



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

Feasibility and Availability of Pairing Departures from Closely Spaced Parallel Runways For Wake Avoidance

Clark Lunsford

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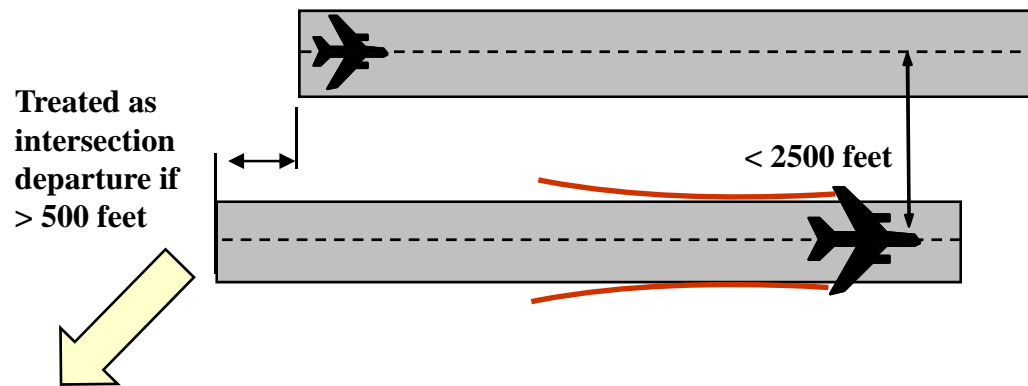
Outline

- **Review of departure wake rules, WTMD implementation, and Paired Departure Concept**
- **Paired Departure window definition**
- **Sample window calculation and availability estimate**
- **Operational concept details**
- **Illustration of Paired Departures from two perspectives**
- **Conclusions and Next Steps**

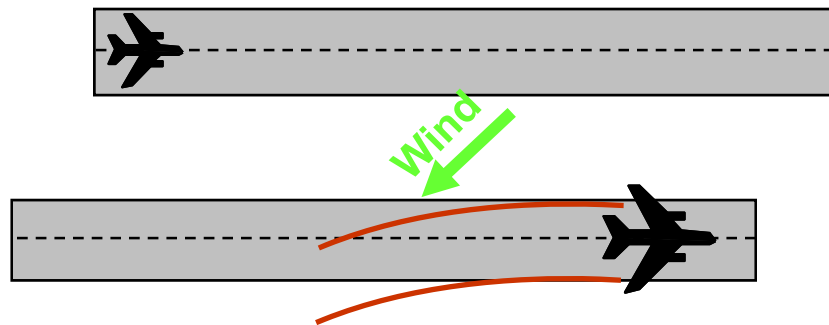


Evolution of Concepts for Departures From Closely Spaced Parallel Runways

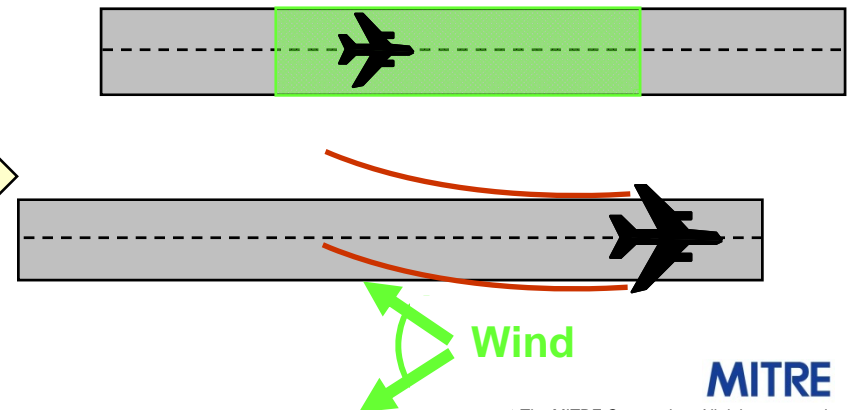
Current Rules: Aircraft departing after Heavy or B757 must wait 2-3 minutes for wake (always, no visual separation for departure wake)



WTMD: Wake delay avoided due to wind moving wake away from parallel runway (available 10-30% of time depending on airport and season)



Paired Departure: Wake delay avoided with a short interval (window) between departures. Accommodates additional wind conditions.





Premise for Paired Departures

- As a lead aircraft departs, it takes a certain amount of time for the wake to drift toward the parallel runway, depending on:
 - Crosswind strength (surface and up to 1000 ft above ground level)
 - Wake strength and self-transport
 - Spacing between runways
 - Spacing between departure paths (FTE, divergence)
- The trailing aircraft departure path must be protected both during its takeoff and until the departure paths diverge





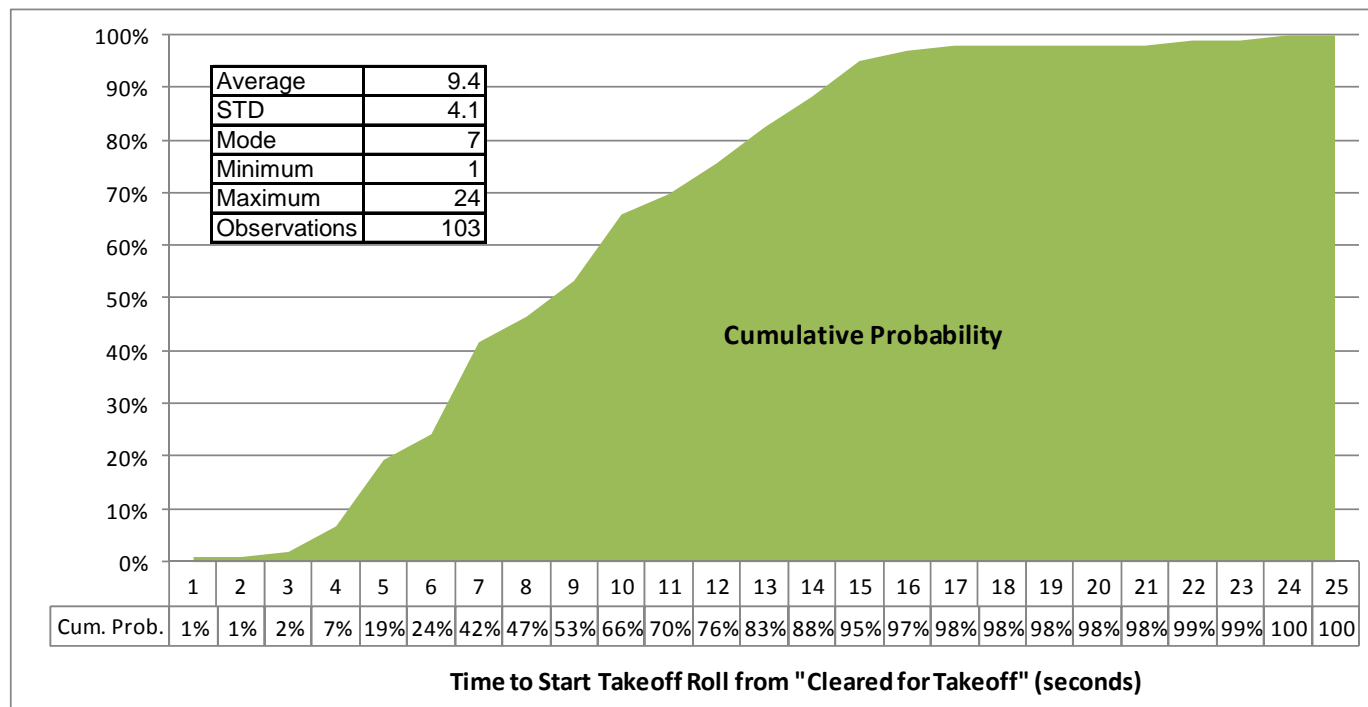
Paired Departure Window Definition

- Paired Departure window referenced to start of roll of lead heavy aircraft
- Key parameters
 - Time delay in trailer starting takeoff roll once clearance is received
 - Performance differences between aircraft for takeoff roll and initial climb
- Select two reference points for evaluation
 - 1.3 nm from start of roll (In Ground Effect)
 - 3 nm from start of roll (Out of Ground Effect)
 - Protected from the time the quickest heavy aircraft generates a wake until the slowest trailer reaches that point (on parallel departure path)



Time Delay in Starting Takeoff Roll

- No published data found, so collected data at PHL and SEA
- Average delay from “Cleared for Takeoff” to start of takeoff roll was about 9 seconds
- 98% of observations had delay less than 18 seconds





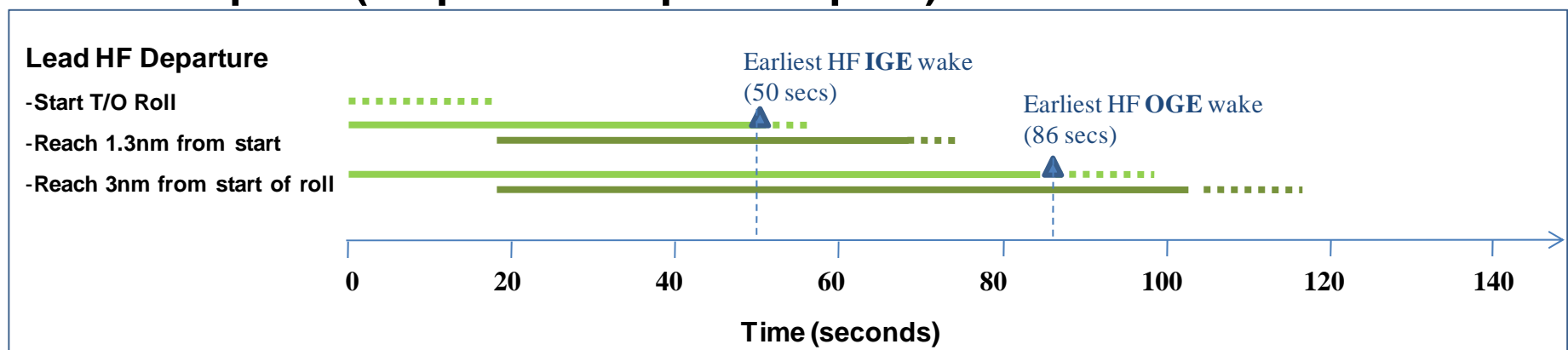
Define 30 Second Time Window

- **Establish constant value for all airports to provide a uniform procedure to ATC and flight crews**
- **Maximum allowable winds, and resulting availability, dependent on parallel runway geometry**
- **Time window includes**
 - **6 seconds for controller to issue clearance**
 - **18 seconds for trailing aircraft to start its takeoff roll**
 - **6 second additional uncertainty buffer**



How Much Time Allowed for Wake Transport?

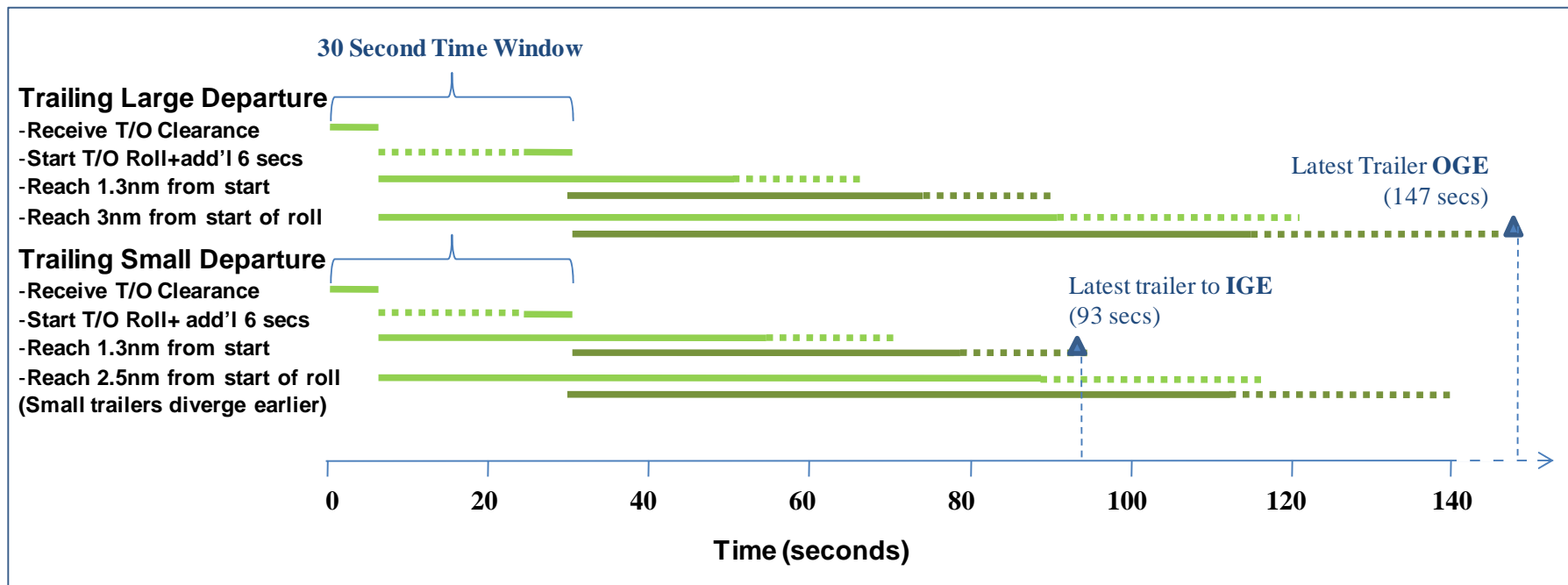
- EUROCONTROL Base of Aircraft Data (BADA) used to estimate range of performance for 82 aircraft types
- Select two reference points for evaluation
 - 1.3 nm from start of roll (In Ground Effect)
 - 3 nm from start of roll (Out of Ground Effect)
 - Protected from the time the quickest heavy aircraft generates a wake until the slowest trailer reaches that point (on parallel departure path)





How Much Time Allowed for Wake Transport? (concluded)

- Assume Trailer starts roll at end of allowable window (must take full wake delay if not rolling by then)
- Wake transport time allowed IGE is $93 - 50 = 43$ seconds
- Allowed for OGE is $147 - 86 = 61$ seconds

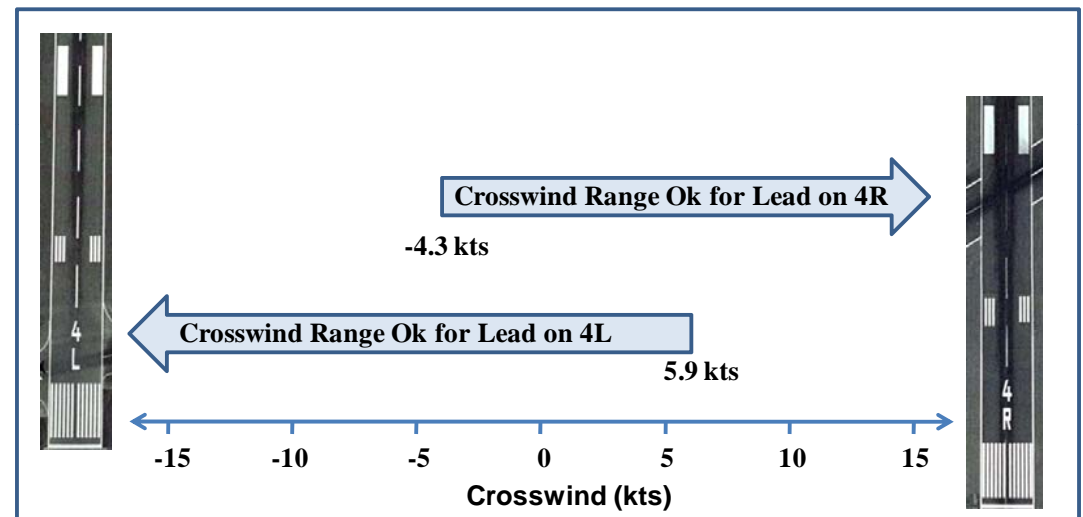




What Crosswinds Can Be Allowed?

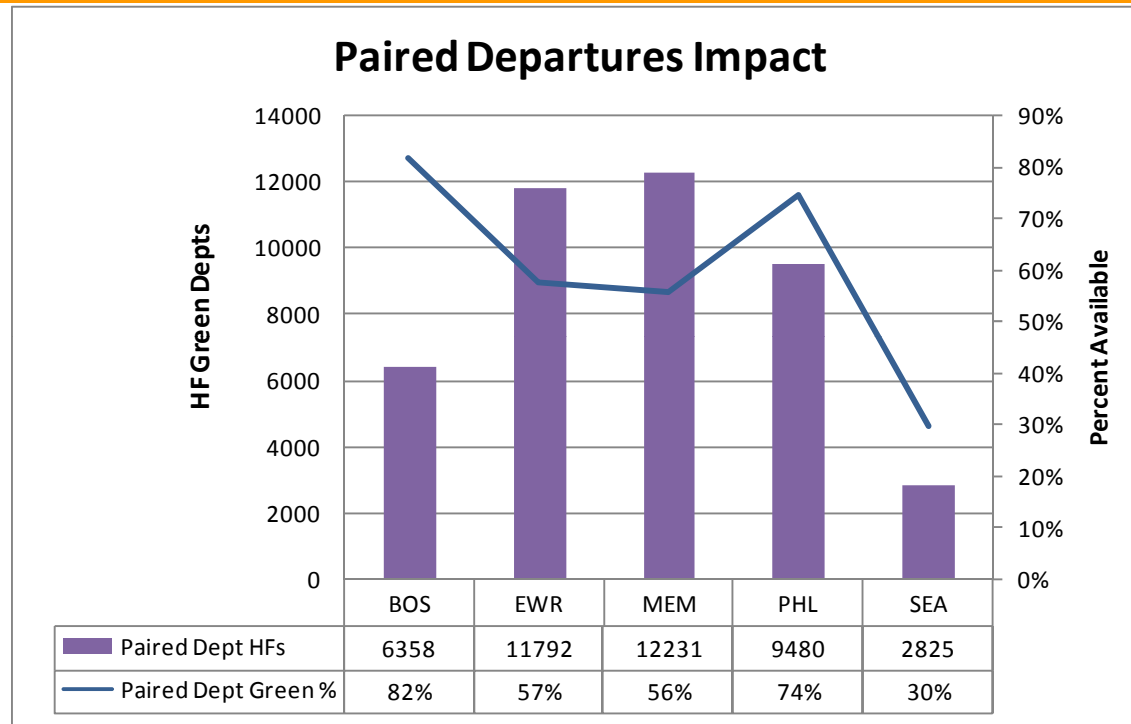
- Sample computation for BOS
- Deduction for Wind Forecast Algorithm performance

Airport	BOS	BOS	BOS	BOS
Runway (leader)	4R	4L	22R	22L
Threshold offset (+=forward relative to parallel runway)	990	-990	384	-384
Runway Spacing	1500	1500	1500	1500
Minimum Crosswind Transport Time IGE	43	43	43	43
Minimum Crosswind Transport Time OGE	61	61	61	61
Time Adjustment for Threshold Offset (forward adds to minimum crosswind transport time)	3.6	-3.6	1.4	-1.4
Safety buffer time	6	6	6	6
IGE Allowable Adverse Crosswind (kts)	9.3	11.6	9.9	10.8
Forecast Algorithm deduction (kts)	5.0	5.0	5.0	5.0
IGE Available	58%	88%	81%	64%
OGE Allowable Adverse Crosswind (kts)	9.8	10.9	10.1	10.6
Forecast Algorithm deduction (kts)	5.0	5.0	5.0	5.0
OGE Available	61%	82%	82%	68%





Paired Departures Potential Benefits



- **Computed allowable adverse crosswind considering runway spacing, aircraft position uncertainty, wingspan, wake self-transport IGE, and 30 second window**
- **Deduct 5kts to estimate impact of forecast algorithm**
- **Use one year of winds (surface to 1000ft), determine available times. Count Heavy and B757 depts (at least 1000/3, operational day, ASPM runway config shows using parallels)**



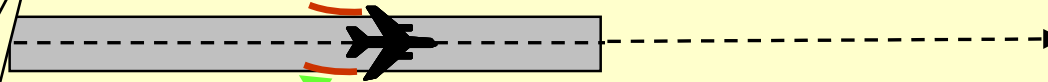
Paired Departure Concept Feasibility

Paired Departure: Wake delay of 2-3 minutes avoided with short time interval (window) between departures

Departure Time Window



Diverging Turn



Some Crosswind
Toward Parallel Allowed

United 123,
cleared for
takeoff runway
one left, no
delay, paired
departure
rolling

- **Trailing aircraft starts takeoff roll within 30 seconds of lead Heavy**
- **Controller provides Paired Departure takeoff clearance**
- **Time window can be judged by controller and pilot by**
 - **Timer or Clock (same as for wake delay)**
 - **Landmark, such as trailer must roll before leader crosses runway 28R**
 - **CDTI or tower automation**



Operational Feasibility Issues and Concept Details

- **Flight crew awareness of procedure**
 - Described in departure procedure reference material
 - Use announced on ATIS, mentioned with taxi instructions, included in takeoff clearance
 - Uniform timing for all airports
- **Takeoff clearance and timing**
 - Clearance similar to when arrivals and departures use the same runway to convey timely response needed
 - “American 123, cleared for takeoff, runway one two right, no delay, aircraft on two mile final”
 - “American 123, cleared for takeoff, runway one two right, no delay, paired departure rolling”
 - Ability to have aircraft takeoff in quick succession is similar to current departures at SFO off 1L/1R to depart in gap between arrivals to 28s



Operational Feasibility Issues and Concept Details (continued)

- **Discussions with ATC supervisors and pilots indicate simple timers (like those currently used to judge wake delay) may be sufficient**
 - **Felt automation aids could help situational awareness, especially in low visibility or darkness**
 - **Landmarks on airport used for same runway separation could be a visual cue to when 30 seconds has expired (e.g. 4500 ft point in Heavy takeoff roll)**
 - **During busy operations, ATC would likely cancel clearance and apply full wake delay if trailing departure failed to roll promptly. Likely would not wait for full 30 seconds.**
 - **ATC may need Local Assistant or second Local Controller during busy periods if they have other responsibilities (e.g. runway crossings, arrivals)**

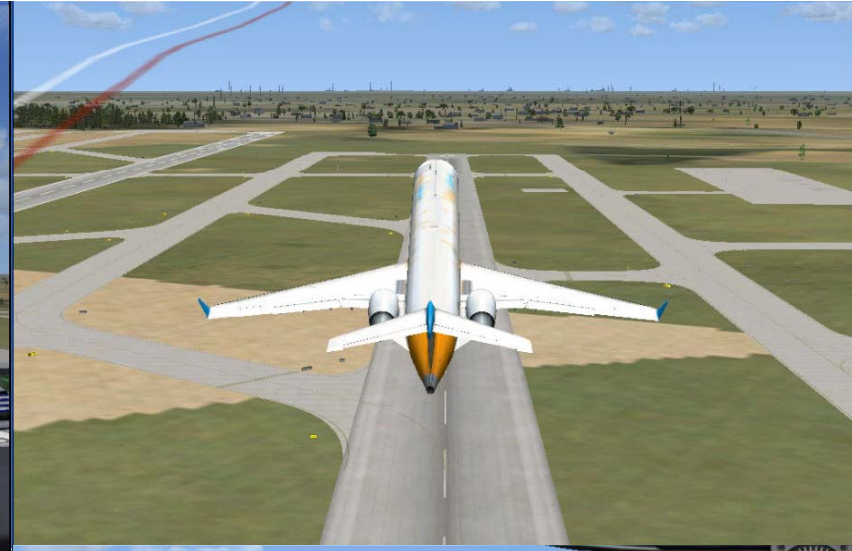
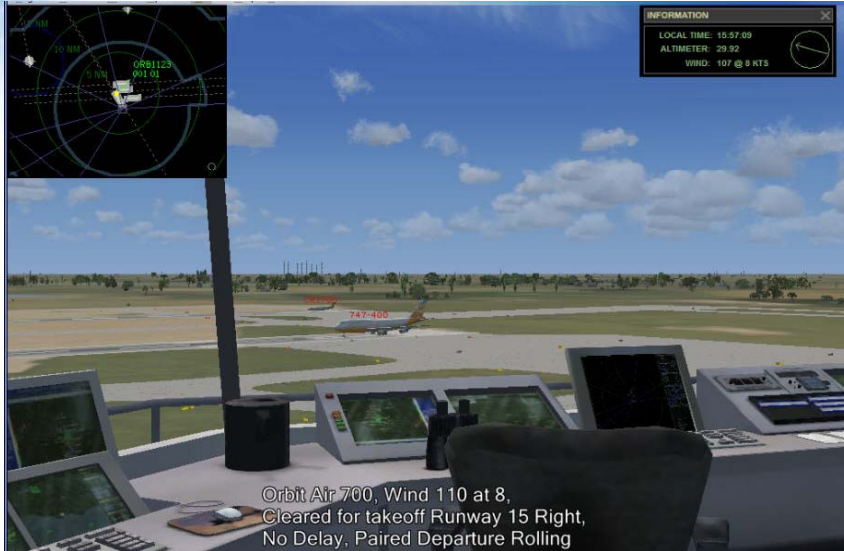


Operational Feasibility Issues and Concept Details (concluded)

- **Timing for start of takeoff roll will be more reliable from Taxi-In-Position-and Hold (TIPH)**
 - **Use may not need to be restricted to just TIPH**
 - **ATC can verify that flight crew can “take it on a roll” when issuing the takeoff clearance when aircraft are next in line on the taxiway**
- **Major issue is who has responsibility in the case of an aircraft starting its roll too late and taking off anyway**
 - **Once the clearance has been accepted, the flight crew could have responsibility for executing it within required parameters, similar to today for Standard Instrument Departures**
 - **ATC with monitoring role as a safeguard**
- **Paired Departure procedure will not be used for all aircraft departing after a Heavy**



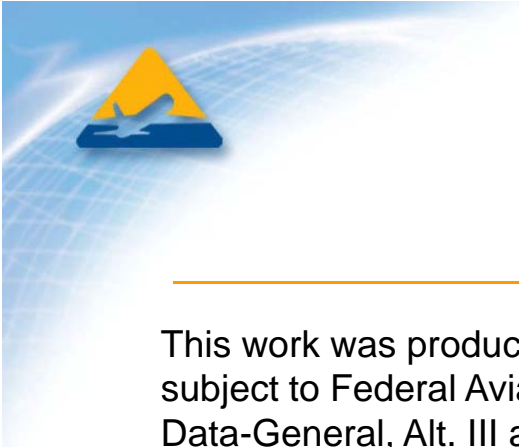
Paired Departure Illustration Movies





Conclusion

- **Goal this year was to continue last year's analysis and**
 - Develop a design for the paired departure window
 - Estimate the likely availability at multiple airports
 - Add additional detail to the operations concept
- **The 30 second window appears to result in significant availability and benefit at airports that were analyzed**
- **Automation requirements may be limited to**
 - WTMD wind forecast algorithm (with modified thresholds)
 - WTMD tower supervisor and local controller displays and alerting
 - CDTI based and tower automation based tools would provide additional situational awareness
- **Next steps**
 - Collection of more detailed aircraft takeoff performance data
 - Discussions with broader range of ATC supervisors and pilots
 - Potential Human-in-the-Loop simulations to assess feasibility further
 - Initial safety analysis



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