Future Federal Aviation Administration (FAA) Developments of Roughness Evaluation for In-Service Airport Pavement

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Project Background

- **Currently, the FAA uses only the Boeing Bump Index (BBI) to quantify in-service airport pavement roughness thresholds.**
- **The Airport Pavement R & D Section collected and analyzed airport pavement roughness data using the Mike Monroney Aeronautical Center (MMAC) B737 and A330 simulators.**
- **We have also instrumented the FAA owned B727-100 with an inertial profiler system.**
- **To date, we have collected Boeing 727 inertial profiling data at 20 knots (37.0 km/hr.)**
- **Inertial profiler installed on portside main gear**

Objective

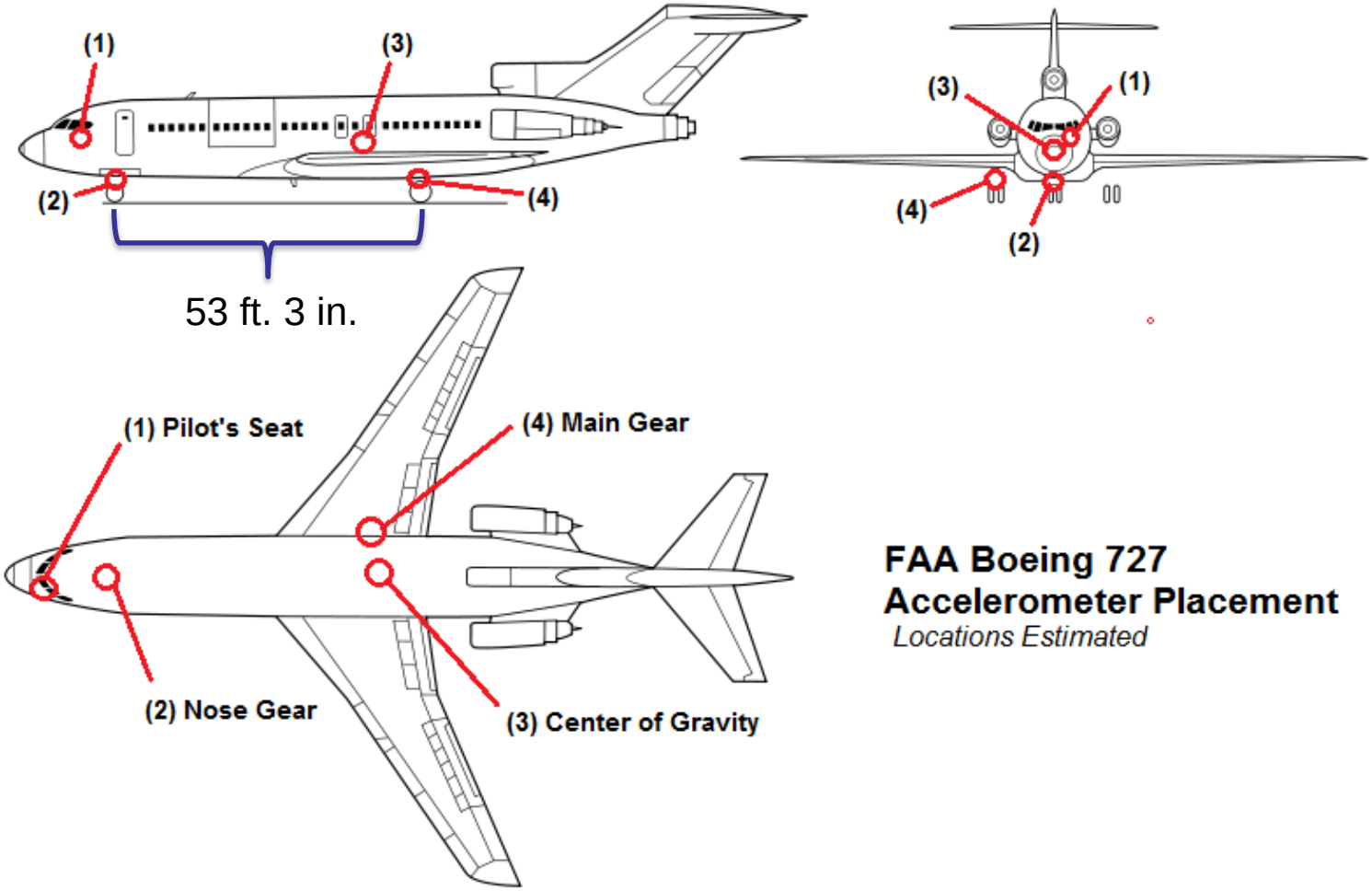
- **Correlate the current ProFAA roughness indices to the aircraft simulator responses.**
- **Compare the field-measured B727 acceleration to the ProFAA simulated aircraft acceleration to optimize the ProFAA aircraft simulation.**
- **Develop new roughness index for in-service runway pavement based on the ProFAA aircraft simulation model.**

Statistical Analysis for New Roughness Index Development

- **Evaluate the correlations between ProFAA indices and MMAC simulators International Organization for Standardization (ISO) indices.**
- **Divide data into groups: runway/taxiway, B737/A330.**
- **Develop regression models between ProFAA indices and ISO indices for each data group using linear regression analysis techniques.**
- **Choose the best regression model of each situation for the new roughness index development**
- **The new roughness index will be developed from ISO indices based on the regression models**

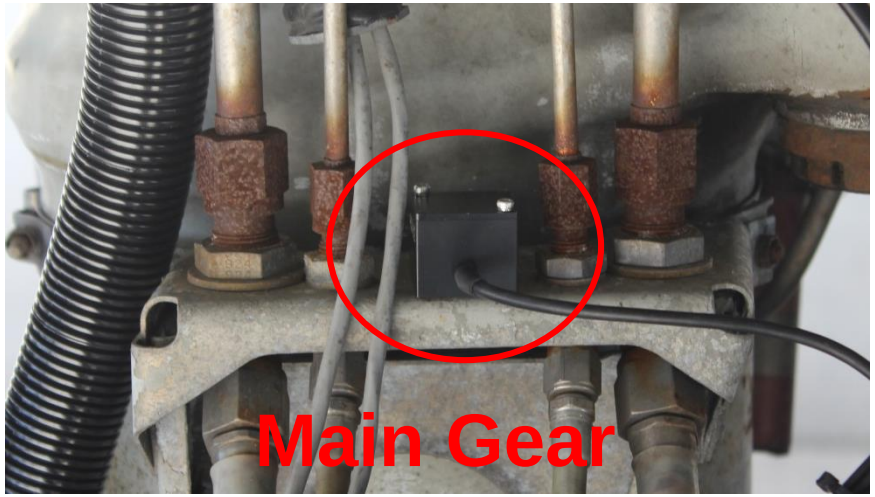
Boeing 727-100 Longitudinal Profile Data Collected at a Domestic Location

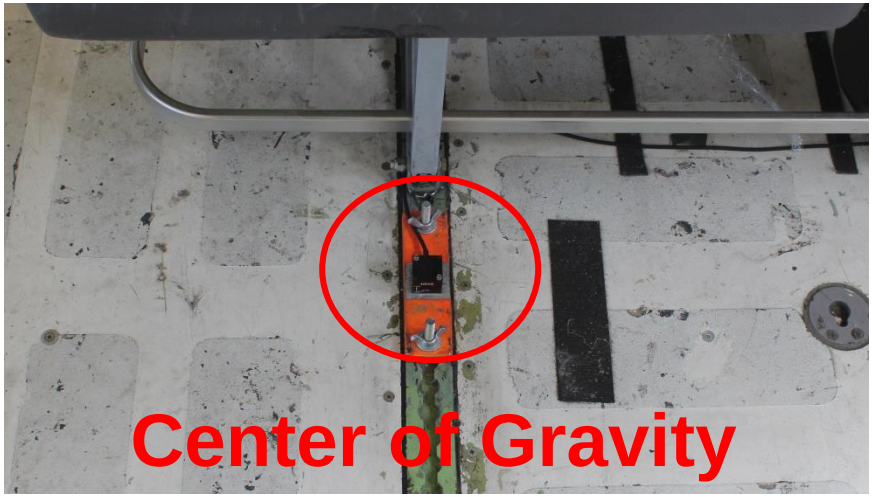
Accelerometer Locations on the B727-100

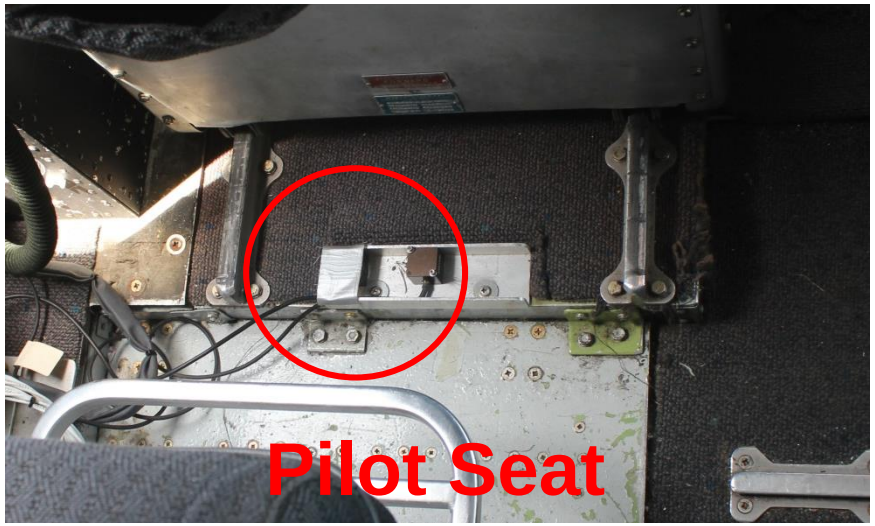


FAA Boeing 727
Accelerometer Placement
Locations Estimated

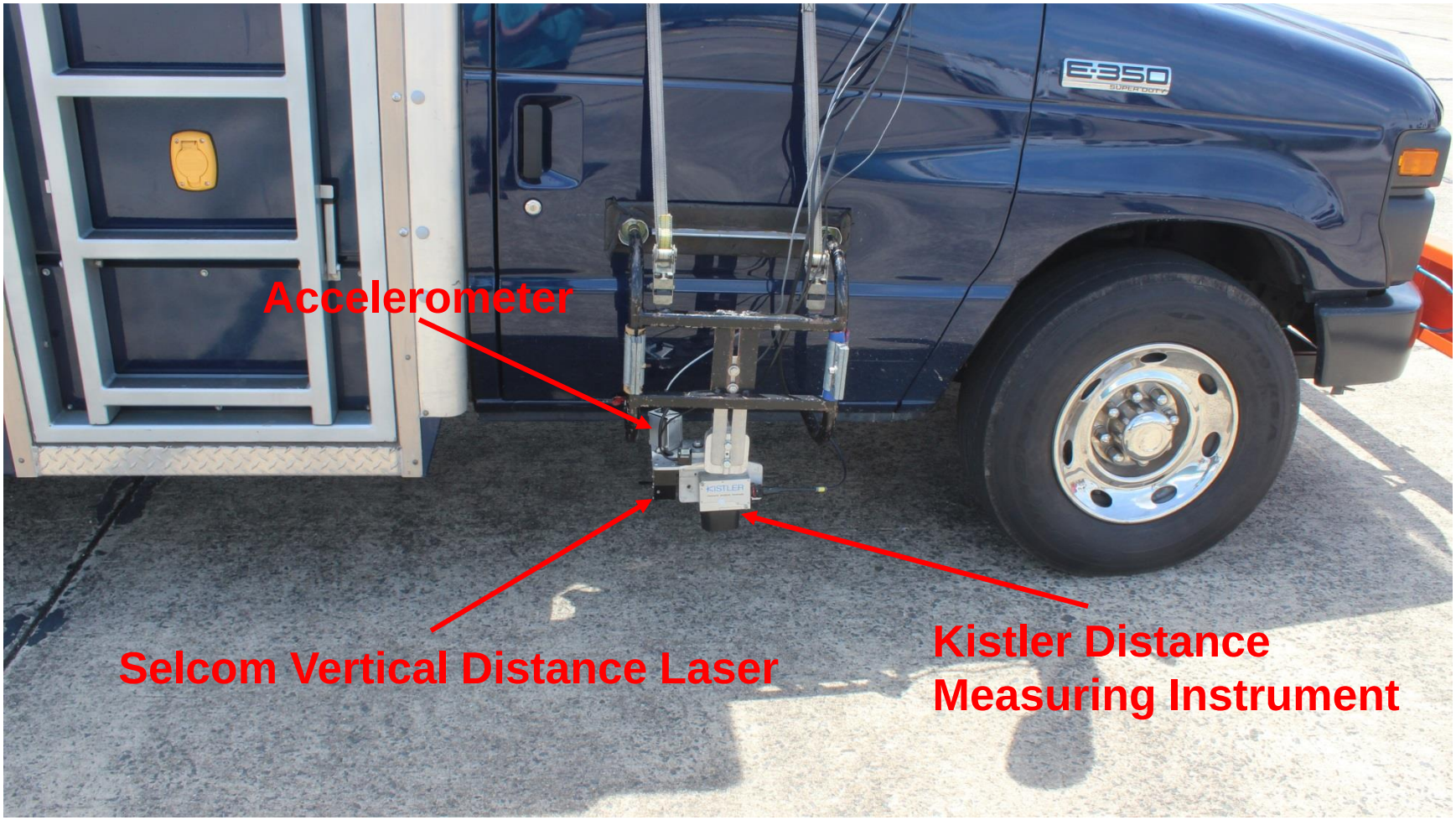
Accelerometers on the B727







FAA NDT Van Inertial Profiler



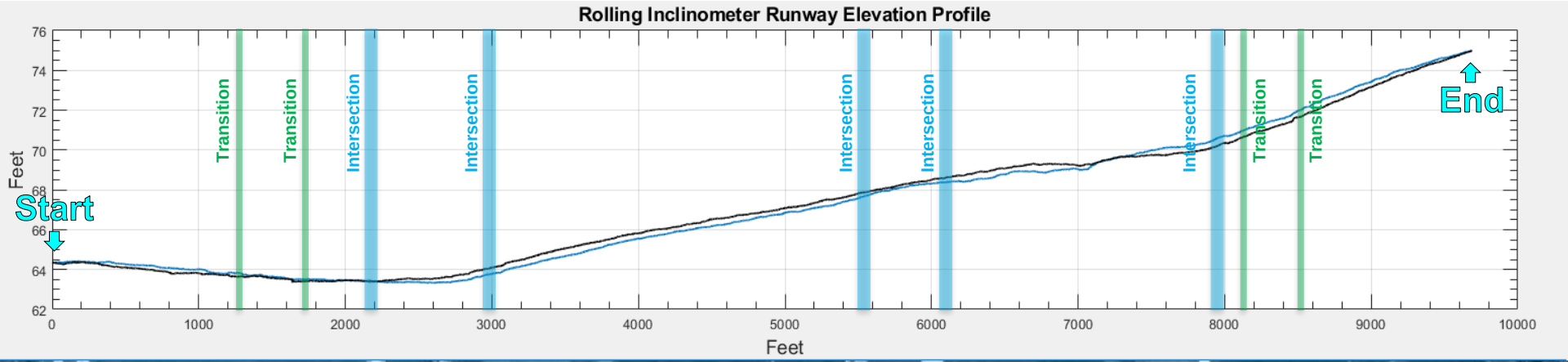
Profiling Equipment Testing Path Traveling E to W

All locations referenced from East end of Runway:
Arresting gears system locations: 1400, 8200 ft.
Runway intersections locations : 2000, 2800, 5300, 5850, 7750 ft.
Asphalt/Concrete transition locations: 1190, 1600, 7970, 8370 ft.
Total Length: 10,000 ft. – Asphalt Runway

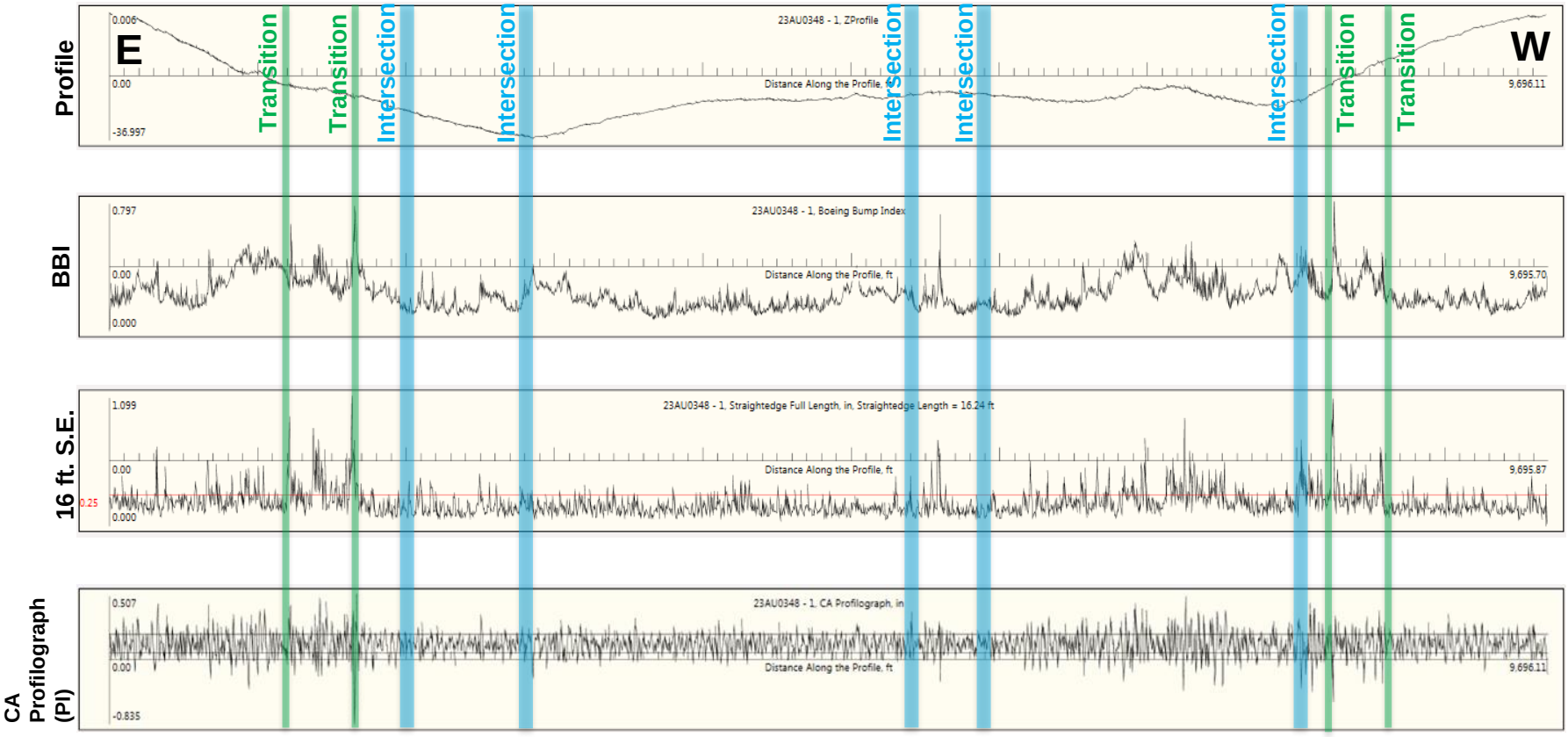
Rolling Inclinometer Profile

- **A walk-behind rolling inclinometer profiler was used to collect elevation profiles on the runway. This device uses angle measurements to produce an elevation profile and compute roughness indices.**
- **A measurement wheel and a PVC spacer was used to keep a consistent distance from the centerline on the same path as the profiler attached to the B727.**
- **GPS data was also collected with the use of an attached GPS device.**

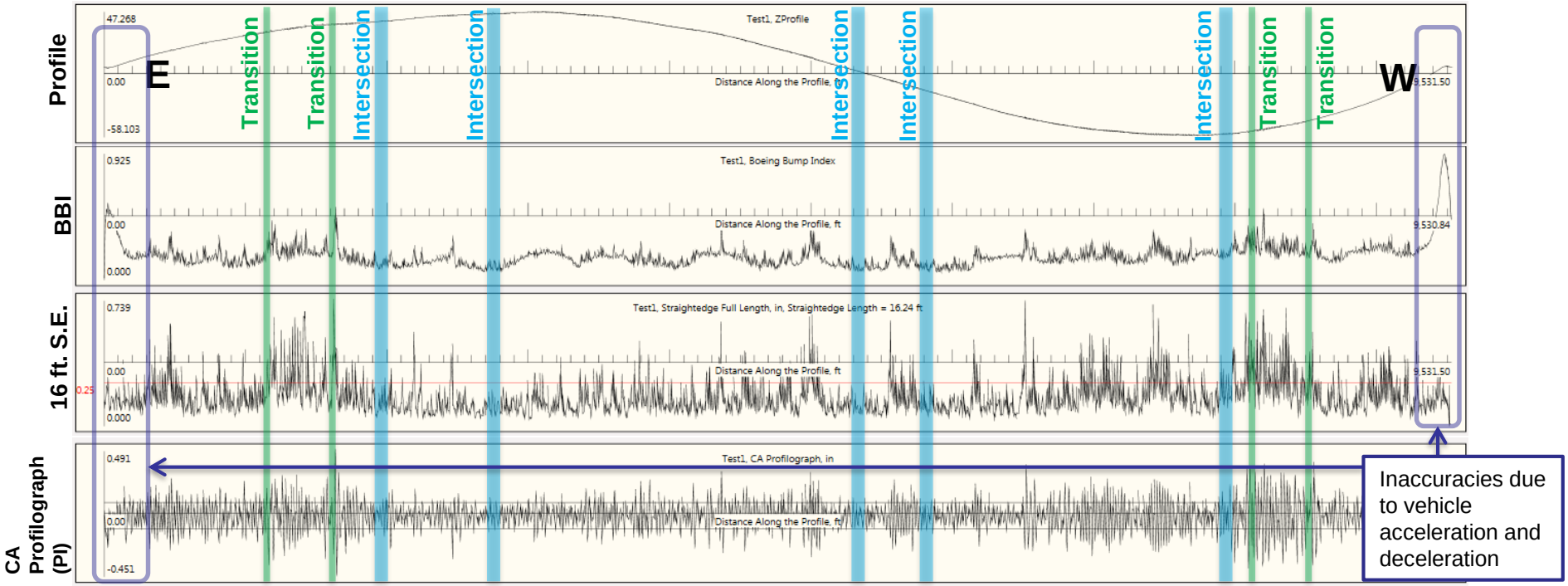
Rolling Inclinometer Runway Elevation Profile Traveling E to W: Plotted with Matlab



Rolling Inclinometer Runway Elevation Profile Traveling E to W: ProFAA Roughness Analysis



B727 Inertial Profiler Profile Traveling E to W: ProFAA Roughness Analysis



- **Roughness evaluation of B727 inertial profile shows consistent trends with that found from the rolling inclinometer elevation profile.**
- **Inaccuracies that exist due to vehicle acceleration and deceleration are truncated from the data for roughness index calculation, and are ignored for roughness evaluation**

B727 ProFAA Roughness Indices (RW)

Roughness Index	727 I.P. 20 Knots Run 1*	727 I.P. 20 Knots Run 2*	Rolling Inclinometer 1*	Rolling Inclinometer 2*	NDT Van I.P. 25 mph Run 1*	NDT Van I.P. 25 mph Run 2*
Straightedge	0.1688 in	0.1713 in	0.1894 in	0.2194 in	0.1145 in	0.1145 in
Boeing Bump Index	0.1693	0.1644	0.2490	0.2844	0.2567	0.2737
IRI (1/4 Car)	122.8 in/mile	129.3 in/mile	156.1 in/mile	182.5 in/mile	98.4 in/mile	99.6 in/mile
CA Profilograph (Profile Index)	20.6 in/mile	26.1 in/mile	31.1 in/mile	37.0 in/mile	9.2 in/mile	11.1 in/mile

*Data collected from same location on runway (14 feet South of Centerline)

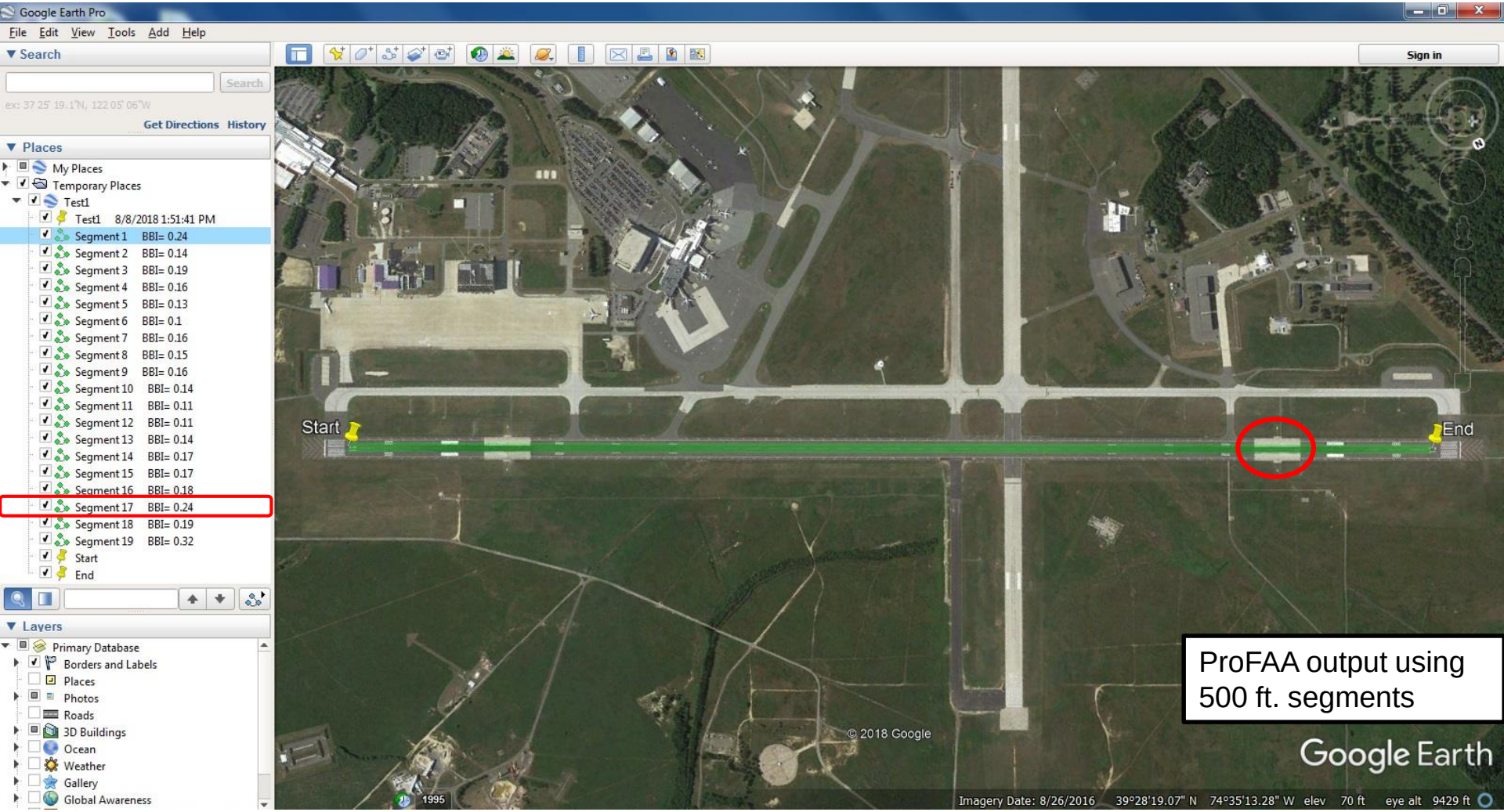
Status of New Index Development

- **Linear statistical correlation model was obtained between BBI and WtRMS for runways from aircraft simulator study, which will be used for the new in-service runway roughness index development.**
- **Compare the ISO weighted B727 cockpit acceleration from field measurement at 100 knots to the ISO weighed B727 cockpit acceleration from ProFAA simulation at 100knots to optimize the simulation and expand the simulation to B737 (in progress)**
- **Obtain the new runway roughness index based on the ISO weighted cockpit acceleration from ProFAA B737 simulation through the correlation model. (in progress)**

Conclusions and Recommendation

- **Statistical regression analysis was conducted to correlate ProFAA computed indices with Boeing 737-800 and Airbus A330-200 aircraft simulators test results.**
- **It can be found that the indices are directly related to WtRMS of acceleration. So far, WtRMS shows good correlation with ProFAA computed indices.**
- **Boeing Bump Index (BBI) has a very good linear statistical correlation with WtRMS for runways. This correlation model can be used for the new in-service runway roughness index development.**

ProFAA Analysis Of Boeing Bump Index



ProFAA output using 500 ft. segments

Conclusions and Future Work

- **The FAA B727 is being tested to evaluate the airplane responses due to the pavement profiles.**
- **The test was done at 20 knots. Future tests will be conducted at 100 knots to better simulate runway conditions.**
- **Field B727 test results will be compared to the existing aircraft simulation model in ProFAA for improvement.**
- **The new roughness index will be developed based on B737 vertical accelerations from the improved ProFAA aircraft simulation model.**

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