A Methodology for Evaluating Current and Future Airport Capacity

for

NEXTOR National Airspace Performance Workshop

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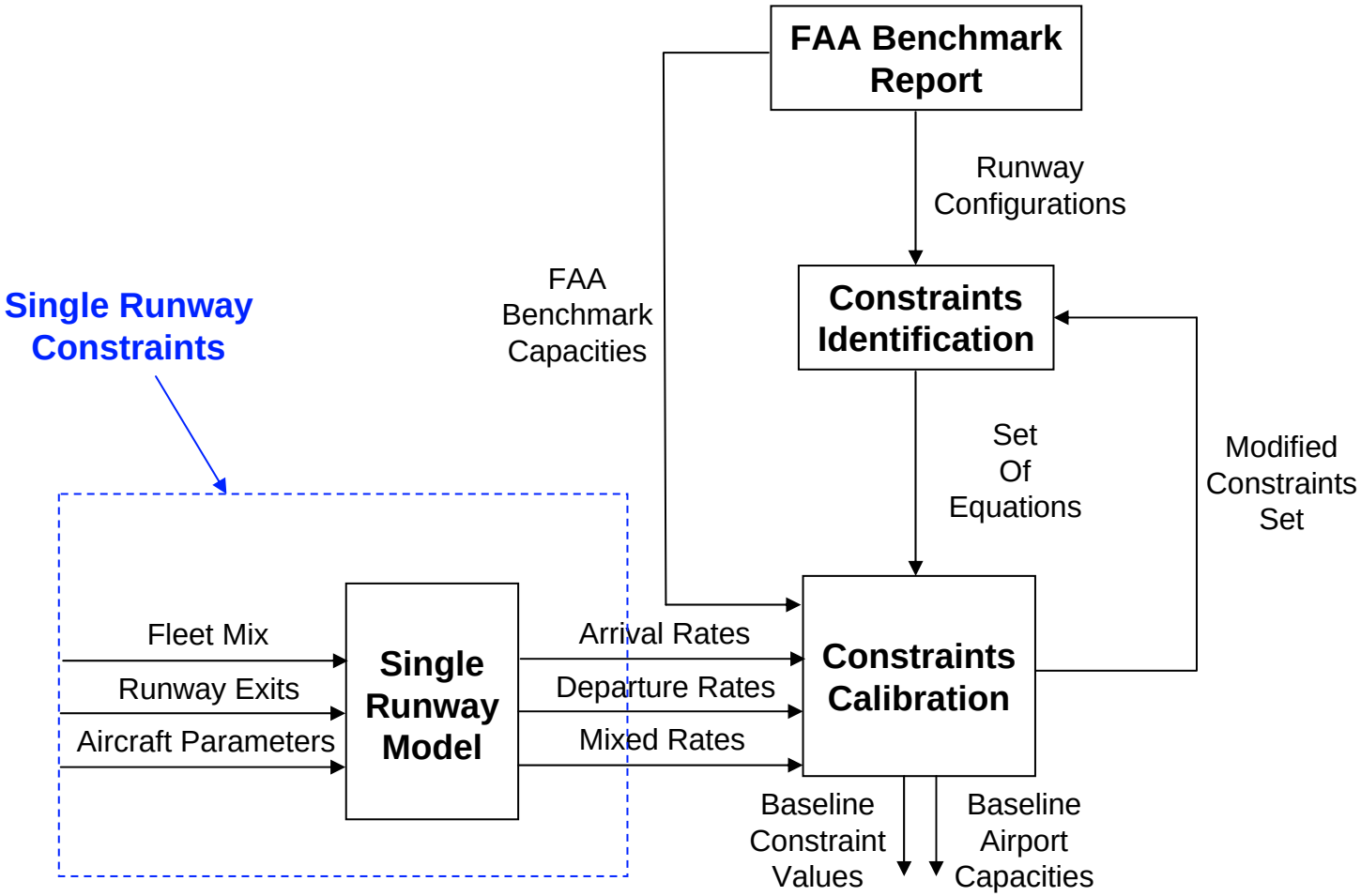
Overview

- Model methodology
- NAS baseline calibration
- Potential future alternatives
- Conclusions

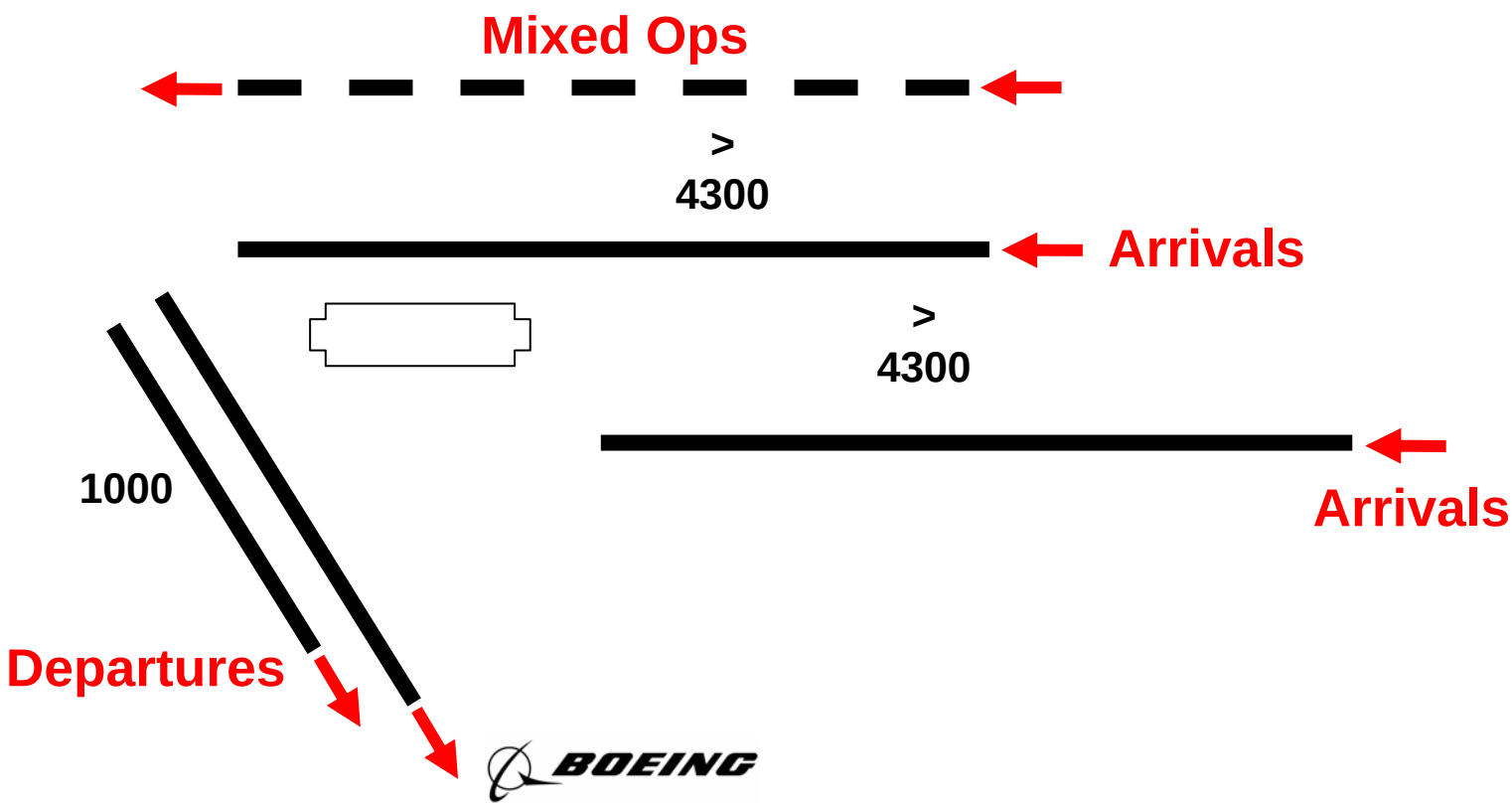
Airport Capacity Constraints Model Objectives

- Baseline Capacity Calibration
  - To define operational constraints at the 35 benchmark airports for VMC, MVMC, IMC
  - To evaluate how much these constraints reduce ideal capacity NAS-wide
- Future Capacity Alternatives
  - Define benefit mechanisms for future alternatives – how do the alternatives mitigate the constraints?
  - Determine model changes to represent each benefit mechanism
  - Evaluate airport capacity benefits of future alternatives

Airport Capacity Constraints Model

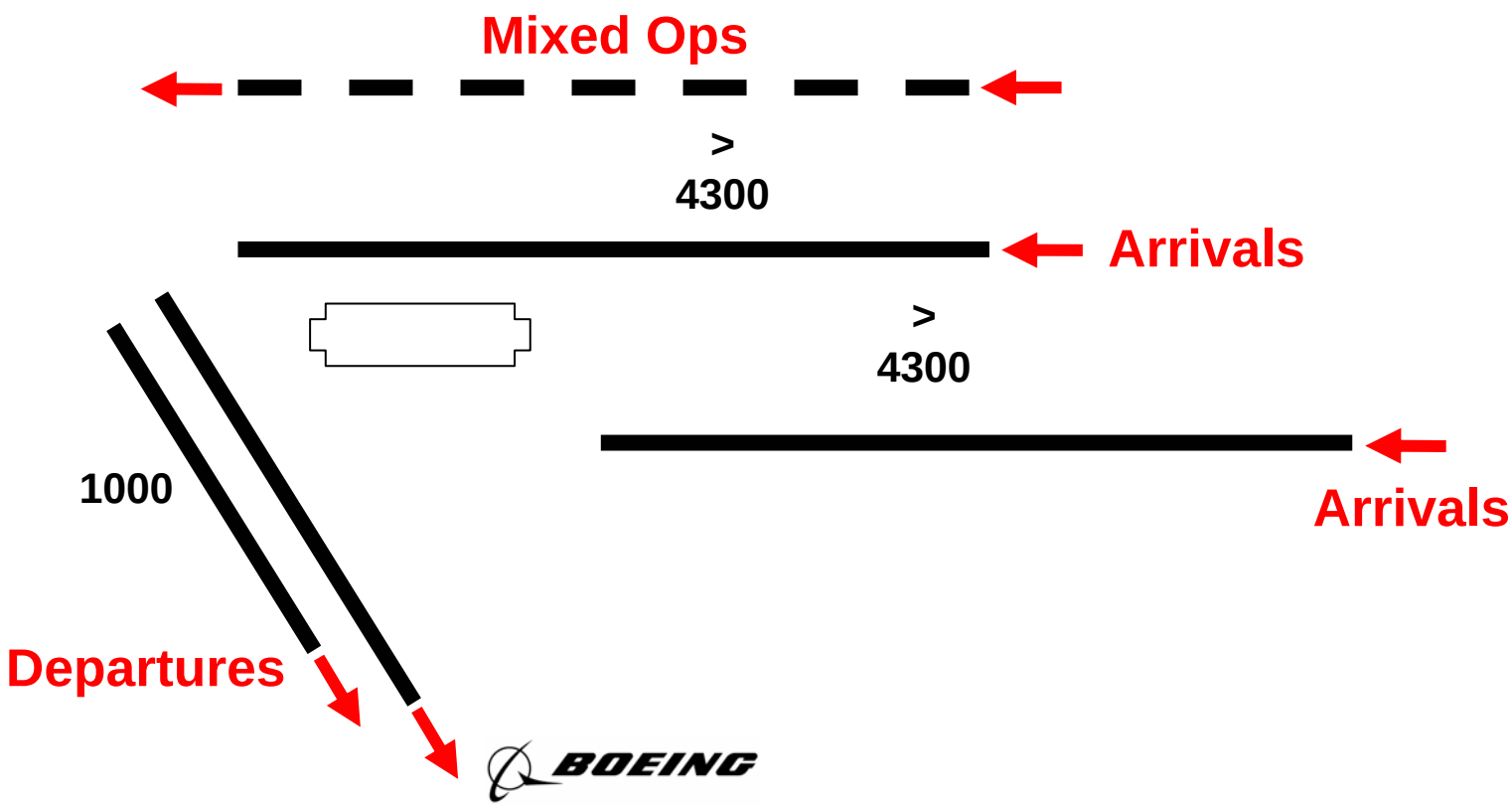


IMC Runway Configuration for Houston Intercontinental Airport (IAH) with New Runway



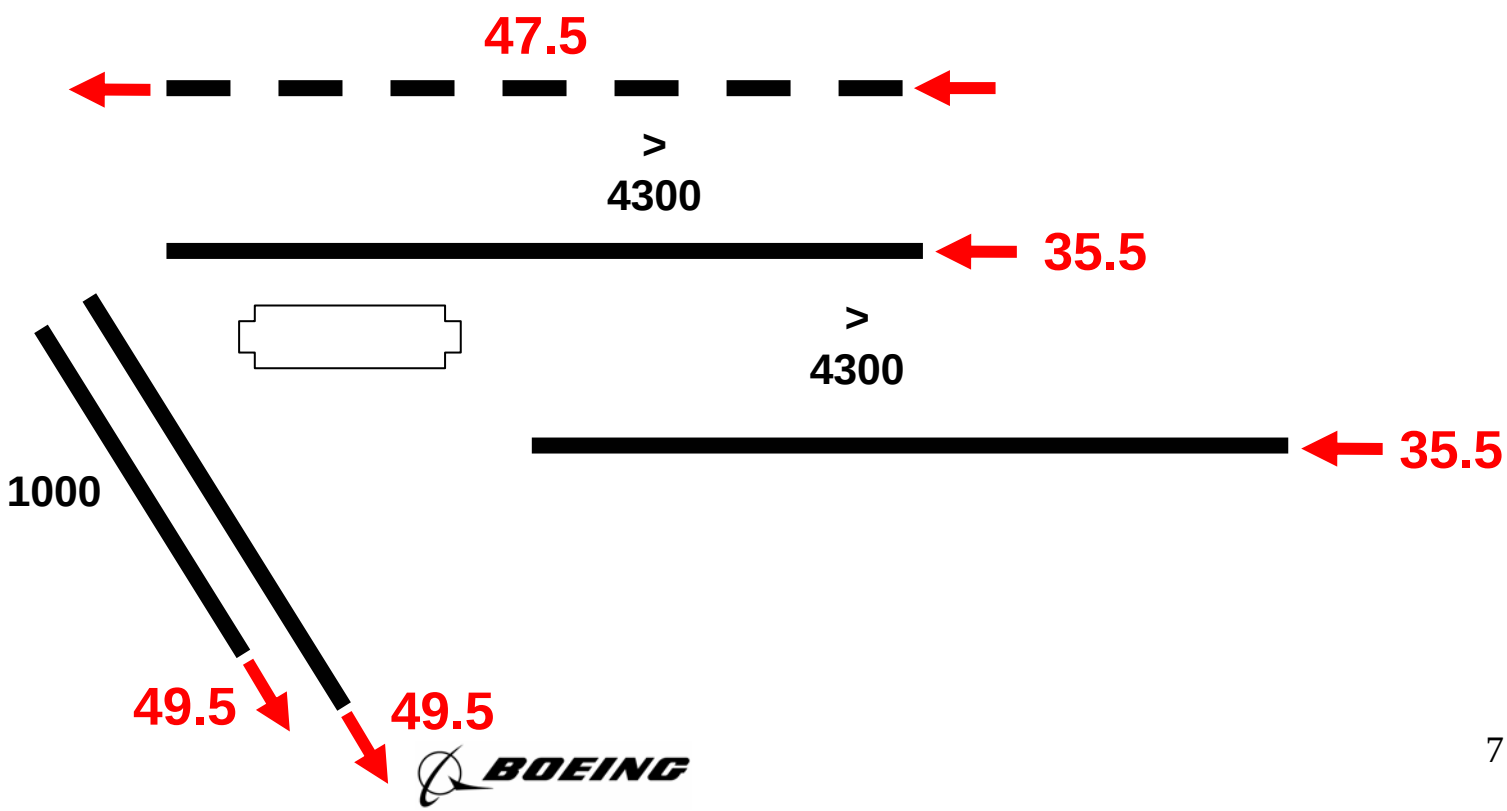
IMC Runway Configuration for Houston Intercontinental Airport (IAH) with New Runway

Arrivals / hr = 35.5
Departures / hr = 49.5
Mixed Ops / hr = 47.5

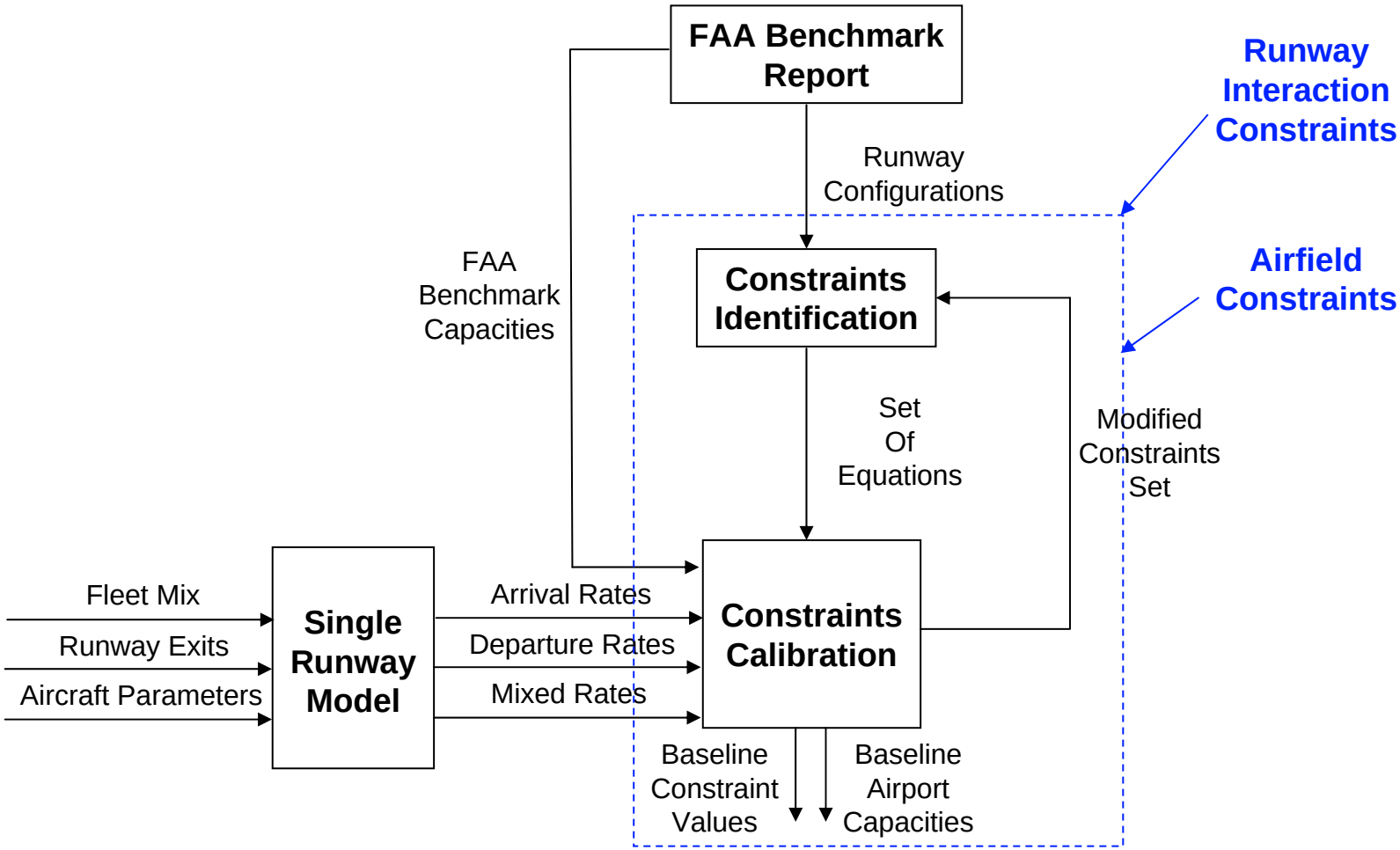


Without Runway Constraints, IAH Should Accommodate 218 Ops/Hour in IMC

Arrivals / hr = 35.5
Departures / hr = 49.5
Mixed Ops / hr = 47.5



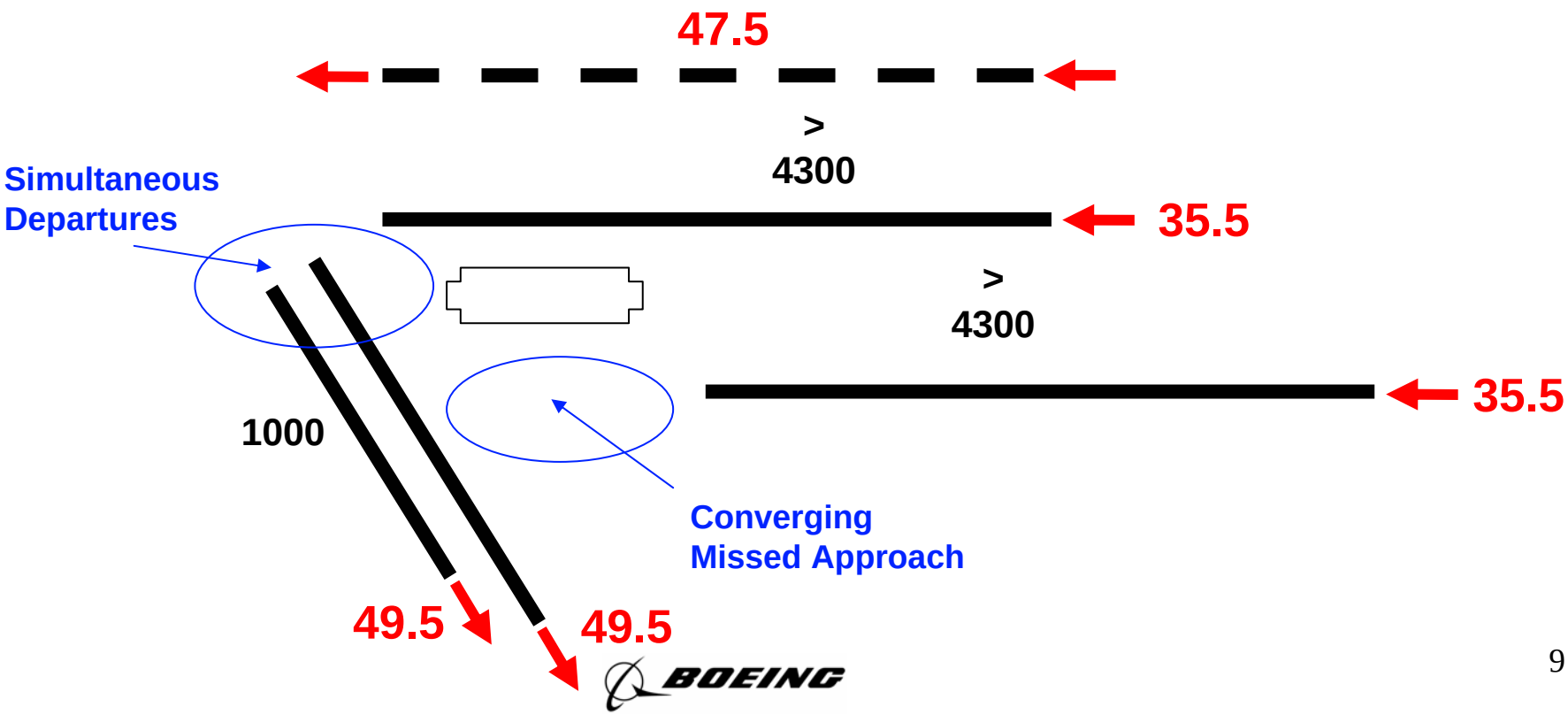
Airport Capacity Constraints Model



However, Runway Interaction and Airfield Constraints Further Limit Operations

2004 Benchmark Report claims 132 ops/hr in IMC with the new runway

Arrivals / hr = 35.5
Departures / hr = 49.5
Mixed Ops / hr = 47.5



Runway Configurations for 35 Benchmark Airports Were Analyzed

- ATL (new runway 2006)
- BOS (new runway 2006)
- BWI
- CLE (new runway 2004)
- CLT
- CVG (new runway 2005)
- DCA
- DEN (new runway 2003)
- DFW
- DTW
- EWR
- FLL
- HNL
- IAD (new runway 2008)
- IAH (new runway 2003)
- JFK
- LAS
- LAX
- LGA
- MCO (new runway 2003)
- MDW
- MEM
- MIA (new runway 2003)
- MSP (new runway 2005)
- ORD
- PDX
- PHL
- PHX
- PIT
- SAN
- SEA (new runway 2008)
- SFO
- SLC
- STL (new runway 2006)
- TPA

9 Runway Interaction Constraint Factors Were Defined

Variable	Description	Runway Config	Operation
α	Closely-spaced parallel runways	700-1199 C/L sep	A/D
λ	Closely-spaced parallel runways	700-1199 C/L sep	A/A, D/D, M/M
β	Closely-spaced parallel runways	1200-2499 C/L sep	A/D
μ	Closely-spaced parallel runways	1200-2499 C/L sep	A/A, D/D, M/M
γ	Closely-spaced parallel runways	2500-3399 C/L sep	A/D
ν	Closely-spaced parallel runways	2500-3399 C/L sep	A/A, D/D, M/M
δ	Closely-spaced parallel runways	3400-4299 C/L sep	All Ops
χ	Crossing runways	Crossing	All Ops
η	Converging runways	Converging	All Ops

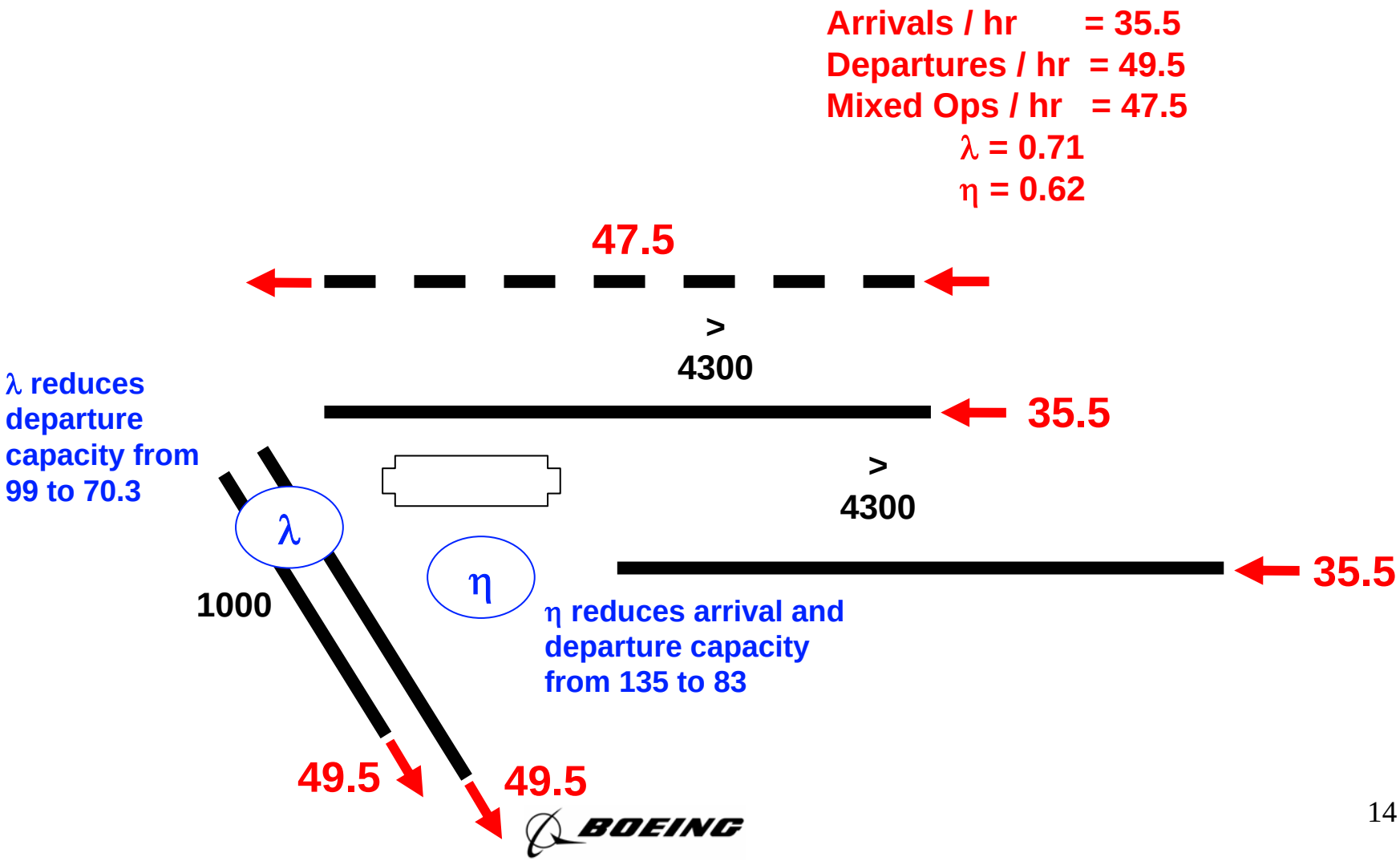
Along with 7 Airfield and Airspace Constraint Factors

Variable	Description	Operation
τ	Airspace constraint	All Ops
θ	Terrain constraint	All Ops
ε	Environmental constraint	All Ops
σ	Surface constraint	All Ops
π	Pilotage constraint	All Ops
ρ	System flow constraint	All Ops
ζ	Short runway constraint	All Ops

Baseline Runway Interaction Performance Targets

Variable	Description	VMC	MVMC	IMC
α	CSPA, 700-1199 C/L sep, A/D	0.92	0.93	0.96
λ	CSPA, 700-1199 C/L sep, A/A, D/D, M/M	0.64	0.61	0.71
β	CSPA, 1200-2499 C/L sep, A/D	0.97	0.96	0.86
μ	CSPA, 1200-2499 C/L sep, A/A, D/D, M/M	0.89	0.70	0.66
γ	CSPA, 2500-3399 C/L sep, A/D	1.00	1.00	0.94
ν	CSPA, 2500-3399 C/L sep, A/A, D/D, M/M	1.00	0.86	0.90
δ	CSPA, 3400-4299 C/L sep, All Ops	1.00	0.91	0.21
χ	Crossing runways, All Ops	0.80	0.76	0.73
η	Converging runways, All Ops	0.81	0.75	0.62
τ	Airspace constraint, All Ops	0.95	1.00	1.00
θ	Terrain constraint, All Ops	0.90	0.88	0.81
ε	Environmental constraint, All Ops	0.98	0.84	0.87
σ	Surface constraint, All Ops	0.96	1.00	0.87
π	Pilotage constraint, All Ops	0.97	0.89	0.82
ρ	System flow constraint, All Ops	0.97	0.95	0.97
ζ	Short runway constraint, All Ops	0.40	0.35	0.66

Runway Interaction Constraints Limit IAH IMC Capacity to 149 Ops/Hr



3 Concept Alternatives Were Analyzed

- NAS Baseline
- Concept Alternatives
  - RNP
  - RNP + LAAS
  - RNP + LAAS + Path Options + ATC Tools + Runway Solutions
    - Predefined 3D paths
    - Required Time of Arrival
    - CTAS TMA + EDA, URET + PARR
    - Advanced runway concepts for closely-spaced parallel, crossing, and converging runways

Benefits Applications

Alts	Applications	Access & Availability	Efficiency	Capacity
RNP	Non-ILS runway approaches between 500 and 250 ft ceilings	✓		
	Reduced airspace volume delay and close airport interactions			
	Increased departure throughput with RNP in VMC, MVMC, IMC			✓
	Increased arrival throughput with RNP in VMC, MVMC, IMC			✓
	Independent converging approaches in MVMC, IMC			✓
	Short final approaches in MVMC		✓	✓
	Continuous Descent Approaches in low traffic volumes		✓	
GLS	CAT III approaches for available runways	✓		
	Improved low visibility departures	✓		
	Increased departure throughput in IMC			✓
	Short final approaches in IMC		✓	✓
	Reduced arrival/arrival spacing due to multiple glideslopes			✓
Path Options + ATC Tools + Runway Solutions	Improved runway throughput with RNP, 3D paths, RTA, and advanced automation for 3D path-based planning		✓	✓
	Runway concepts for single, closely-spaced parallel, converging, and crossing runways		✓	✓
	Terminal arrival metering		✓	
	Approach transitions for parallel independent approaches in IMC		✓	
	Continuous Descent Approaches s in high traffic volumes		✓	

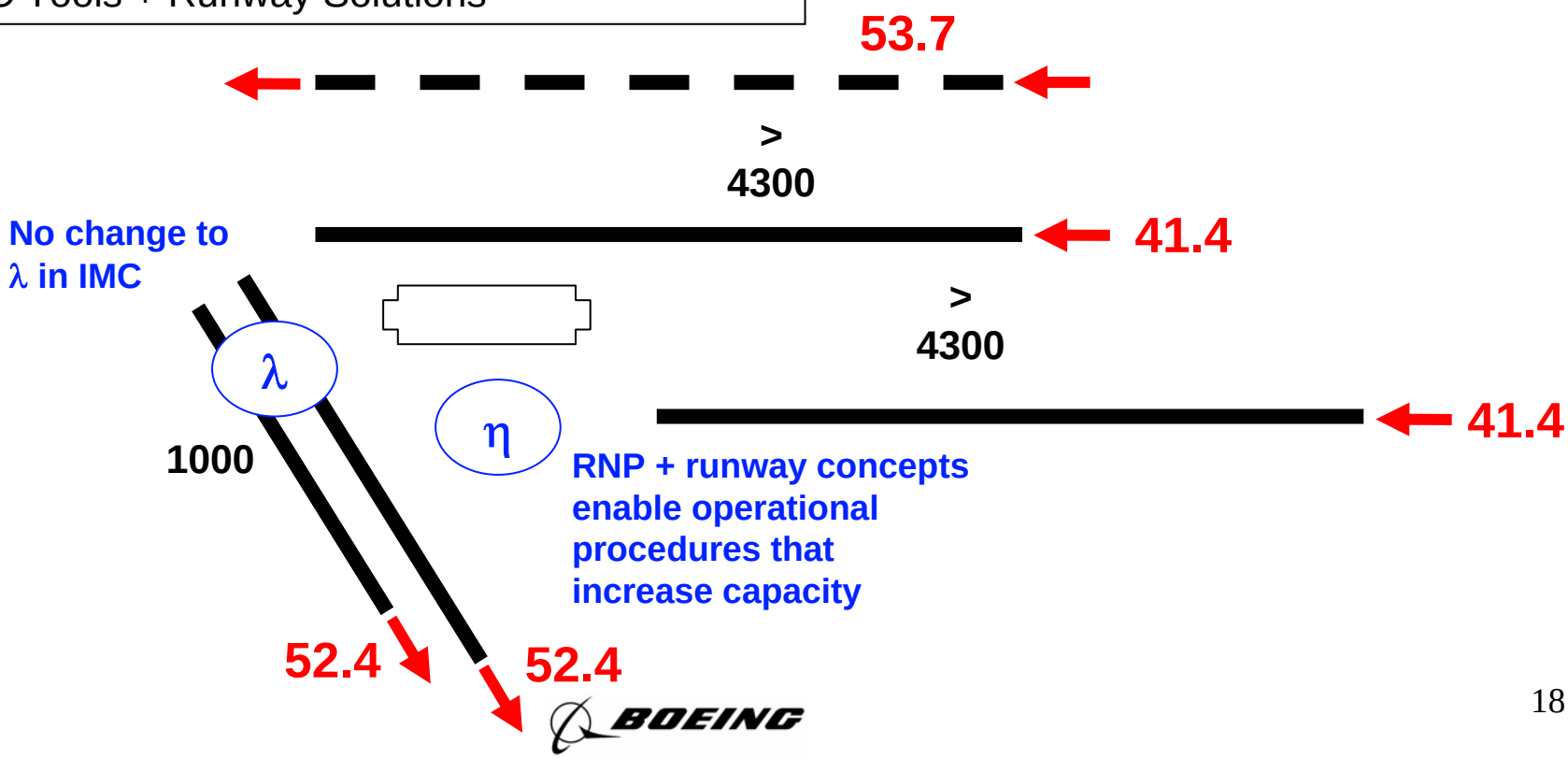
Single Runway and Runway Interaction Performance Targets for Concept Alternatives

Models	Factor	Wx	Baseline	RNP	RNP + GLS	RNP+GLS+ Path Op+ ATC Tools +Rwy Sol
Single Runway Constraints	Mean departure release time & standard deviation	VMC	8 sec, 6 sec	6 sec, 4 sec	6 sec, 4 sec	4 sec, 2 sec
		MVMC	8 sec, 6 sec	6 sec, 4 sec	6 sec, 4 sec	4 sec, 2 sec
		IMC	8 sec, 6 sec	7 sec, 5 sec	6 sec, 4 sec	4 sec, 2 sec
	Outer marker delivery accuracy	All wx	18 sec	16 sec	16 sec	12 sec
	Final approach path length	VMC	3 nm	3 nm	3 nm	3 nm
		MVMC	5 nm	3 nm	3 nm	3 nm
		IMC	5 nm	5 nm	3 nm	3 nm
	Arrival / arrival separation	All wx	Baseline	Baseline	Dual GLS Glideslopes	Dual GLS Glideslopes
Runway Interaction + Airfield Constraints	CSPA, 700-1200, A/A					λ
	CSPA 1200-2500, A/D					β
	CSPA 1200-2500, A/A					μ
	Crossing runways					χ
	Converging runways			η	η	η
	Terrain constraint			θ	θ	θ

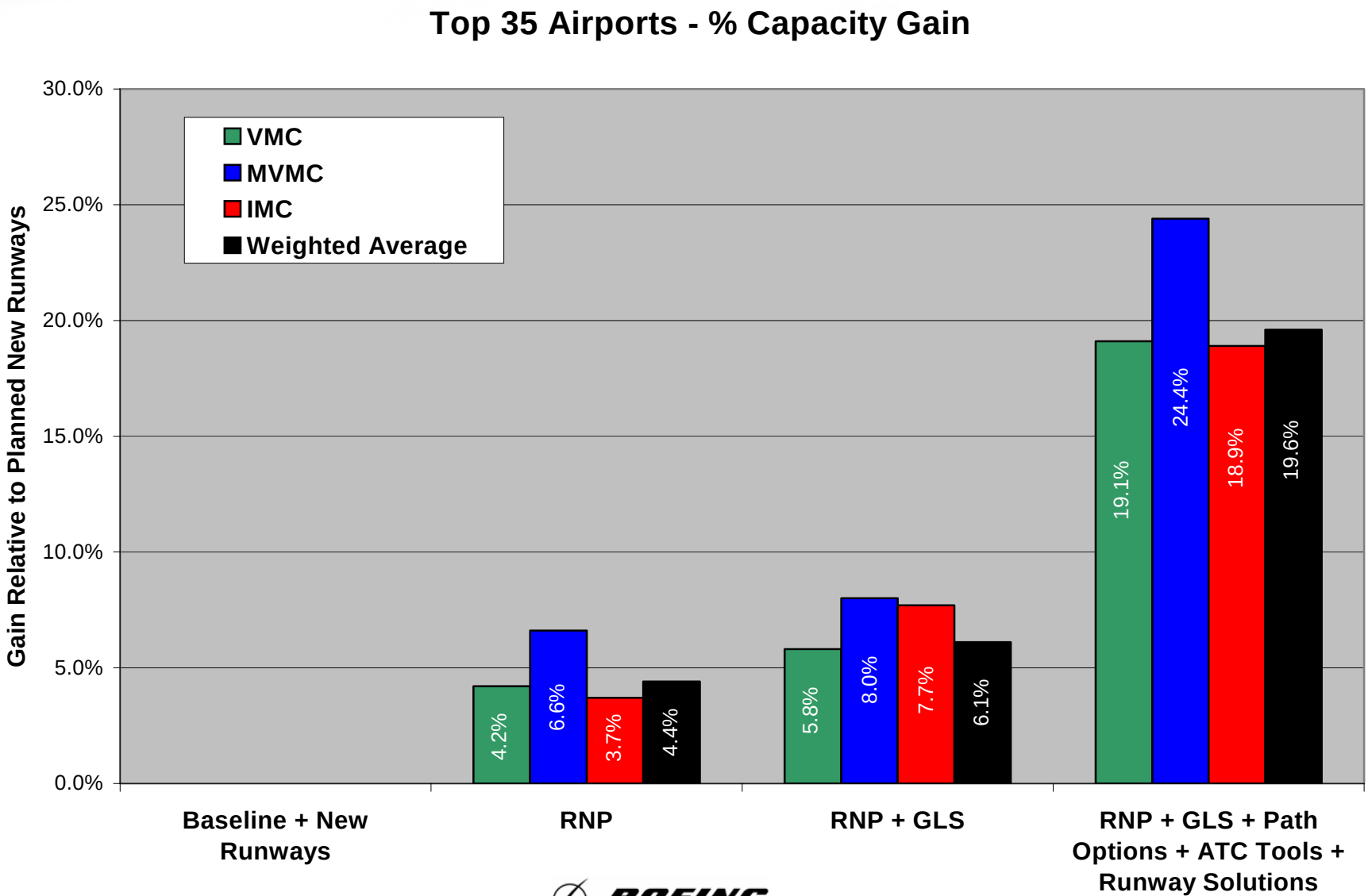
RNP + GLS + Path Options + ATC Tools + Runway Solutions Have the Potential to Increase IMC Capacity at IAH to 194 Ops/Hr

	IMC
Base	149
RNP	161 (8% inc)
RNP + LAAS	167 (12% inc)
RNP + LAAS + Path Options + ATC Tools + Runway Solutions	194 (30% inc)

Arrivals / hr = 41.4
Departures / hr = 52.4
Mixed Ops / hr = 53.7
λ = 0.71
η = 0.85



Concept Alternatives Have the Potential to Increase Capacity in All Weather Conditions



Conclusions

- Model ties benefits to specific performance requirements for new technologies
- Model supports sensitivity assessments and fast turnaround evaluation of range of technology alternatives across the NAS
- The model was calibrated by balancing constraint values so as to minimize the RMS error between the airport capacity values in the FAA Benchmark Report and the equation values
  - VMC – 6%
  - MVMC – 7%
  - IMC – 9%
- The model could achieve better calibration with better data
  - Fleet mix
  - Operational procedures at each airport
- The model should be used for facility benchmarking