Runway Exit Design Tool and Landing Events Database: Industry Meeting

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Virginia Tech

February 2, 2023

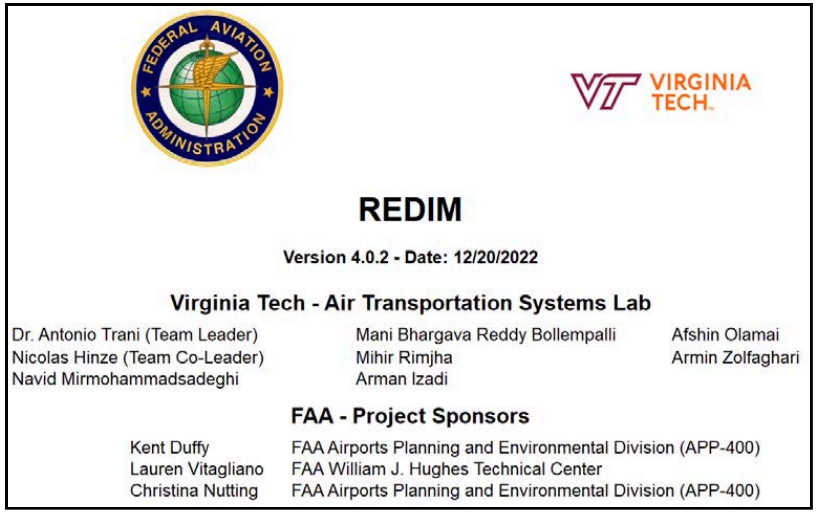
Acknowledgments

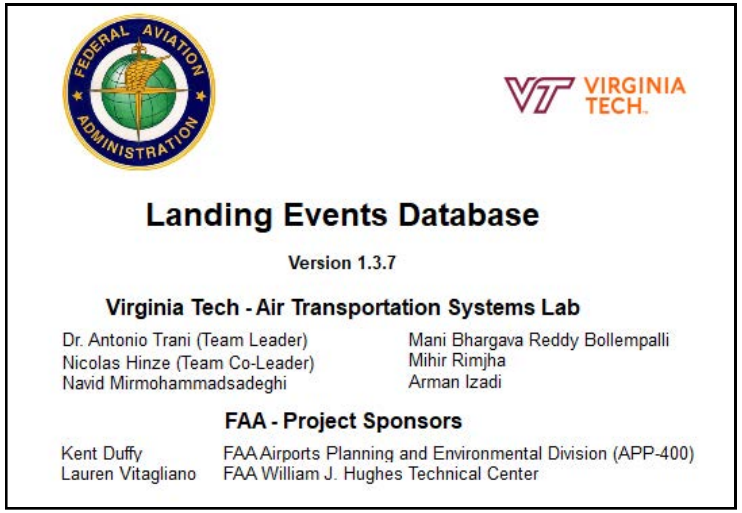
- **Project supported by the Federal Aviation Administration (FAA)**
- **FAA Project Technical Monitors: Kent Duffy, Lauren Vitagliano, and Christina Nutting**
- Project of the National Center of Excellence for Aviation Operations Research **(NEXTOR 3)**

- Special thanks to:
- Tom Tessitore (FAA Technical Center)

Project Tasks and Products Developed or Improved

- **Task 1 (Completed)**
  - Process New ASDE-X and ASSC Data
  - Years 2016, 2017, 2018, 2019, and 2020 supplied by the FAA
  - Include new data in the Landing Events Database
- **Task 2 (Completed)**
  - Incorporated pilot motivational practices into the Runway Exit Tool (REDIM Model)
  - User's can specify pilot motivational practices
- **Task 3 (Completed)**
  - User-Community Feedback
  - Improvements to the model
- **Task 4 (under review by FAA)**
  - Aircraft Database





Process Data and Improve the Landing Events Database

- ASDE-X and Airport Surface Surveillance Capability (ASSC) data
  - Processed ASDE-X and ASSC data with more than 32 million landing events
  - Added six airports to the analysis
  - Landings recorded at 43 airport for years 2015-2020
- Updated runway exit geometry information for 4,806 runway exits at 313 runway ends (43 airports)
- Updated one and five-minute weather data for all 43 airports
- **Product: Landing Events Database 1.3.7**

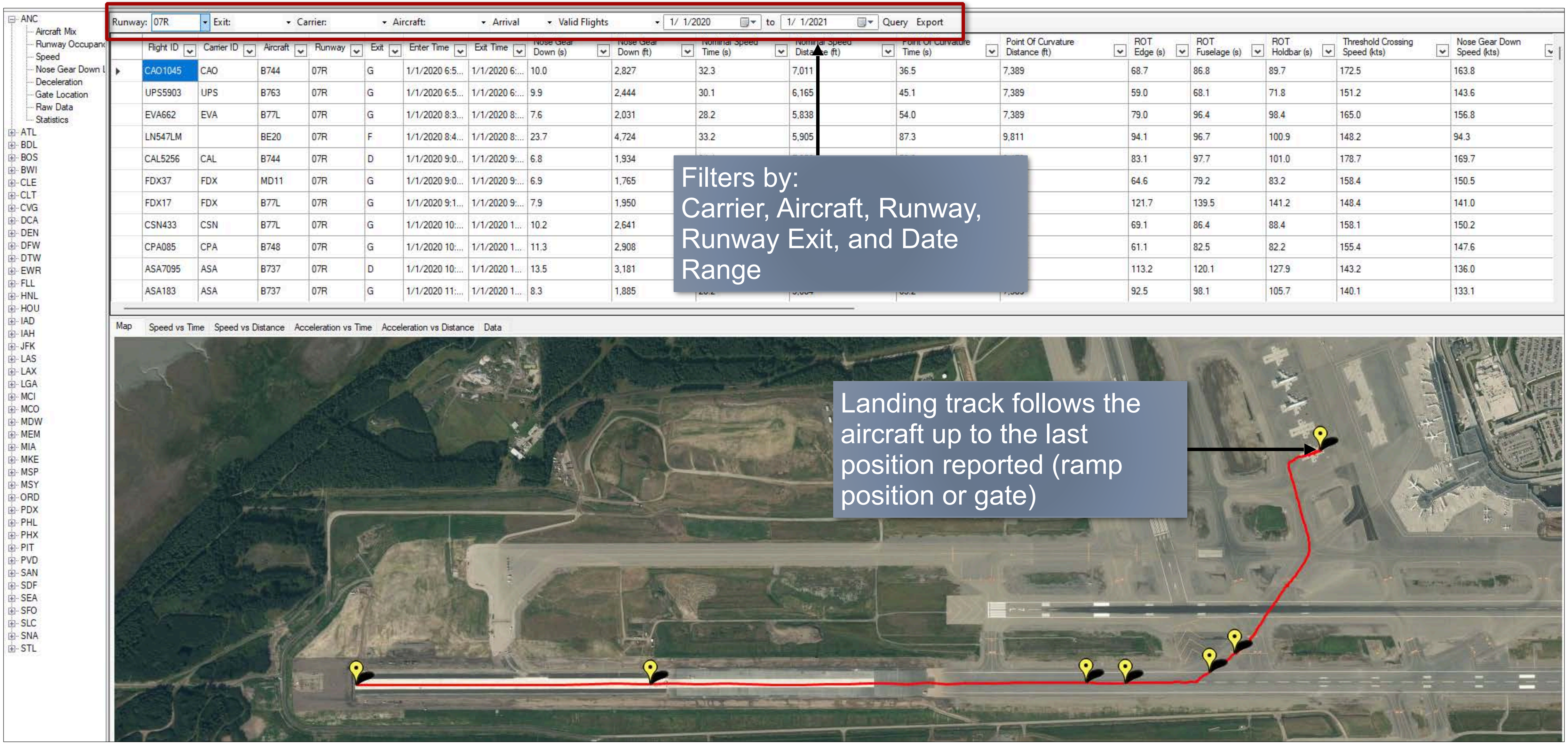
Download the Landing Events Database at:

https://atsl.cee.vt.edu/products/runway-exit-design-interactive-model--redim-1.html

Runway exit polygons at EWR airport

Virginia Tech
Invent the Future

Landing Event Database Tool Version 1.3.7



Runway Exit Tool (REDIM Model) Improvements

- Released the REDIM Tool version 4.02 (December 20, 2022)
  - REDIM uses ASDE-X data collected at 43 airports between 2015 and 2020
  - Support for more than 300 aircraft types
  - Landing parameters are now a function of runway length instead of clusters
  - Turnoff times are now calculated using Point Of Curvature (PC) to runway edge, runway edge to hold bar decelerations
  - Exact exit geometries are supported using cartesian coordinates
  - Runway Threshold to last Exit's Point Of Curvature is now used instead of actual Runway Length
  - Landing roll **pilot motivation** can be adjusted by aircraft type to improve model calibration for specific runways.

Latest Releases of the Runway Exit Tool (REDIM Model)

- Version 4.0.1 - 12/12/2022
  - Various small improvements to the user interface

- Version 4.0.2 - 12/20/2022
  - Performance improvements when using high motivation factors on short runways.
  - Fixed crash affecting AAC C Turboprop aircraft on runways longer than 13,000 feet.

Runway Exit Model (REDIM version 4)

- The REDIM Model uses **nominal** landing roll deceleration and touchdown location distributions derived from 30+ million landings
- Deceleration rates and touchdown locations are a function of:
  - Landing distance to the last runway exit (~landing distance available)
  - Individual aircraft
- **Pilot motivation** can influence the “nominal landing roll behavior” due to multiple factors:
  - Gate location
  - Avoiding a crossing an intersecting runway while landing (LAHSO and non-LAHSO operations)
  - Avoiding crossing an inboard parallel runway used for departures (i.e., avoids long taxi times)
  - Passenger comfort
  - Runway exit location and runway exit types available

Runway Exit Model 4 : Aircraft Database

- 330 aircraft modeled (directly or indirectly)
- Improved database consistent with the updated FAA Aircraft Characteristics Database (ACD)
- Includes the latest generation of aircraft (Airbus 220-300, A320neo, Boeing 737-8Max, etc.)

Aircraft Design Group (ADG): III

ADG III Aircraft

Aircraft ID	Aircraft Name	Engine Type	Aircraft Design Group
A19N	Airbus A319 Neo	Jet	III
A20N	Airbus A320 Neo	Jet	III
A21N	Airbus A321 Neo	Jet	III
A318	Airbus A318	Jet	III
A319	Airbus A319	Jet	III
A320	Airbus A320	Jet	III
A321	Airbus A321	Jet	III
AT42	Aeropatiale ATR-42-200	Turboprop	III
AT43	Aeropatiale ATR-42-300	Turboprop	III
AT44	Aeropatiale ATR-42-400	Turboprop	III
AT45	Aeropatiale ATR-42-500	Turboprop	III
AT46	Aeropatiale ATR-42-600	Turboprop	III
AT71	Aeropatiale ATR-72-100	Turboprop	III
AT72	Aeropatiale ATR-72-200	Turboprop	III
AT73	Aeropatiale ATR-72-300	Turboprop	III
AT74	Aeropatiale ATR-72-400	Turboprop	III
AT75	Aeropatiale ATR-72-500	Turboprop	III
AT76	Aeropatiale ATR-72-600	Turboprop	III
B37M	Boeing 737 MAX 7	Jet	III
B38M	Boeing 737 MAX 8	Jet	III
B39M	Boeing 737 MAX 9	Jet	III

Aircraft Design Group (ADG): V

Aircraft ID	Aircraft Name	Engine Type	Aircraft Design Group
A332	Airbus A330-200	Jet	V
A333	Airbus A330-300	Jet	V
A337	Airbus A330-700 - Beluga XL	Jet	V
A338	Airbus A330-800	Jet	V
A339	Airbus A330-900	Jet	V
A342	Airbus A340-200	Jet	V
A343	Airbus A340-300	Jet	V
A346	Airbus A340-600	Jet	V
A359	Airbus A350-900	Jet	V
B742	Boeing 747-200	Jet	V
B744	Boeing 747-400	Jet	V
B772	Boeing 777-200	Jet	V
B773	Boeing 777-300	Jet	V
B77L	Boeing 777-200LR	Jet	V
B77W	Boeing 777-300ER	Jet	V
B788	Boeing 787-8	Jet	V
B789	Boeing 787-9	Jet	V

Runway Exit Model 4 Improvements: Runway Exit Data Handling

- REDIM offers default runway exits
- REDIM offers a detailed procedure to define custom runway exits using relative(x-y) or absolute coordinates (latitude-longitude)
- REDIM 4 can store runway exits in a runway exit database file

```
Name,Cartesian Exit Example
Radius_Units,ft
Radius,900
XY_Units,m
X,Y
0,0
26.671,2.015
42.047,3.688
57.997,5.654
72.971,8.734
97.812,15.907
113.304,21.596
125.011,26.633
138.622,33.627
152.282,41.414
164.893,49.682
177.397,59.000
292.216,161.161
```

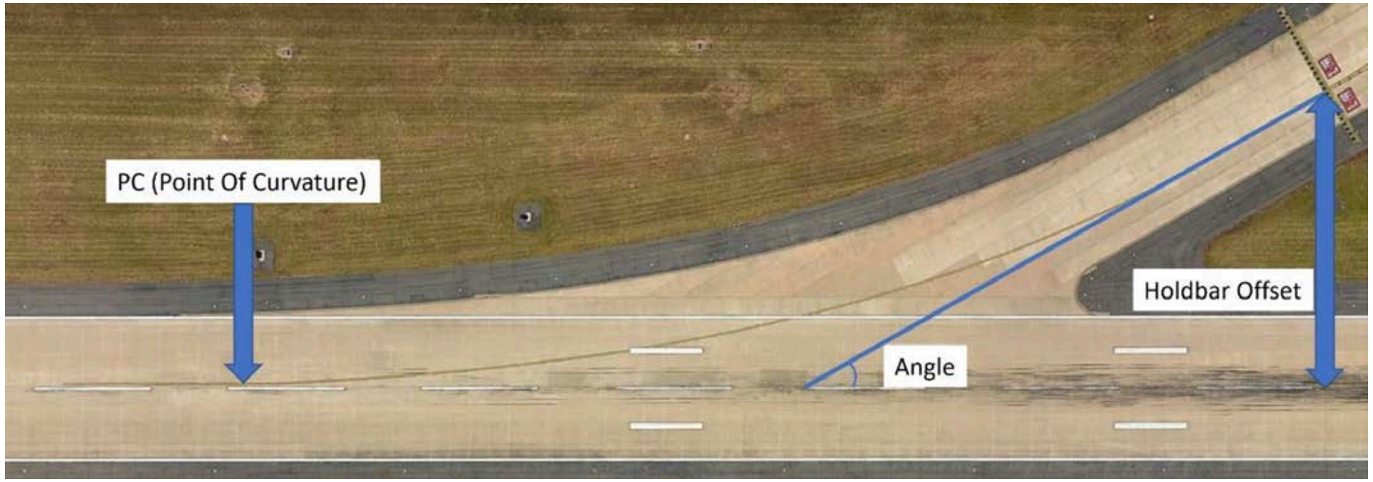
Notes:

- The Point of Curvature (PC) is located at 0,0
- The orientation of the runway is along the x-axis.
- The direction of landing is from left to right.
- Possible units: m (meters) and ft (feet).

```
Name,LonLat Exit Example
Radius_Units,ft
Radius,900
XY_Units,lonlat
Runway_Azimuth_deg,41.3968450417015
Lon,Lat
-87.8833014762658,41.9669286085378
-87.8831069436841,41.9671207368017
-87.8829994220016,41.9672345446757
-87.8828899817503,41.9673539681213
-87.8827983987043,41.9674734340468
-87.8826651370843,41.9676839077378
-87.8825930378926,41.9678224048937
-87.8825452274012,41.9679314508081
-87.8824999334291,41.9680650192218
-87.8824614291183,41.9682036320656
-87.8824356467823,41.9683380281720
-87.8824202207222,41.9684779508170
-87.8824287593785,41.9698616096226
```

Notes:

- Possible radius units: m (meters) and ft (feet)
- The landing direction must be specified in degrees (Runway_Azimuth_deg).



Exit Database   Window   Help

Exit Database

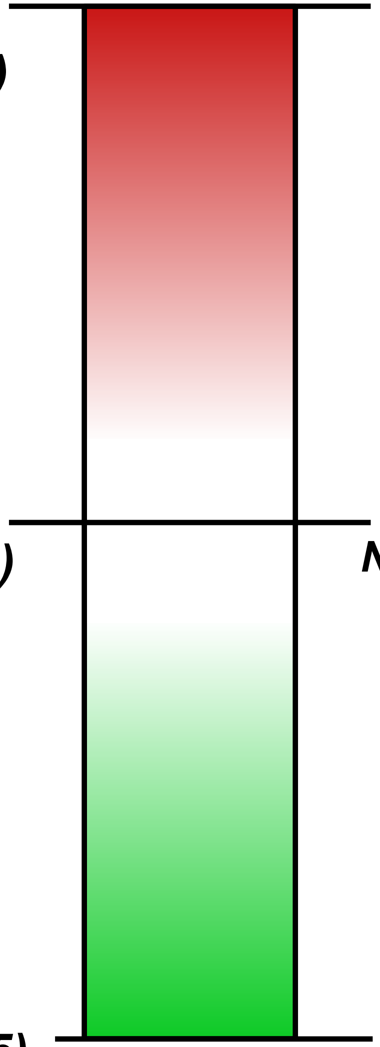
Exit Category: 90 degrees

90 degrees Exits

Exit Name	Radius (ft)	Angle (deg)	Holdbar Offset (ft)	Specification File	Plot	Edit
90 degree	150	90	300		Plot	Edit
90 Degree 175-foot Radius	175	90	300		Plot	Edit
90 Degree 200-foot Radius	200	90	300		Plot	Edit
90 DEegree 250-foot Radius	250	90	300		Plot	Edit

Pilot Motivation Factor

- The research team developed methods to characterize pilot motivation through statistical analyses of individual aircraft data
  - Deceleration rates
  - Touchdown distances
- Briefed a group of pilots invited by the FAA to understand factors that lead to pilot motivation
- All motivation factors provided in the **model are within the kinematic capabilities of each aircraft**



Motivation Factor in the REDIM 4 Model Interface

Evaluate an Existing Runway - Step 2 - Define Aircraft Mix for New Runway

Step 2: Define Aircraft Mix for New Runway

Only provide the aircraft mix for the left or right side of the runway you are modeling.

Aircraft ID	Aircraft Name	Aircraft Design Group	Aircraft Approach Category	Aircraft Mix (%)	Motivation Factor
AT76	Aeropatiale ATR-72-600	III	B		1
B37M	Boeing 737 MAX 7	III	C		1
B38M	Boeing 737 MAX 8	III	D	25	2
B39M	Boeing 737 MAX 9	III	D		1
B712	Boeing 717-200	III	C		1
B721	Boeing 727-100	III	C		1
B722	Boeing 727-200	III	C		1
B733	Boeing 737-300	III	C	25	2
B734	Boeing 737-400	III	C		1
B735	Boeing 737-500	III	C		1
B736	Boeing 737-600	III	C		1
B737	Boeing 737-700	III	C	25	2
B738	Boeing 737-800	III	D	25	2
B739	Boeing 737-900	III	D		1
BCS1	Airbus A220-100	III	C		1
C55B	Cessna Citation Bravo	III	B		1
CRJ9	Bombardier CRJ 900	III	C		1
DC91	Douglas DC-9-10	III	C		1
DC93	Douglas DC-9-30	III	C		1
DH8B	DeHavilland Canada Dash8-200	III	B		1
DH8C	DeHavilland Canada Dash8-300	III	B		1

Total aircraft mix allocated: 100%

Load | Save | Cancel | <- Previous | Next ->

REDIM

Version 4.0.2 - Date: 12/20/2022

Virginia Tech - Air Transportation Systems Lab

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Afshin Olamai
Armin Zolfaghari

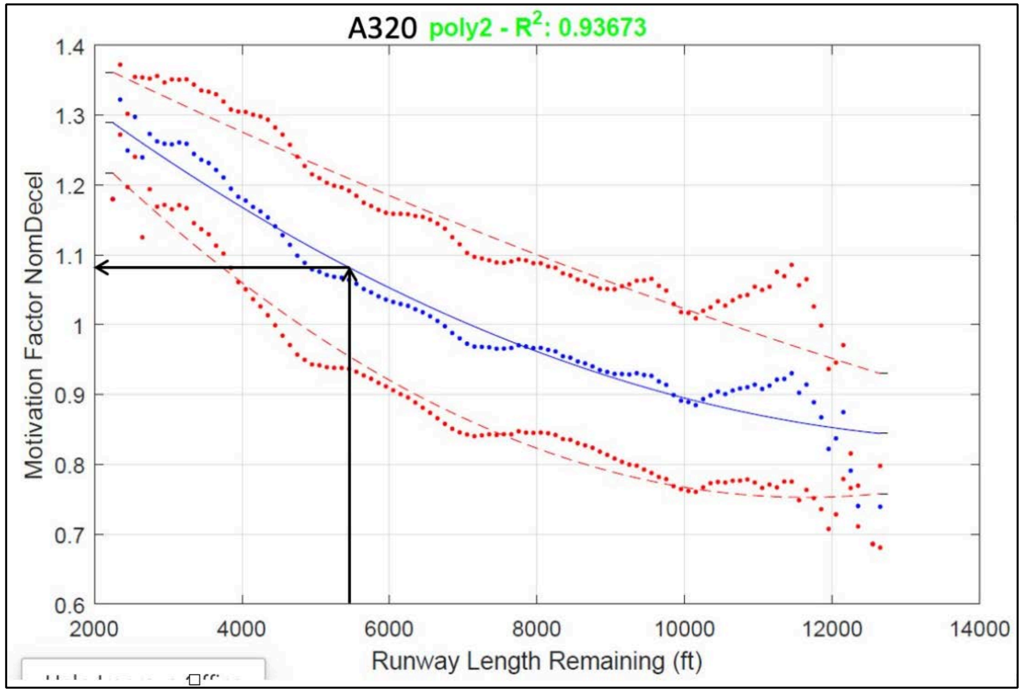
FAA - Project Sponsors

Kent Duffy — FAA Airports Planning and Environmental Division (APP-400)
Lauren Vitagliano — FAA William J. Hughes Technical Center
Christina Nutting — FAA Airports Planning and Environmental Division (APP-400)

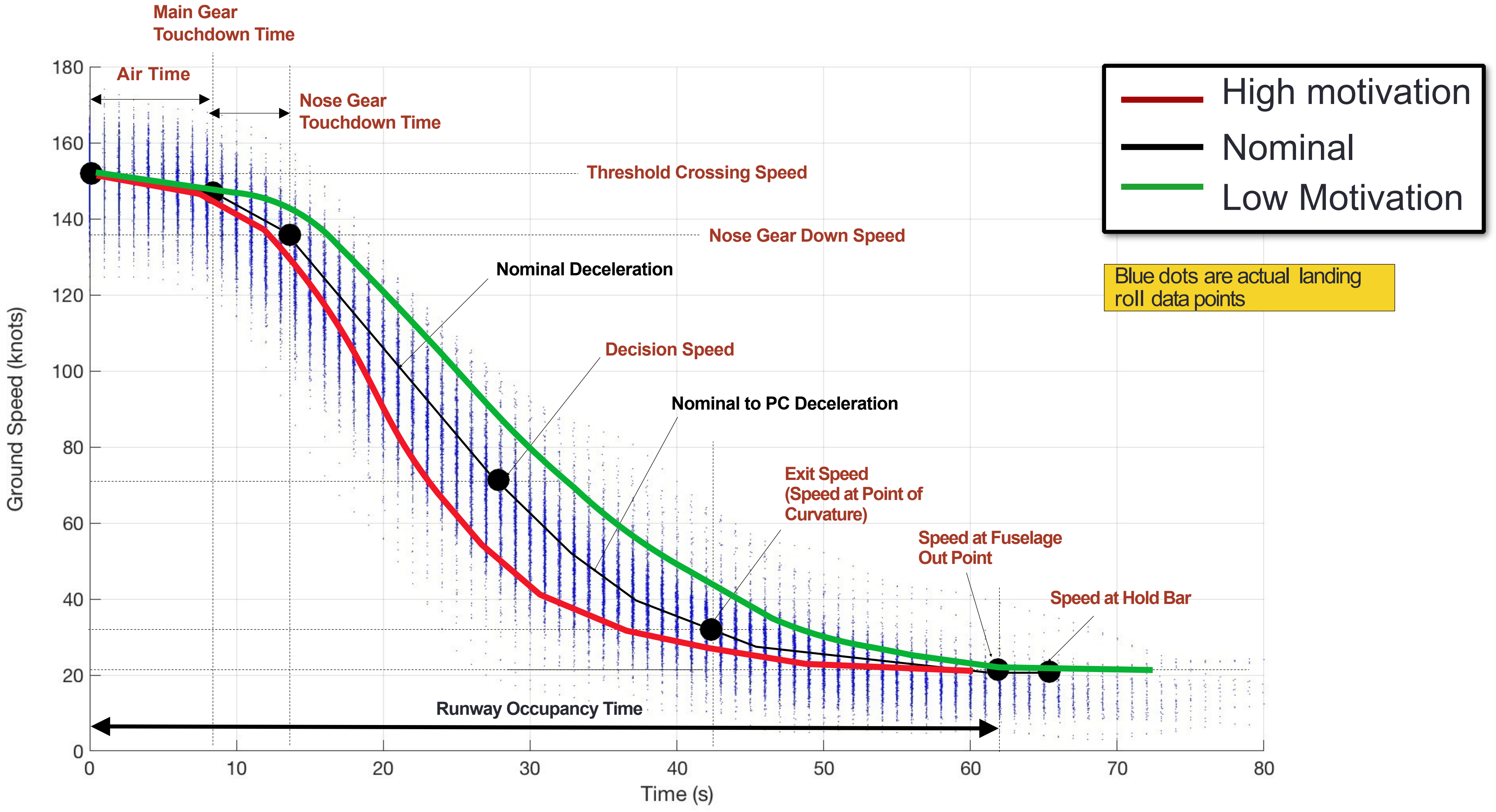
During the landing simulation, Boeing 737-700 will use a motivation factor of 2.0 (high motivation)

Procedure to Estimate Pilot Motivation

- Studied 30+ million landing records in the Landing Events Database
  - Individual aircraft analysis produces unique motivation factor profiles
  - Motivation factors are feasible and observable in the landing event database (i.e., deceleration rates and touchdown locations are practical and feasible)

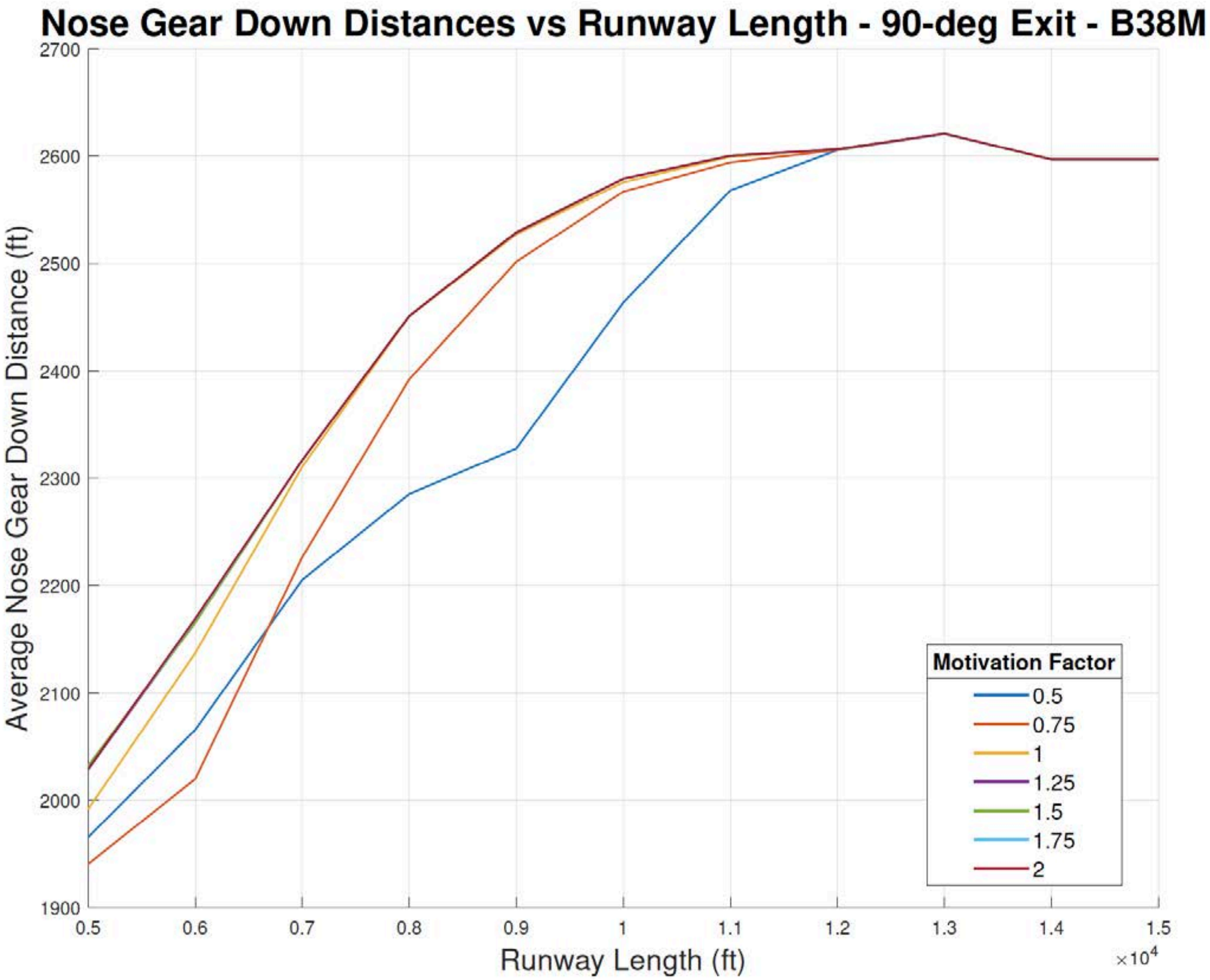


Landing Roll Profiles versus Pilot Motivation

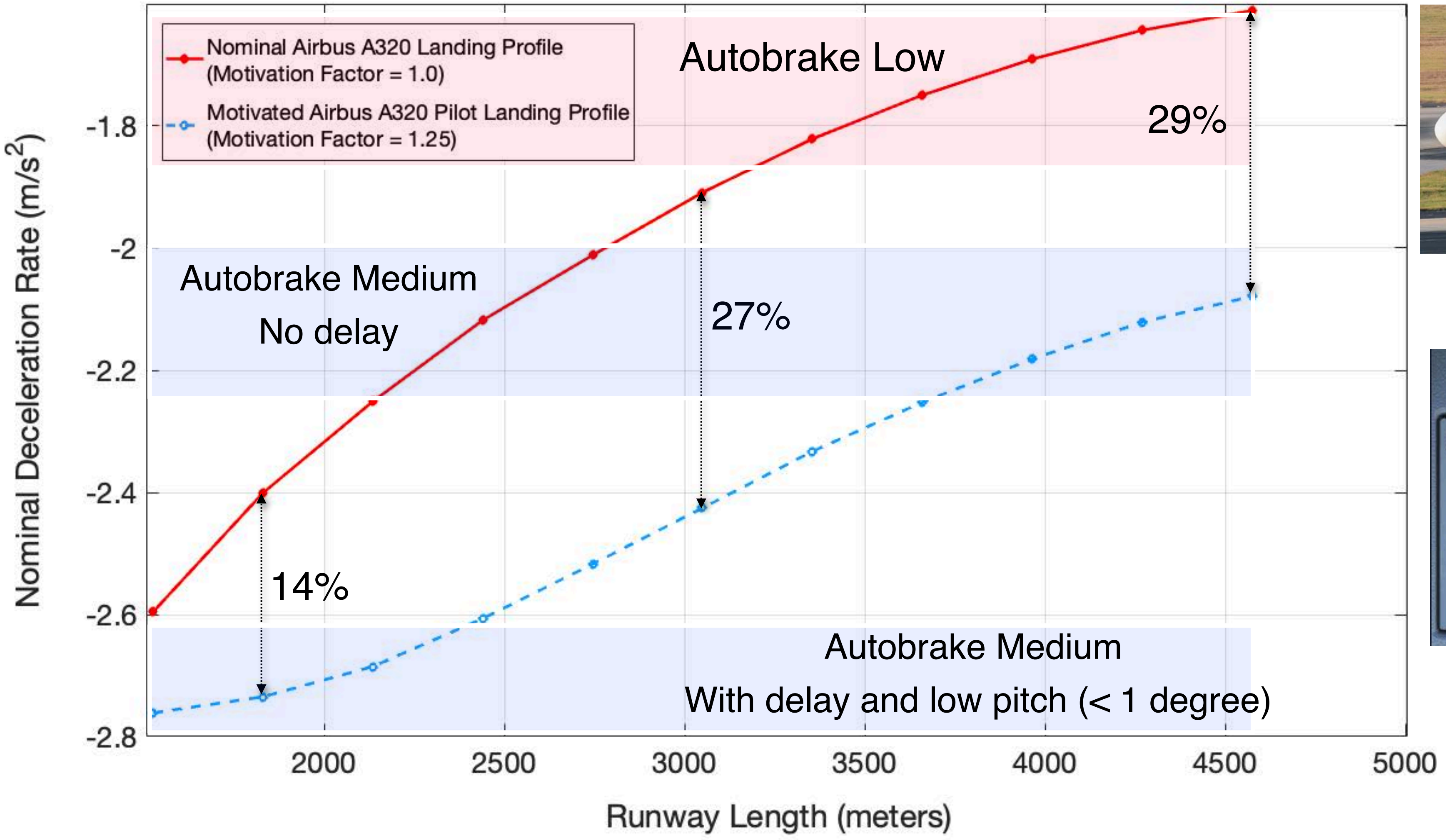


Pilot Motivation in the REDIM 4 Model Starts with Modified Touchdown Locations

- The natural trend of touchdown locations is built into the model based on actual data
  - Short runways produce early touchdown locations
- High motivation factors above 1.5 may reduce the touchdown location by 120-150 feet (~4.8%) on a 8,000-foot runway



Pilot Motivation Factor Effect on Nominal Deceleration Rate Spread Between MF 1 and MF 1.25 Averages 20% for Runways Up to 3,050 meters (10,000 feet)

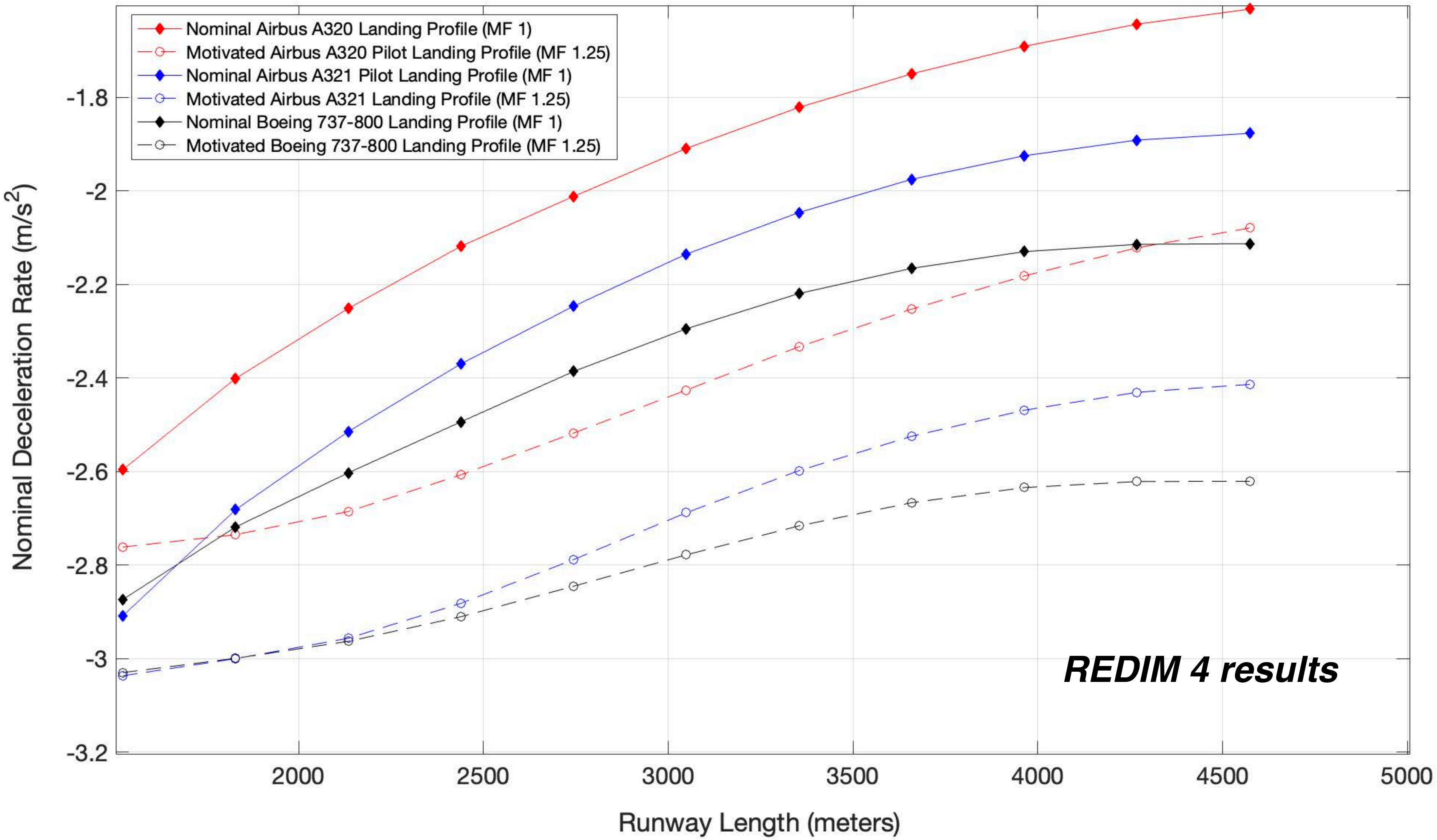


Airbus A320

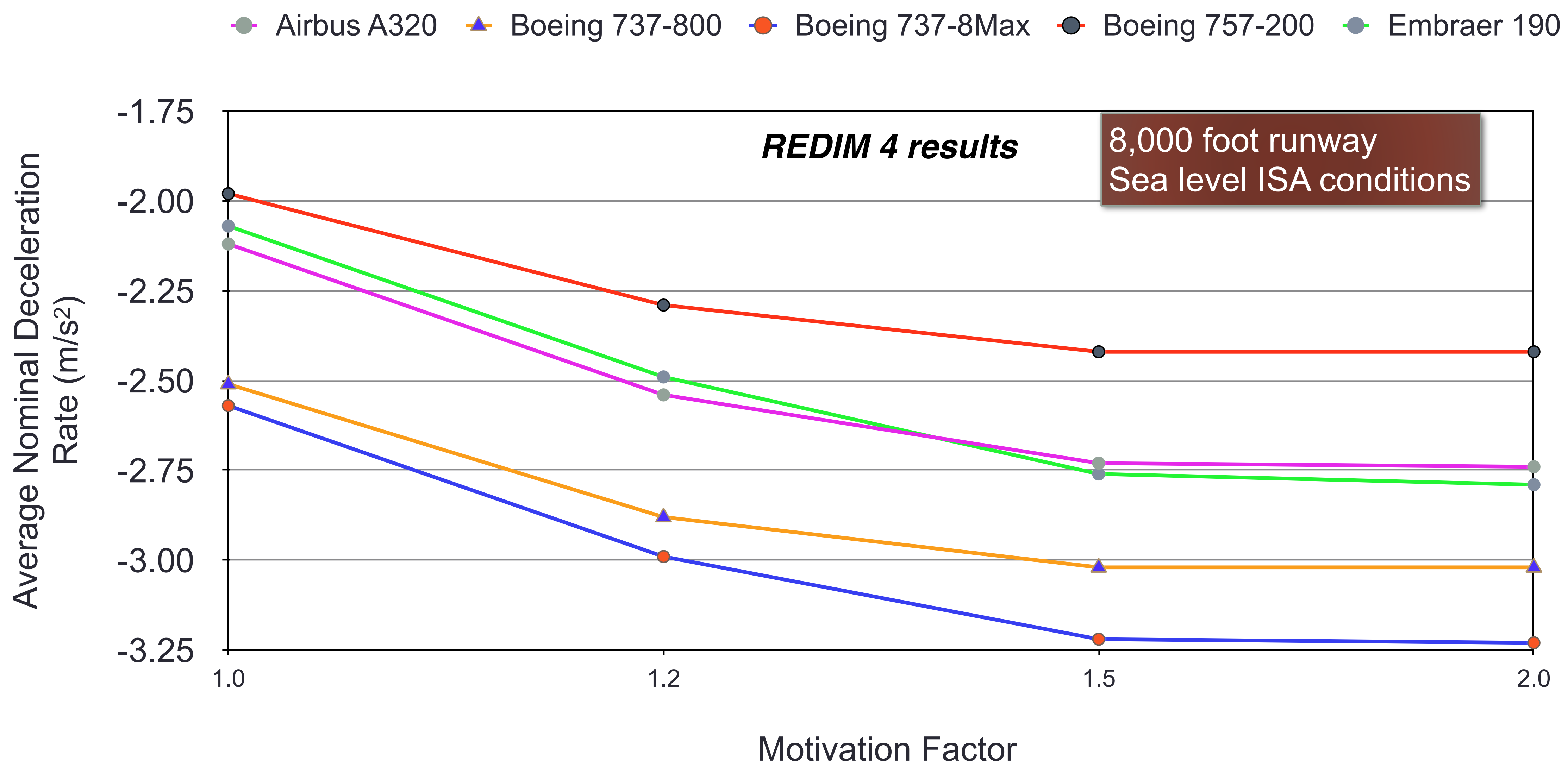
Airbus A320 Autobrake Panel

(https://docs.flybywiresim.com/pilots-corner/a32nx-briefing/flight-deck/front/autobrake-gear/)

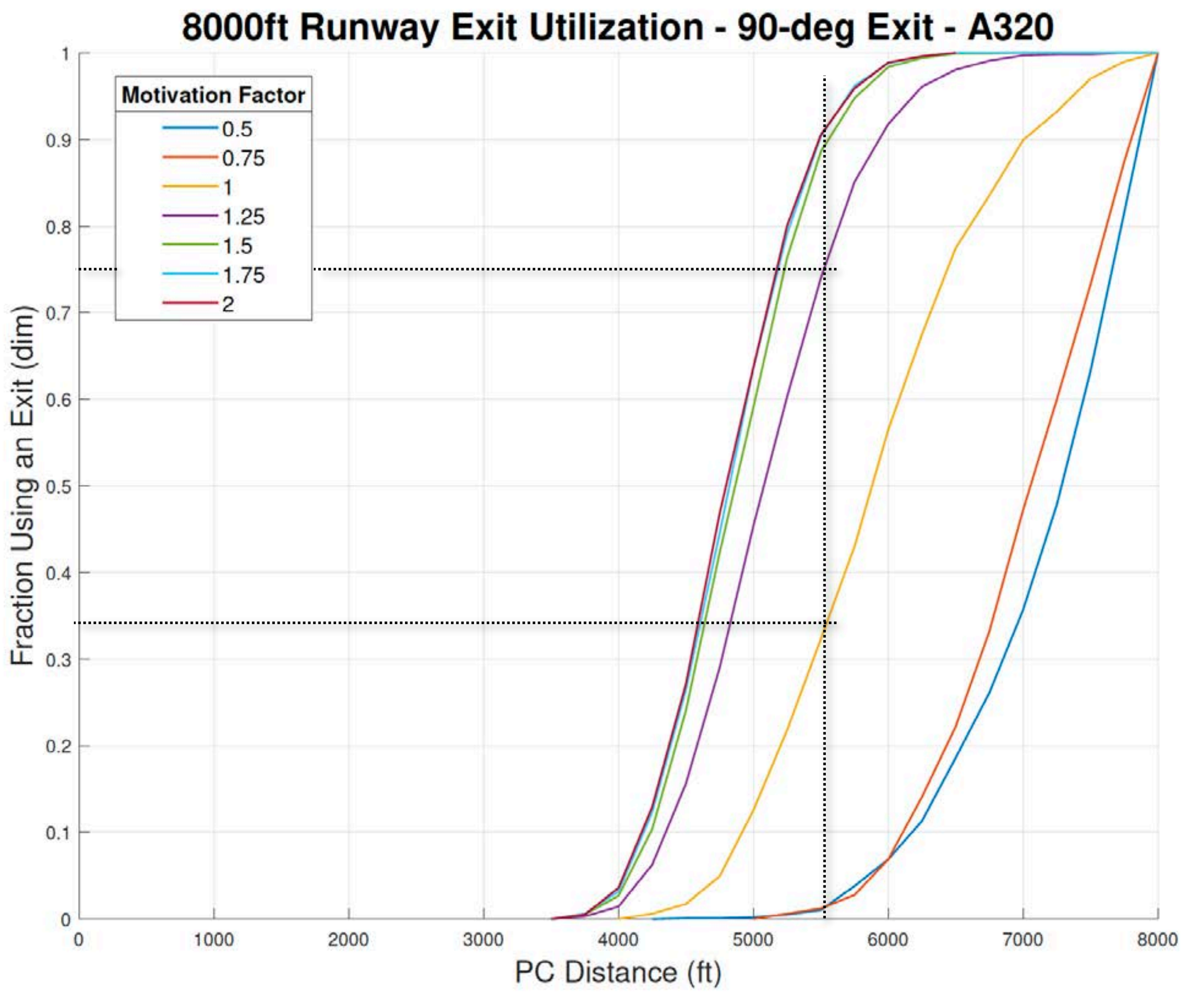
Nominal Deceleration Rate and Pilot Motivation Factor



Nominal Deceleration Rate and Pilot Motivation Factor



Practical Implications of Changing the Pilot Motivation Factor on a 2,440-meter (8,000 feet) Runway



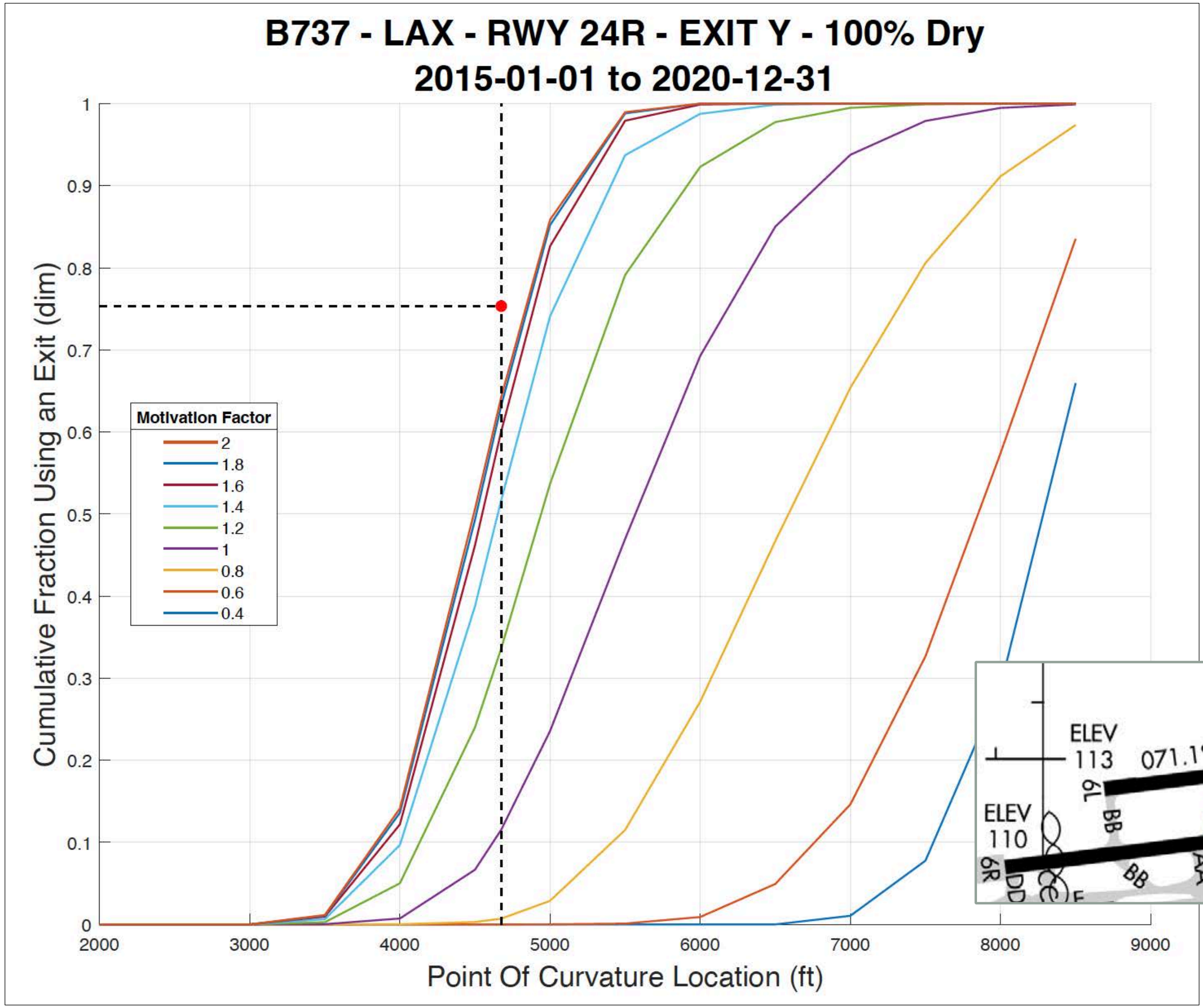
Increasing the pilot motivation factor from 1.0 to 1.25 doubles the cumulative runway exit probability of right-angle exits at a location 5,500 feet along the runway.

Airbus A320

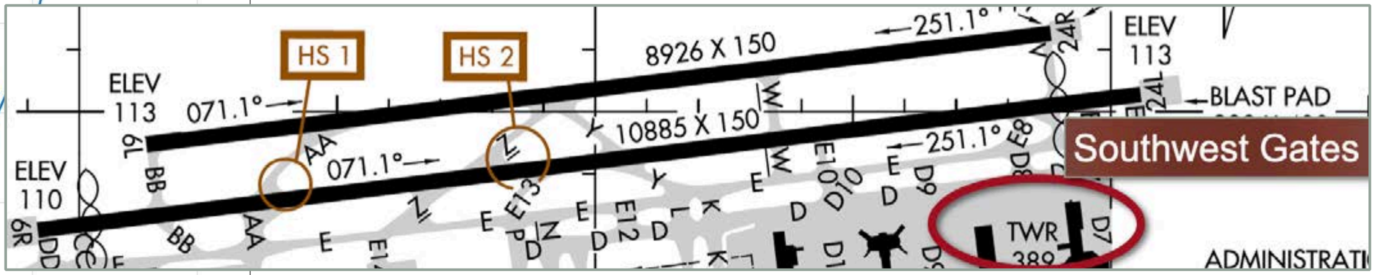
Example Motivation Factors at Selected Airports

- Practical examples of how to translate motivation factor (MF) to real-world landing performance
  - Los Angeles Runway 24R
  - Milwaukee Runway 7R
  - LaGuardia Runway 31
- REDIM model motivation factor guidance for model users

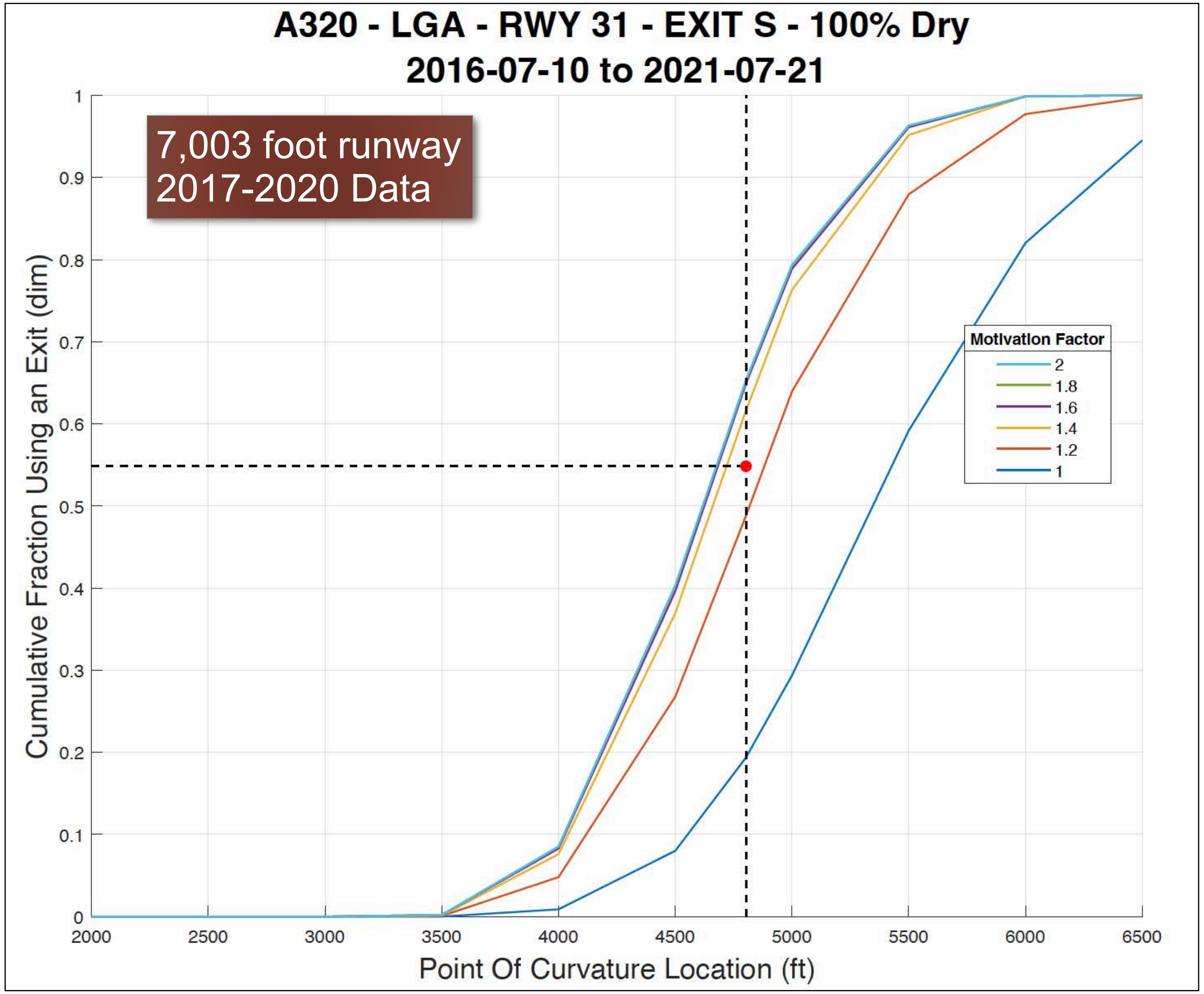
77.5% of Motivated Pilots of Boeing 737-700 Landings Exit at Yankee (Y)



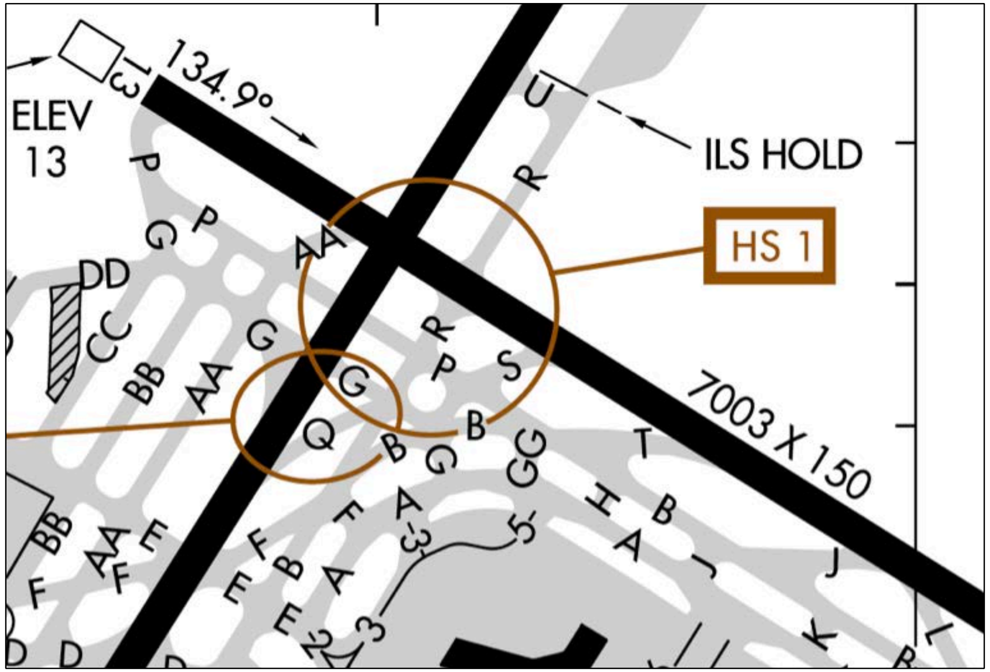
- A case of very high pilot motivation
- Motivation factor slightly higher than 2
- Nominal deceleration rate for a Boeing 737-700 landing on a 9,000 foot runway is 2.05 m/s^2
- Observed deceleration rate of 2.69 m/s^2 on runway 24R by one motivated airline
- Upper bound pilot motivation factor in the REDIM model is 2



55% of Airbus A320 Landings at LGA Runway 31 Use **Exit Sierra (S)**

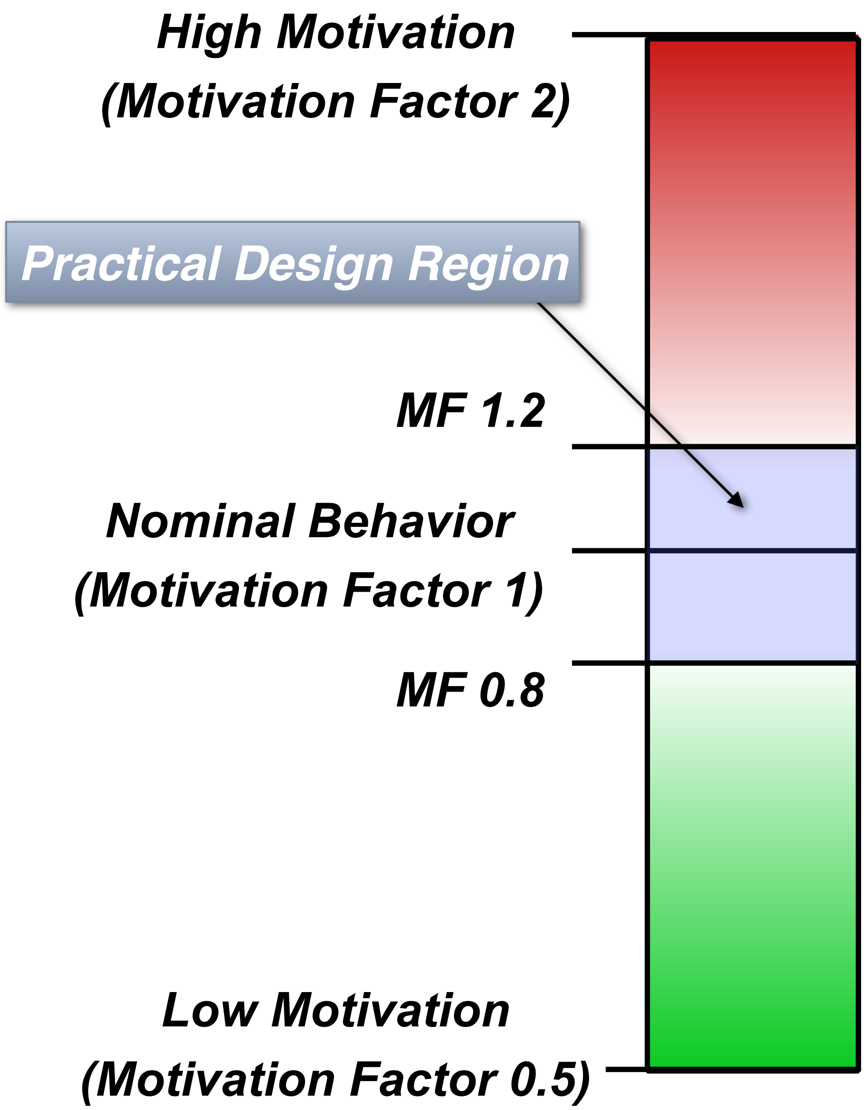


- A case of higher than nominal pilot motivation
- Pilots are motivated is to avoid crossing runway 4/22 while landing on runway 31
- Observed motivation factor is ~1.25



Recommended Guidance for Motivation Factors

- REDIM 4 is designed to predict nominal landing roll behavior on a runway with a motivation factor MF 1.0
- High motivation factors are observed at some U.S. airports (MF 1.25 or higher)
- Practical design guidance should limit the placement of runway exits using MF factors between 0.8 and 1.2 to avoid high deceleration rates that may not be desirable in real-world commercial operations
  - Higher maintenance costs due to heavy braking
  - Passenger comfort
- For narrow-body aircraft, a motivation factor of 1.2 translates into 15-20% increase in deceleration rates compared to the nominal landing conditions



Runway Exit Design Tool (REDIM Model) Resources

Download REDIM 4

- REDIM 4.0.0 - Windows Installer
- User Group
- User Manual
- FAQs
- Change Log

Download Landing Events Database

- Landing Events Database 1.3.7 - Windows Installer
- User Manual

Detailed Documentation for REDIM 4

- Aircraft Database
- Exit Clusters

Webinars

- 3/16/2022: Presentation - Video
- 6/8/2021: Presentation - Video
- 6/18/2020: Presentation - Video

1.9 GB installer

FEDERAL AVIATION ADMINISTRATION

VIRGINIA TECH.

REDIM

Version 4.0.0.7 - Date: 10/31/2022

Virginia Tech - Air Transportation Systems Lab

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Nicolas Hinze (Team Co-Leader)
Navid Mirmohammadsadeghi
Mani Bhargava Reddy Bollempalli
Mihir Rimjha
Arman Izadi
Afshin Olamai
Armin Zolfaghari

FAA - Project Sponsors

Kent Duffy — FAA Airports Planning and Environmental Division (APP-400)
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Christina Nutting — FAA Airports Planning and Environmental Division (APP-400)

Runway Exit Design Interactive Model (REDIM)

User Guide

Version 4

10/31/2022

Groups — Conversations — Search conversations within ru...

Runway Exit Design Interactive Model (REDIM) — 1–15 of 15

Welcome to the Runway Exit Design Interactive Model (REDIM) user group. This group will be used for announcing new versions of REDIM and to provide technical support for REDIM.

Download REDIM at https://atsl.cee.vt.edu/products/runway-exit-design-interactive-model--redim-.html

Nicolas Hinze	**REDIM 4 has been released.** — We are pleased to announce that RE...	Nov 1
Nicolas Hinze 2	**REDIM 4.0.beta6 has been released.** — Please find the REDIM 4.0 F...	Sep 12
Nicolas Hinze	**REDIM 4.0.beta5 has been released.** — We are pleased to announce...	Jul 27

Runway Exit Design Model User Group

https://atsl.cee.vt.edu/products/runway-exit-design-interactive-model--redim-1.html

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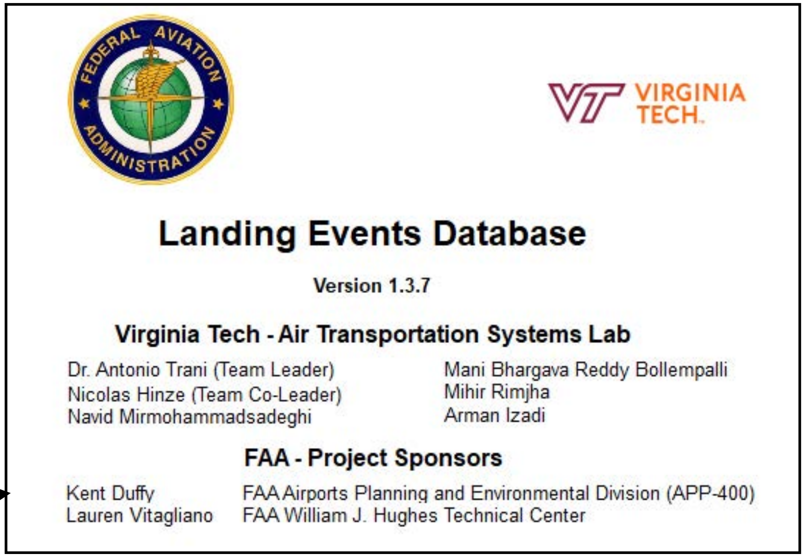
- 6/18/2020: Presentation - Video

94 MB installer



https://atsl.cee.vt.edu/products/runway-exit-design-interactive-model--redim-1.html

Runway Exit Design Tool Database and Runway Exit Clusters

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Download Landing Events Database

- Landing Events Database 1.3.7 - Windows Installer
- User Manual

Detailed Documentation for REDIM 4

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Webinars

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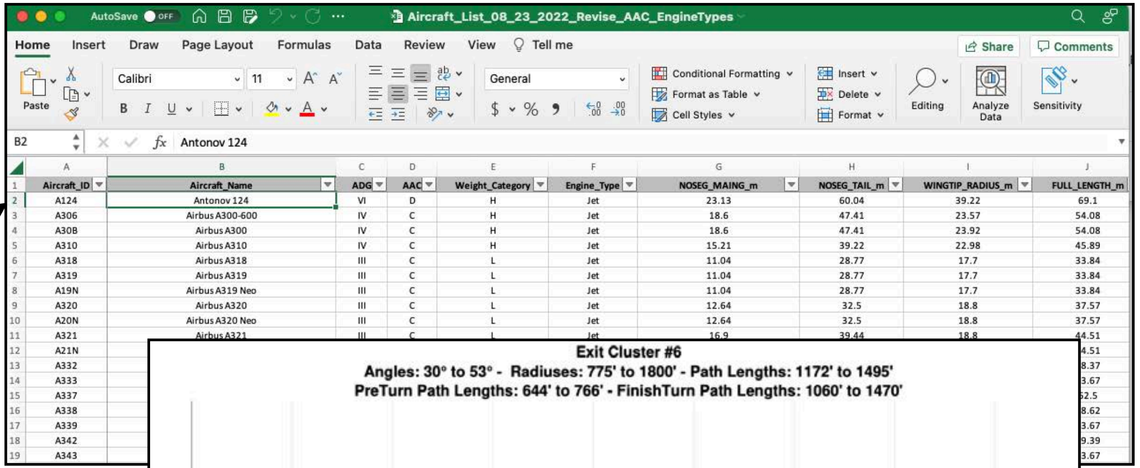
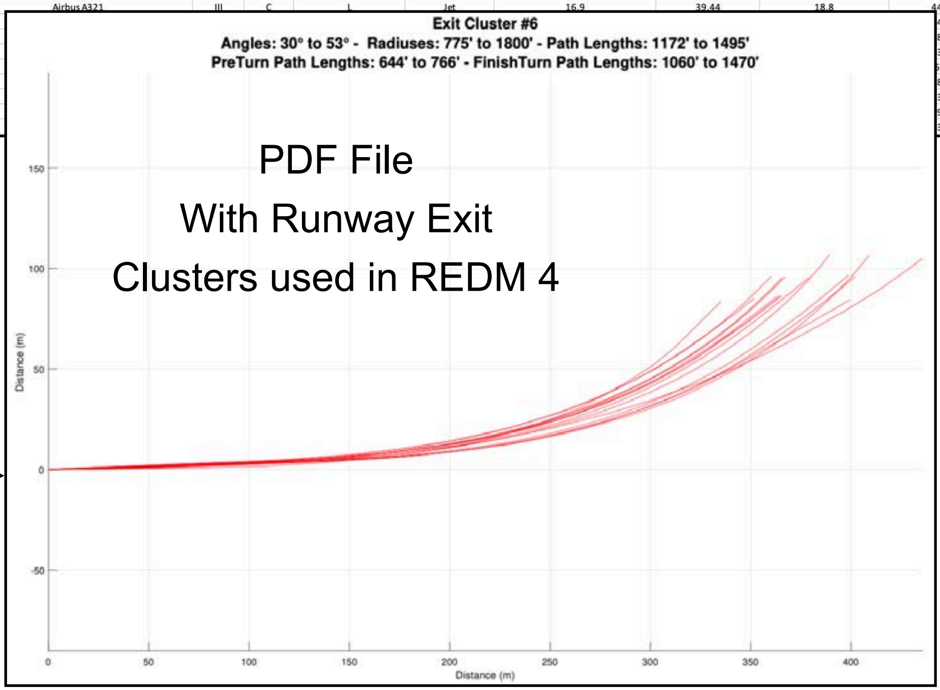
Excel File



	A	B	C	D	E	F	G	H	I	J
1	Aircraft_ID	Aircraft_Name	ADG	AAC	Weight_Category	Engine_Type	NOSEG_MAING_m	NOSEG_TAIL_m	WINGTIP_RADIUS_m	FULL_LENGTH_m
2	A124	Antonov 124	VI	D	H	Jet	23.13	60.04	39.22	69.1
3	A306	Airbus A300-600	IV	C	H	Jet	18.6	47.41	23.57	54.08
4	A30B	Airbus A300	IV	C	H	Jet	18.6	47.41	23.92	54.08
5	A310	Airbus A310	IV	C	H	Jet	15.21	39.22	22.98	45.89
6	A318	Airbus A318	III	C	L	Jet	11.04	28.77	17.7	33.84
7	A319	Airbus A319	III	C	L	Jet	11.04	28.77	17.7	33.84
8	A19N	Airbus A319 Neo	III	C	L	Jet	11.04	28.77	17.7	33.84
9	A320	Airbus A320	III	C	L	Jet	12.64	32.5	18.8	37.57
10	A20N	Airbus A320 Neo	III	C	L	Jet	12.64	32.5	18.8	37.57
11	A321	Airbus A321	III	C	L	Jet	16.9	39.44	18.8	44.51
12	A21N									[illegible]
13	A332									[illegible]
14	A333									[illegible]
15	A337									[illegible]
16	A338									[illegible]
17	A339									[illegible]
18	A342									[illegible]
19	A343									[illegible]



PDF File
With Runway Exit
Clusters used in REDM 4

https://atsl.cee.vt.edu/products/runway-exit-design-interactive-model--redim-1.html

Runway Exit Design Tool Application in FAA Advisory Circular 150/5300-13B

U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject: Airport Design | Date: 3/31/2022 | AC No: 150/5300-13B
Initiated By: AAS-100 | Change:

4. Assess the exit taxiway location's impact on runway occupancy time and capacity.

   a. The Runway Exit Design Interactive Model (REDIM) is the preferred quantitative method for determining the location and mix of high speed and right-angle runway exits. See https://www.faa.gov/airports/engineering/design_software/ for airport design software.

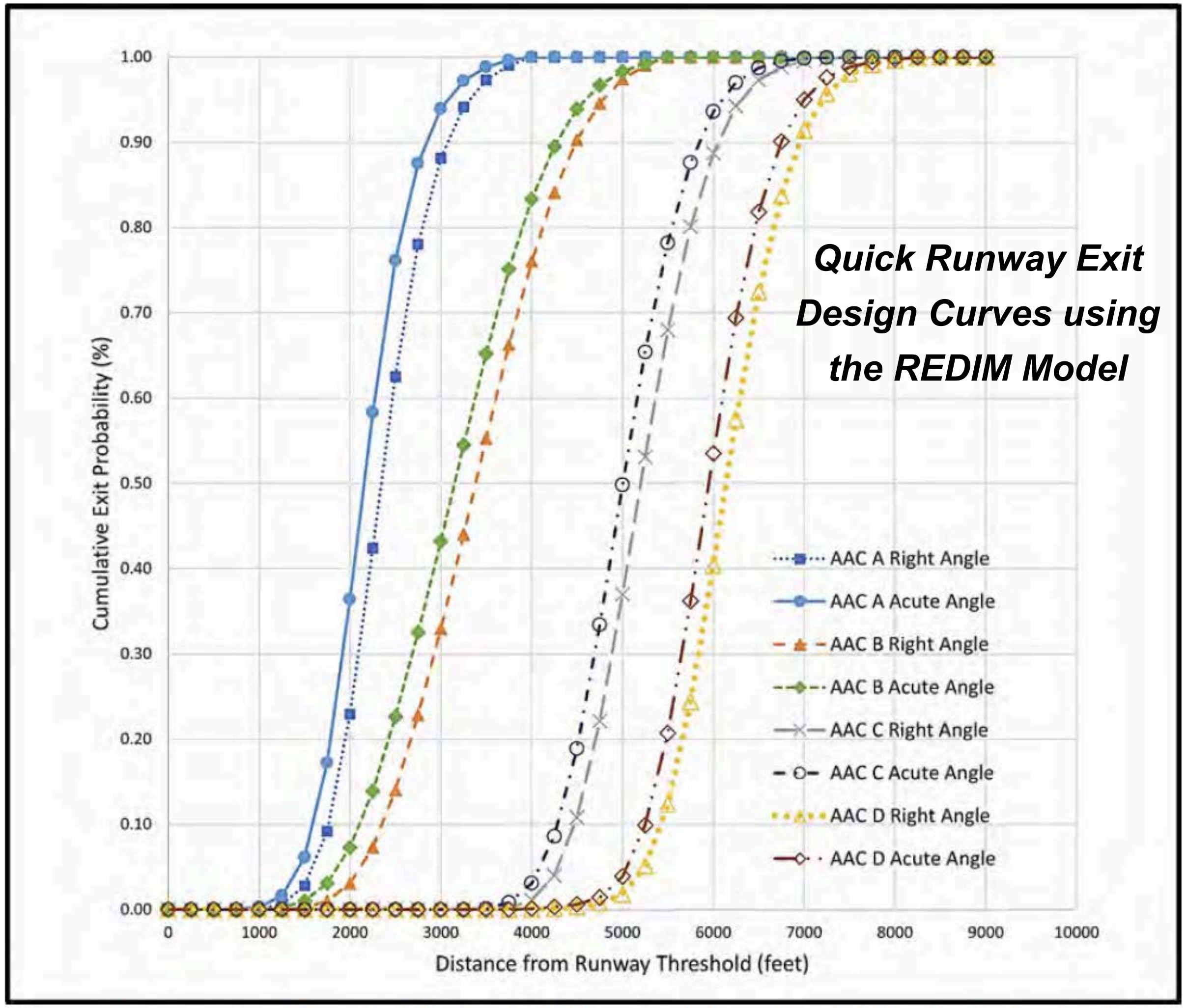
   b. Fast-time simulation modeling, used alone, is not a reliable means of locating exit taxiways.

   c. Figure 4-17 provides a simplified method using cumulative distributions of exit usage by the AAC at airports with an elevation under 2,000 feet (610 m) MSL.

      i. Figure 4-17 uses the same observed aircraft performance data contained in REDIM.

      ii. This method is appropriate to use for the initial, conceptual planning for location of exit taxiways.

Figure 4-17. Cumulative Probability of Aircraft Able to Exit by AAC at Airports With an Elevation Less Than 2,000 feet (610 m) MSL



Quick Runway Exit Design Curves using the REDIM Model

Improvements to the FAA Aircraft Characteristics Database

- Updated the existing Aircraft Characteristics Database (ACD)
  - Merged information collected in the development of the Runway Exit Tool project with Traffic Systems Management Count Data (TFMS-C) and FAA Flight Standards information
  - Update Taxiway Design Group (TDG) in the FAA ACD with new groups defined in FAA AC 150/5300-13B

ICAO_Code	FAA_Designator	Manufacturer	Model_FAA	Model_BADA	hysical_Class_Eng	Num_Engin	AAC	ADG	TDG
A10	A10	FAIRCHILD	Fairchild A10	Fairchild A-10A	Jet	2	C	II	2A
A124	A124	ANTONOV	Antonov AN-124 Ruslan	Antonov AN-124-	Jet	4	D	VI	5
A19N	A19N	AIRBUS	Airbus A319 Neo	Airbus A319 Neo	Jet	2	C	III	3
A20N	A20N	AIRBUS	Airbus A320 Neo	Airbus A320-271N	Jet	2	C	III	3
A21N	A21N	AIRBUS	Airbus A321 Neo	Airbus A321-251N	Jet	2	C	III	3
A306	A306	AIRBUS	Airbus A300 B4-600	Airbus A300B4-62	Jet	2	C	IV	5
A30B	A30B	AIRBUS	Airbus A300-B2	Airbus A300B4-20	Jet	2	C	IV	5
A310	A310	AIRBUS	Airbus A310	Airbus A310-204	Jet	2	C	IV	5
A318	A318	AIRBUS	Airbus A318	Airbus A318-112	Jet	2	C	III	3
A319	A319	AIRBUS	Airbus A319	Airbus A319-131	Jet	2	C	III	3
A320	A320	AIRBUS	Airbus A320	Airbus A320-231	Jet	2	C	III	3
A321	A321	AIRBUS	Airbus A321	Airbus A321-111	Jet	2	C	III	3
A332	A332	AIRBUS	Airbus A330-200	Airbus A330-243	Jet	2	C	V	5
A333	A333	AIRBUS	Airbus A330-300	Airbus A330-301	Jet	2	C	V	5
A337	A337	AIRBUS	Airbus A330-700 - Beluga XL	Airbus A330-700	Jet	2	C	V	5
A338	A338	AIRBUS	Airbus A330-800	Airbus A330-800	Jet	2	C	V	5
A339	A339	AIRBUS	Airbus A330-900	Airbus A330-941	Jet	2	C	V	5
A342	A342	AIRBUS	Airbus A340-200	Airbus A340-213	Jet	4	D	V	5
A343	A343	AIRBUS	Airbus A340-300	Airbus A340-313	Jet	4	D	V	5
A345	A345	AIRBUS	Airbus A340-500	Airbus A340-541	Jet	4	D	V	6
A346	A346	AIRBUS	Airbus A340-600	Airbus A340-642	Jet	4	D	V	6
A359	A359	AIRBUS	Airbus 350-900	Airbus A350-941	Jet	2	C	V	5
A35K	A35K	AIRBUS	Airbus A350-1000 XWB	Airbus A350-1041	Jet	2	D	VI	6
A388	A388	AIRBUS	Airbus A380-800	Airbus A380-841	Jet	4	C	VI	6
A400	A400	AIRBUS	Airbus A400M Atlas	Airbus A-400M	Turboprop	4	C	IV	3

Characteristics/Fields	Characteristics/Fields
Main Gear Width (MGW) Outer to Outer	Approach Speed (Vref)
Wheelbase	Wingspan
Maximum Take-Off Weight (MTOW)	Length
Main (Landing) Gear Configurations	Class
Wake Category (Replaced with "ICAO Wake Turbulence Category")	Cockpit to Main Gear (CMG) Distance
ATCT Weight Class	FAA Weight
Tail Height at Operating Empty Weight (OEW)	Consolidated Wake Turbulence (CWT)
RECAT 1.5 Wake Category	Same Runway Separation (SRS)
RECAT 2.0 Wake Category Appendix A	ICAO Weight
RECAT 2.0 Wake Category Appendix B	Land and Hold Short Operations (LAHSO)
Minimum Parking Area Sizing	Total Operations 2021-2022
Maximum Landing Weight (MLW)	Rotor Diameter
Manufacturer	FAA Registry (Yes/No)
Model	Registration Count
ICAO Code	Taxiway Design Group (TDG)
Physical Class Engine	Aircraft Design Group (ADG)
Number of Engines	
Aircraft Approach Category (AAC)	

- *387 distinct aircraft types*
- *181,844 aircraft in FAA US registry*
- *56.5 million IFR operations (years 2021-2022)*

Conclusions

- This project improved three products:
  - REDIM model 4 includes pilot motivation, improved runway exit definitions, and improved statistical distributions for individual aircraft (i.e., larger sampling datasets)
  - Landing Events Database (version 1.3.7) includes a larger dataset (32 million records), more airports covered (43 airports), and improved filters to facilitate runway operational analyses
  - Aircraft characteristics database (ACD) includes updated TDG groups, and 34 validated fields
- The project demonstrates that NEXTOR 3 products are useful to researchers and industry practitioners

Possible Improvements to REDIM 4

- Ability to set multiple motivation factors by aircraft type.
  - Example: Boeing 737-8Max
    - 30% MF = 0.9, 40% MF = 1.1, and 30% MF 1.3
- Ability to adjust PC Speeds and/or decelerations on exits.
  - This would allow for better “calibration” of the model by industry. For some airports like EWR 4L/22R, REDIM overestimates PC Speeds on high-speed exits due to the close proximity of a parallel taxiway (i.e., 400 feet).
- Add more flexibility to the “Improvement Case”.
  - Right now, REDIM can only place new exits between two consecutive existing exists.
  - Practitioners need the ability to place exits between any two exits instead and consider existing exits in between.

Contact Information and Web Site

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