Speed Profiles Analysis Supporting the FAA Wake Initiatives

FOQA and Threaded Track Data

MITRE – Lisa Spinoso and Clark Lunsford

Volpe National Transportation Systems Center (Volpe) – Steve Mackey, Melanie Soares and Hadi Wassaf

WakeNet-Europe 2014

May 13-14, 2014

EUROCONTROL Experimental Centre (EEC)

Brétigny-sur-Orge, France

Approved for Public Release; Distribution Unlimited. 14-1657

Volpe MITRE

The FAA Wake Turbulence Research Program obtained approval from the Aviation Safety Information Analysis and Sharing (ASIAS) Issue Analysis Team to perform this analysis using Flight Operational Quality Assurance (FOQA) data.

Acknowledgements

- **The authors would like to recognize the following for their continued support throughout this effort:**
  - Jeffrey Tittsworth – AJV-2A, FAA Wake Turbulence Research Program Manager
  - Steve Barnes – Former Manager AFS-440, Flight Standards Service - Flight Technologies and Procedures Division
  - Wayne Gallo – AFS-430, Flight Standards Service - Flight Technologies and Procedures Division

Speed Profile Objective

- **Provide improved information for actual approach and departure speeds observed in different aircraft types**
  - Book Speeds ➔ Observed Speeds
- **Better knowledge of operational speeds by aircraft type will enable more accurate determination of**
  - Wake generation strength
  - Wake encounter severity
  - Separation in time (Time-To-Fly)
- **For use of expanding number of FAA related wake initiatives. Applications for two specific initiatives highlighted**
  - Wake Recategorization (RECAT)
  - Wake Turbulence Mitigation for Arrivals Procedures (WTMA-P)

Recap on RECAT

Wake Recategorization (RECAT)

RECAT is a 3 phase international effort to incrementally safely optimize wake turbulence separation

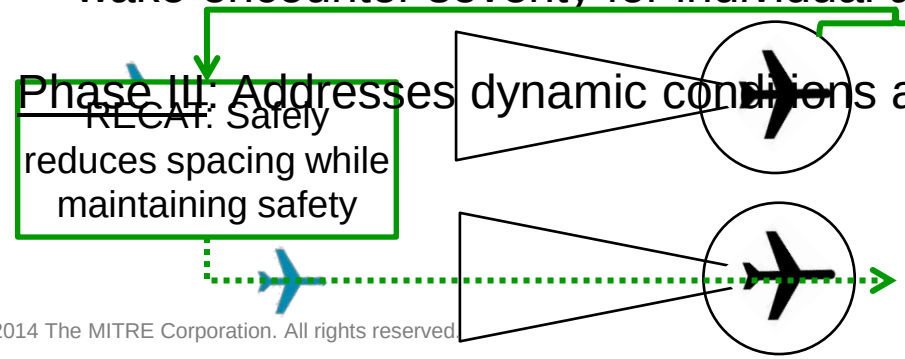
- Phase I: Establishes six new wake classes with the goal of increasing capacity while maintaining or improving safety, based on analysis of 61 of the most common aircraft types at major US and EU airports

Current US Wake Categories

Leading Aircraft \ Trailing Aircraft	A380	Heavy	B757	Large	Small
A380	MRS	6	7	7	8
Heavy	MRS	4	5	5	6
B757	MRS	4	4	4	5
Large	MRS	MRS	MRS	MRS	4
Small	MRS	MRS	MRS	MRS	MRS

- Phase II: Aims to determine pairwise leader/follower wake separation minima for individual aircraft types, based on analysis of 115 of the most common aircraft types at 95 airports globally
  - An aircraft speed profile has a strong influence on the wake strength and wake encounter severity for individual aircraft types
- Phase III: Addresses dynamic conditions as they apply to pairwise separation

Phase 2: Research in Progress



US: United States of America
EU: European
MEM: Memphis International Airport
SDF: Louisville International Airport
CVG: Cincinnati/Northern Kentucky International Airport

MITRE

Approach Speed Profiles

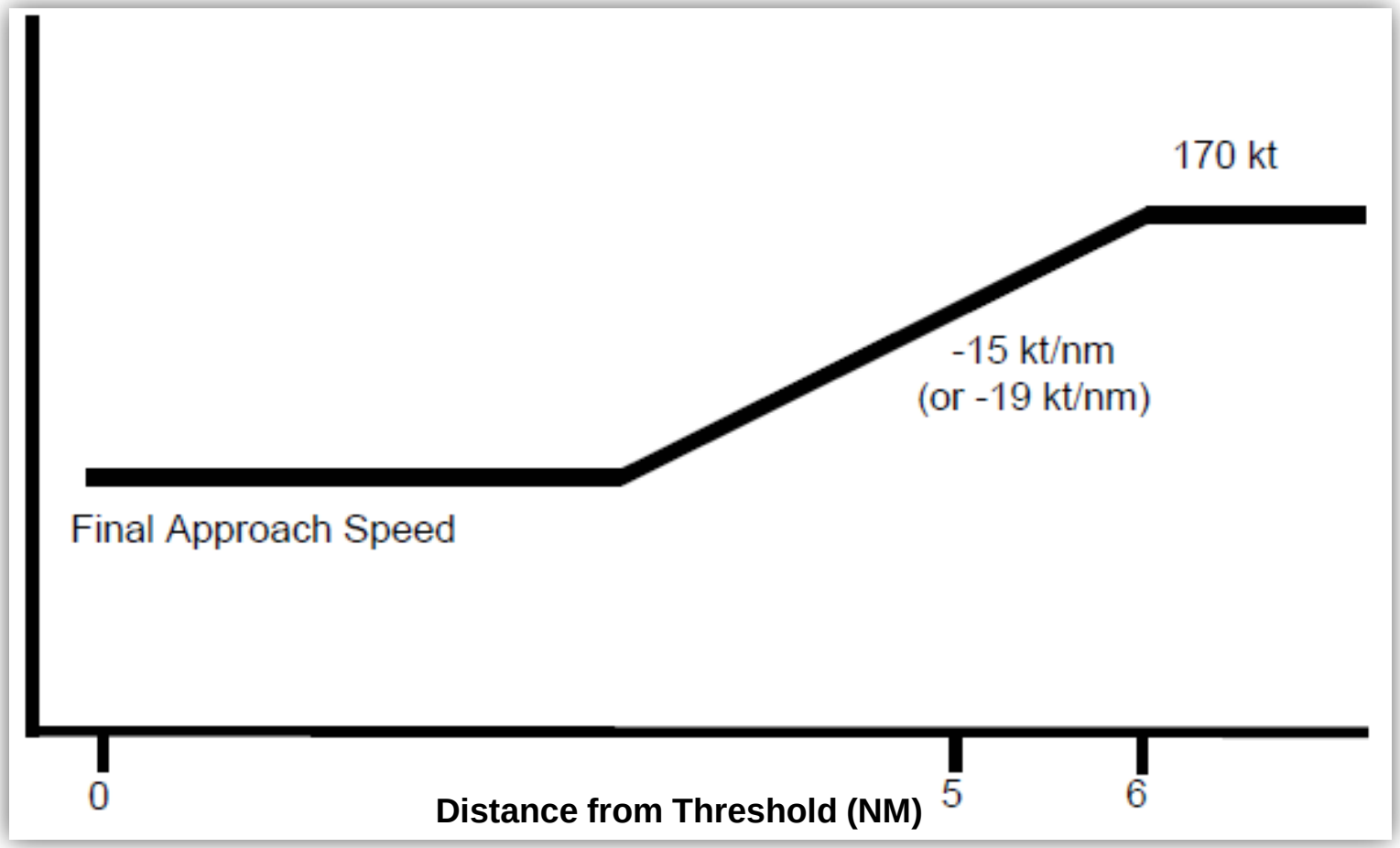
MITRE

RECAT Speed Profiles by Aircraft Type

RECAT Phase 1

Example: CRJ2

RECAT Phase I used publicly available approach speeds, adjustment for 85% max landing weight and a nominal deceleration profile.



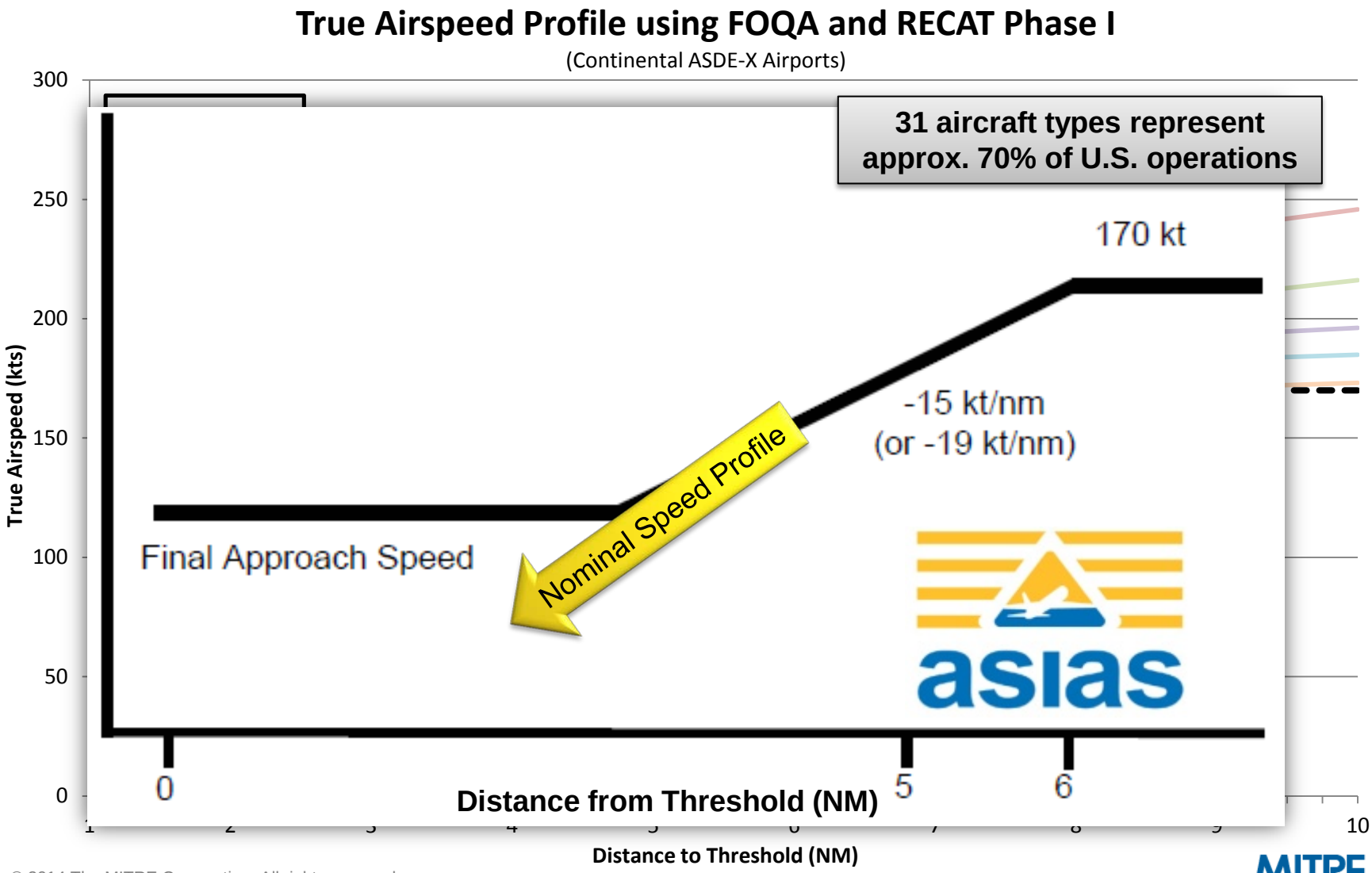
CRJ2: CANADAIR Regional Jet CRJ-200
NM: Nautical Mile

MITRE

RECAT Speed Profiles by Aircraft Type

RECAT Phase 1 ➢ FOQA Data

Example: CRJ2

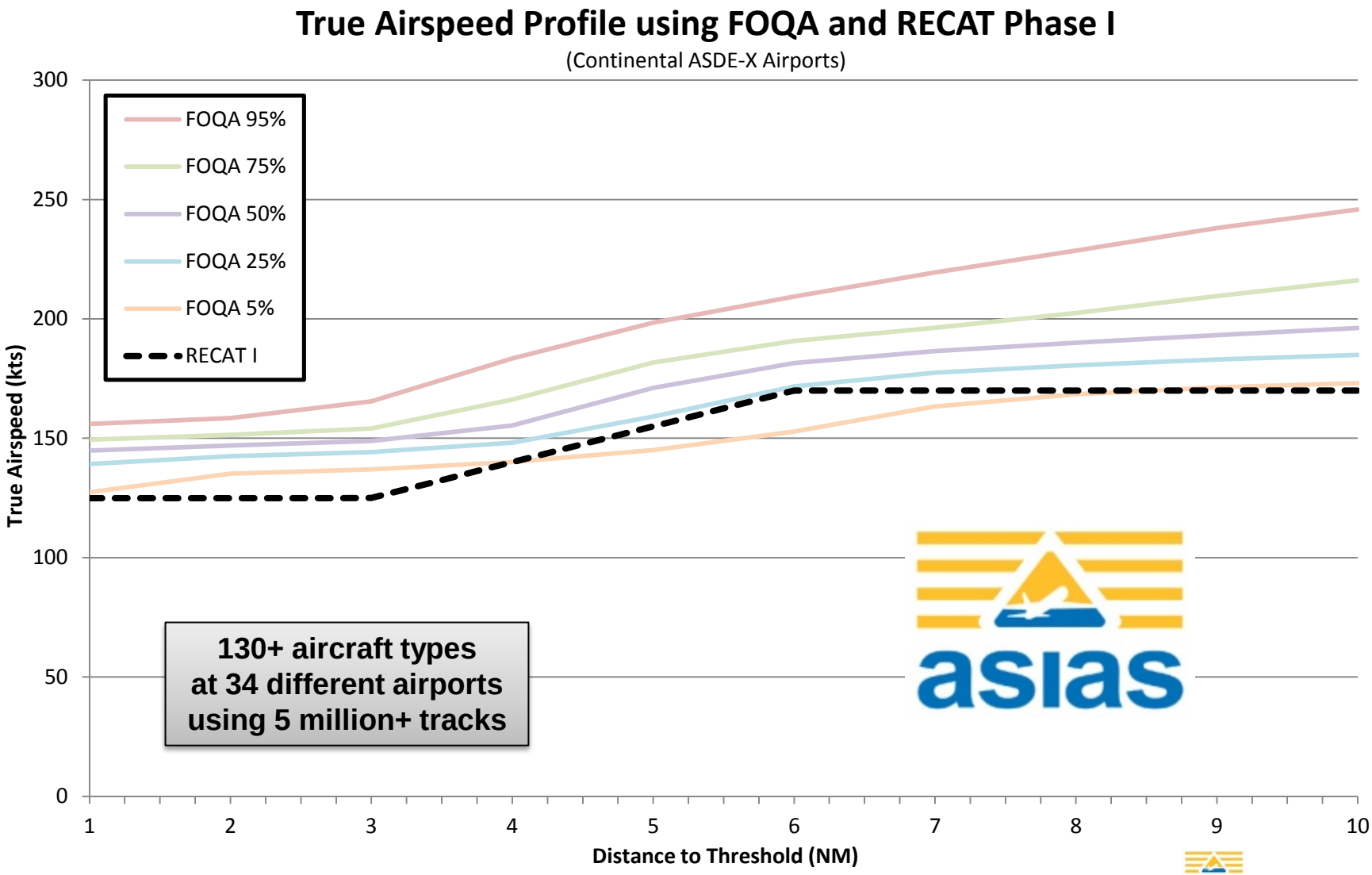


MITRE

RECAT Speed Profiles by Aircraft Type

RECAT Phase 1 ➢ FOQA Data ➢ Threaded Track Data

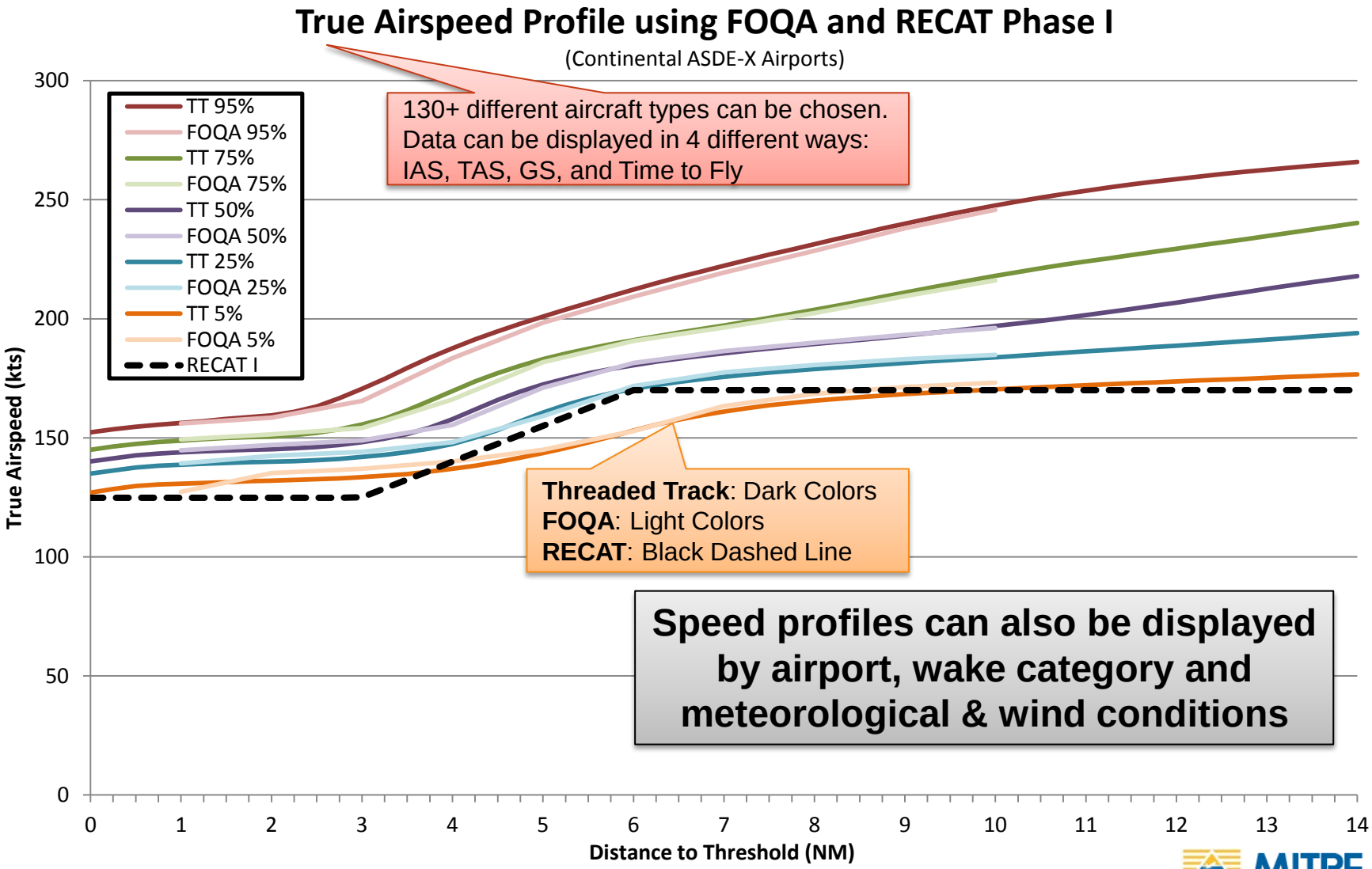
Example: CRJ2



RECAT Speed Profiles by Aircraft Type

RECAT Phase 1 ➢ FOQA Data ➢ Threaded Track Data

Example: CRJ2



Sample Results and Discoveries

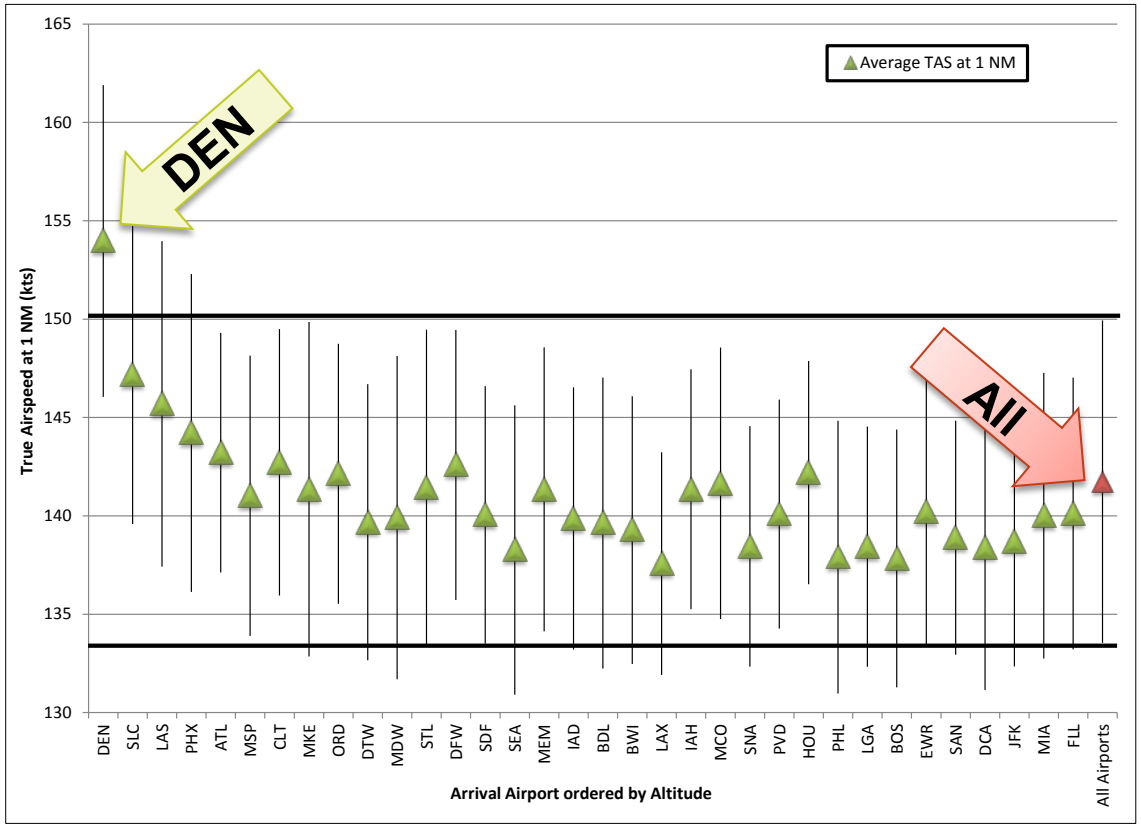
- Approach Speed Sensitivity Analysis
- Deceleration of Jets vs. Turboprops
- Time-to-Fly
- Application to WTMA-P
- Gross Landing Weight

MITRE

Approach Speed Sensitivity Analysis

- **There has been further investigation on the variance of final approach speed by**
  - Airport elevation
  - Runway length
  - Arrival Rate
  - Annual airport operations
  - Aircraft weight & length
  - Temperature
  - IMC/VMC
  - Wind, etc.

- **FAA is undergoing a sensitivity analysis on how airport altitude and special operations effect the variance in final approach speed.**



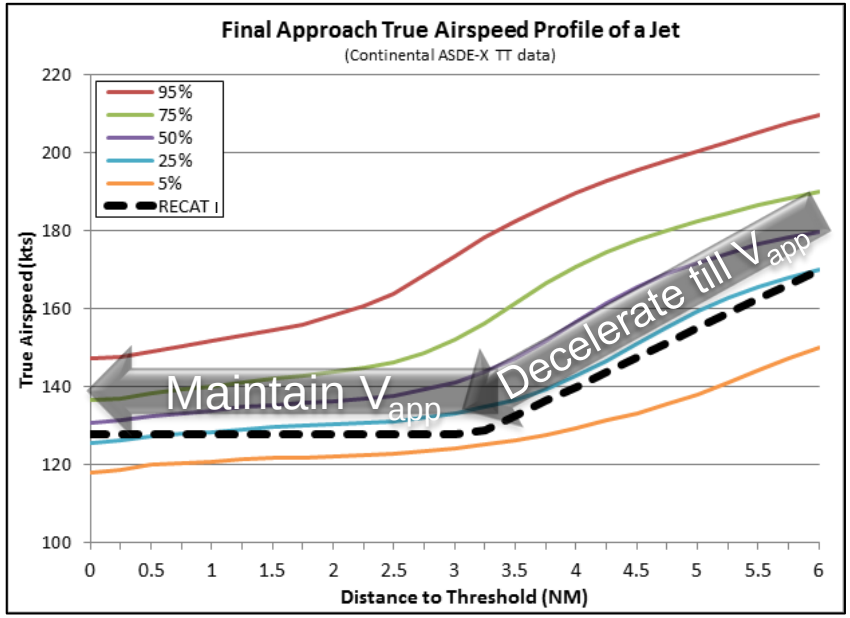
Average and Standard Deviation of Approach Speeds by Airport ordered by Altitude

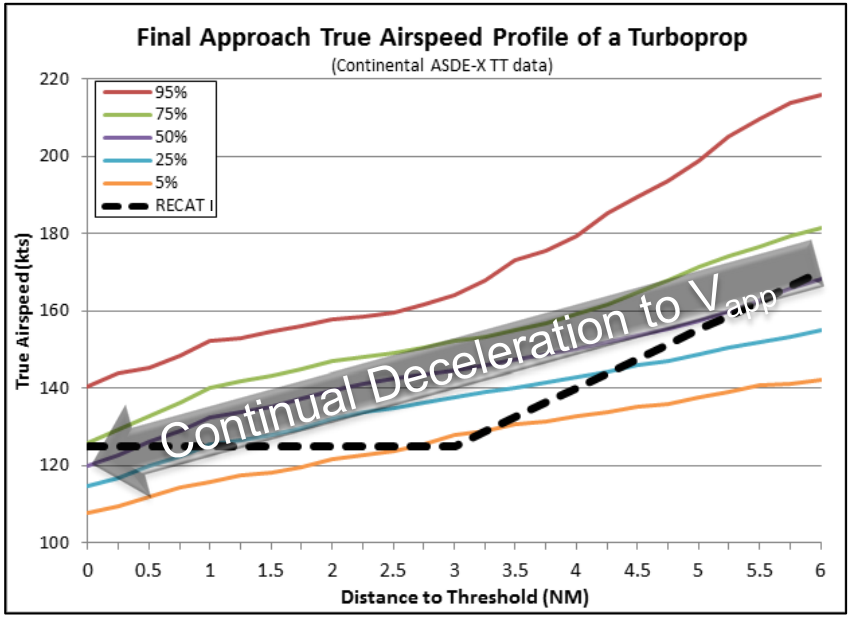
IMC: Instrument meteorological conditions
VMC: Visual meteorological conditions
DEN: Denver International Airport

MITRE

A Comparison of Deceleration Profiles for Jets and Turboprops

The turboprop waits as long as feasible to slow to their landing speed to fit into the pace of the arrival stream and to not cause problems for the trailing jets.





This difference in approach speed management impacts the time it takes the turboprop to fly specific wake separations and also influences its wake severity metric

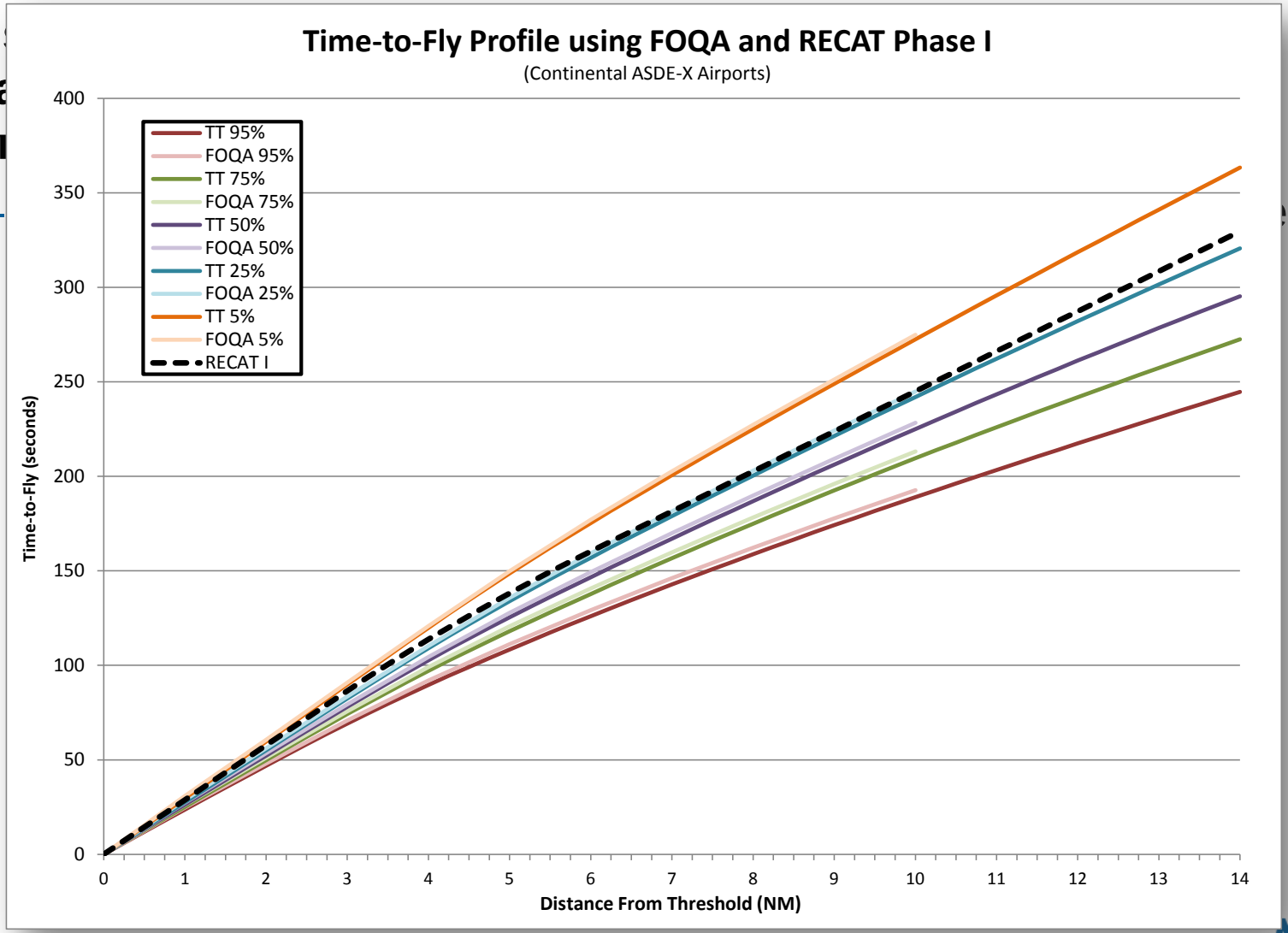
- All key factors in determining safe wake separations.

MITRE

Time-To-Fly

Example: CRJ2

- U
  va
  pr



MITRE

WTMA-P application of Threaded Track

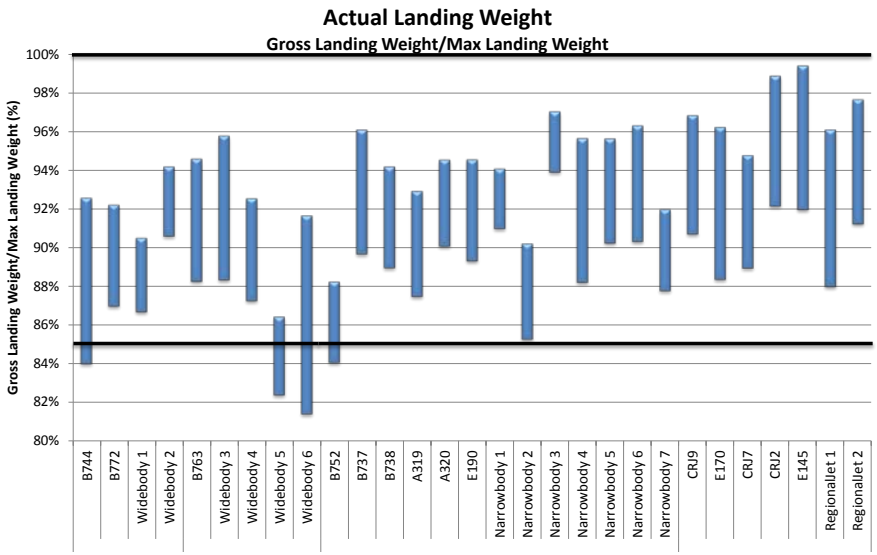
Wake Turbulence Mitigation for Arrivals Procedures (WTMA-P)

- **Concept permits reduced inter-aircraft radar separation during dependent parallel precision approaches**
  - Based on geometry of approach path and approved for specific aircraft types as leader and follower.
  - Extension of 7110.308 to include heavier aircraft than FAA *Large* and *Small* as leaders where possible.
- **Previous analysis used "book speeds" at threshold crossing and a nominal Out of Ground Effect ground speed for all aircraft**
- **For improved fidelity of the analysis, WTMA-P assessment incorporated Threaded Track speed profiles**
  - Observed approach speeds are typically higher than book speeds
- **Applied these profiles to both Near/In and Out of Ground Effect wake proximity frequency and severity analysis (out to 14 NM)**
  - Evaluated for both the single runway baseline and WTMA-P operations on closely spaced parallel runways
- **Also used observed speeds to determine nominal compression values between leader and follower aircraft**

Gross Landing Weight

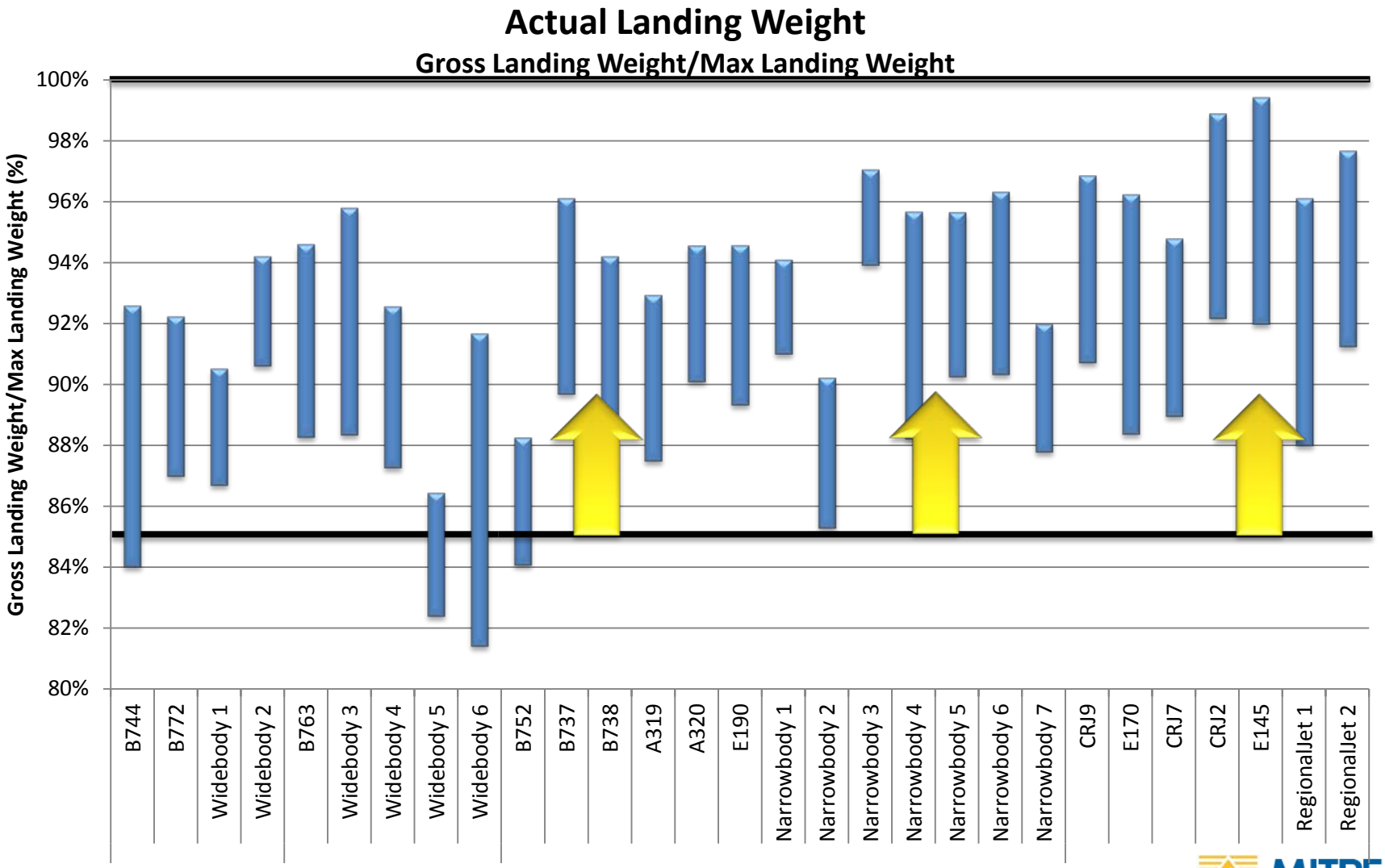
- **Aircraft weight is an important factor in determining the strength of the wake that is generated by an aircraft.**
  - Weight information is not generally available in recorded air traffic data
- **Analysis of average landing weights through ASIAS helped the RECAT Team to appropriately represent landing weight in Phase II separation calculations**

$$\frac{\textit{FOQA Gross Landing Weight}}{\textit{RECAT II Database Max Landing Weight}}$$



asias MITRE

Gross Landing Weight



asias MITRE

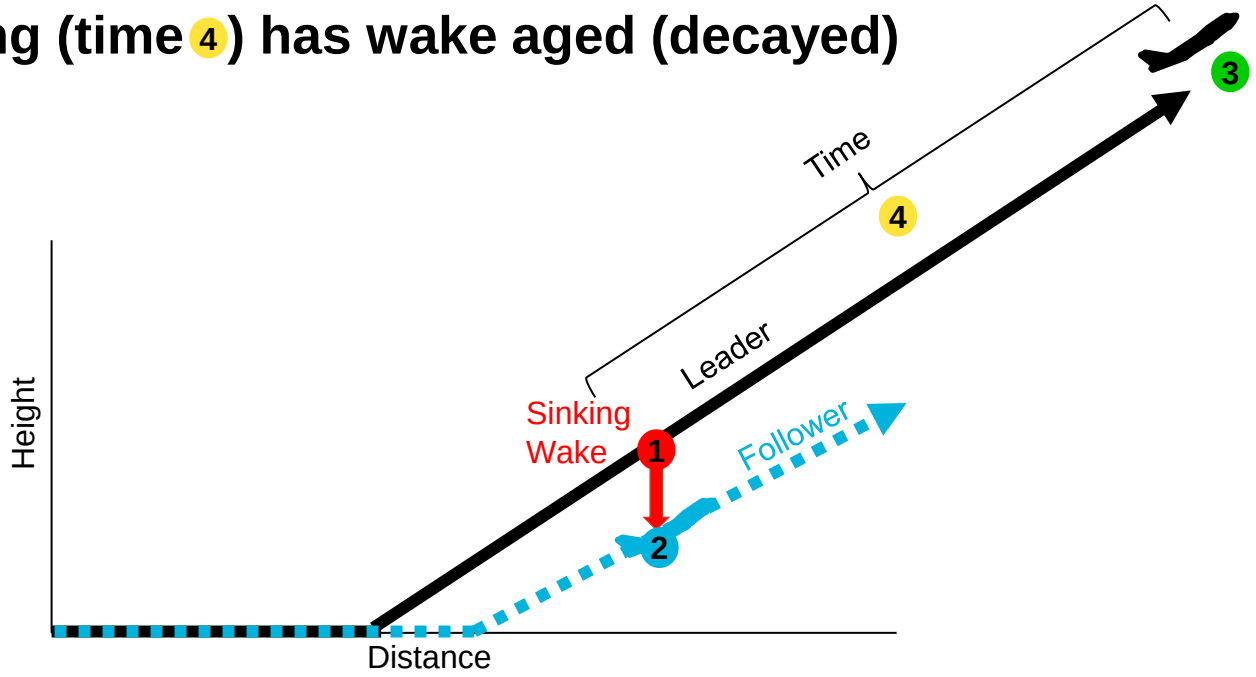
Initial Departure Speed Profiles

MITRE

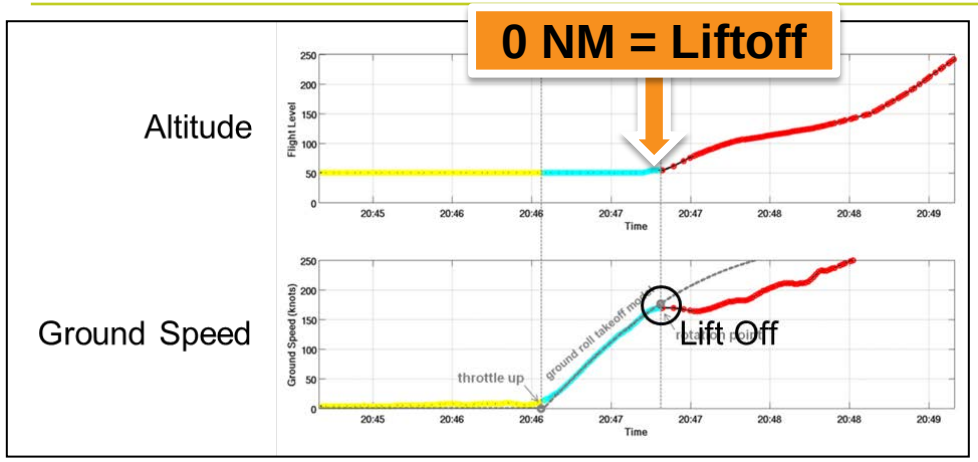
Sensitivity Analysis

Departure Characteristics to Consider

- How fast is the leader at wake generation point 1 (for initial wake strength)
- How fast is follower at wake encounter point 2 (for wake encounter reaction)
- How far down track (distance 3) is leader aircraft
- How long (time 4) has wake aged (decayed)



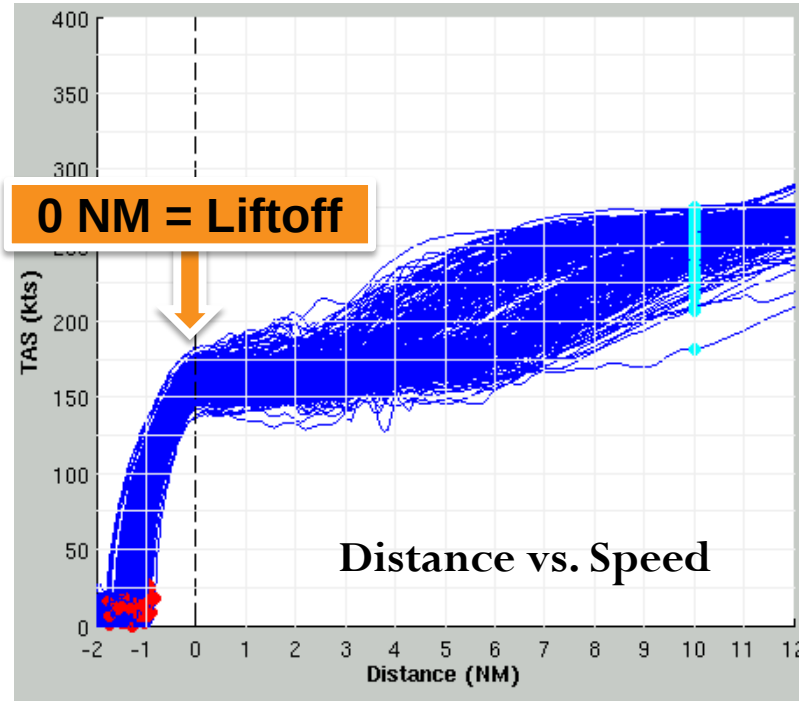
Initial Comparison of Departure Speed Profiles



Determined lift-off point and time for the departure speed profile

Need to determine operational ranges and dependence on primary factors

- **Aircraft type, weight, power settings, temperature, airport specific, etc.**

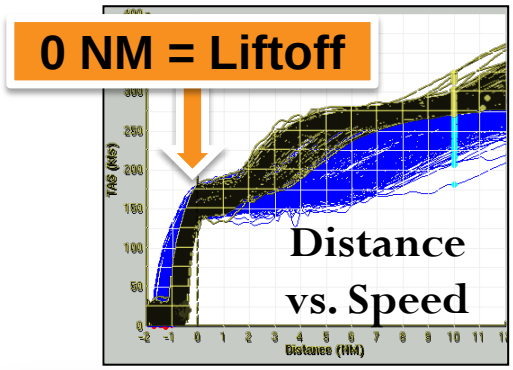


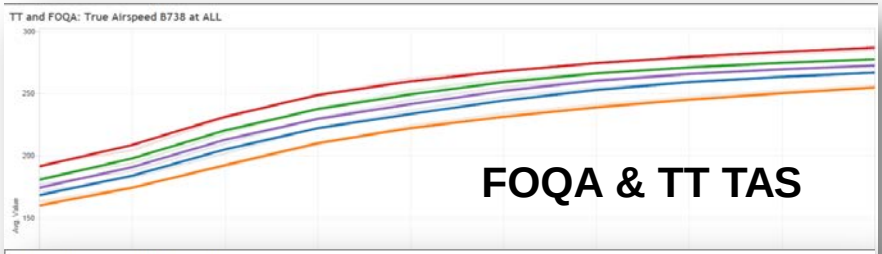
MITRE

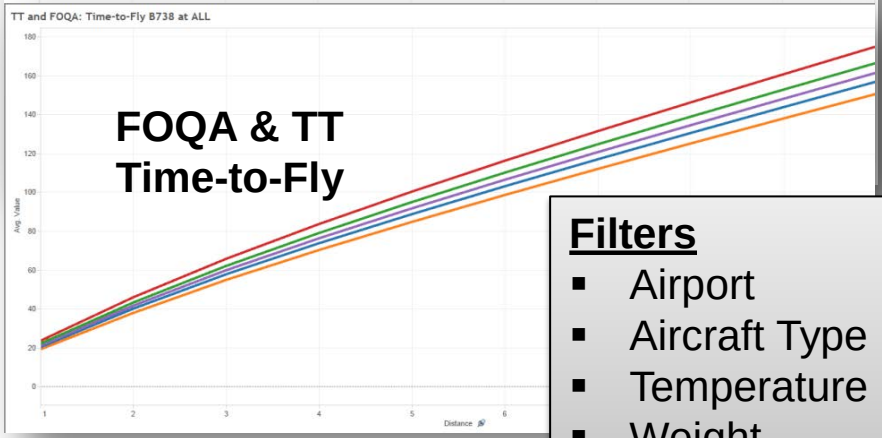
Threaded Track Validation with FOQA Data

True Airspeed, Time-to-Fly, Height Above Takeoff Initial Cut

- **Created an interactive workbook to investigate departure Threaded Track and FOQA data.**
  - TAS, Time-to-Fly, Height Above Takeoff
  - FOQA data provided is not as granular as Threaded Track data.
- **Threaded Track departure dataset captured a year's worth of surveillance data**
  - 5 million+ tracks
  - 34 major airports
  - 125 aircraft types







Filters

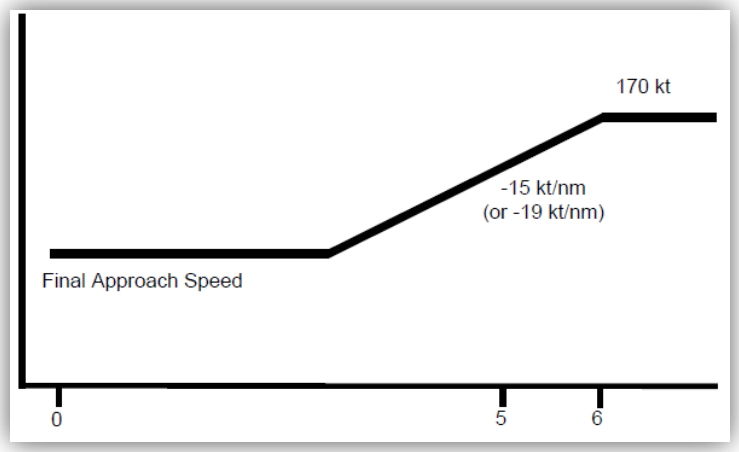
- Airport
- Aircraft Type
- Temperature
- Weight
- Altitude

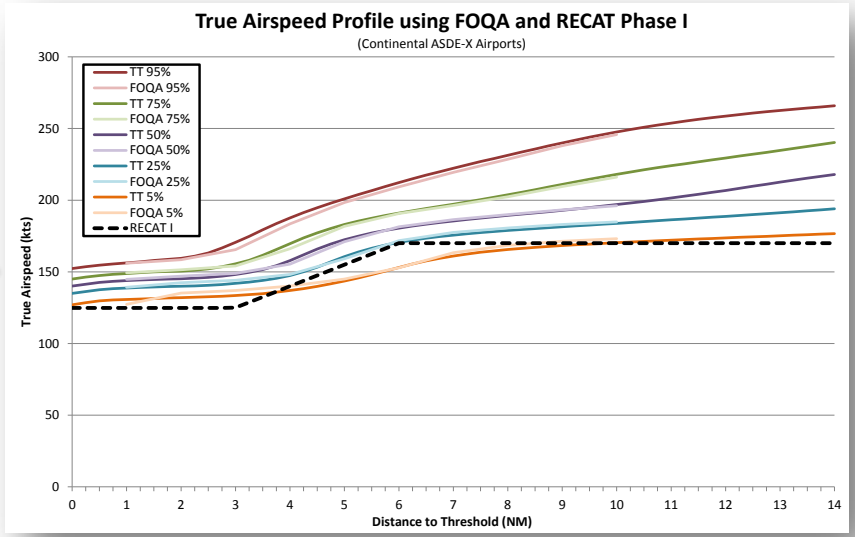
Next Steps for Departure Analysis

- **Departure speed and Time-to-Fly validation by aircraft type**
- **Departure speed sensitivity analysis**
  - Variations by airport, field elevation, departure rate, temperature, weight, runway length, etc.
- **Document the departure speeds for RECAT Phase II methodology report**

Thank You

- **Objective**
  - Provide improved information for actual approach and departure speeds observed in different aircraft types





Book Speeds ➔ Observed Speeds

MITRE

Approved for Public Release; Distribution Unlimited. 14-1657

Fiscal Year:	2014
Outcome Number:	02
PBWP Reference:	2-2.B1-1