Enhancing Pavement Management

APR's Products and Services

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APR Consultants

- APR was Incorporated in 1993
- Develop Products and Services to Evaluate Airfield Pavement Profiles
  - Quantify Ride Quality
  - Pavement Management
  - Develop Repair Solutions
  - Evaluate Pavement Design
  - Measure Pavement Profiles
  - Track Profile Shape Changes

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Quantifying Ride Quality

- APR Pioneered the use of Aircraft Simulation to Assess Pavement Rideability
  - Takeoff, Landing, Constant Speed Taxi, Aborted Takeoff
  - Emulates 14 Different Commercial Aircraft
  - Predict Responses at Pilot's Station and Center of Gravity
  - Predict Pavement Loads
- Integrates into Airport's Pavement Management Program

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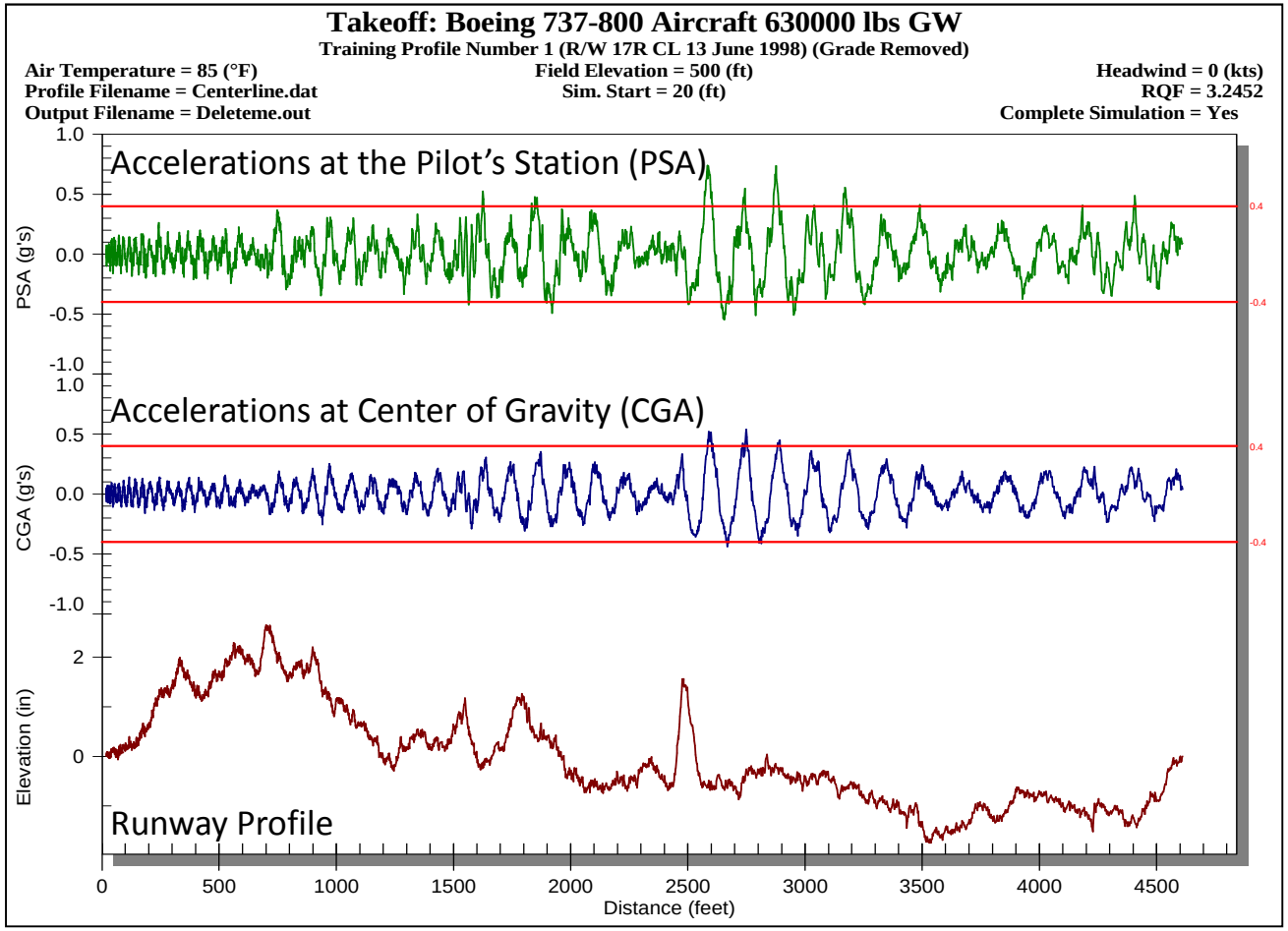
Aircraft Simulation



Profile Measurement

- The Auto Rod and Level
  - Measures a True Elevation Data Point Every .25-Meter
  - Can Measure a 3,300-Meter Line of Survey in Approximately 1 Hour
  - Equipment is Rugged and Weatherized
  - Requires a Team of Two plus Vehicle to Transport

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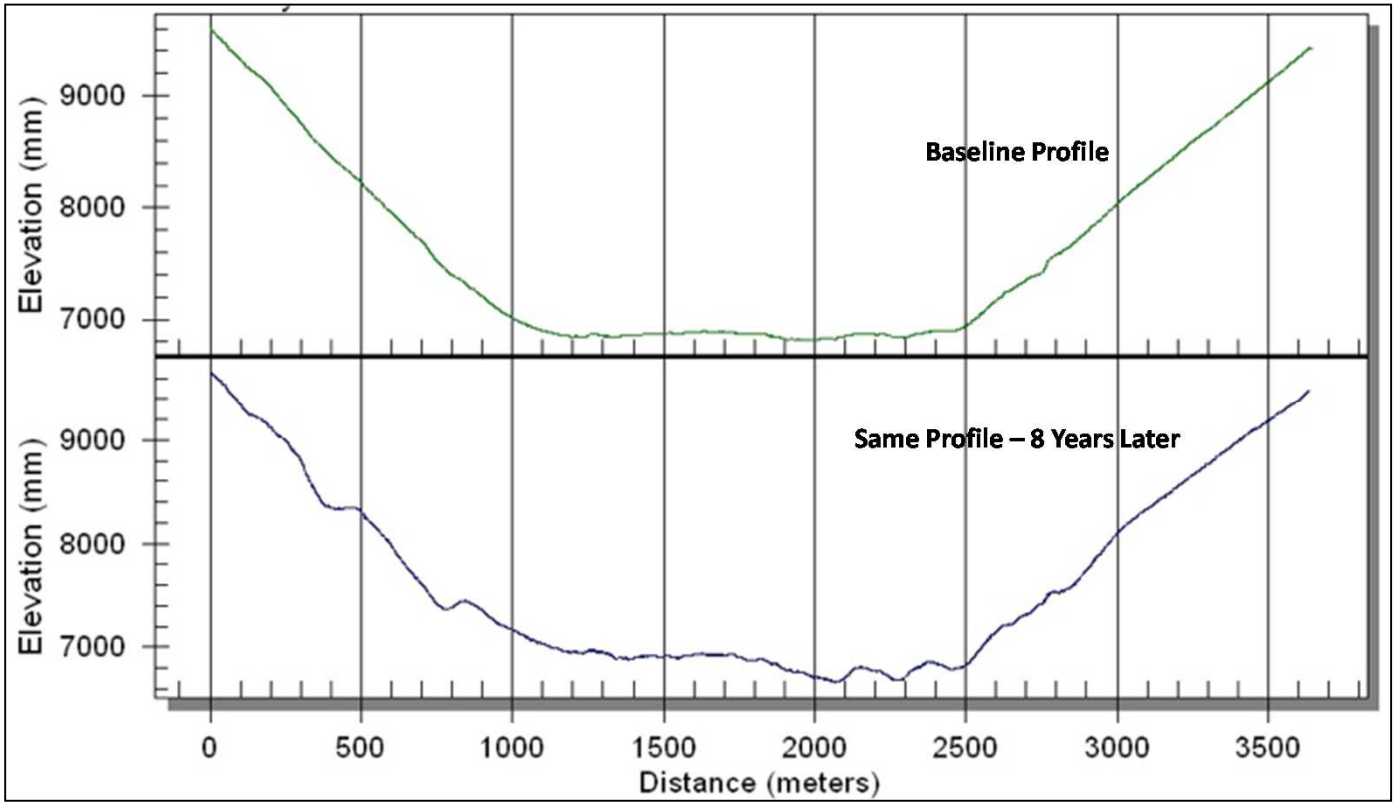
Why Measure True Profile?



- Perfect for Pavement Management
  - Track Settlement over Time.

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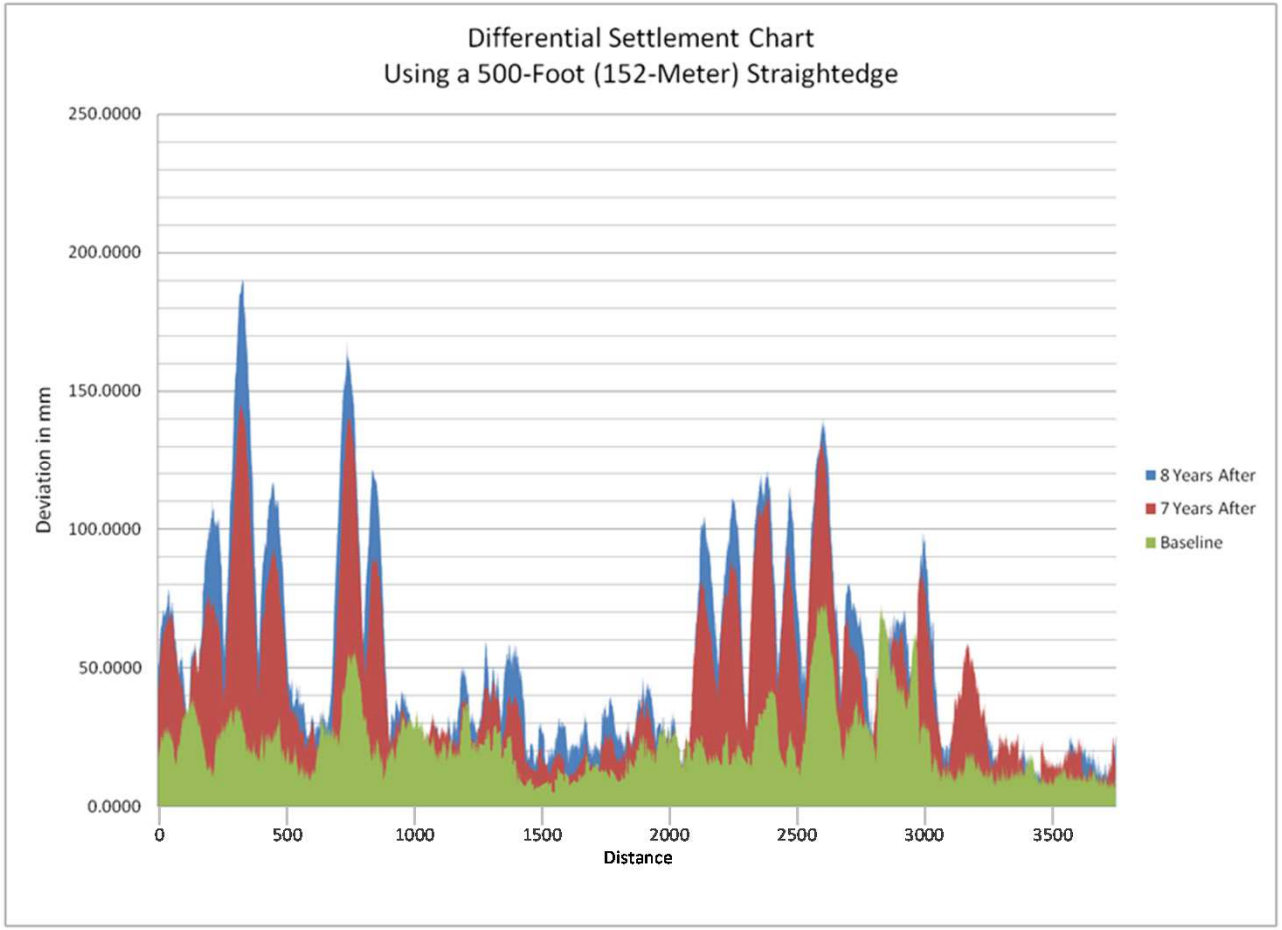
Why Measure True Profile (Con't)?



- Quantify Amount of Settlement
- Predict When Repairs Will be Necessary

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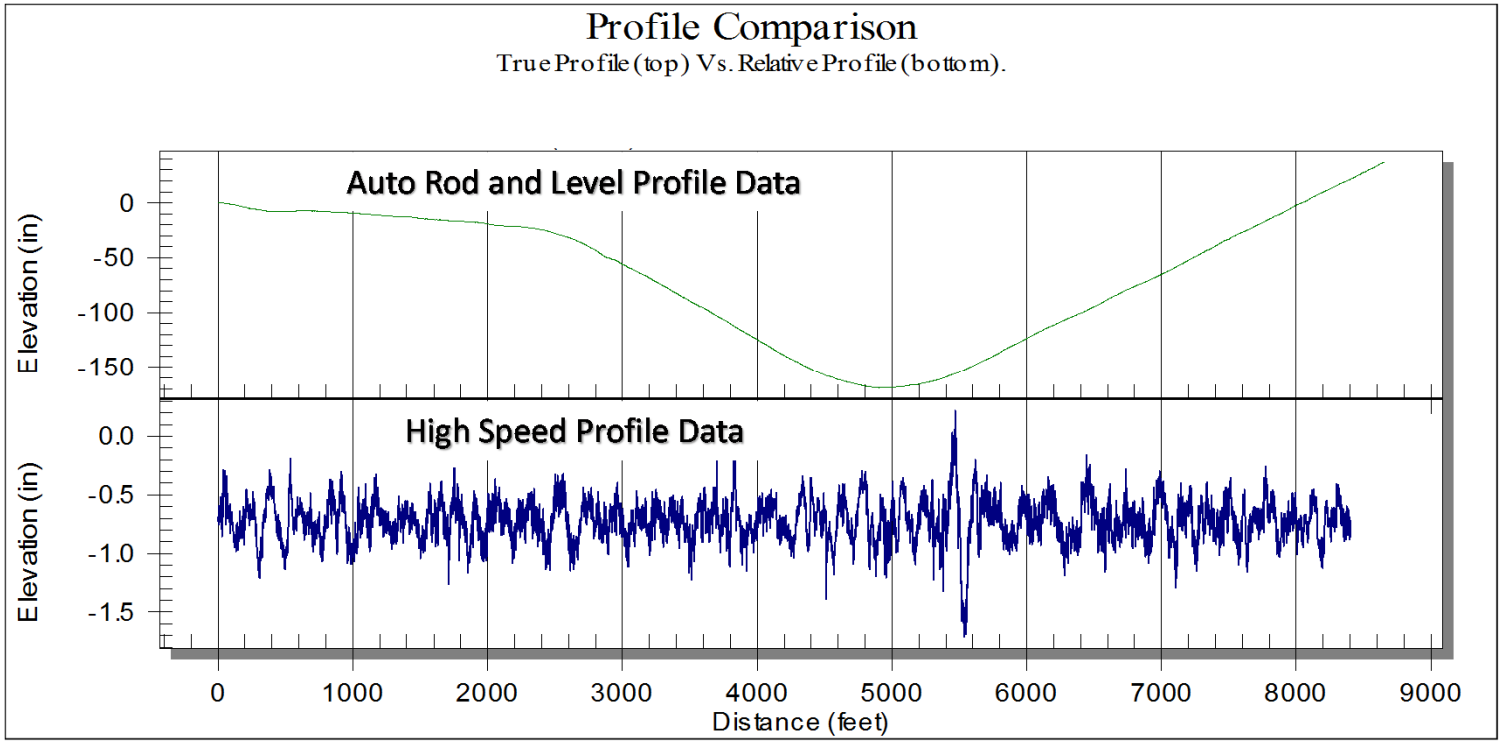
Why Measure True Profile (Con't)



- Important to Capture All Wavelengths and Grade Changes
  - Due to Gear Spacing and Speed of Encounter, Aircraft will Respond to Events up to 100-Meter Long
- AR&L Measures All Wavelengths Relatively Quickly

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Why Aircraft Simulation

- The Best Method of Reporting Runway Ride Quality is to use Instrumented Aircraft
- Next Best is Aircraft Simulation
  - Validated Accuracy and Repeatable
  - Multiple Commercial Aircraft Types Available
  - Simulates Any Operation in Any Condition
  - If Roughness Exists, Aircraft Simulation will Identify the Event's Precise Location

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Why Aircraft Simulation (Con't)

- A Common Alternative to Aircraft Simulation is using the Boeing Bump Index (BBI) Contained in ProFAA
  - BBI can be a Good "First Look" Depending Upon the Roughness Type
  - By its Nature, BBI is Limited in What it Can Detect
  - Can Falsely Declare a Rough Runway as Acceptable

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Real-World Runway Roughness

- Multiple Events Located in the Runway's Overrun Area
- Approximately 300 meters of undulating pavement
- Wavelengths are approximately 30 meters
- Undulations Result in a Harmonic Resonance about the Aircraft's Nose Gear Resulting in Accumulating Nose Pitch

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Why Does BBI Fall Short?

- BBI Only Evaluates at One Event at a Time
  - Multiple Event Roughness Typically Produces Greater Aircraft Responses than Single Event
  - Multiple Event Roughness is More Common than Single Event Roughness
- Does Not Take into Account Aircraft Specifics
  - Does Not Account for:
    - Speed of Encounter
    - Weight of Aircraft
    - Gear Spacing (Distance from Nose to Main Gear)

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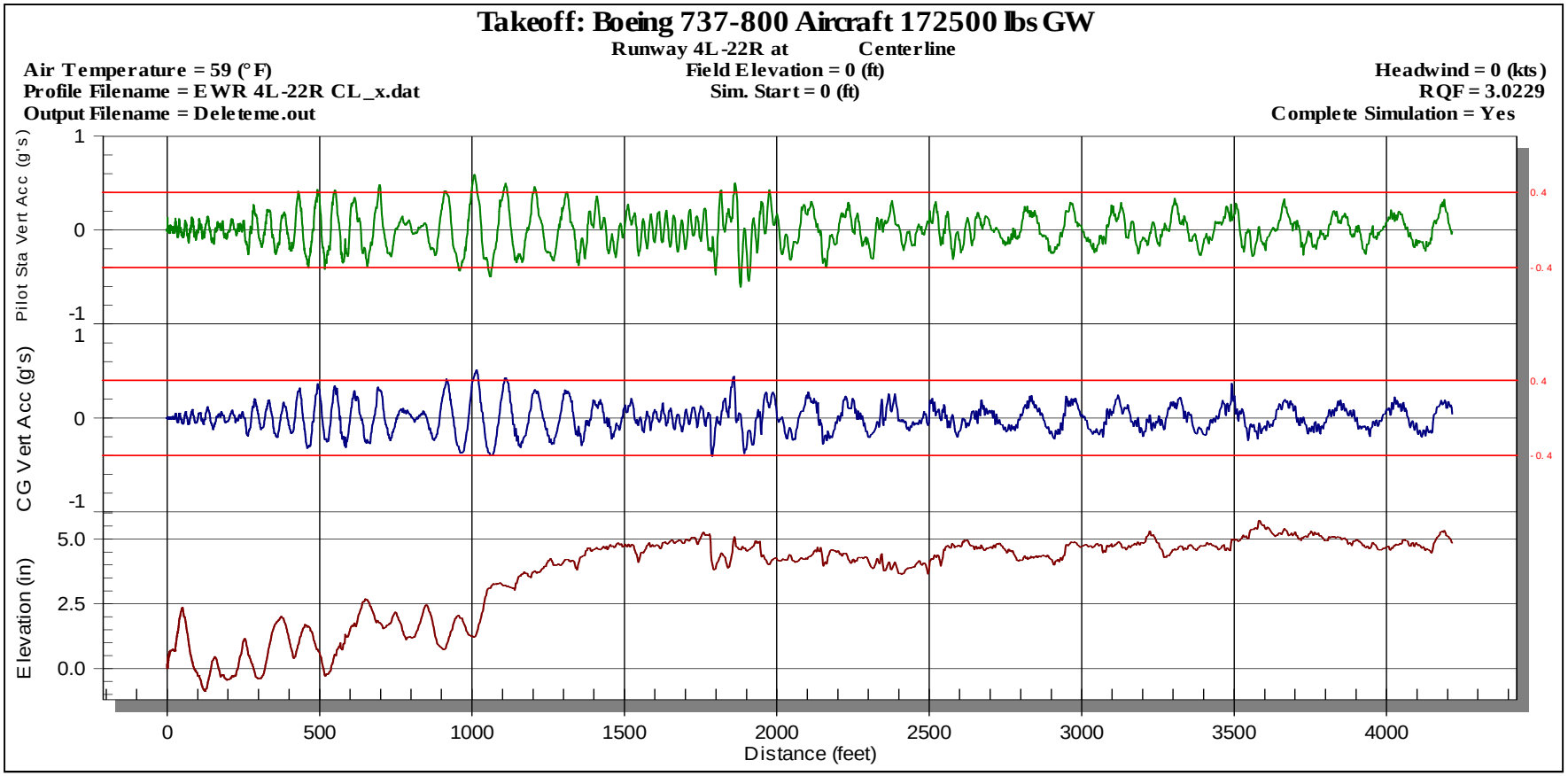
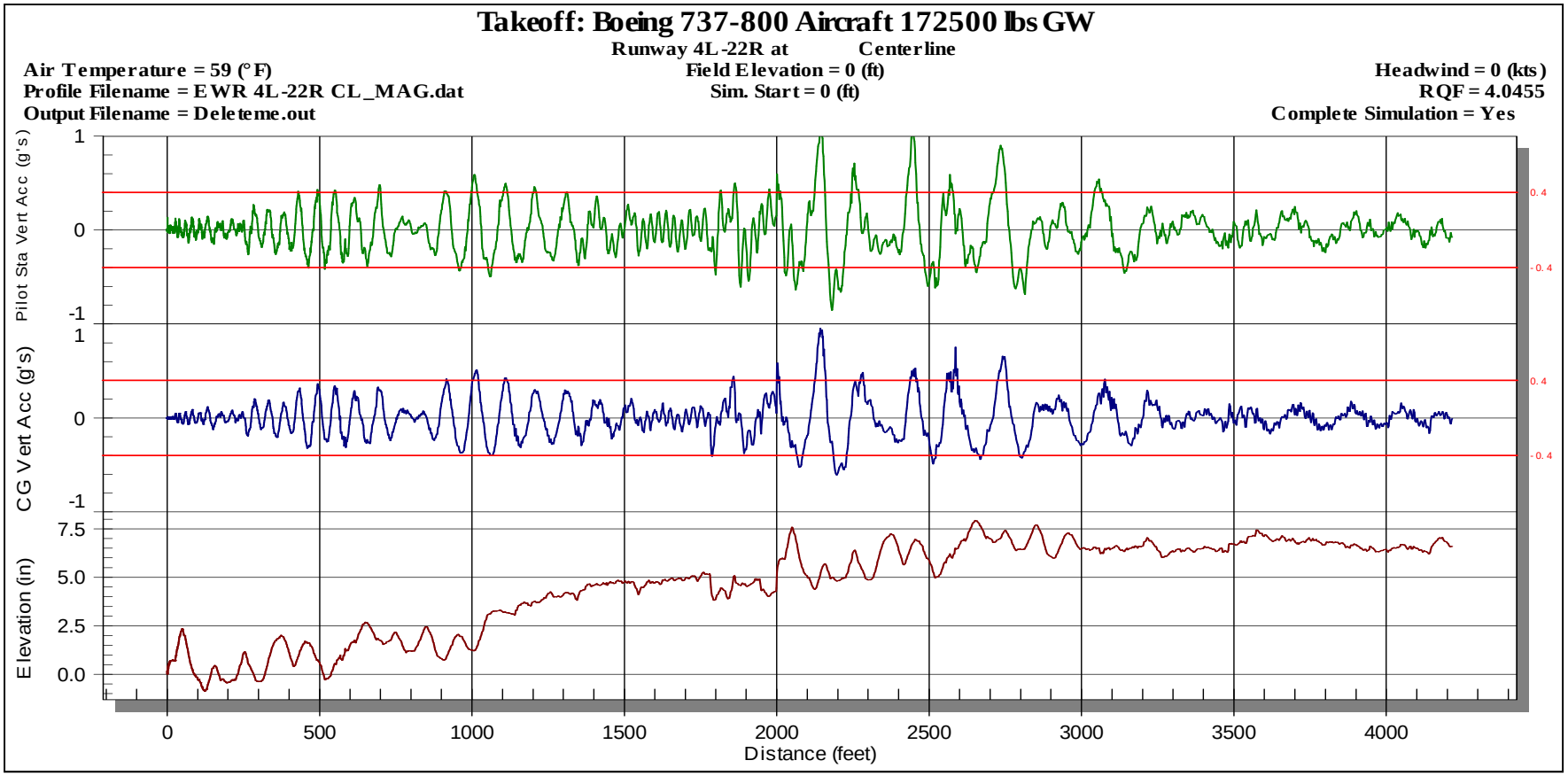
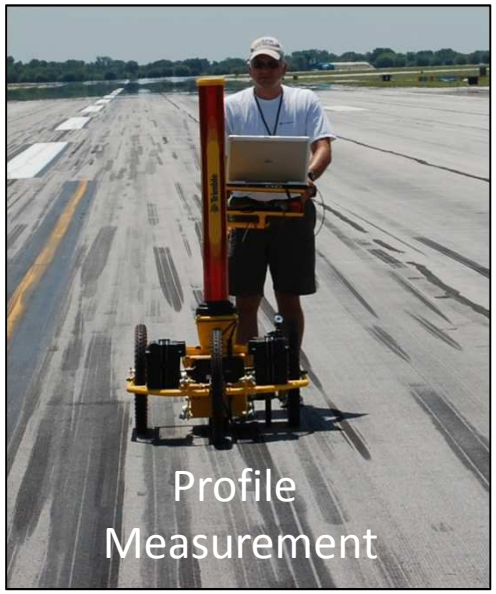
Takeoff with Roughness in the Overrun

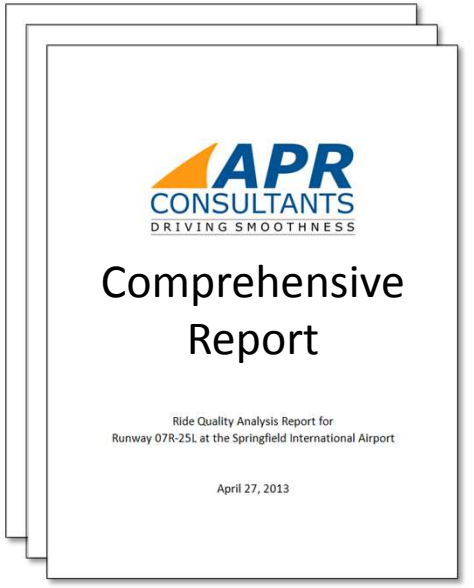


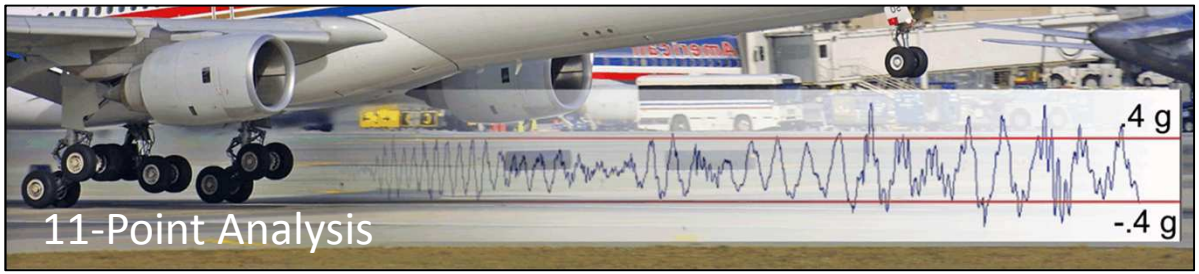
Takeoff with Roughness at 600 Meters



Using Technology to Meet Client's Needs







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Profile Measurement

- APR Sells the AR&L
  - Provides Most Flexibility for Owner to Measure on Demand
- APR Can Provide the Profile Measurement as a Service
- Alternative Profile Measurement Techniques
  - High-Speed Profile Data
    - APR Cannot Attest to Simulation Accuracy
  - Traditional Survey Profile Data
    - Slow But Effective

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Analysis – Profile Evaluation

- Thorough Analysis of the Measured Profile Data
  - Visual Profile Analysis
    - Perform a Visual Inventory of Suspicious Areas Prior to Simulations
  - Baseline Comparison (If Applicable)
    - Direct Comparison to Baseline Profile
    - 150-Meter Straightedge Analysis

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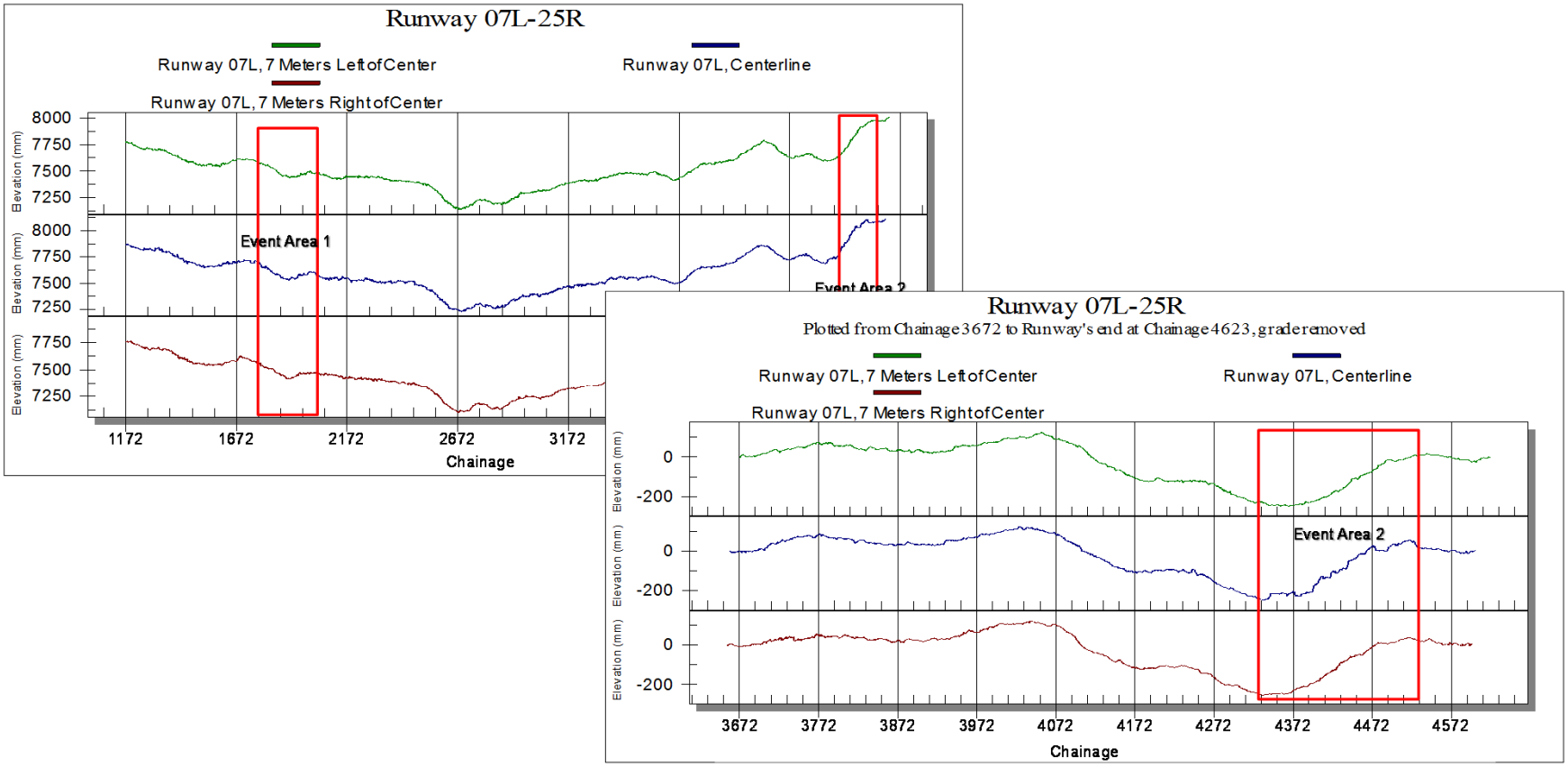
Analysis – Profile Evaluation



Analysis – Aircraft Simulation

- Simulations are Conducted on Both Ends of the Runway
- Two Classes of Aircraft – Narrow and Wide Bodied Aircraft
  - VSweep Analysis
    - Simulates All Possible Speeds on Every Meter of Measured Profile
  - Constant Speed Taxi
  - Conventional Takeoff
  - Aborted Takeoff
  - Landing

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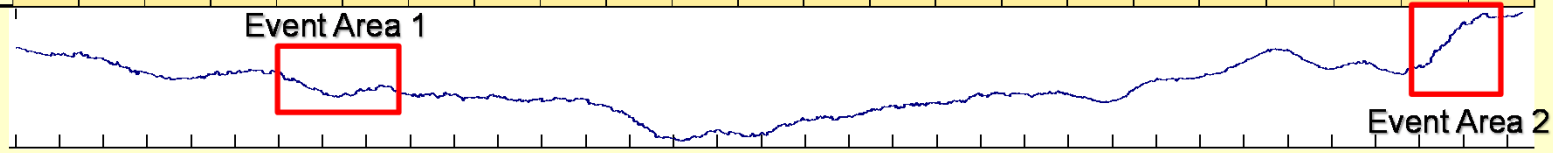
Analysis – VSweep

		Section	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	Line of Survey	Chainage	1172-1322	1322-1472	1472-1622	1622-1772	1772-1922	1922-2072	2072-2222	2222-2372	2372-2522	2522-2672	2672-2822	2822-2972	2972-3122	3122-3272	3272-3422	3422-3572	3572-3722	3722-3872	3872-4022	4022-4172	4172-4322	4322-4472	4472-4625
737-800		RQI	3.49	3.45	2.62	3.26	3.50	2.92	2.87	2.72	2.23	2.64	2.70	2.46	2.76	3.19	2.58	2.06	2.18	2.29	2.03	2.09	2.77	4.80	3.00
		PSA Peak (g's)	0.65	0.63	0.58	0.59	0.72	0.58	0.54	0.44	0.41	0.54	0.58	0.42	0.61	0.64	0.60	0.39	0.44	0.47	0.41	0.34	0.57	1.02	0.60
		CG Peak (g's)	0.12	0.15	0.12	0.14	0.16	0.13	0.14	0.14	0.11	0.18	0.17	0.19	0.15	0.14	0.12	0.13	0.11	0.12	0.12	0.17	0.15	0.20	0.11
747-400		RQI	0.71	0.79	0.60	0.76	0.89	0.85	0.94	0.71	0.77	0.90	0.81	0.87	0.81	0.69	0.86	0.66	0.60	0.52	0.63	0.87	0.68	1.61	0.66
		PSA Peak (g's)	0.16	0.17	0.10	0.15	0.15	0.15	0.19	0.13	0.17	0.15	0.16	0.15	0.15	0.12	0.18	0.13	0.11	0.10	0.11	0.18	0.15	0.31	0.13
		CG Peak (g's)	0.06	0.07	0.05	0.06	0.08	0.08	0.08	0.06	0.06	0.07	0.07	0.08	0.08	0.06	0.09	0.06	0.07	0.05	0.05	0.10	0.09	0.13	0.09



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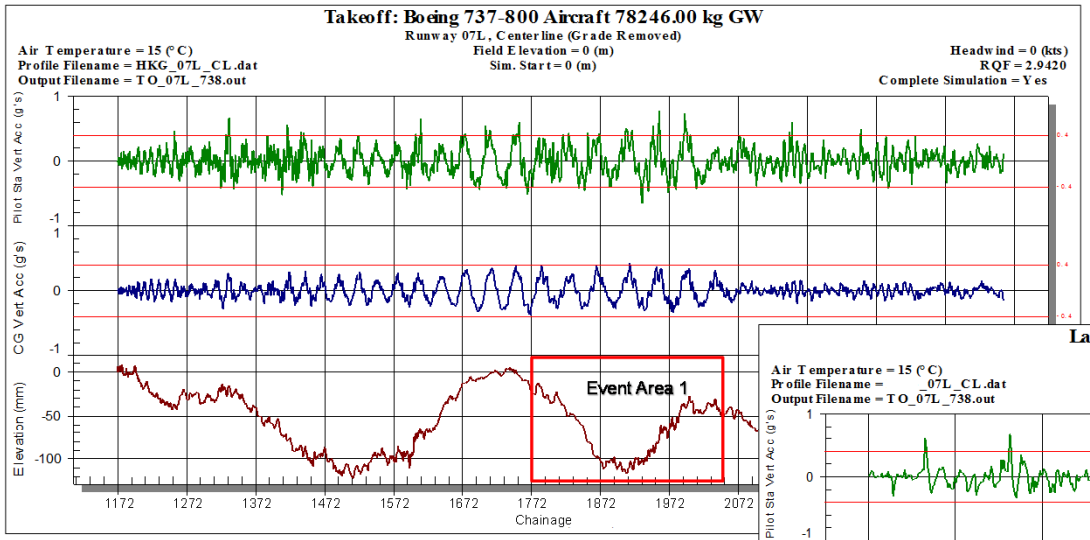

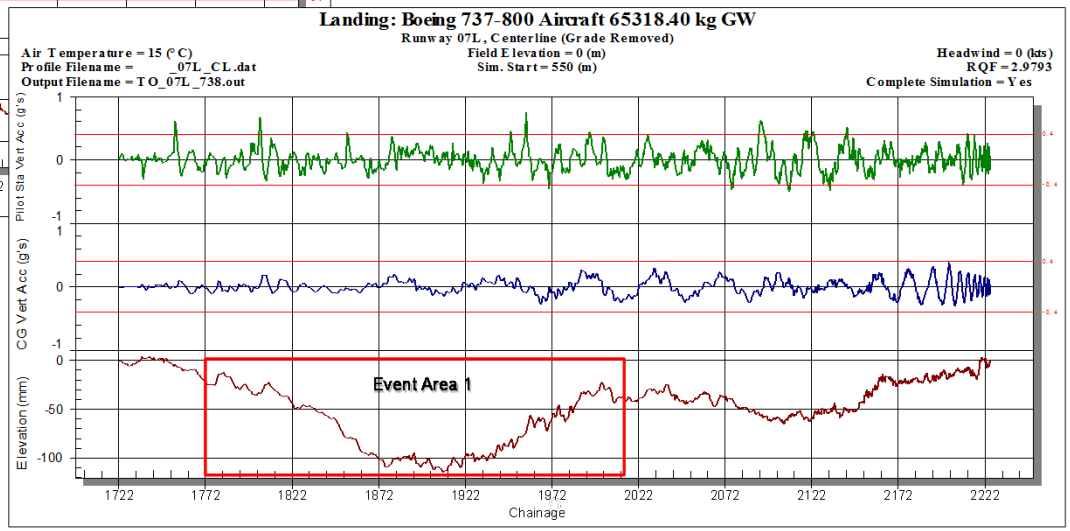

Analysis – Straightedge Analysis

- APR's Standard Analysis Conducts a Variety of Straightedge Analyses
  - 3-meter / 3mm Straightedge
    - Compare to ICAO Annex 14
  - 30-meter / 25mm Straightedge
    - Identify Events that will Cause Poor Aircraft Response
  - Straightedge Analysis Sweep
    - Compares Subject Runway to That of Known Rough and Known Smooth Runways

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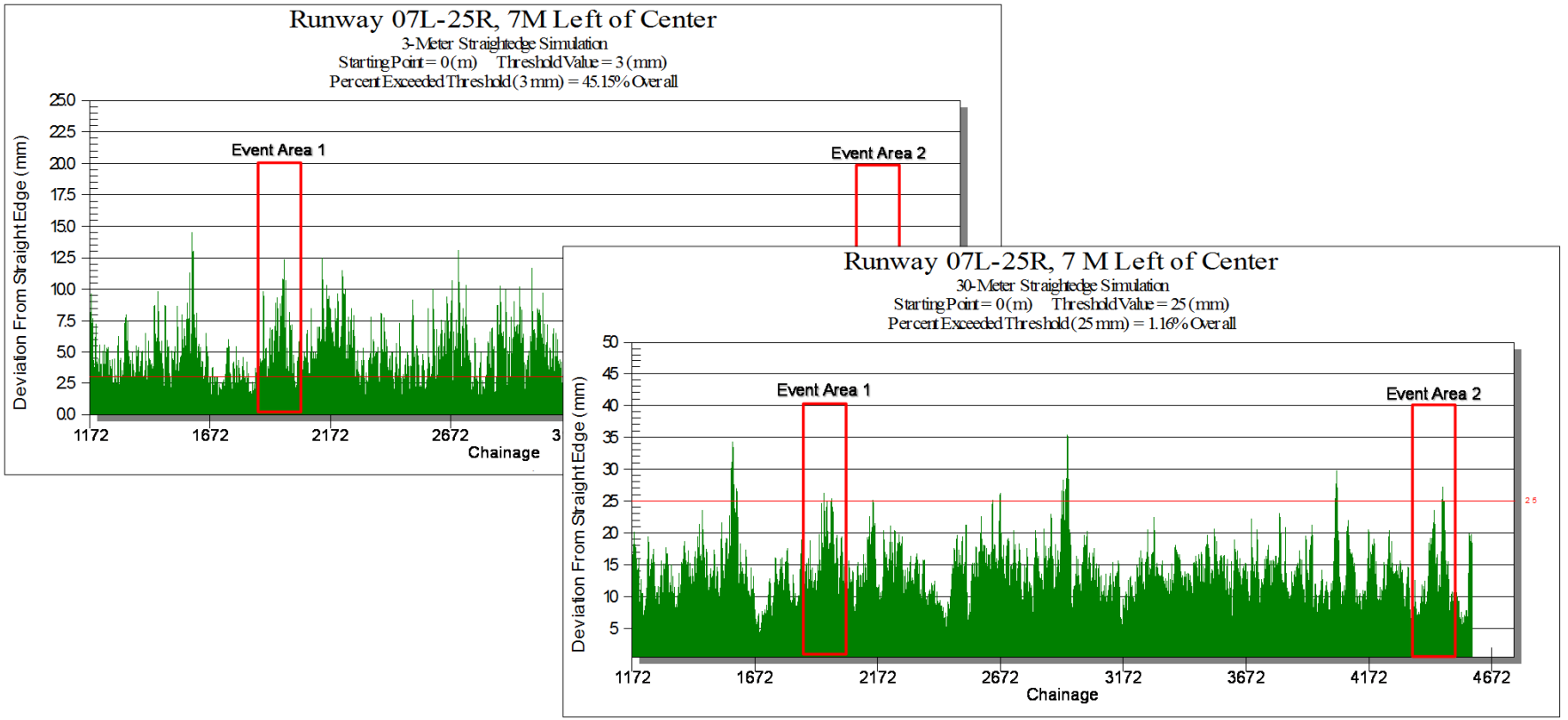
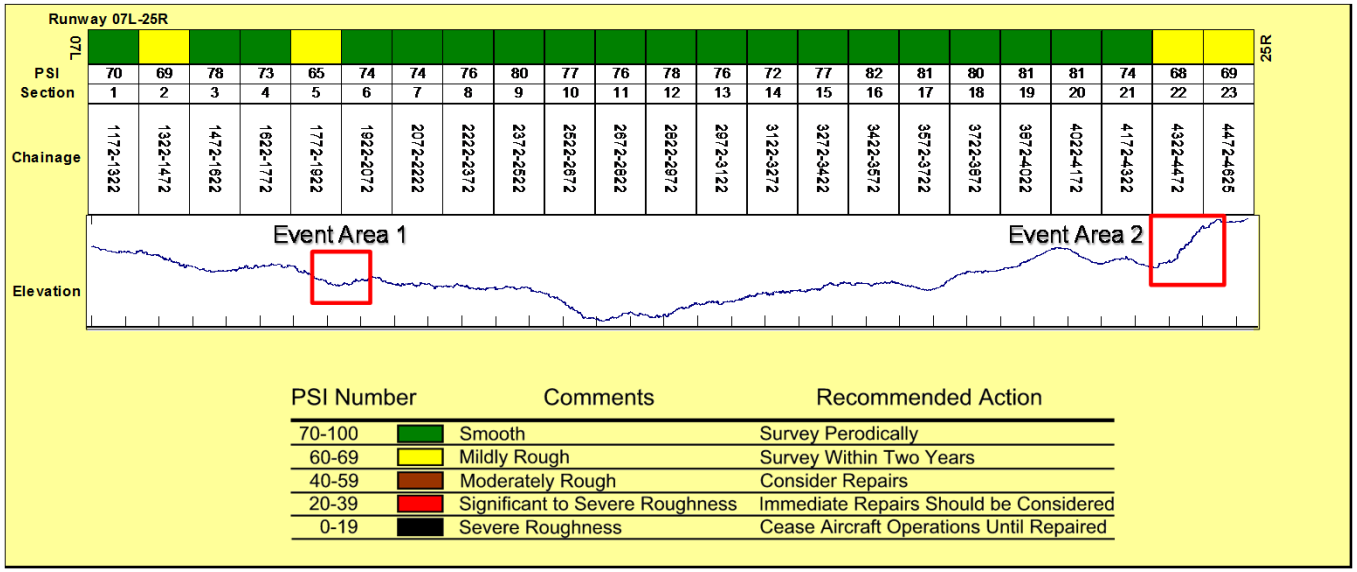
Analysis – Straightedge Analysis



Graphical Summary

Pavement Smoothness Index



- Included in the Report's Executive Summary
  - Divides Runway into 150-meter Sections
  - Each Analysis is Numerically Incorporated into One Index for each Section
  - Easy to Understand and Compare to Previous Reports

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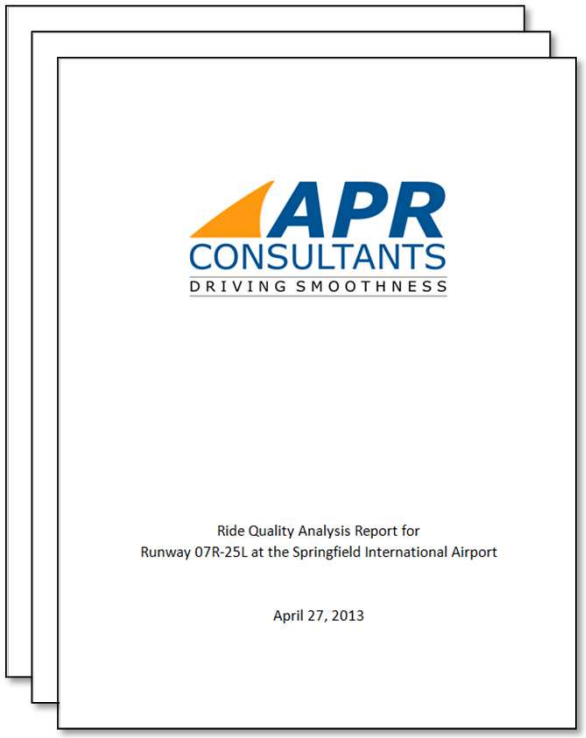
Analysis – Report Deliverable

- Includes Detailed Analysis and all Plots:
  - All Profiles
  - All Baseline Comparisons
  - All Aircraft Simulations
  - All Straightedge Analyses
- Includes 22 Years of Experience and Engineering Judgement



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Conclusions

- APR has Been Enhancing Pavement Management for 22 Years
- In that Time, APR has Developed Effective Methods of Profile Measurement, and Analysis Software
- This Technology is Very Effective at:
  - Identifying Ride Quality of Airfield Pavements
  - Monitoring Profile Shape Changes (Settlement)
  - Pavement Repairs
  - Design Evaluation

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The End

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