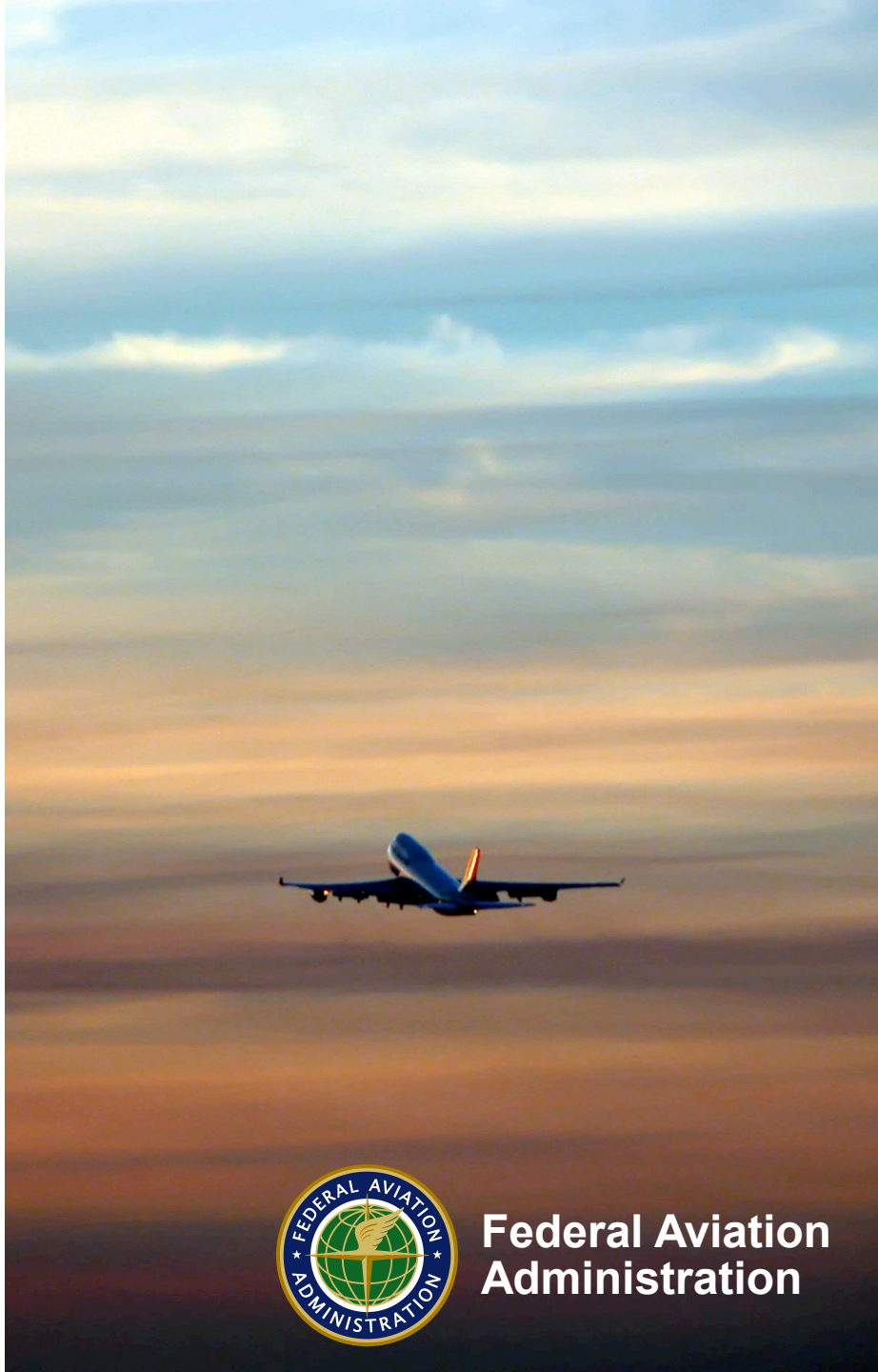
Airport Pavements

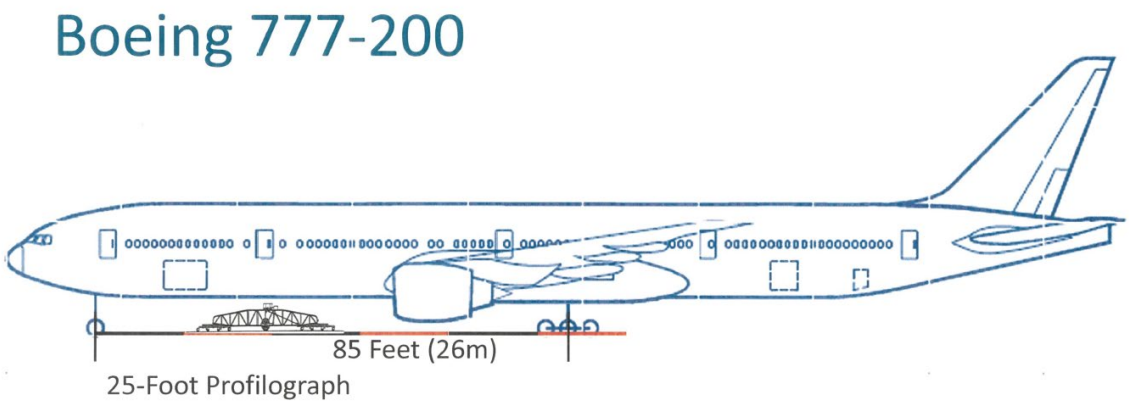
Runway Roughness Index

Presented to:	Research, Engineering and Development Advisory Committee
By:	Matthew Brynick, RPA6 Manager
Date:	March 4, 2020



Objectives

- **Increase Safety**
- **Validate use of BBI**
- **Evaluate effect of**
  - aircraft type
  - pavement type
  - pavement use
- **Develop RRI**
- **Update FAA AC 150/5380-9**
- **Update FAA ProFAA**

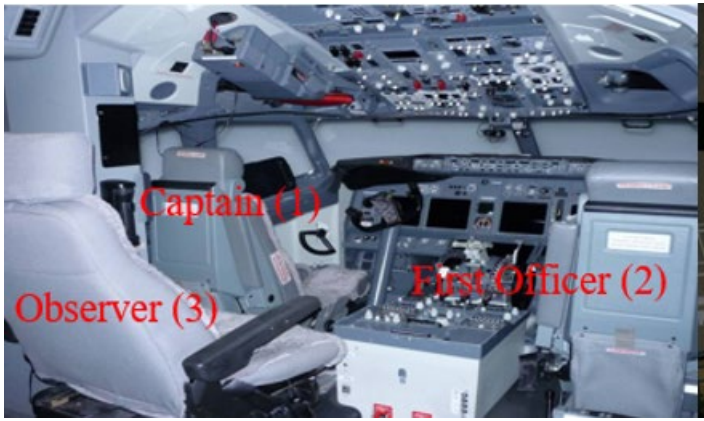


Milestone Schedule

Task	Year			
	2019	2020	2021	2022
1. Conduct Literature Review	[redacted]			
2. Validate the BBI, Revise the BBI or Develop the Alternative Runway Roughness Index	[redacted]			
3. Conduct Full-Scale Test	[redacted]			
4. Collaborate with Boeing and Third Parties on Pavement Roughness Research		[redacted]		
5. Update FAA AC 150/5380-9 and ProFAA			[redacted]	

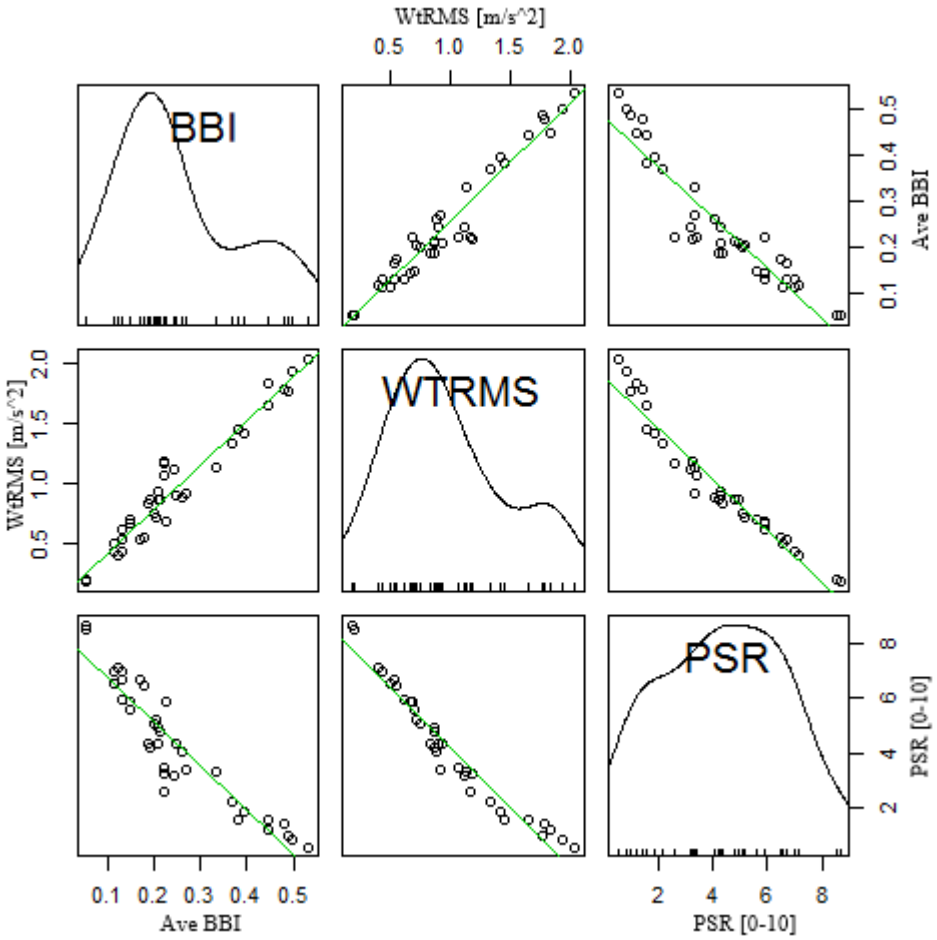
Literature Review

- **Mike Monroney Aeronautical Center (MMAC) B737-800 and A330-200 simulators.**
- **FAA and ICAO uses only the Boeing Bump Index (BBI) to quantify in-service airport pavement roughness thresholds.**
- **Collection Systems**
  - Inertial profiler, walk-behind profiler



Validate BBI

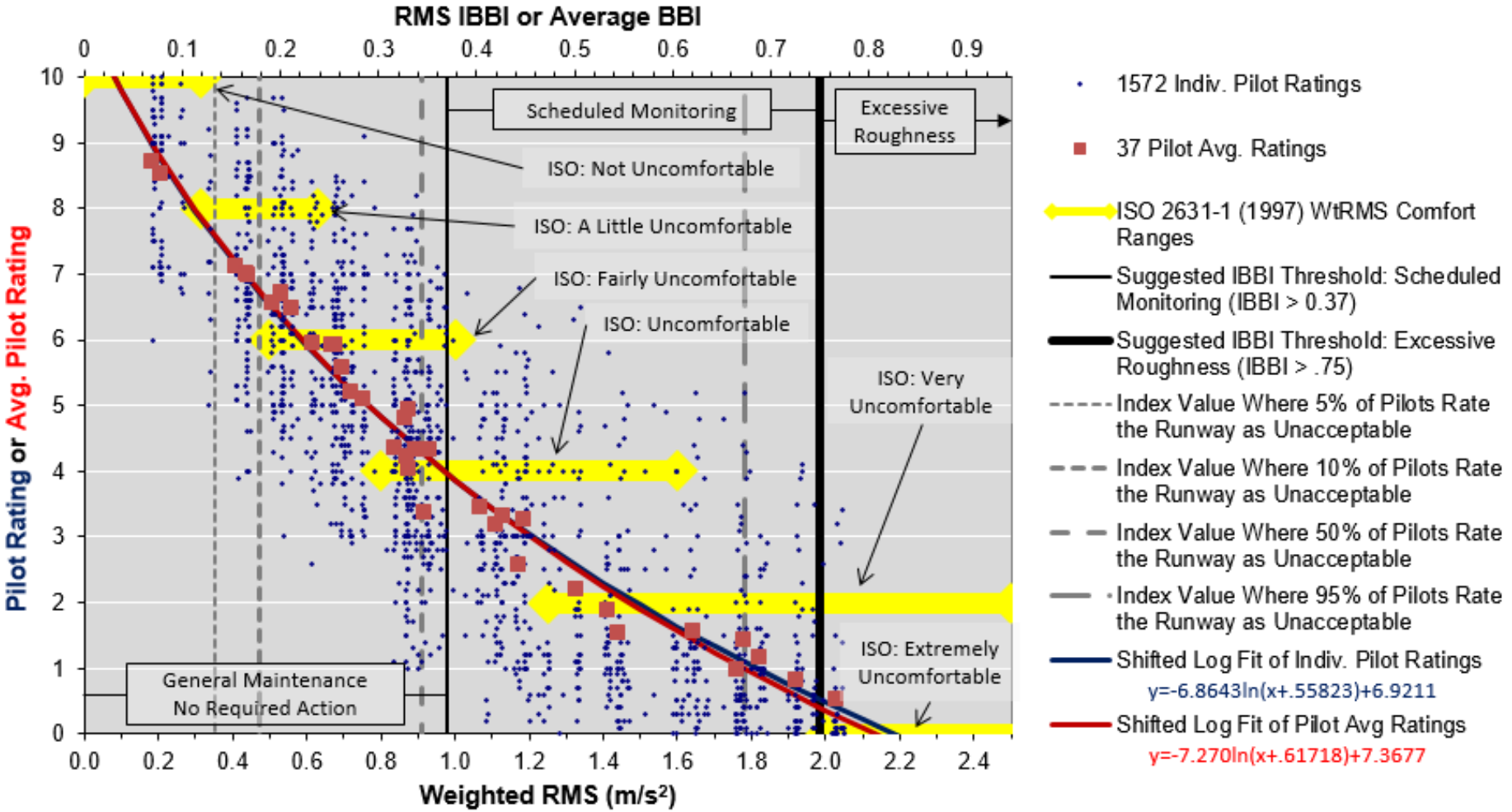
- **A statistical correlation was established between BBI, PSR and WtRMS using the MMAC data**
- **good correlation between**
  - Average BBI and WtRMS
  - WtRMS and PSR
  - BBI and PSR



Runway Roughness Index Development

- **The Runway Roughness Index (RRI) was developed by considering three factors:**
  - BBI (Boeing Bump Index)
  - PSR (Pilot Subjective Rating)
  - WtRMS (ISO weighted root mean squared) of vertical acceleration
- **ISO discomfort levels based on WtRMS have significant overlap with each other**
- **The PSR was used to develop prediction curves based on WtRMS**

PSR, WtRMS, BBI and RRI



WtRMS, RRI, and PSR

Suggested RRI Thresholds

	WtRMS	RMS RRI	Predicted Pilot Rating using Indv	Predicted Pilot Rating using Avg
Suggested RMS RRI Threshold: Scheduled Monitoring (RRI > 0.37)	0.98	**0.37**	4.0	4.0
Suggested RMS RRI Threshold: Excessive Roughness (RRI > .75)	1.98	**0.75**	0.4	0.5

MMAC Unacceptable Runway Pilot Evaluations

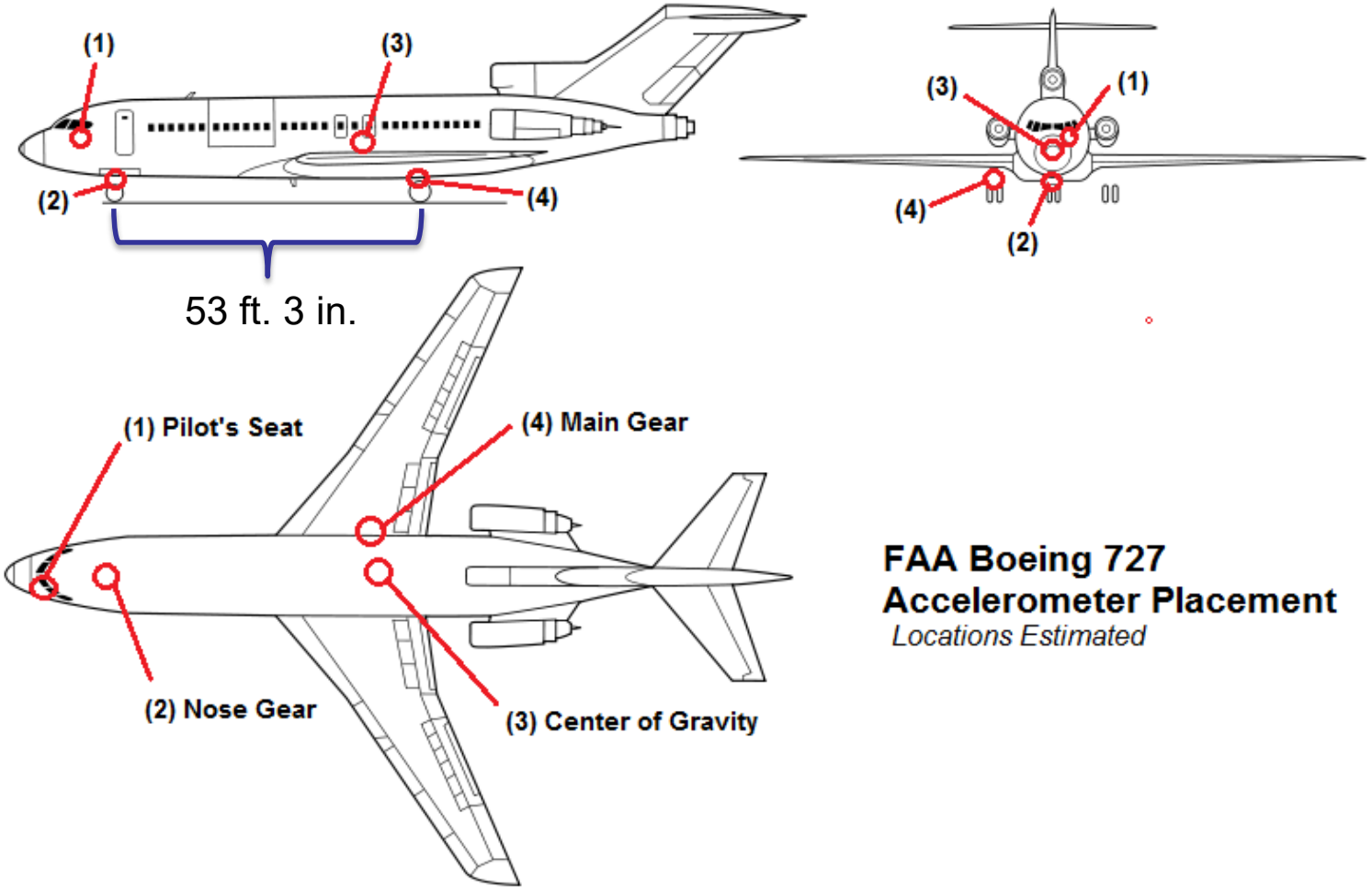
	WtRMS	RMS RRI	Predicted Pilot Rating using Indv	Predicted Pilot Rating using Avg
Index Value Where 5% of Pilots Rate the Runway as Unacceptable	**0.35**	0.13	7.6	7.6
Index Value Where 10% of Pilots Rate the Runway as Unacceptable	**0.47**	0.18	6.8	6.7
Index Value Where 50% of Pilots Rate the Runway as Unacceptable	**0.91**	0.34	4.3	4.3
Index Value Where 95% of Pilots Rate the Runway as Unacceptable	**1.78**	0.67	1.0	1.1

ISO Comfort Ratings

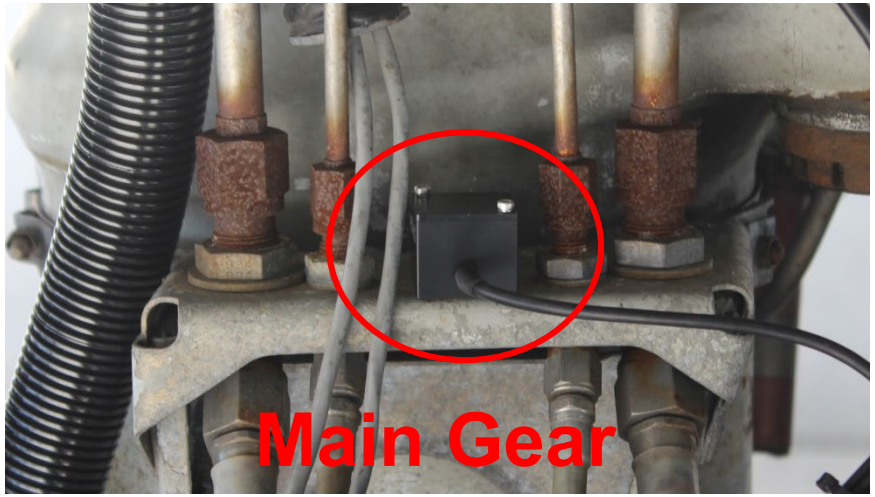
ISO Description		WtRMS	RMS RRI		Predicted Pilot Rating using Individual	Predicted Pilot Rating using Average
Not uncomfortable	min	0.000	0.000	max	10.9 (10)	10.9 (10)
	max	0.315	0.119	min	7.9	7.9
A Little Uncomfortable	min	0.315	0.119	max	7.9	7.9
	max	0.630	0.238	min	5.8	5.7
Fairly Uncomfortable	min	0.500	0.189	max	6.6	6.5
	max	1.000	0.378	min	3.9	3.9
Uncomfortable	min	0.800	0.302	max	4.8	4.8
	max	1.600	0.605	min	1.6	1.6
Very Uncomfortable	min	1.250	0.473	max	2.8	2.9
	max	2.500	0.945	min	-0.9 (0)	-0.8 (0)
Extremely Uncomfortable	greater than	2.000	0.756	less than	0.4	0.5

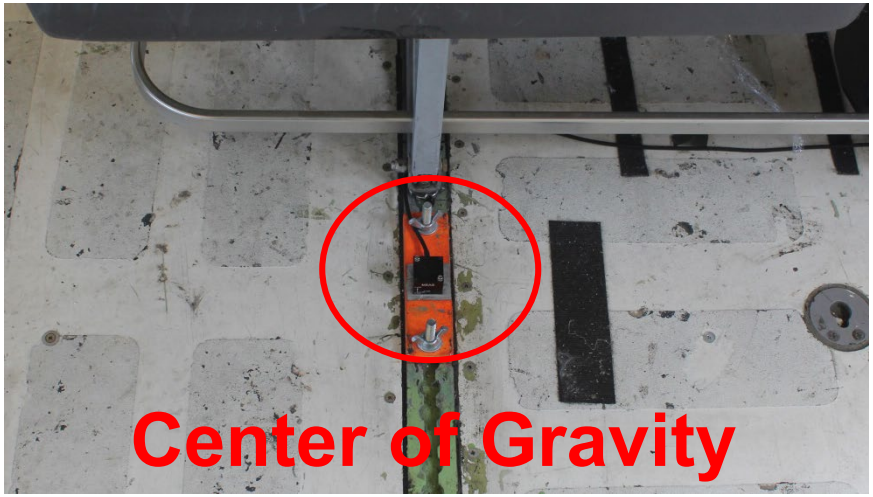
Boeing 727-100 Longitudinal Profile Data Collected at ACY

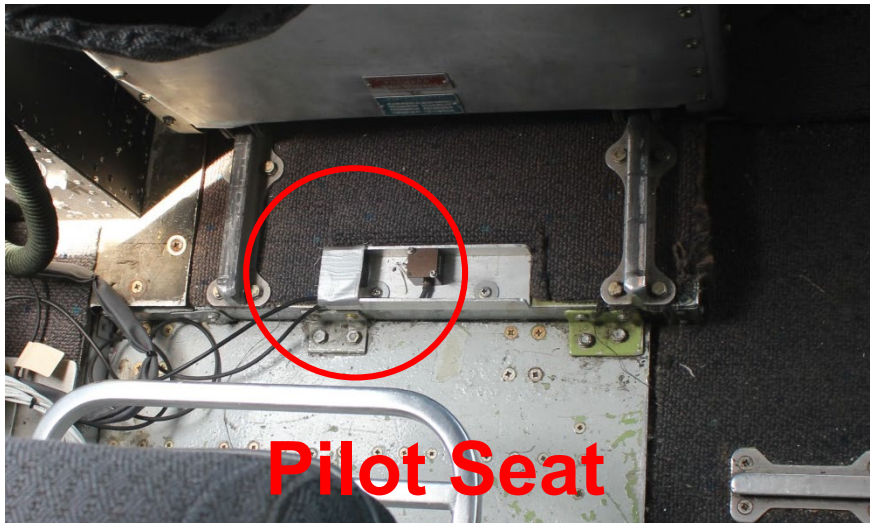
Accelerometer Locations on the B727-100



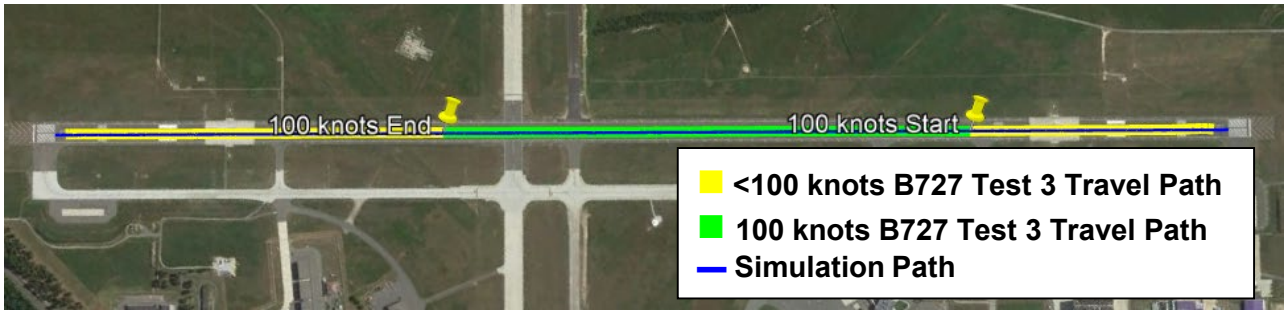
Accelerometers on the B727

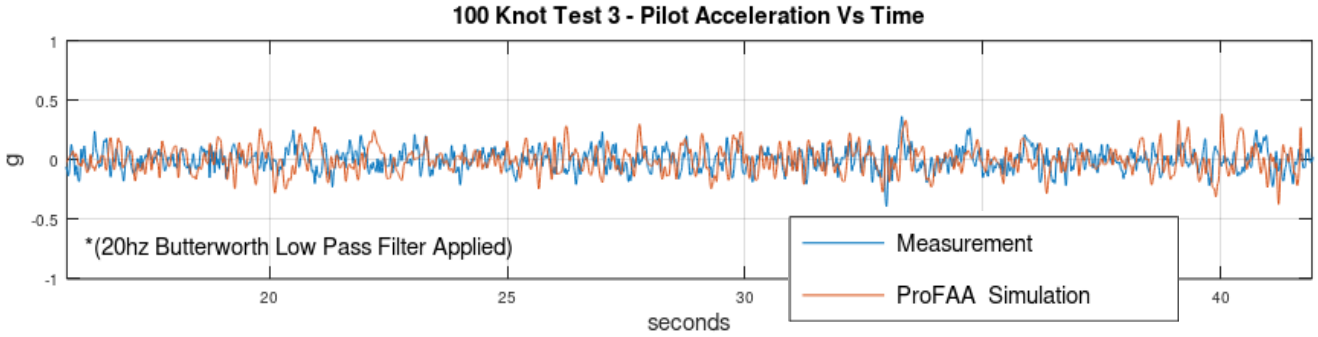






100 Knots Testing With The FAA Owned Boeing 727-100 R&D40





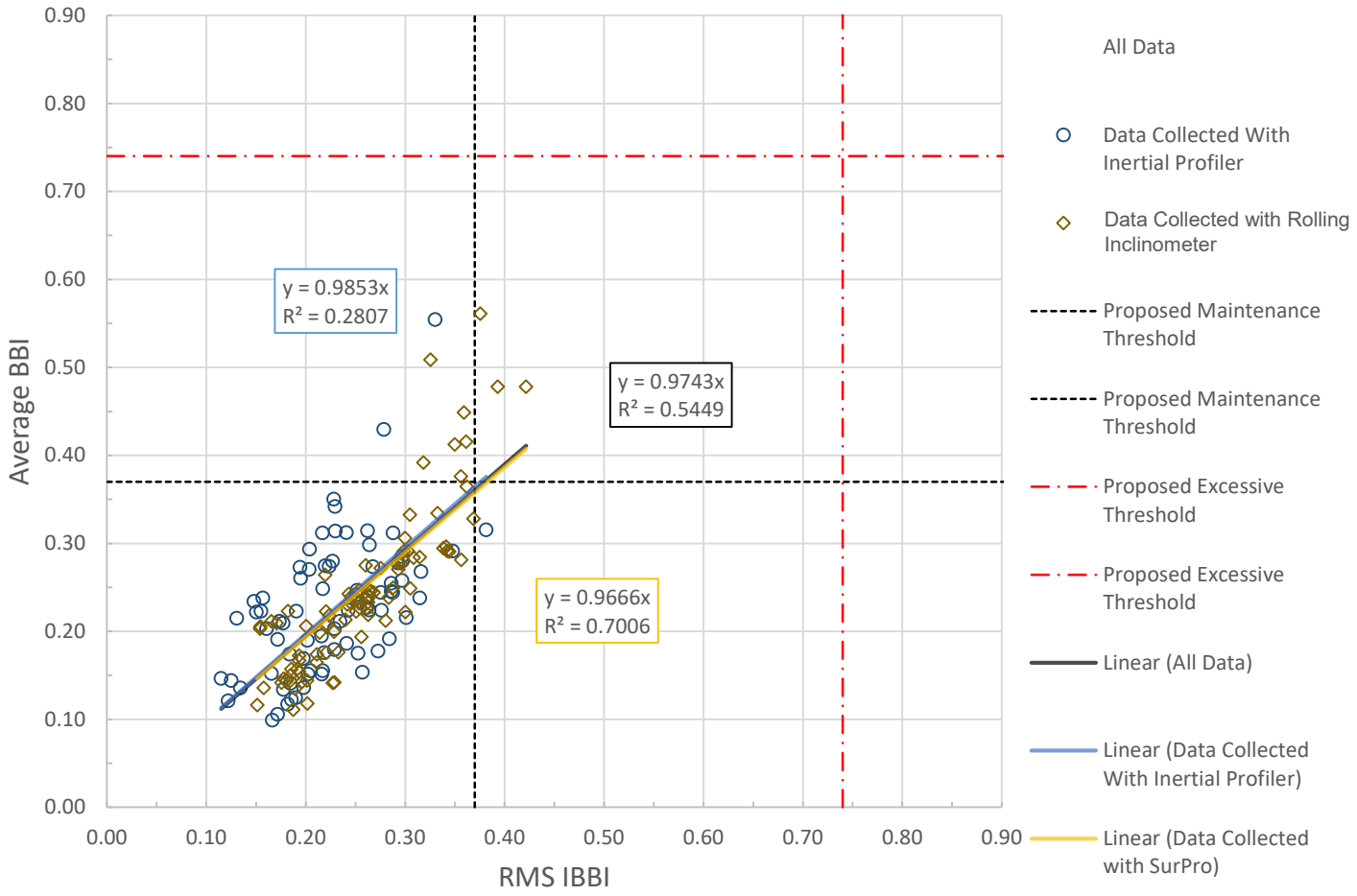
Plane Location	Measurement or Simulation	Record Length	Weighted RMS	Weighted MTVV	Weighted VDV	DKup	Weighted Crest Factor
		[seconds]	[m/s^2]	[m/s^2]	[m/s$^{1.75}$]	[m/s^2]	[m/s^2]
Center of Gravity	Measured	26.22	0.21	0.29	2.35	1.02	5.29
Cockpit	Measured	26.22	0.70	1.13	7.47	3.12	4.11
Center of Gravity	ProFAA Simulation	26.02	0.37	0.63	4.20	1.65	4.54
Cockpit	ProFAA Simulation	26.02	0.79	1.31	8.74	3.89	4.75

RRI Comparison And Analysis

- **A comparison between the RRI was performed using previously collected profile data.**
- **The data distribution can be seen below**

Device	Total Number of Airports	Total Number of Profiles	Number of Asphalt Profiles	Number Of Concrete Profiles	Asphalt / Concrete Profiles
Rolling Inclinometer	15	89	46	37	6
Inertial Profiler	15	86	31	47	8

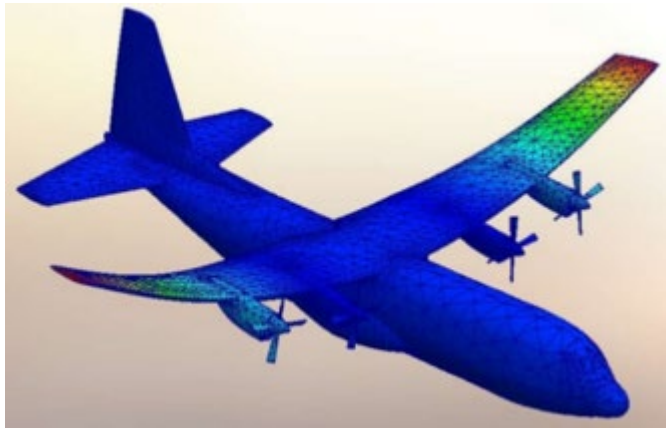
RRI vs. Boeing Bump Index (BBI)

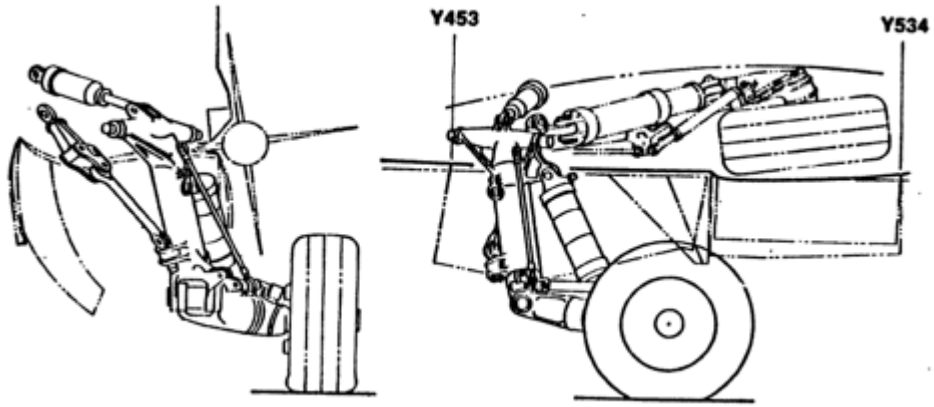


Collaborative Research

- **Boeing, ERDC, ASTM E17, GDIT, APR Consultants**
- **BAA Solicitation 692M15-20-R-00004**

Topic Number: ARAP0001: Develop Measurements, Specifications, and Guidance for Multiple Bump Events of Airport Pavement Roughness to Supplement the Existing Pavement Surface Boeing Bump Index (BBI)





FAA AC 150/5380-9 and ProFAA

- **Runway Roughness Index (RRI)**
- **Multiple Event Bump**
- **Taxiway Roughness Index**