Winds Study to Support RTCA SC 206 Subgroup 7 Development of Wind Guidance Document for ATM

Principal Investigators – Michael McPartland & Tom Reynolds

Presented at 2016 Summer FPAW

Eldridge Frazier, FAA

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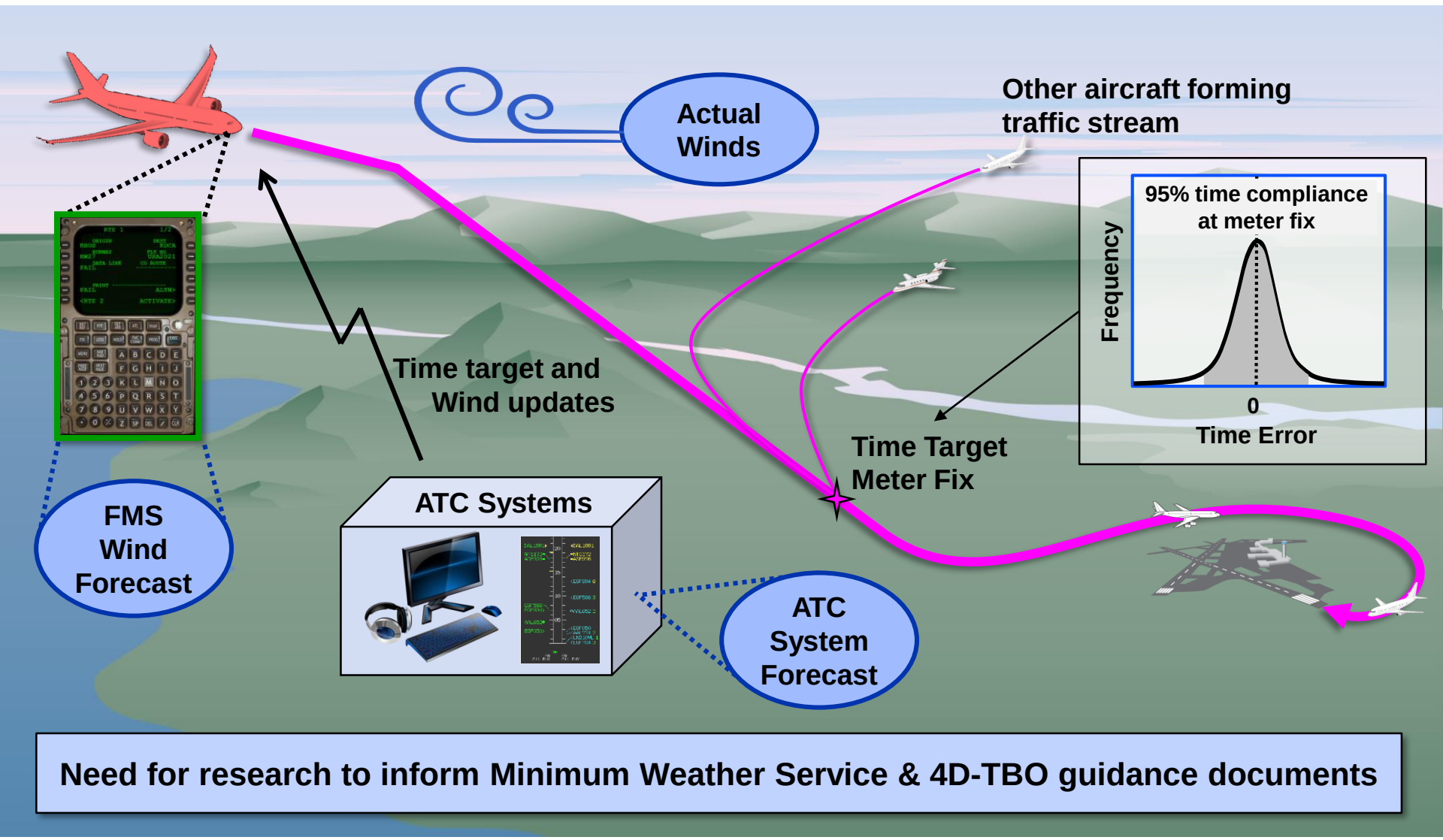
NextGen Programs of Interest

- **Wind and temperature forecasts can have a significant affect on aircraft trajectory estimation**
  - **Ground systems**
  - **Airborne systems ← (WTIC)**

- **RTCA SC-206 "Aeronautical Information and Meteorological Data Link Services"**
  - **Required Time of Arrival (RTA)**
  - **Wake Vortex Mitigation**
  - **Interval Management (IM)**

RTCA
THE GOLD STANDARD FOR AVIATION SINCE 1935

Required Time of Arrival Overview



Need for research to inform Minimum Weather Service & 4D-TBO guidance documents

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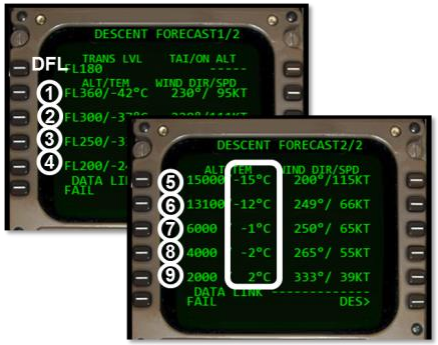
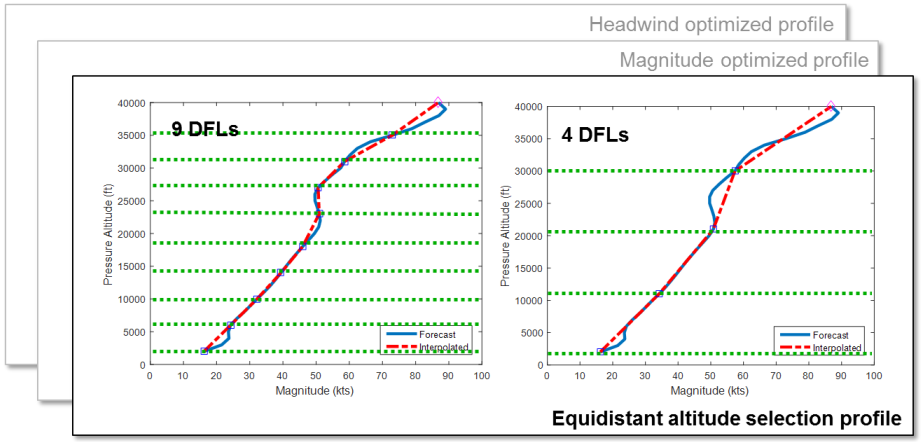
RTCA RTA Performance Research Questions

Determine affect of:

- **Forecast source**
  - GFS
  - HRRR
  - Perfect forecast (truth)
- **Forecast age:**
  - Published at least 2 hours prior to in-air update
- **Number of FMS descent forecasts levels (DFLs)**
  - 4
  - 9



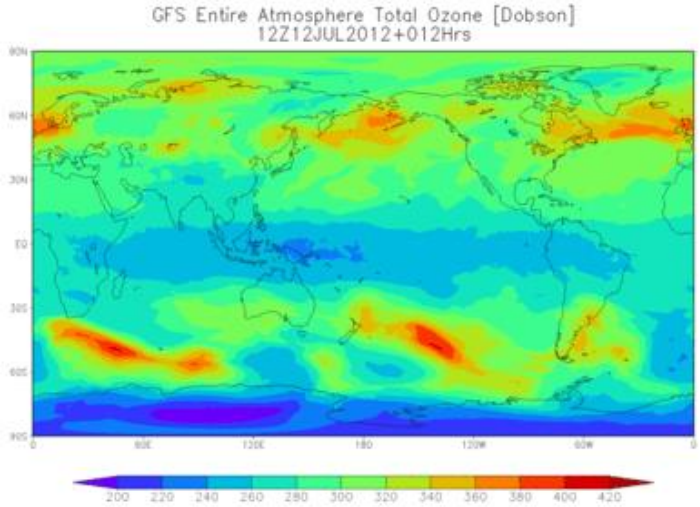
- **How descent forecasts are selected**
  - Optimized to match wind magnitude
  - Optimized to match trajectory headwind
  - Equidistant spacing (from cruise to surface)



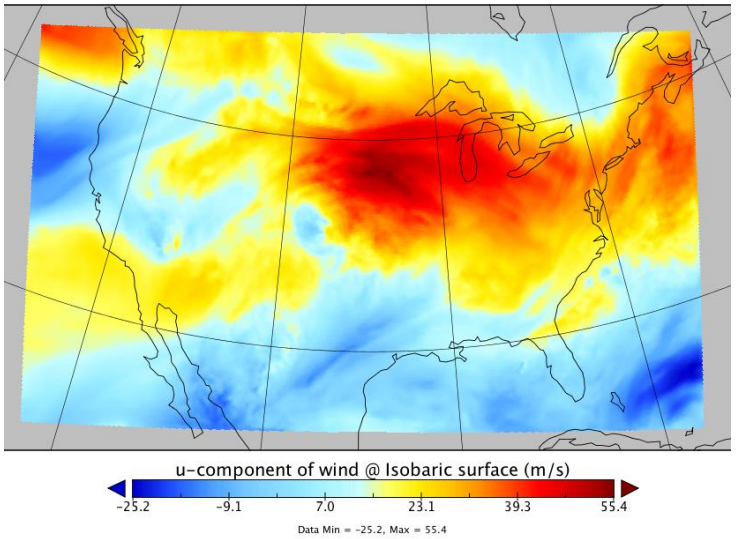
Introduction to GFS & HRRR

- **GFS (Global Forecast System)**
  - **28 km grid (0.5° averaged)**
  - **26 pressure levels**
  - **Published 4 times per day: 00Z, 06Z, 12Z, 18Z**
  - **Forecast: +03, +06, +12,…+192hrs**
  - **Global coverage**

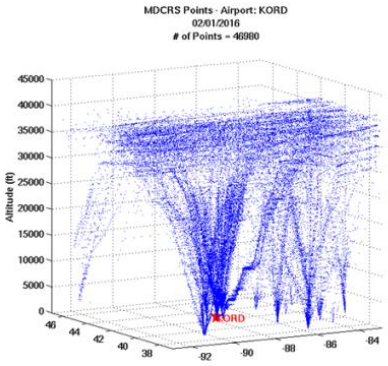
- **HRRR (High-Resolution Rapid Refresh)**
  - **3 km grid**
  - **50 pressure levels**
  - **Published every hour**
  - **Forecasts: +01, +02, +03,…+18hrs**
  - **CONUS**

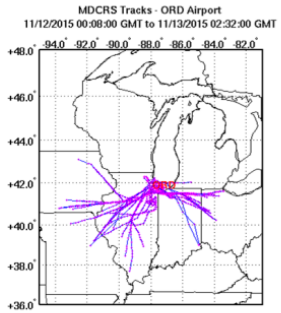


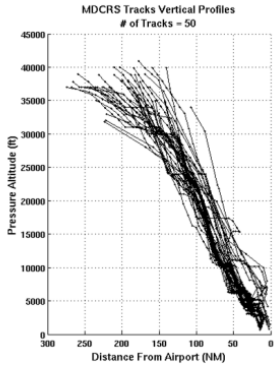
u-component of wind @ Isobaric surface



Analysis Methodology



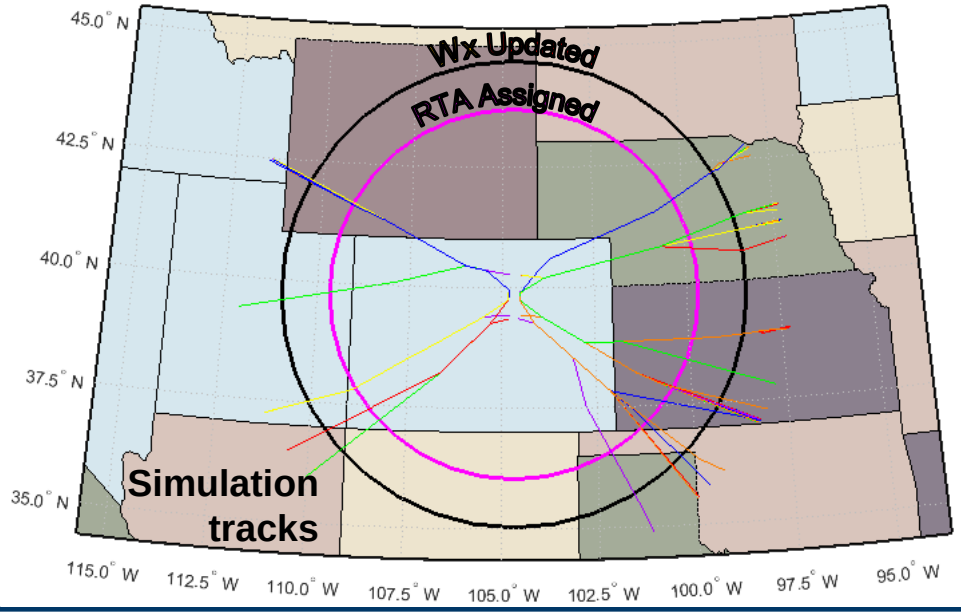




- Identify MDCRS flights that stayed on route
- Use aircraft-measured winds as simulated winds
- Reproduce flights with simulated B757 and advanced FMS

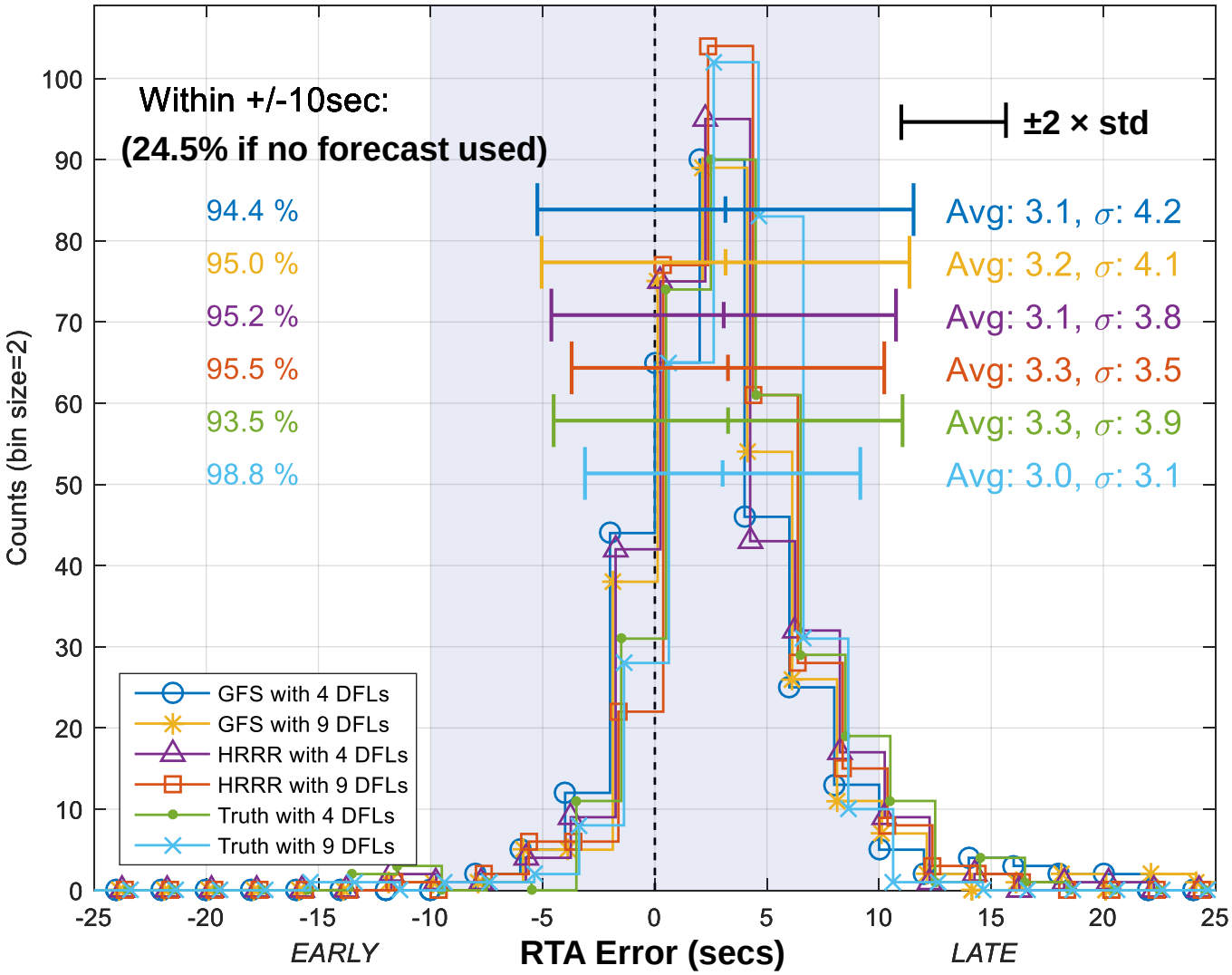
CONOPS

- Provided 2-hr old Wx updates 10 minutes prior to RTA freeze horizon
- Assign RTA time and fix 230 NM from destination
- Descents to ~ 10-15kft



Aggregated RTA Performance

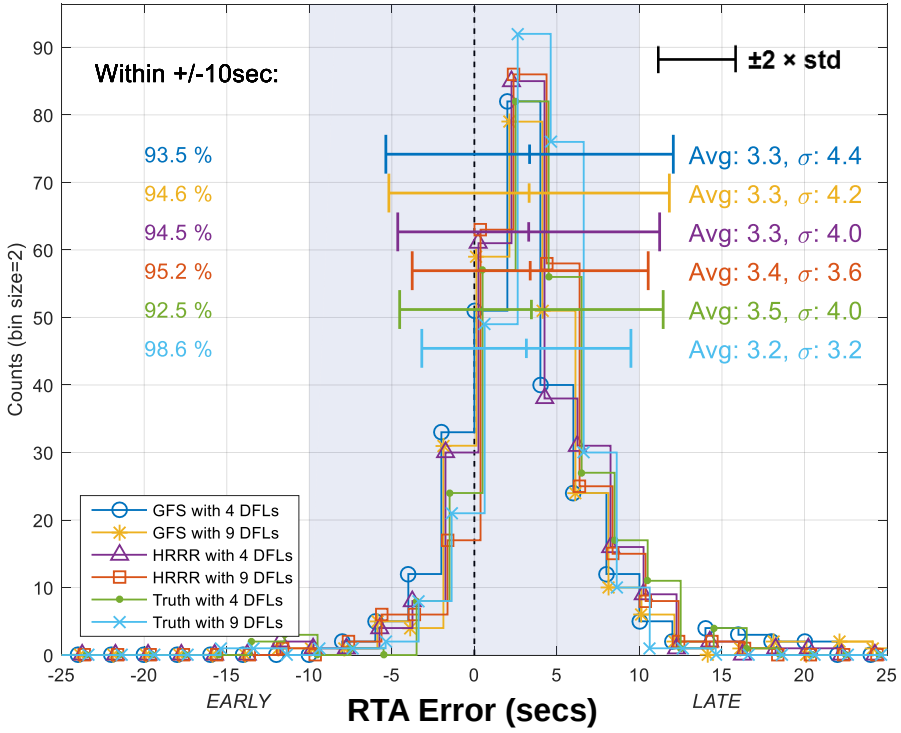
- **Airports evaluated**
  - **KATL, KBOS, KDEN, KEWR, KMDW, KORD, KPHX**
- **340 flights**
  - **Feb 1 – Mar 31, 2016**
- **GFS & HRRR based on 2 hr forecast**
- **Truth based on MDCRS**



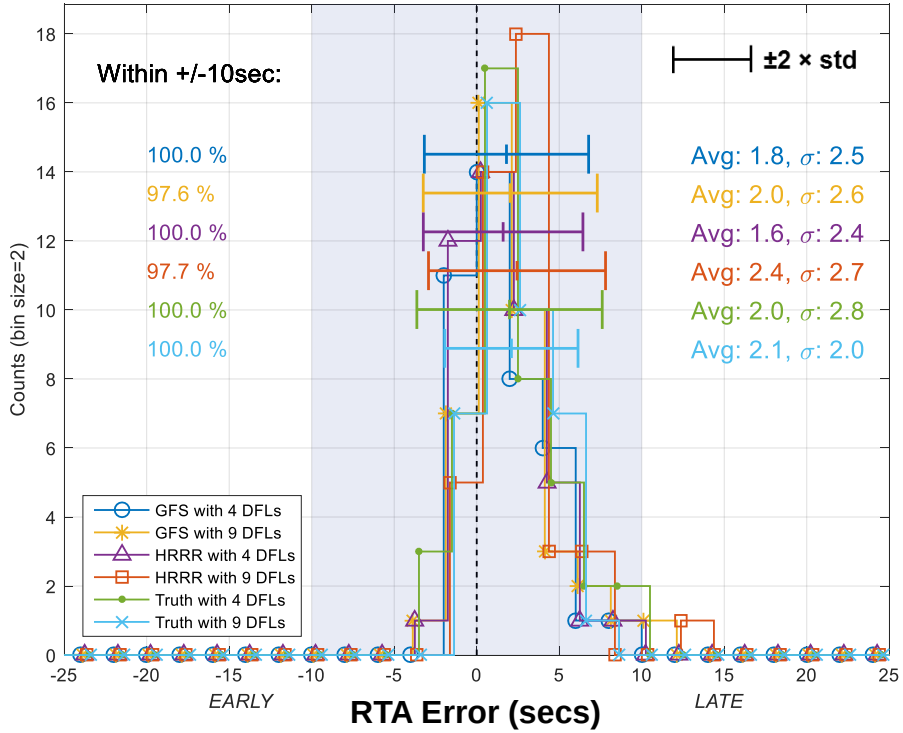
Effect of Speed Constraints

- **Speed constraints on STARs**
  - **Reduce speed control authority**
    - **Thus reduced RTA performance**
  - **FMS honors speed constraints even with RTA operations (SC-214)**

With speed constraints



Without speed constraints



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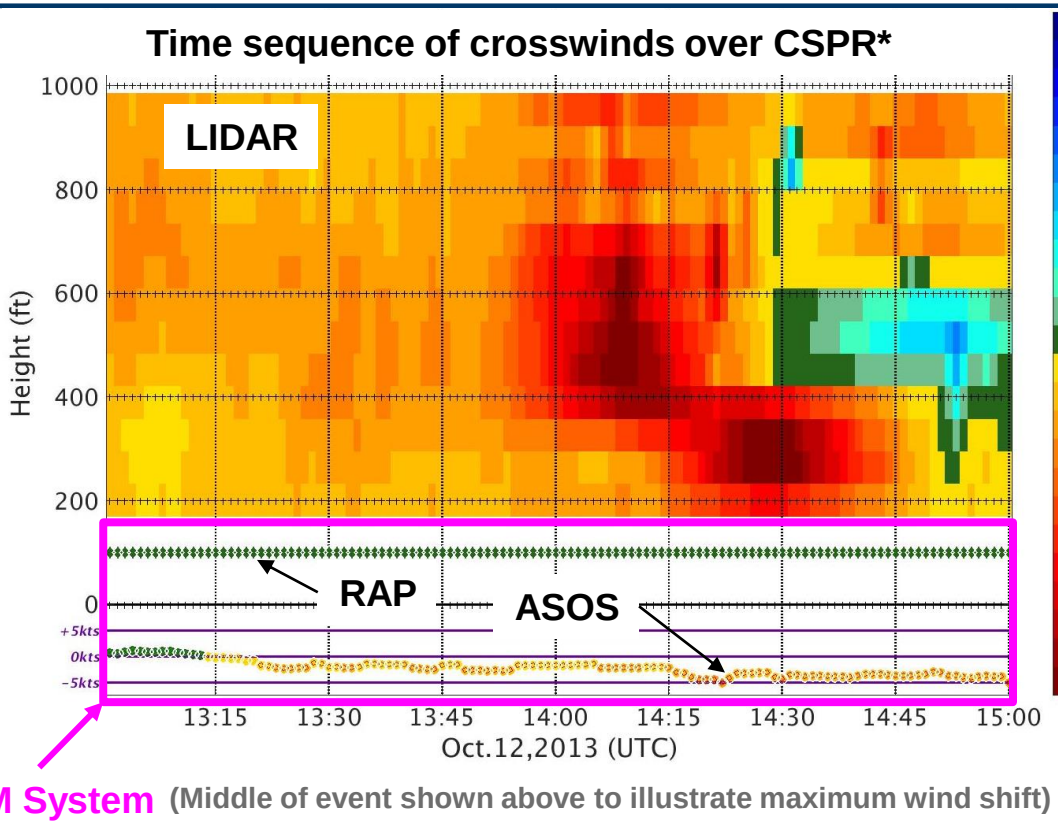
Wake Vortex Mitigation

- FAA looking to wind dependent strategies to increase throughput
- Use wind forecast system to predict “wake safe” regions
- Wake Terminal Mitigation System has access to
  - high fidelity wind observations near the ground (ASOS)
  - Numerical Weather Forecast Model predictions (for above ground)
- WTM System correctly handles forecast model error periods (see right) but at a cost of availability of increased throughput
  - Example wind shift removes availability ~45 minutes
  - System unavailable for hours

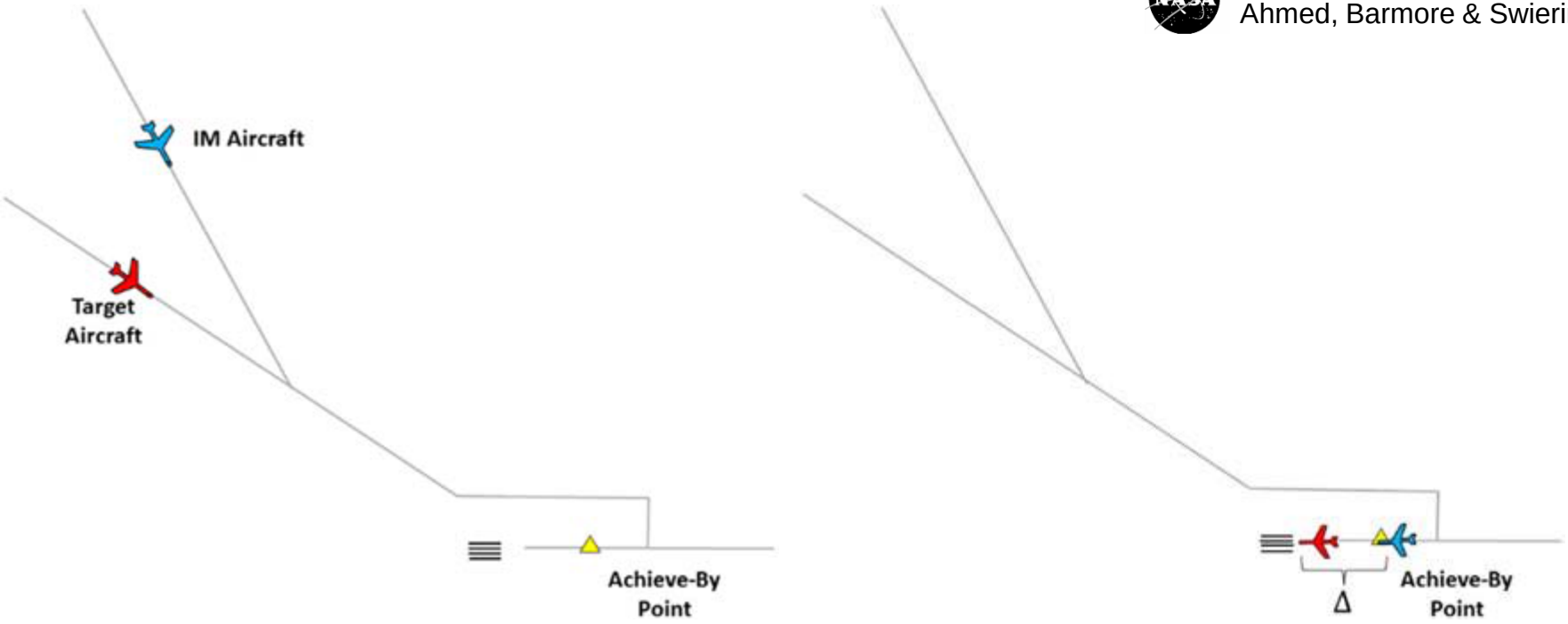


- <u>Aloft observations, such as real-time aircraft winds would address this problem</u>

*Closely Spaced Parallel Runway (CSPR)

Interval Management Concept

NASA/TM–2016-219203
Ahmed, Barmore & Swieringa



- **ATC provides IM clearance to the aircraft near top of descent (left).**
- **Pilots follow onboard speed guidance to achieve precise spacing interval at the achieve-by point , Δ behind the target aircraft (right).**
- **Δ may be a time or a distance**

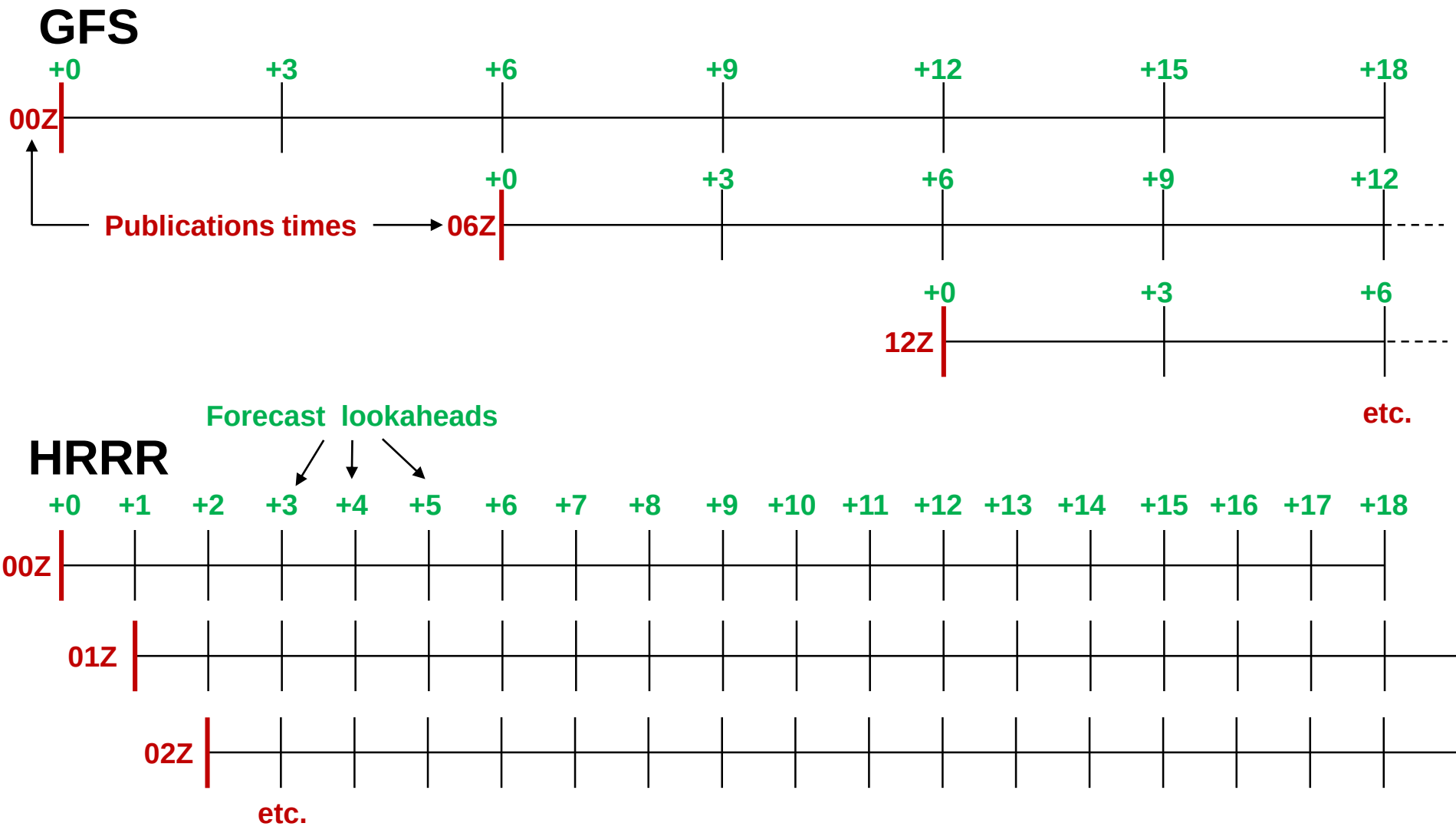
Conclusions

- Wind and temperature forecasts can have a significant affect on aircraft trajectory estimation
- Supporting various RTCA activities
- Key RTA analysis findings
  - 9 DFLs better than 4, but not significantly for cases examined
  - Performance of GFS nearly as good as HRRR
  - Performance with 2-hr HRRR forecast data nearly as good as “truth”
  - Procedural speed constraints have major impact on RTA performance
- Next Steps
  - NAS-wide comparison of flights with and without speed constraints
  - Conduct RTA flights down to Initial Approach Fix
  - Analyze impacts of using aircraft-derived winds
    - Modify Mode-S EHS interrogator
  - Generate methods to provide confidence of wind forecasts

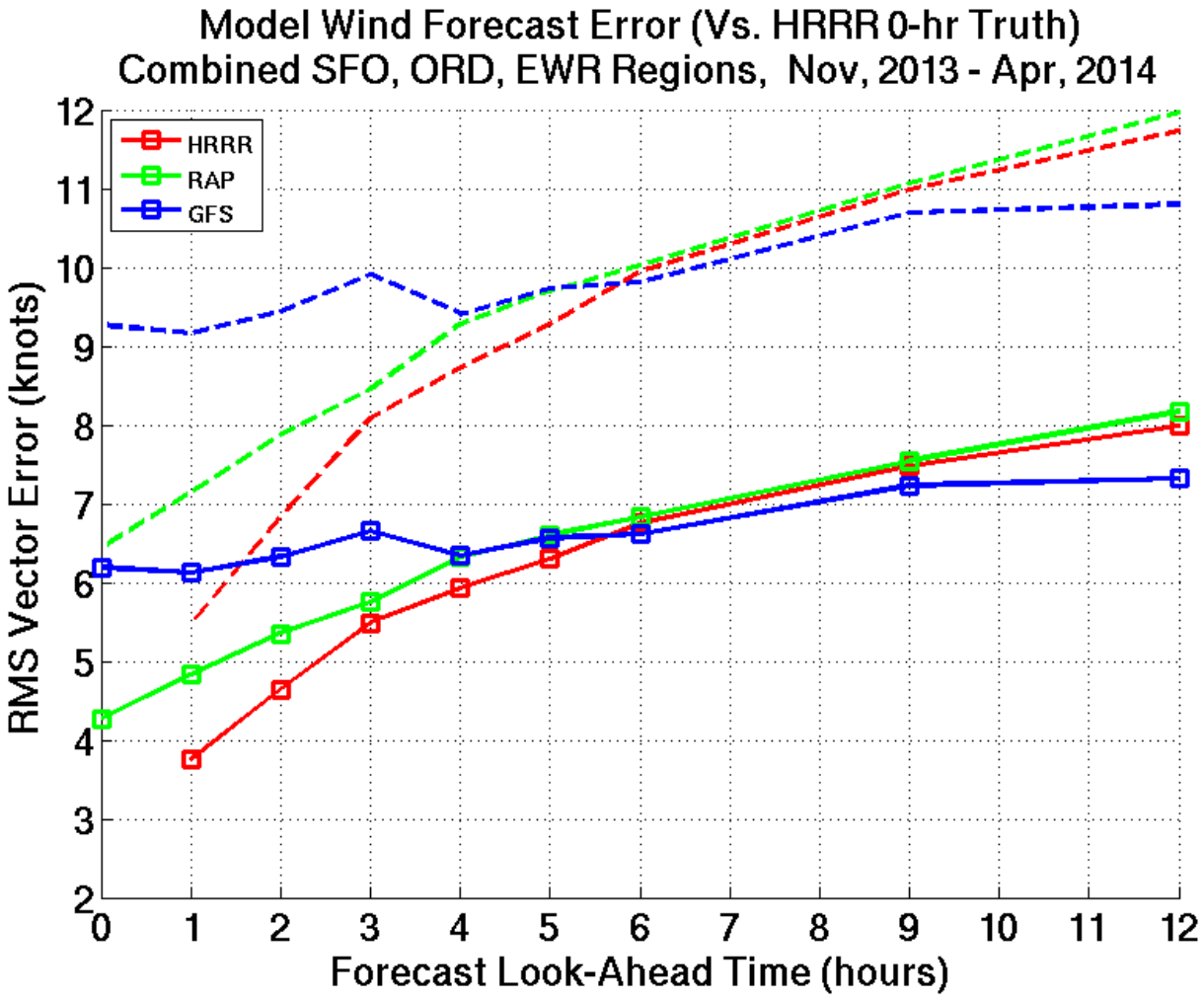
MIT/LL ASR-9 radar

Backups

GFS & HRRR Timelines



Wx Forecast Performance



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