

C/AFT
Advanced Navigation
Focus Group

Overview

- Navigation Focus Group Goals
- Definition of Near-Term Focus
- Cost/Benefit Model Assumptions & Data Requirements
- Issues
- Summary

Advanced Navigation Focus Group Goals

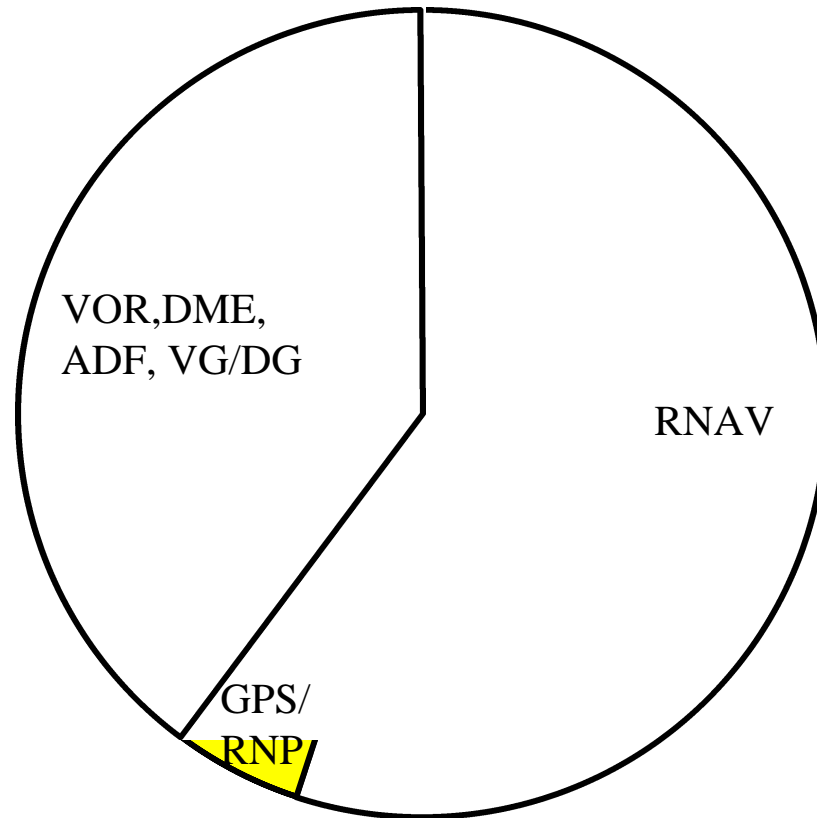
- Near-Term Goal is to demonstrate the value of existing navigation technology
 - airplanes have navigation capabilities that aren't being used
 - new procedures required
 - no additional technology enablers required
- Goal for all-airline meeting in Toulouse (Oct 13th) is to present draft results of initial cost-benefit model
- Next Steps will be to analyze Navigation Enhancements in conjunction with other enablers (e.g. surveillance)

Near-Term Focus

What exactly are we analyzing?

- The value of operational enhancements associated with two existing navigation capabilities.
 - RNAV
 - RNAV --> RNP 0.3 + Vertical Navigation
 - Include definition of RNAV per Frank Alexander
 - RNP 0.3 implies accuracy and integrity (summarize AWOP definition)

Air Transport System Capability to Enable Capacity



Where does VNAV/RNP 0.3 fit into this picture??

Availability of Navigation Capabilities

Terminology

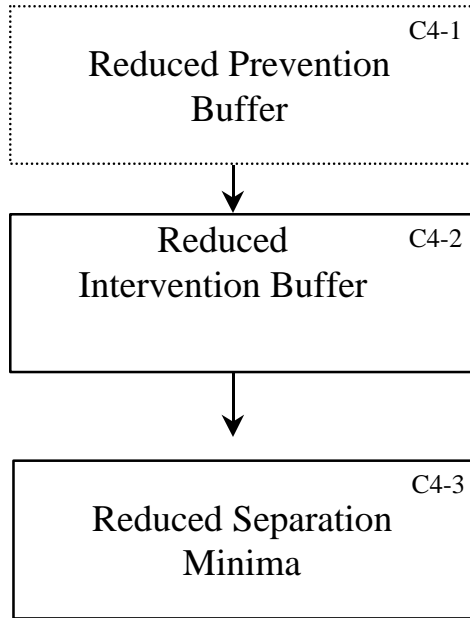
- Capability
 - Specific navigation enabler, e.g. BRNAV
- Operational Enhancement
 - An operational change leading to benefit.
- Benefit
 - Increased capacity, efficiency, or other cost savings (e.g. training)

Capability: RNAV

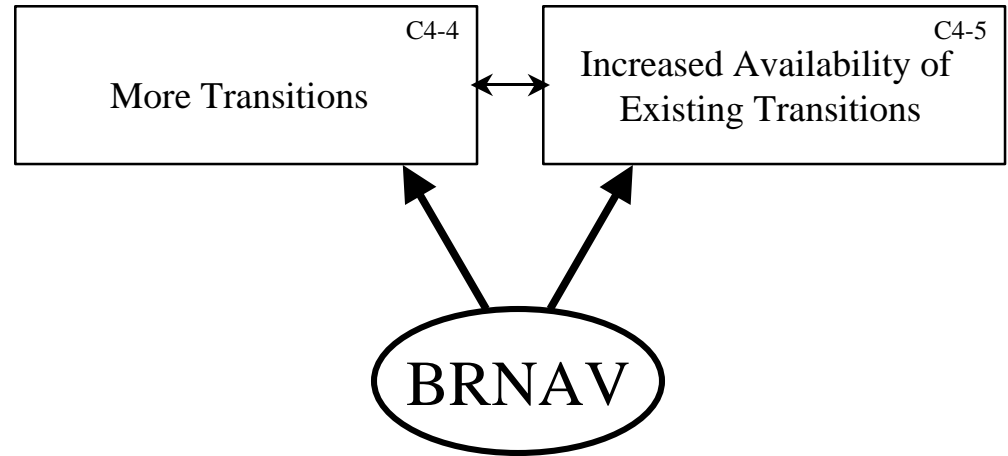
- Operational Enhancements:
 - Enhanced Route Structure
 - Adding routes, provides higher flexibility
 - routes that support more efficient operations (e.g. deconflicting airspace)
 - Better Approach Transitions
 - More laterally efficient approach /departure transitions
 - Continued operations when communications lost
 - Note: Rainer says this was important in Frankfurt
 - Predictable Operations
 - Reducing pilot and controller communication workload (fly-over/fly-by may be required)
 - Note: this implies FMS
 - reduced comm between controller/pilot and between controller/controller (sector coordination)

4. Approach / Departure Transition Capacity Transitions

Airplane-Level Capacity Effects



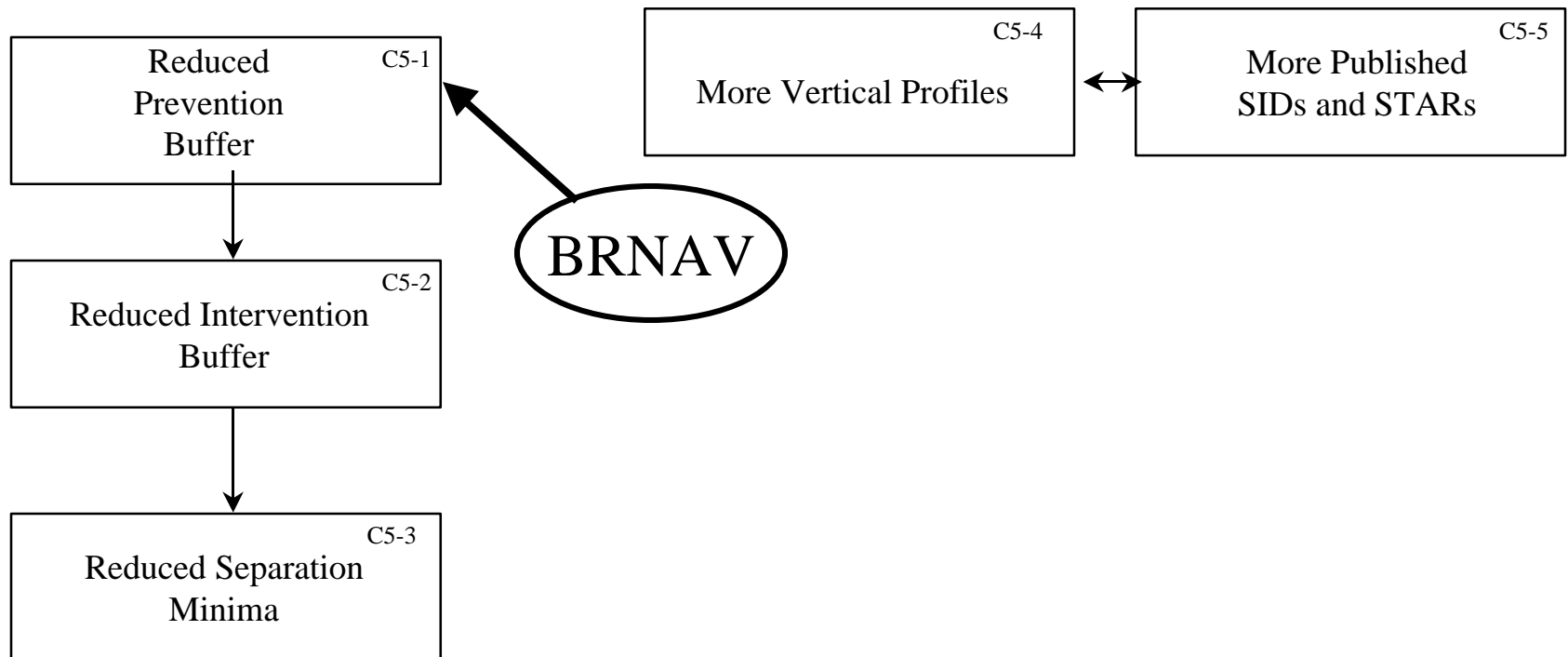
System-Level Capacity Effects



5. Cruise / Terminal Transition Capacity Transitions

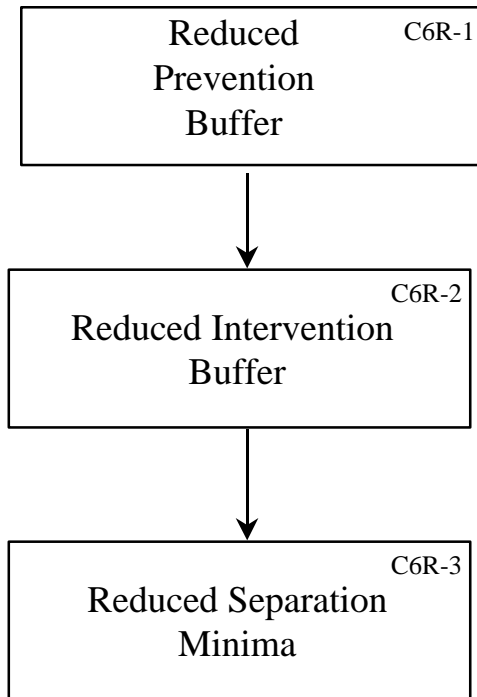
Airplane-Level Capacity Effects

System-Level Capacity Effects

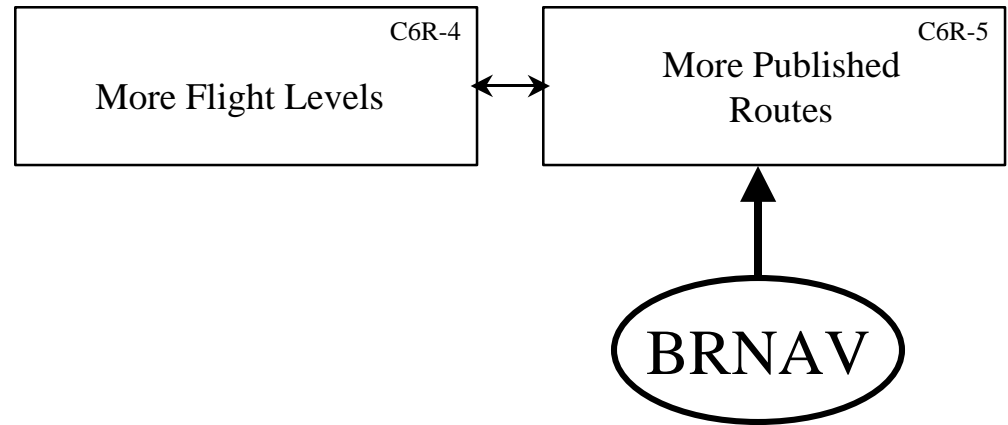


6. En-Route Capacity Transitions (Radar Environment)

Airplane-Level Capacity Effects



System-Level Capacity Effects



Capability:

RNAV --> RNP 0.3 + Vertical Navigation

- Operational Enhancements
 - RNP Approach Transitions
 - Allow increased capacity in marginal weather conditions.
 - Requires RNP
 - Access to runways when ILS not available (e.g. construction, scheduled maintenance)
 - When ceilings deteriorate controllers increase buffers between arriving aircraft. RNP 0.3/VNAV may give controllers more confidence and allow prevention buffer to be reduced. This assumes that buffers not a factor in VMC conditions.
 - Requires VNAV + RNP 0.3
 - More precise missed approach path may result in lower landing minimums
 - Requires RNP 0.3

Capability:

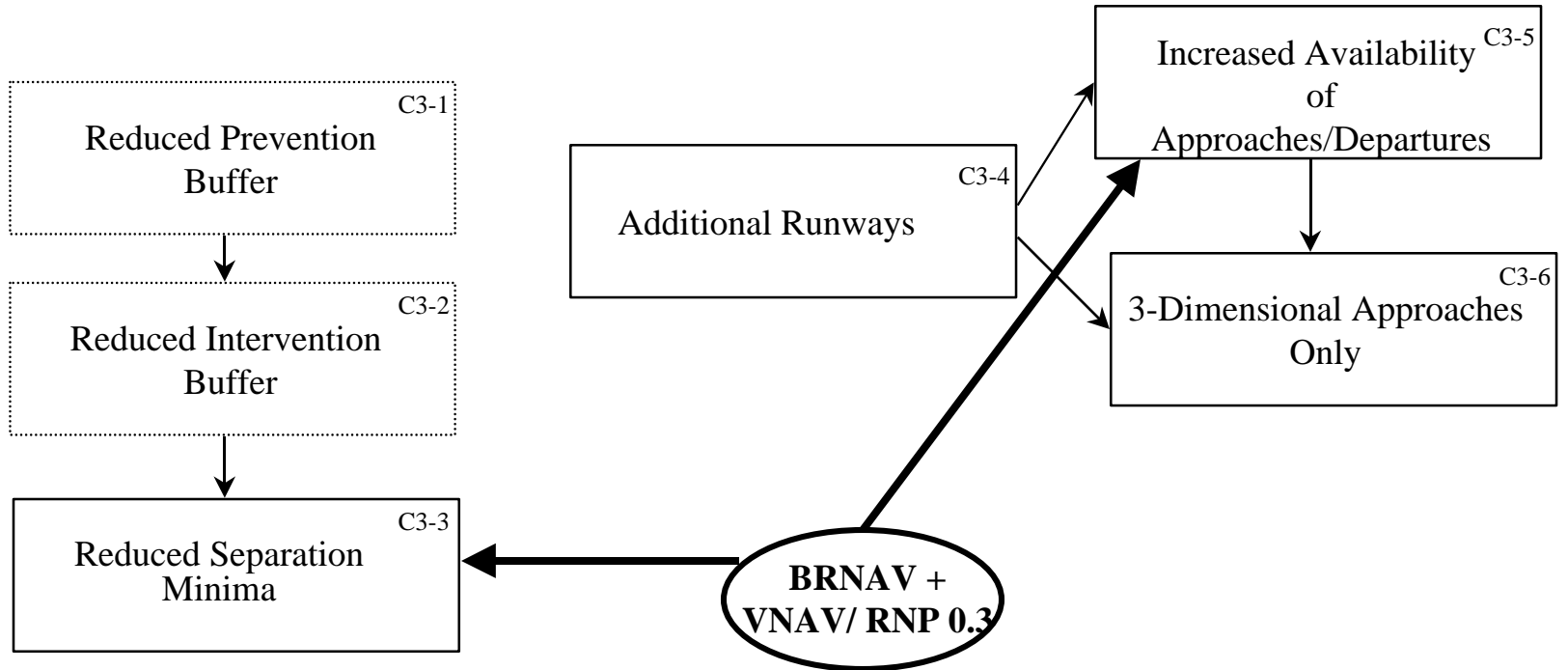
RNAV --> RNP 0.3 + Vertical Navigation

- Operational Enhancements, continued
 - Improved usage of runway infrastructure (efficiency).
 - Maintain VMC acceptance rates under IMC conditions.
 - E.g. converging runway procedures, parallel runway procedures
 - requires new criteria
 - Requires RNP 0.3
 - Improved departure procedures
 - With departure procedures that bound geometric vertical performance can use dump space and allow shorter departure paths
 - Requires RNP 0.3 and VNAV (VNAV is for arrival portion so that we can have better departure)
 - Tighter Spacing of Departure Procedures
 - Obstacle-clear departures
 - Noise-optimized departures
 - Requires RNP 0.3
 - RNP with stabilized vertical path angle for approaches other than ILS
 - Requires VNAV and RNP for lower minimums

3. Final Approach / Initial Departure Capacity Transitions

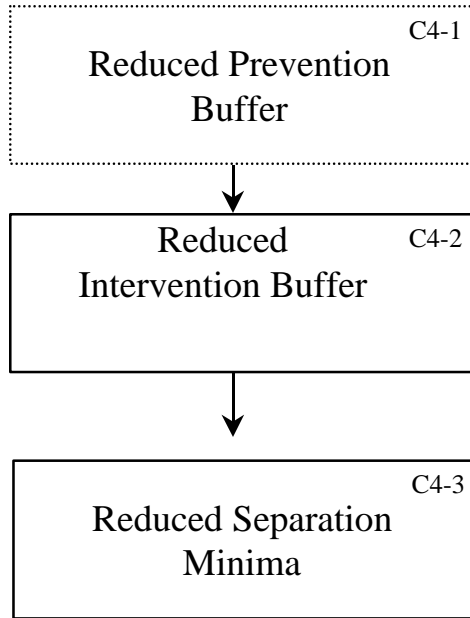
Airplane-Level Capacity Effects

System-Level Capacity Effects

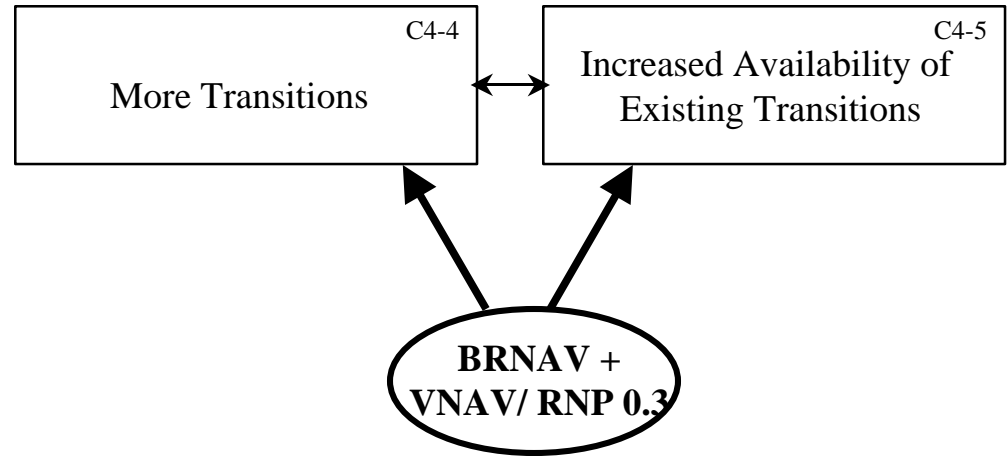


4. Approach / Departure Transition Capacity Transitions

Airplane-Level Capacity Effects

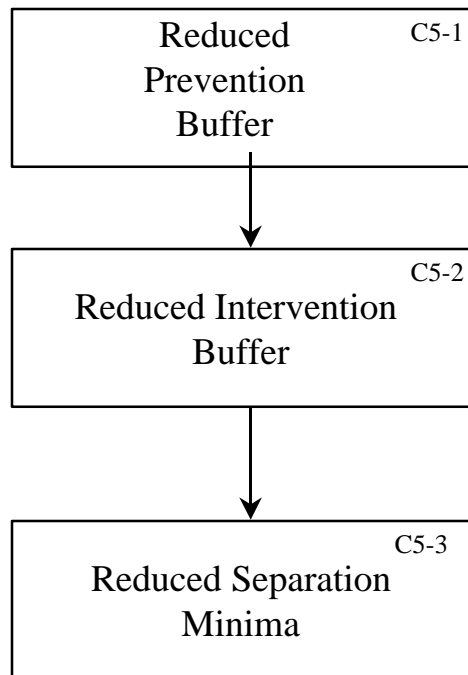


System-Level Capacity Effects

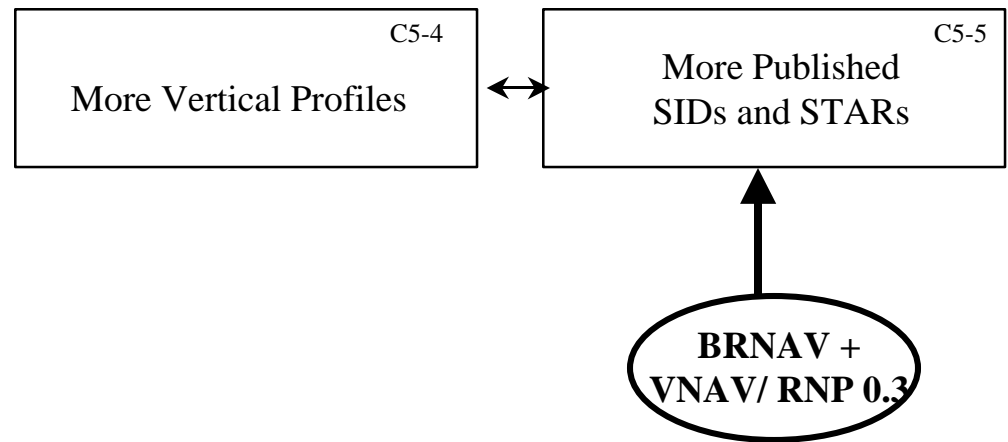


5. Cruise / Terminal Transition Capacity Transitions

Airplane-Level Capacity Effects



System-Level Capacity Effects



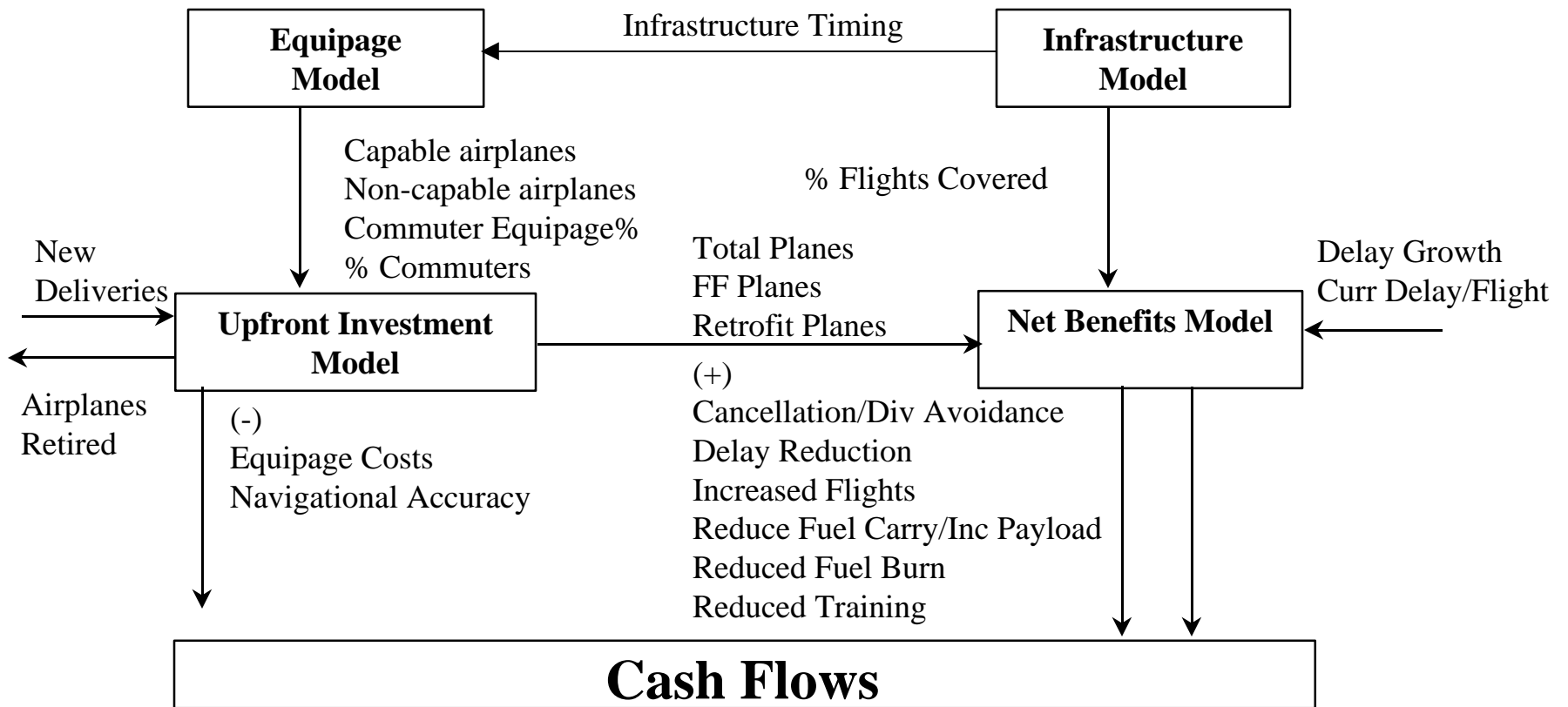
Near-Term Cost Benefit Model

Assumptions and Data Requirements

Model Assumptions

- This is not an alternatives analysis. We are looking at navigation enablers only.
- Analysis is from airline point of view (airline as an industry, not single airline)
- Model will be built to accommodate any region
- 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 datalink analysis
- Infrastructure costs included for regions with route charges
- The present balance between predictable delay and throughput is maintained.

Navigation Investment Model



Net Benefits Model

Benefit 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).
 - Increased Flights
 - quantified as number of flights added per year over airspace region.
- 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

Indirect Benefits

- Environmental benefits are quantified indirectly as:
 - Capacity
 - Increased flights by reducing environmental loading per flight (reduced noise footprint)
 - Efficiency
 - Reduced Emissions modeled indirectly as Reduced Block Fuel and Reduced Fuel Burn: consistency leads to more efficient operations
- Some environmental benefits not modeled
 - Noise (cost savings to Air Traffic Service Provider for insulation and noise-proofing)
 - Cost avoidance from having to limit flight schedule

Benefits Matrix

		BRNAV		BRNAV + VNAV + RNP 0.3				
Benefit Types		More routes	Better Approach Transitions	Tighter Approach Transitions (Better +)	ILS out	in lieu of NPA	Improved Departure Proc's	More Published Departures
Capacity	Cancellation / Diversion Avoidance				X	X		
Capacity	Delay Reduction	X	X	X		X		X
Capacity	Increased Flights						X	X
Efficiency	Reduced Fuel Carried or Increased Payload		X	X	X	X	X	
Efficiency	Reduced Fuel Burned					X		
Training	Training				X	X		

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

Benefits Matrix

		BRNAV		BRNAV + VNAV + RNP 0.3				
Benefit Types		More routes	Better Approach Transitions	Tighter Approach Transitions (Better +)	ILS out	in lieu of NPA	Improved Departure Proc's	More Published Departures
Capacity	Cancellation / Diversion Avoidance				Lower minimums allow near-ILS capability for landing	lower minimums allow increased access		
Capacity	Delay Reduction	Applies primarily to Europe	Similar to Atlanta Study or improved integrity of departure schedule	Higher controller confidence allows reduced buffer		Lower minimums and higher controller confidence allows reduced buffer		May be trade-off between increased flights and delay reduction
Capacity	Increased Flights						Environmental benefit	Environmental benefit
Efficiency	Reduced Fuel Carried or Increased Payload		More laterally efficient paths	More laterally and vertically efficient paths	More available alternates	Stabilized descent	Tighter containment on departure paths and path shortening	
Efficiency	Reduced Fuel Burned					Stabilized descent		
Training	Training				Don't need to train for special conditions when ILS out	Only need to train one kind of approach		

Infrastructure Model

- Procedures are 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 high-density areas
 - Stage 3. Air Traffic Service Provider developing public procedures in low-density areas

Equipage Model

- “Non-commercial” airplanes will be added to model for equipage, but not benefits
- BRNAV Capability
 - all forward-fit airplanes will be BRNAV capable
 - some in-service airplanes already BRNAV capable
 - of those not yet capable, some will retrofit BRNAV capability
 - some will not retrofit, and will be slowly retired out of the model

Equipage Model, continued

- BRNAV + VNAV + RNP 0.3 Capability
 - assume all airplanes BRNAV capable
 - some forward-fit airplanes will be RNP 0.3 compliant and VNAV capable
 - RNP/ANP annunciation not required
 - compliance to RNP 0.3 must be shown if RNP 0.3 not standard (note, GNSS would assure RNP 0.3)
 - some in-service airplanes already VNAV and RNP 0.3 capable
 - of those not yet capable, some will retrofit
 - some will not retrofit, and will be slowly retired out of the model

Up-Front Investment Model

- Retrofit equipage for BRNAV
- Retrofit Equipage for VNAV + RNP 0.3
- Forward fit equipage for VNAV + RNP 0.3
- Navigational Accuracy
 - 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

Recurring Costs

- Database integrity requirements for RNP operations

Data Requirements

Benefit Calculations

- Cancellation / Diversion Avoidance

(% of Flights Cancelled) * (Cost per Cancellation) * (% Equipped flights not Cancelled) * (Cumulative Equipped Planes) * (Flights per Year) * (Flights Covered by a Procedure)

- Delay Reduction

- Percent Equipped Planes = (Cumulative Total Planes) / (Total Planes)
- Atlanta Delay Savings per Flight = (Atlanta study national delay minutes saved) / (Number of departures)
- Delay Savings per Flight = (Atlanta Delay Savings per Flight) * (Atlanta Discount Factor) * (1 + Delay Growth per Yr) ^ Yr
- Value of Delay = (Delay Savings per Flight) * (DOC per minute) * (Total Planes) * (flights per Year)
- The final delay savings is found by applying the Percent Equipped Planes and the Value of Delay to the delay vs. equipage curve. The Percent Equipped Planes is used against the Y-axis to find the corresponding Percent of Full-Up Delay Reduction Achieved per Flight. This Percent is then multiplied to the Value of Delay to give the Delay Savings.

Benefit Calculations

- **Increased Flights**

(Value Added per Flight) * (Flights Added per Equipped flight) * (Cumulative Equipped Planes) * (Flights per Year) * (Flights Covered by a Procedure)

- **Reduced Fuel Carried**

TBD

- **Increased Payload**

(Pounds Added per Equipped Flight) * (Value per Payload Pound) * (%flights Payload Limited) * (Cumulative Equipped Planes) * (Flights per Year) * (Flights Covered by a Procedure)

- **Reduced Fuel Burn**

(Fuel Saved per Equipped Flight) * (Cost per Fuel Gallon) * (Fuel Inflation) * (Cumulative Equipped Planes) * (Flights per Year) * (Flights Covered by a Procedure)

- **Training**

TBD

Data Requirements

- See Spreadsheet

Issues

- We will do one run for the BRNAV capability and one run for each op enhancement under BRNAV/VNAV
 - how do we combine benefits?
- Infrastructure costs included for regions with route charges
 - Do we want to model infrastructure costs for US too? Even though charges are indirect.
- Need to differentiate between benefits -- need rules for when to apply one or the other
- Noise and limitation of flight schedule cost avoidance not in model, do we want to include them?
- How do we calculate training benefits at industry level

Summary

- Need data for first run of model!

Intangibles

- Simplified Route Descriptions -- pilots like it -- repeability of departures, less chance of human error.