CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

Paired Approach Procedure For Closely Spaced Parallel Runways (CSPRs)

CAASD

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Why Paired Approaches
Example of Current Operations at SFO

Simultaneous parallel approaches to SFO: Source: Chin Khor

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Paired Approach Goal
Go Boldly in IMC to CSPRs

Original photo by Chin Khor modified in Photoshop by Robert Eftekari

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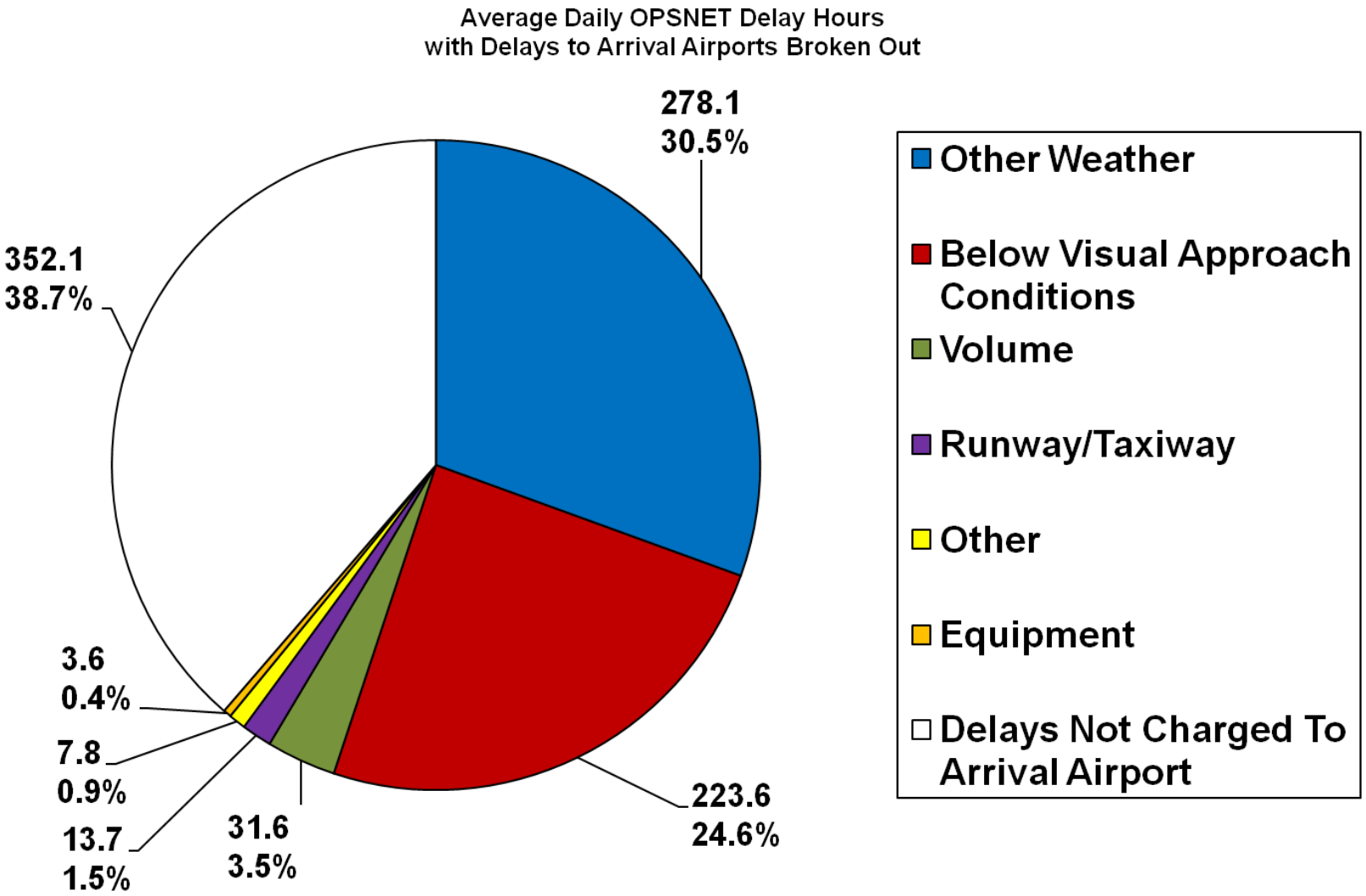
Average OPSNET Delays in NAS 2000-2009



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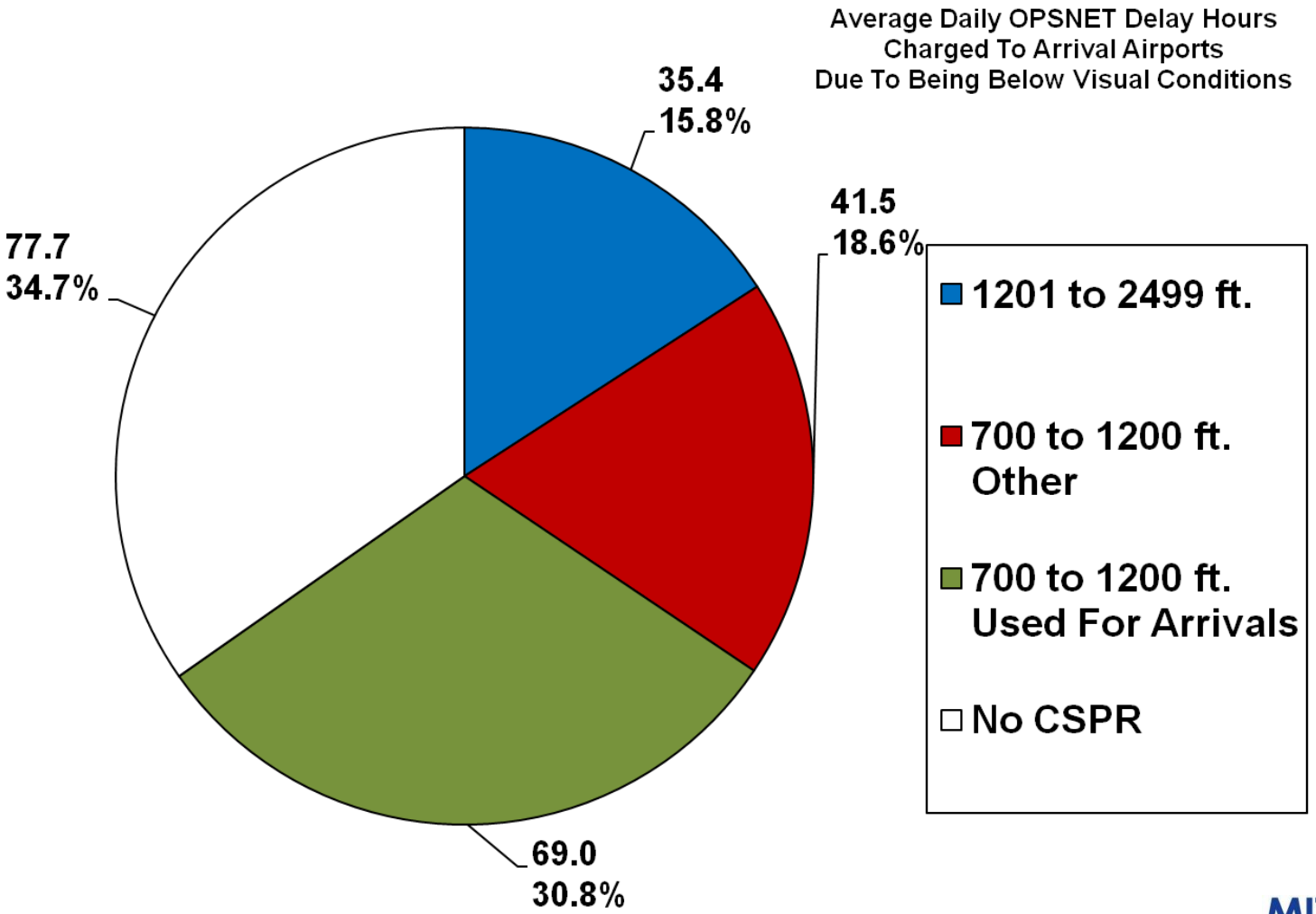
Average OPSNET Delays charged to Arrival Airport being below Visual Conditions (2000-2009)



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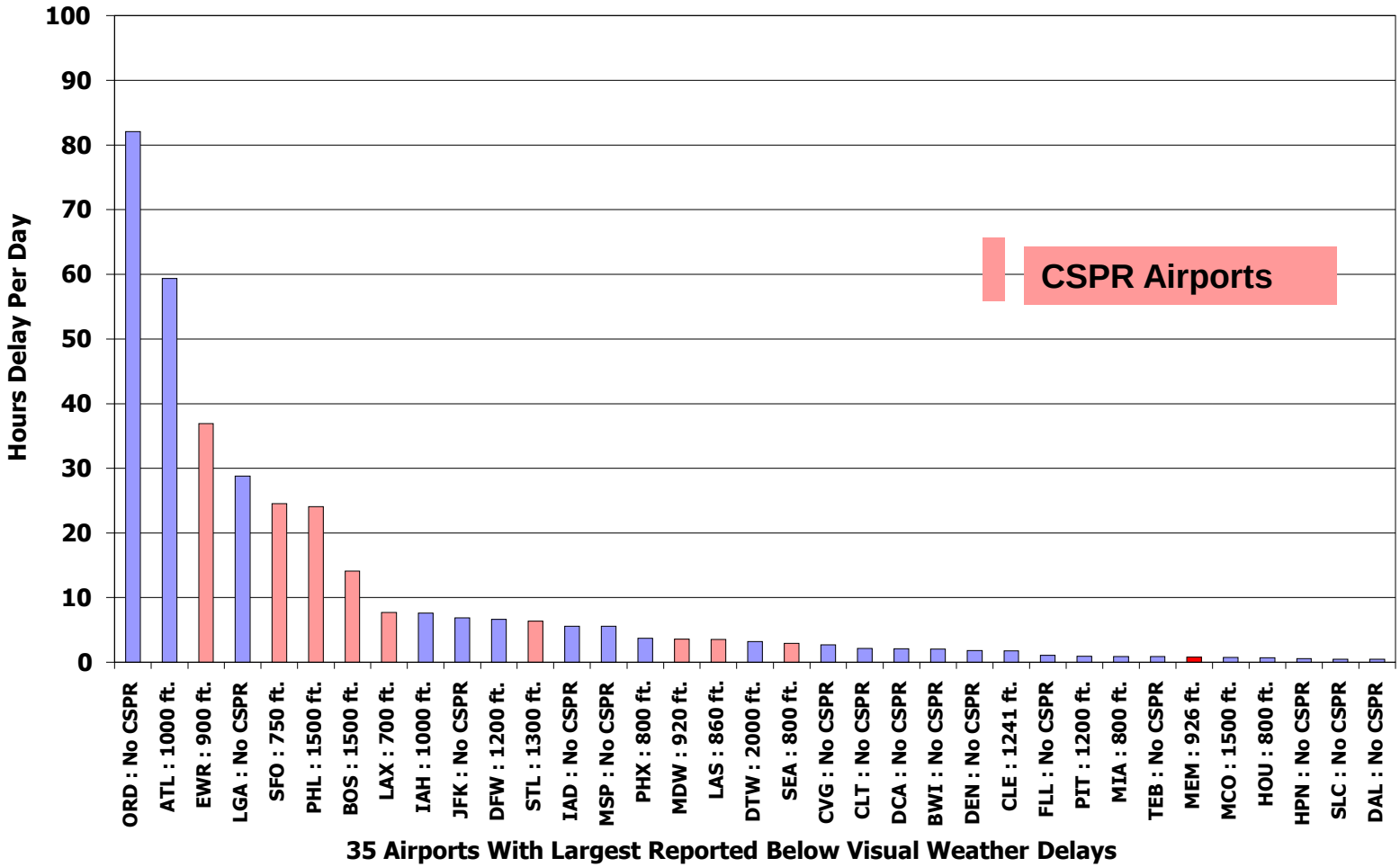
Average Daily Delay Hours Associated With Arrival Airport Weather Below Visual Conditions (2000-2007)



Source: OPSNET

Note: The top 10 airports have 81% of total delay on previous page, and the top 35 have 98%

The airports highlighted in red have CSPR spacing < 1200 ft. and have used these CSPR for simultaneous arrivals in visual conditions

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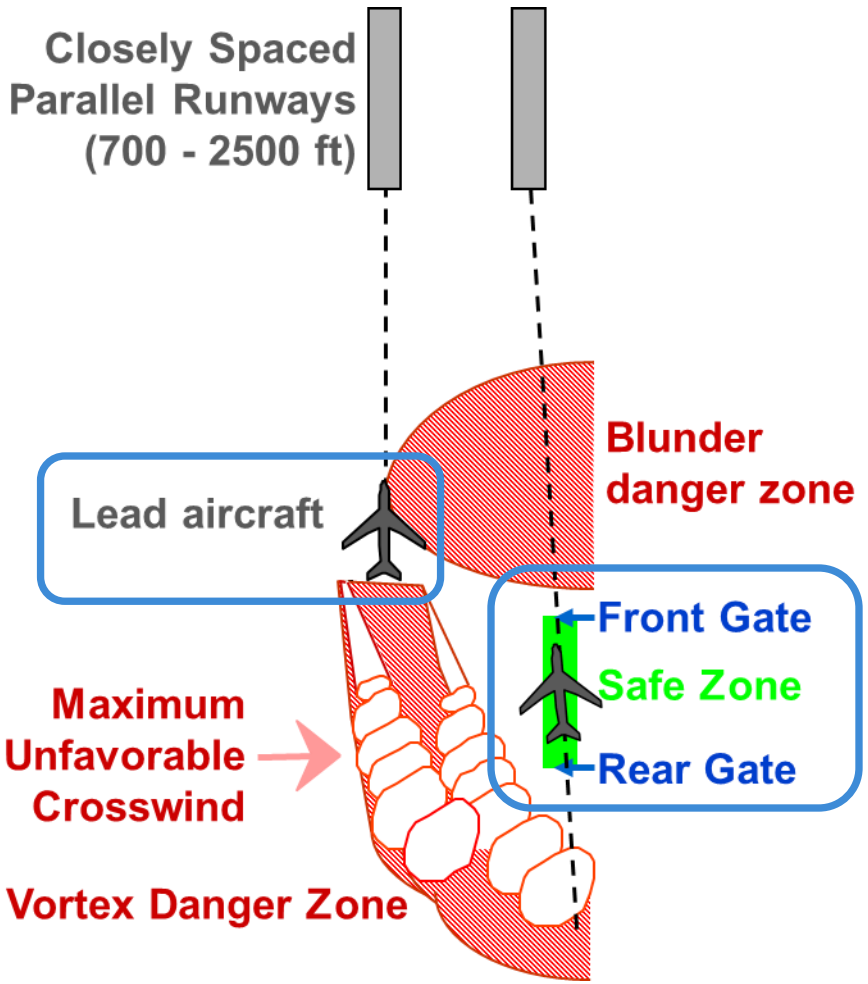
What is a Paired Approach (PA)?

- **Paired Approach**
  - **"Dependent" like approach to CSPRs < 2500 feet**
  - **Controller initially sets up procedure**
  - **Lead aircraft ADS-B Out**
  - **Trail aircraft equipped with ADS-B In and capable of maintaining safe zone position with CDTI**
  - **Capacity nearly 75% of full up visuals**
- **Evolution**
  - **Phase I: non–escape version**
  - **Phase II: escape version (SAPA)**



Phase I Procedure

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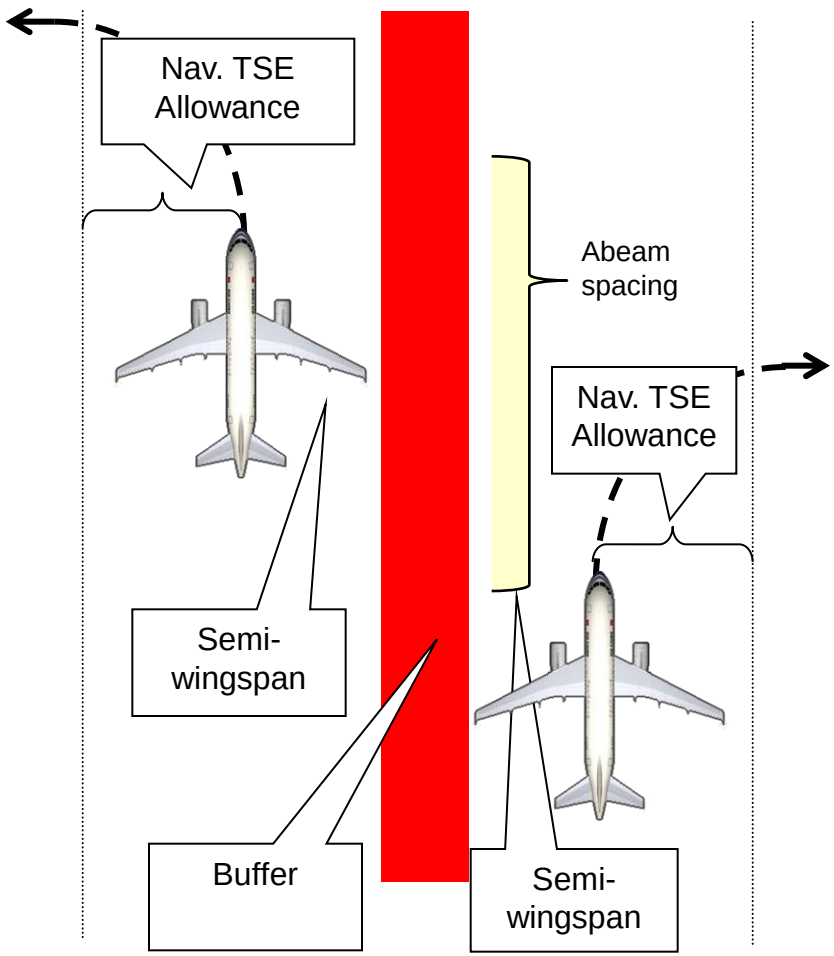
Phase II: SAPA

Escape Maneuver by Non-blundering Aircraft



- **Precision GNSS navigation (GBAS or SBAS LPV)**
- **Digital flight controls (Category III capable; auto-coupled)**
- **ADS-B: aircraft auto-couple status**
- **Pre-defined escape maneuver when other aircraft blunders, decouples from the autopilot, or loses precision GNSS guidance**
  - **blunder detection & resolution**
- **LNAV-guided missed approach**
- **Aircraft pair (or triplet) *approximately abeam* for wake avoidance**
- **Cat II or lower minima**

SAPA= Simplified Aircraft Based Paired Approach Concept

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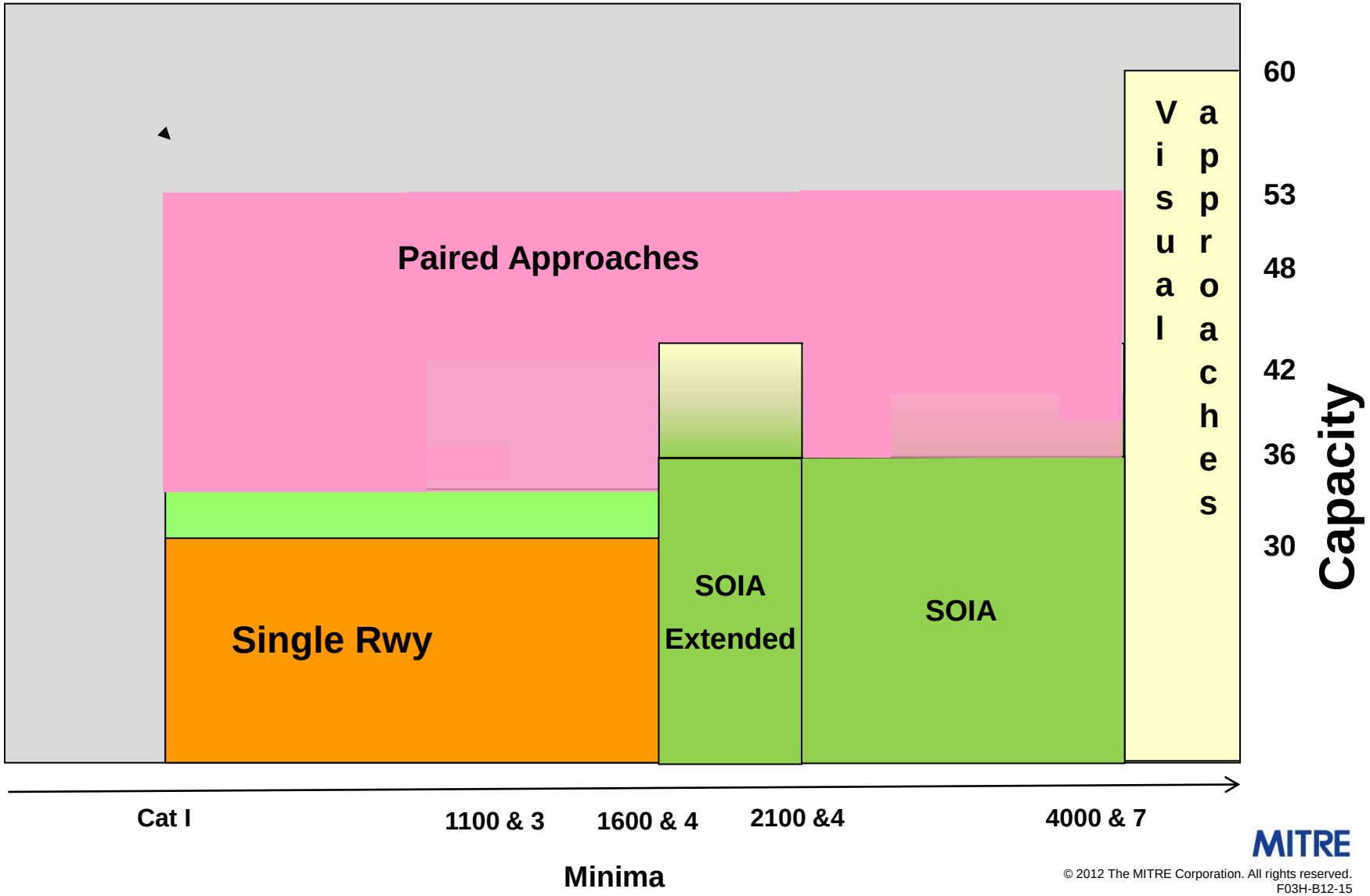
Paired Approach Benefit

Procedures for Closely Spaced Parallel Runways
Example of SFO (Notional)



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Applicability

- 48 airports could have a potential application of a 700 ft rule
  - 30 airports in current configurations
  - 18 airports with potential new construction

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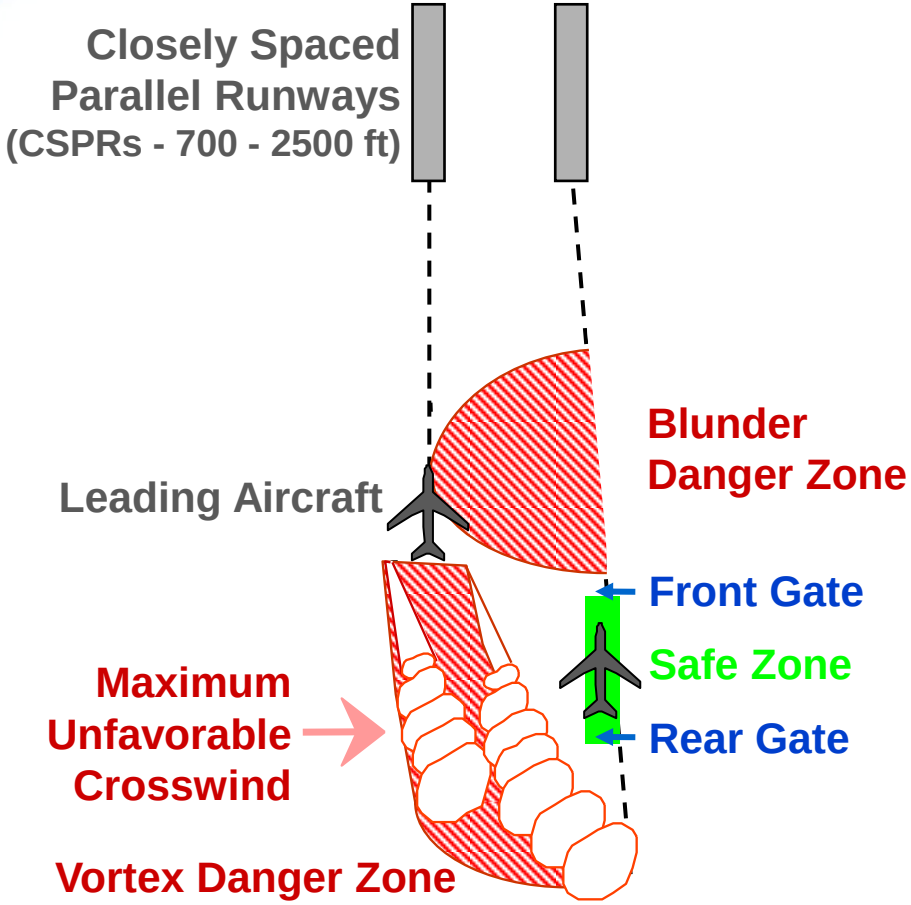
Paired Approach Phase I
No Escape Maneuver by Non-blundering Aircraft



Cat I minima, conventional navigation, offset approach

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Paired Approach Phase I Procedure

Winds ok
for PA procedure

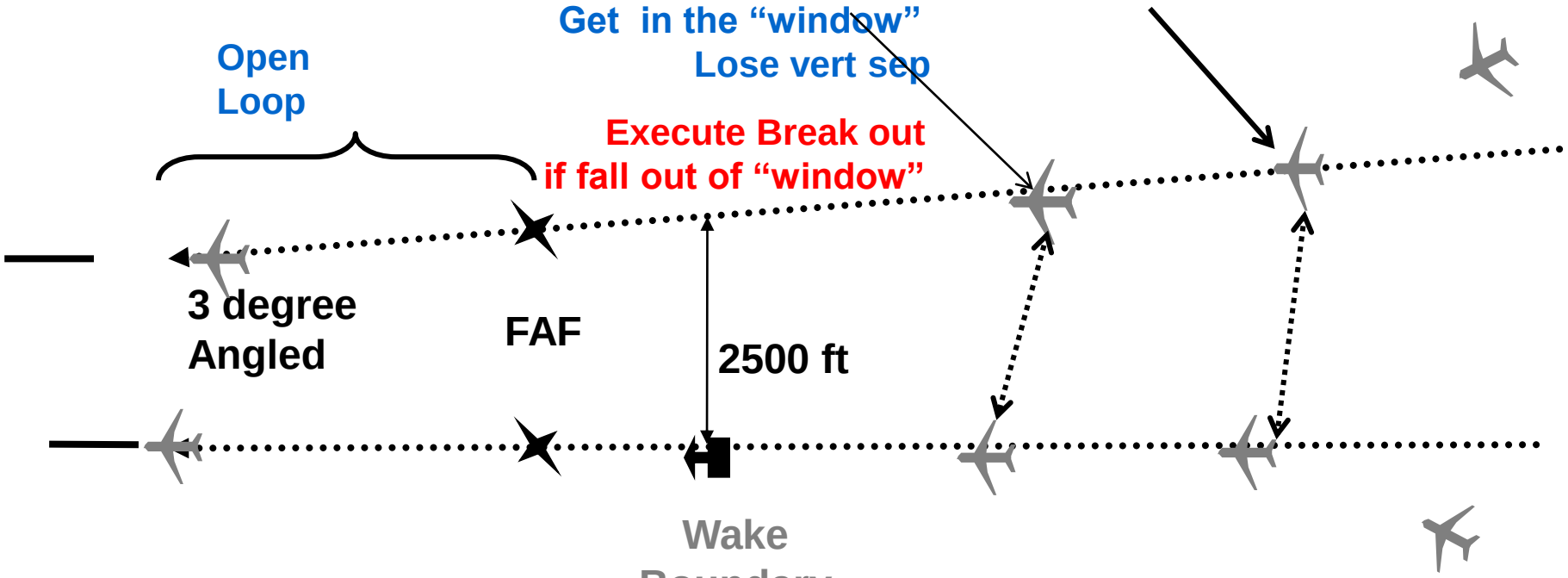
ATC pairs
a/c; higher FAS
in trail (20 kts)

ATC
Delivers a/c
1.5 +/- ½ nmi, 1000 ft
~ 15 nm from runway

Crews engage tools
Get in the "window"
Lose vert sep

Open
Loop

Execute Break out
if fall out of "window"



Wake
Boundary
Point

Either a/c can lead; but who leads may be restricted depending on site

TCAS Interaction: No RAs

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Infrastructure Requirements

- **Ground Element**
  - **Wake vortex advisory system (wind field forecast)**
    - **extends systems now under development**
  - **Mods to automation to indicate ADS-B equipage**
- **Air - for trailing aircraft**
  - **ADS-B in: Current rule adequate**
  - **Cockpit tools: Interval Management tools**
  - **RNP (0.3)**
- **Air - for leading aircraft**
  - **ADS-B out: Current rule adequate**

*** Note: Not yet known whether TIS-B may be adequate for the leading aircraft**

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Collision Analysis Results (Front Gate Values)

3 Degree Angled Approach, 700 ft RCL spacing

Front Gate Distance outside marker (ft)	Front Gate Distance Inside Marker	Escape with 3 Second Delay In Breakout	Escape with 5 Second Delay In Breakout	Escape with 8 Second Delay In Breakout	Non-Escape	% Accep-table Pairings
0	0	0	3E-4			99.99
500	250		2E-4			99.99
1000	750		3E-5	2E-3		99.99
2000	750			2E-4	3E-4	99.99
3000	750			<1E-4	3E-4	99.99
3500	750				7E-5	99.99

Green = requirement met; Yellow = requirement marginally met

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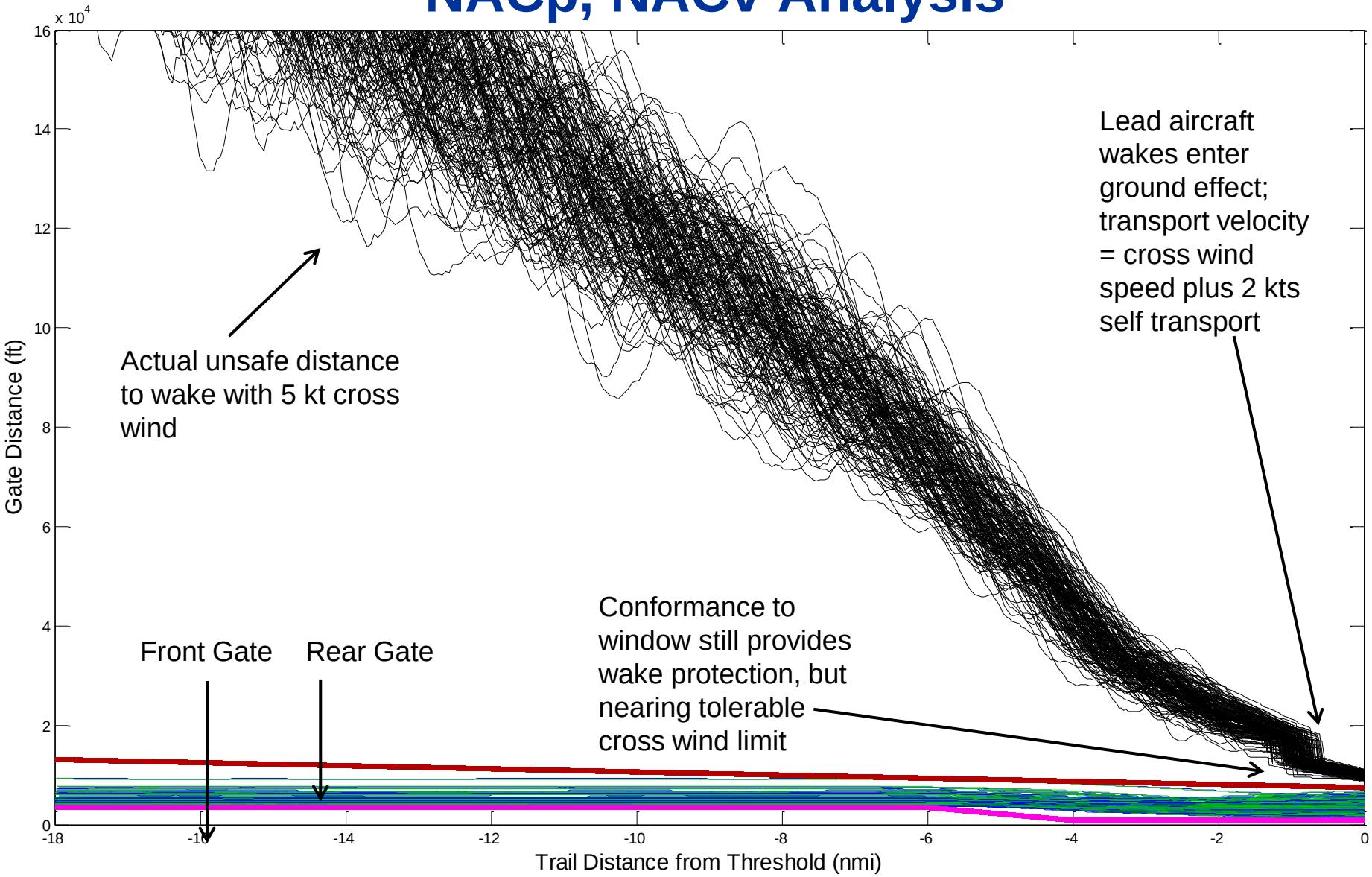
NACp, NACv Analysis



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ADS-B Guidance Display early in approach

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ADS-B Guidance Display
Late in approach

- **Leader lines gone**
- **Picnic table gone, since no speed guidance**
- **Forward gate = 1250’ (vertical line has disappeared)**
- **Aft gate = 7000’ (vertical line stretches to 8000’ point)**

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Traffic Display in Electronic Flight Bag

Traffic &

Traffic Data

Gates

Commanded Speed

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ADS-B Requirements for Phase I

- **Current ADS-B rule can support Phase I version of Paired approaches**
  - **Requires compensation for poor integrity by layering of multiple independent systems**
- **Paired Approach Phase I Interval Management requirements consistent with known performance reqts for Flight Deck based Interval Management, except :**
  - **Velocity validation required (similar to that used for SURF)**

- **Note: These conclusions do not apply to Phase II version of paired approaches (SAPA)**

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TCAS Interaction: Preliminary Results

(IM performance not reflected)

- **TCAS II algorithm exercised in Paired Approach Monte Carlo simulation**

Sample Size = 10,000 pairs

Non-scape, SFO, 3 deg. offset, nominal	
RAs	
total RAs	0
p(RA) <	1.00E-04
TAs	
Total TAs	1502
p(TA) =	0.1502

Non-escape, SFO, 3 deg. offset, blunders anywhere	
RAs	
total RAs	31
p(RA|blunder) =	0.0031
TAs	
Total TAs	1105
p(TA|blunder)	0.1105

No RA's in normal operation

Yes TA's

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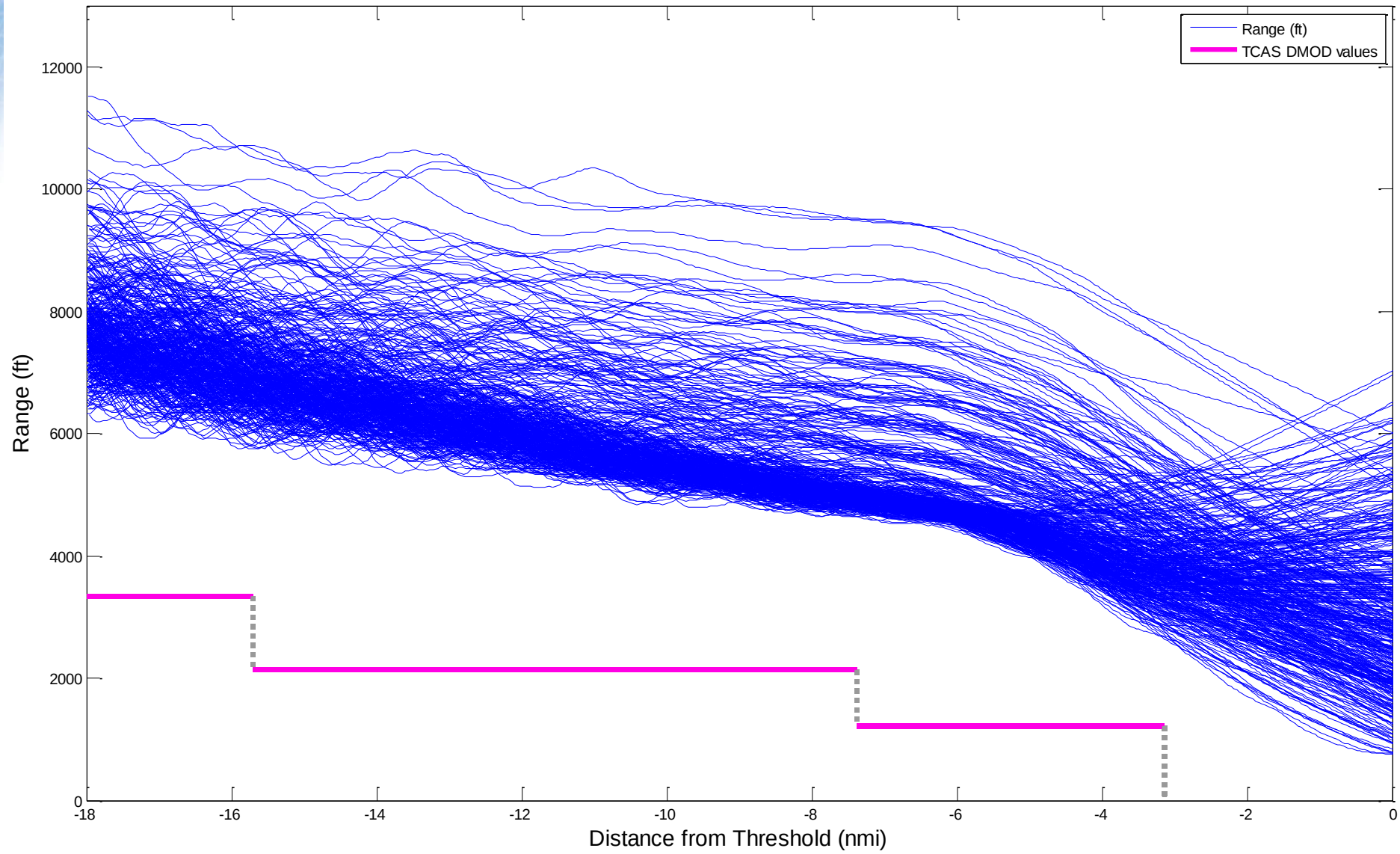
Analysis of TCAS Behavior

Preliminary Results: IM performance not reflected



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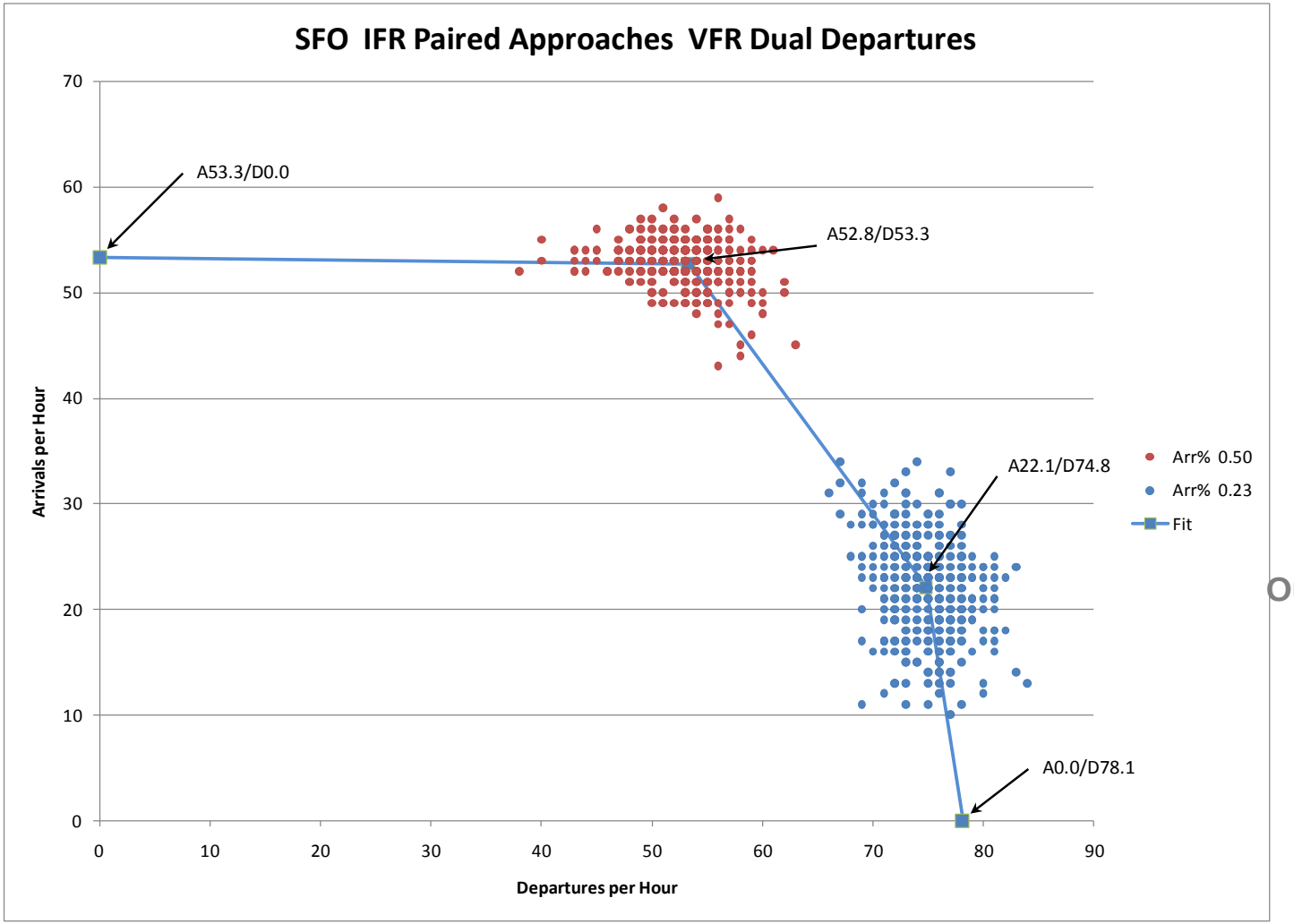
Paired Approach Capacity
Example of SFO



Outline

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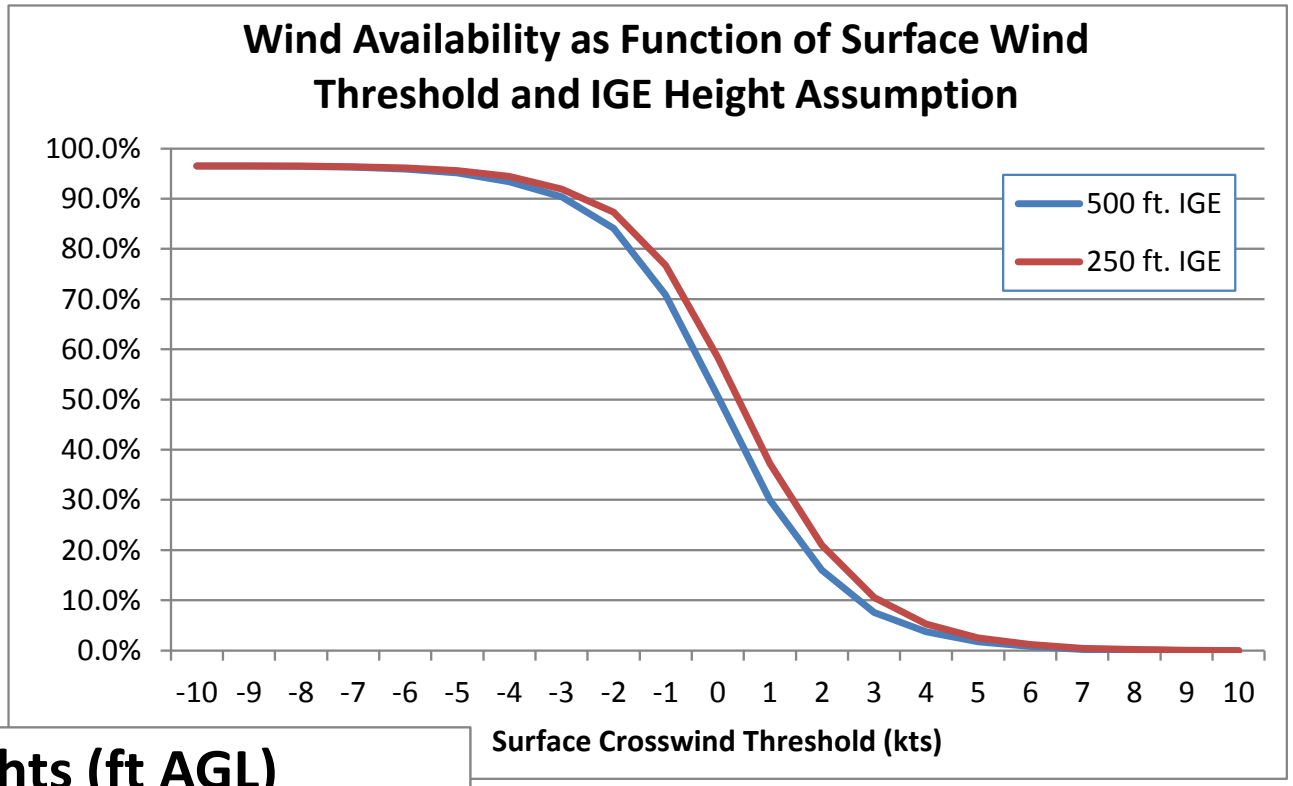
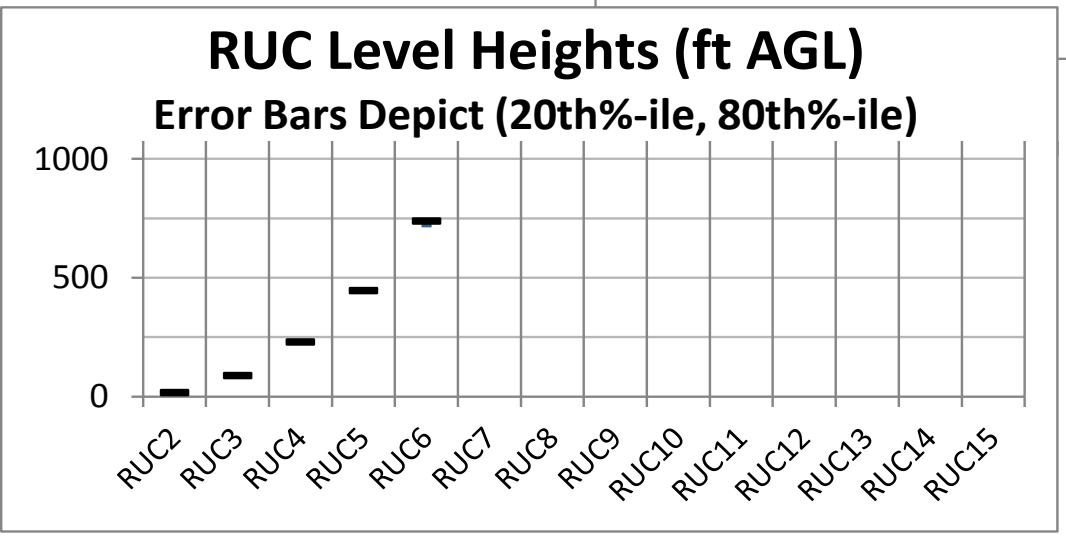
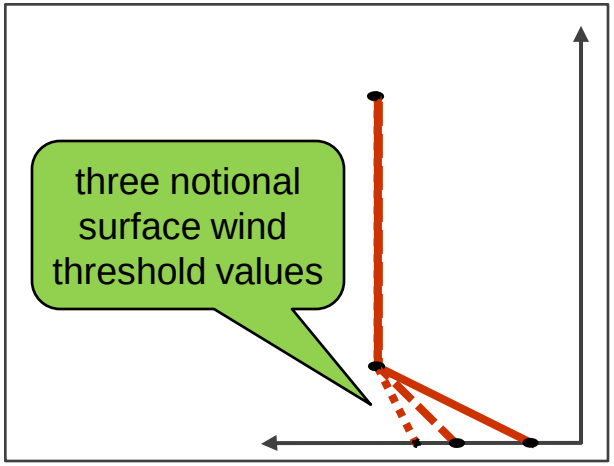
Wind Availability: Example of SFO

- Surface threshold value affects availability
- Aloft Threshold constant at -10kts
- Near 90% availability for surface adverse wind threshold of 3 knots or more







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Outlook

- **NGIP target: AC/TSO guidance in 2017**
- **ADS-B in Aviation Rulemaking Committee recommendation: capability in 2017**

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