate Model Assumptions

- All forward-fit airplanes will be RNAV capable
- Many in-service airplanes already RNAV capable
- Of those not yet capable, some will retrofit RNAV capability
- Some will not retrofit, and will be slowly retired out of the model

RNAV Up-Front Investment Model Assumptions

- Retrofit equipage
- Cost Issues
  - Navigational Infrastructure
    - increase route charges due to more navaids, applies to all airplanes in airspace (N/A in US)
      OR
    - equipage with GNSS. Note: some airplanes may equip with GNSS for other reasons, but those costs will not be included

Model Inputs
Constants

- Start Year of Model 2000
- Final Year for Equippage = 2015
- Final Year for Benefit = 2020
- Discount Rate = 12%
- Inflation Rate = 3.5%
- Direct Operating Cost (DOC) per minute = $25
  - Does not include amortization of costs for ownership
- Percentage of Fuel-related DOC = 30%
- Fuel inflation rate = 5%

Model Inputs
Traffic Growth

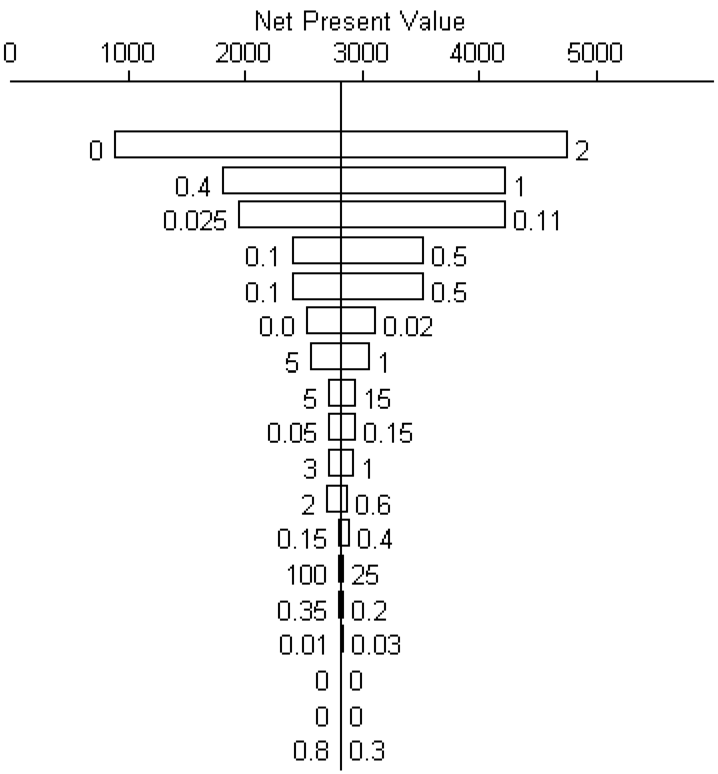
- Number of planes at start of model: 5194 (from ATA)
- Number of flights/airplane/year: 1570
- Number of planes in 2015:
  - Low estimate: 8054
  - Medium estimate: 8943
  - High Estimate: 9289

RNAV Model Results

RNAV Model Results

Tornado Diagram

Variable	Base Case	Variance Contribu-tion(%)	Low	High
Min Saved per Equip Flt	1	51.0	0	2
Flights Covered % (Stage 3)	0.65	19.9	0.4	1
Delay Incr % per Yr	0.07	17.8	0.025	0.11
% RNAV E-Flts Saved	0.25	4.2	0.1	0.5
% Flights Cancelled ATC	0.25	4.2	0.1	0.5
Stage 0 Retrofit %	0.01	1.1	0.0	0.02
Stage 1 Duration	3	0.8	5	1
Miles Saved	10	0.1	5	15
Flights Covered % (Stage 2)	0.1	0.1	0.05	0.15
Stage 2 Duration	2	0.1	3	1
Delay vs Equip Curve	1	0.0	2	0.6
Retired Planes % of New	0.22	0.0	0.15	0.4
Cost per Retrofit $K	60	0.0	100	25
Minimum Equip Reqd	0.25	0.0	0.35	0.2
Flights Covered % (Stage 1)	0.02	0.0	0.01	0.03
Commuter Equip %	0	0.0	0	0
Commuter Plane %	0	0.0	0	0
Atlanta Discount Factor	0.5	0.0	0.8	0.3



Base Case Value 2824.05

RNAV Model Results

Tornado Diagram - Important Variables

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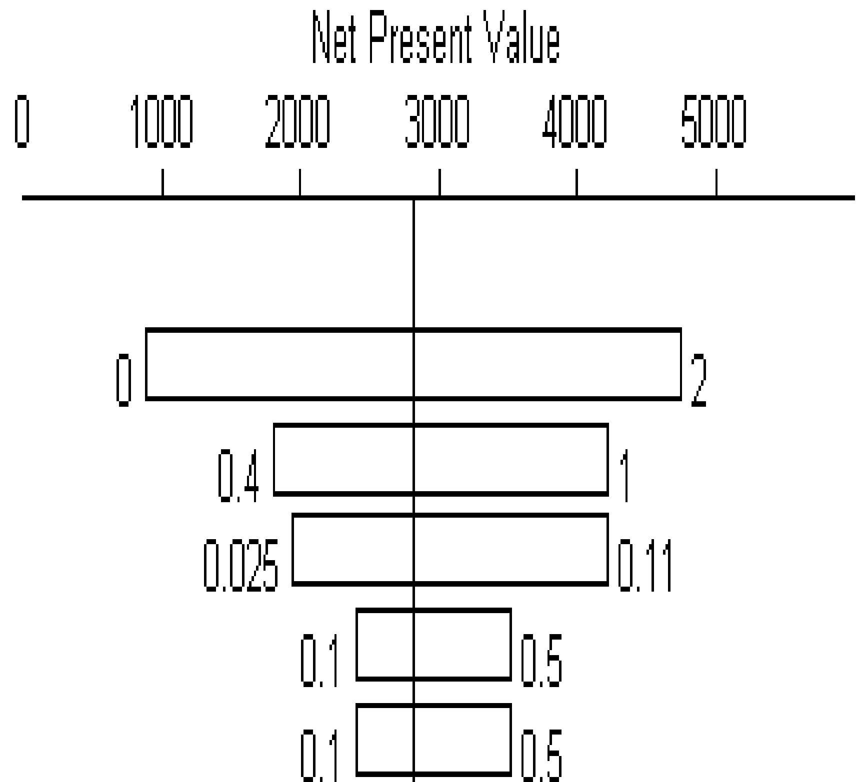
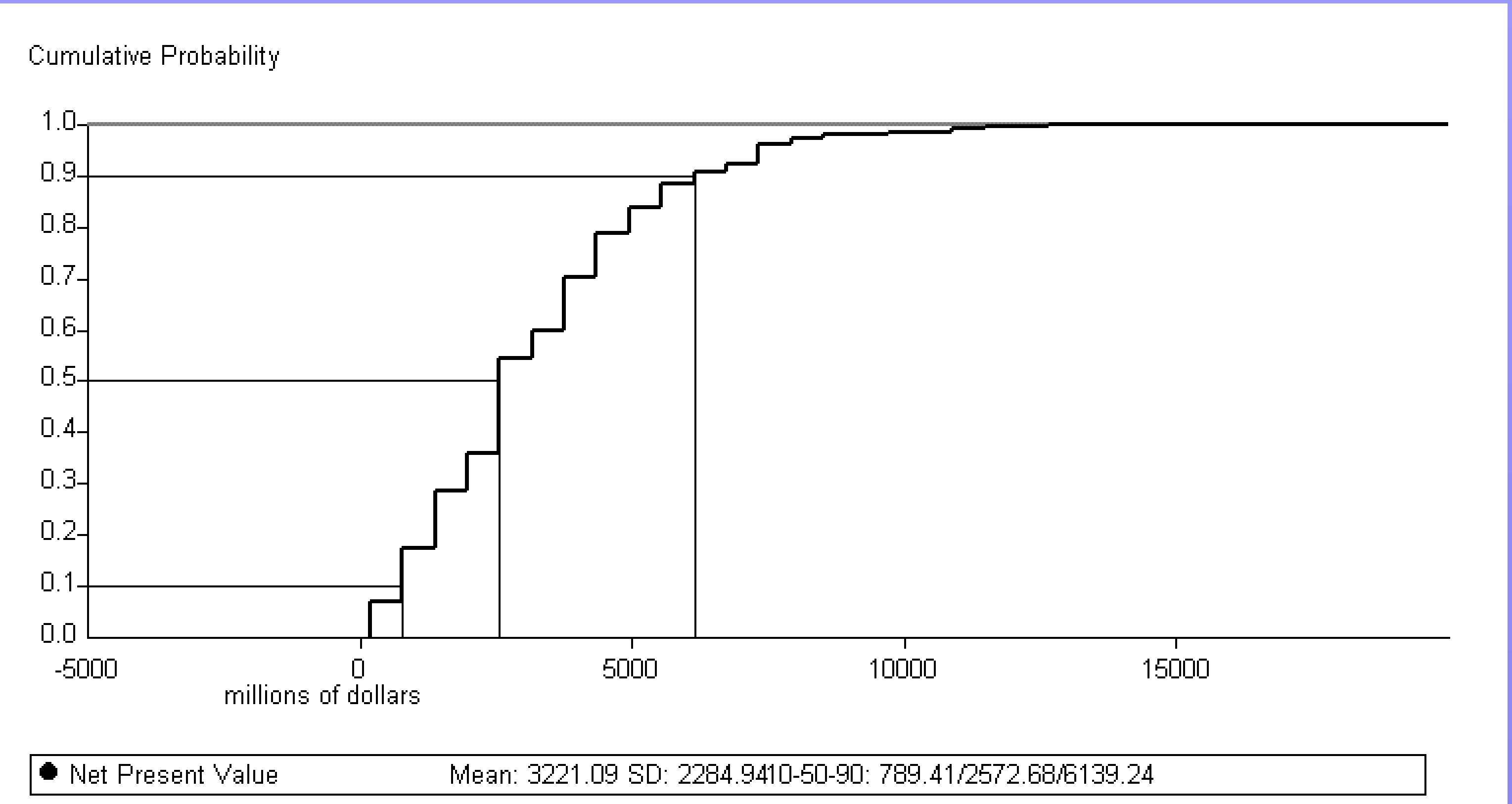


RNAV Model Results

Cumulative Probability Distribution



RNAV Model Results

Project Summary

Project Name:	**Advanced Navigation**				
Variable	Expected Value	10%	50%	90%	Unit
R&D Investment	27.2352	27.235	27.235	27.235	millions of dollars
Contribution	3248.33	816.64	2599.92	6166.47	millions of dollars
Productivity	**119.27**				
Net Present Value	3221.09	789.405	2572.68	6139.24	millions of dollars

Conclusions

- RNAV benefits are potentially high because of high level of initial equipage
- Benefits inhibited by ATC congestion may be mitigated by other means (e.g. RVSM, datalink, ADS-B)
- No operational trial or simulation data exists to quantify RNAV benefits (e.g. Atlanta study for data link)
  - Need better delay reduction data
- Need better understanding of ATC cost structure
  - Airspace redesign cost and procedure development
  - Controller training.

Issues

- Benefits data not available for RNAV, RNP 0.3, or Vertical Navigation Operations
- How do we include ground infrastructure costs (procedure development) for U.S.?
- Why hasn't this been done? (may require other enablers such as RVSM, datalink or ADS-B)
- How do we calculate training benefits at industry level?
- Database integrity requirements for RNP operations
- Regional Jets not included in the analysis

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Next Steps

Capability: RNAV --> RNP 0.3

- RNP Approach Transitions
  - Reduced Block Fuel / Time. More laterally and vertically efficient paths.
- More precise missed approach path may result in lower landing minimums
  - Delay Reduction / Cancellation Avoidance. Lower minimums than current straight ahead missed approach path.
  - Reduced Block Fuel / Time. More efficient missed approach procedures.
  - Training. Common training for all instrument approach procedures.

Capability: RNAV --> RNP 0.3 (cont'd)

- Improved usage of runway infrastructure (efficiency).
  - Delay Reduction. Maintain VMC acceptance rates under IMC conditions (e.g. converging runway procedures, parallel runway procedures)
  - Note. Requires new criteria
- Tighter Spacing of Departure Procedures
  - Delay Reduction. Increased departure rate because of improved departure procedures.
  - Increased Flights. Reduced noise footprint allows more flights.
  - Reduced Block Fuel / Time. More efficient obstacle clearance procedures. (e.g. engine out procedures).
    - Individual airlines may decide to take this benefit as increased payload, but modeled as reduced block fuel.
  - Reduced Fuel Burned.

Capability: RNAV --> RNP 0.3 + Vertical Navigation

- Access to runways when ILS not available (e.g. construction, scheduled maintenance)
  - Cancellation Diversion. Lower minimums allow near ILS capability for landing.
  - Reduced Block Fuel / Time. More available alternates.
  - Training. Don't need to train for special conditions when ILS out.
- Improved departure procedures
  - Delay Reduction. Increase departure rate by allowing separate departure paths for different aircraft types (e.g. turboprop performance departures in Frankfurt)
  - Reduced Block Fuel / Time. Tighter containment on departure paths and path shortening.
- RNP with stabilized vertical path angle for approaches other than ILS
  - Cancellation Avoidance. Lower minimums allow increased access.
  - Increased Flights. Reduced noise footprint allows more flights
  - Reduced Fuel Burned. Due to stabilized descent.
  - Training. Only need to train one kind of approach.