Roughness Index Computations by Straightedge Type Measurements in ProFAA

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SRA International, Inc.

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ProFAA

- The FAA's computer program for computing pavement elevation profile roughness indexes
- Straightedge Index, Boeing Bump Index, IRI, Profilograph Index, and BandPass Filter
- Dynamic Coefficient of Nose Strut Force and Main Strut Force, CG, and CP for B-727, B-747, DC-9, and DC-10
- MakeSplineFit
  - File Format Conversion Program
  - "*.txt" → "*.pro"
- Free Download
  - http://www.airporttech.tc.faa.gov/pavement/25rough.asp

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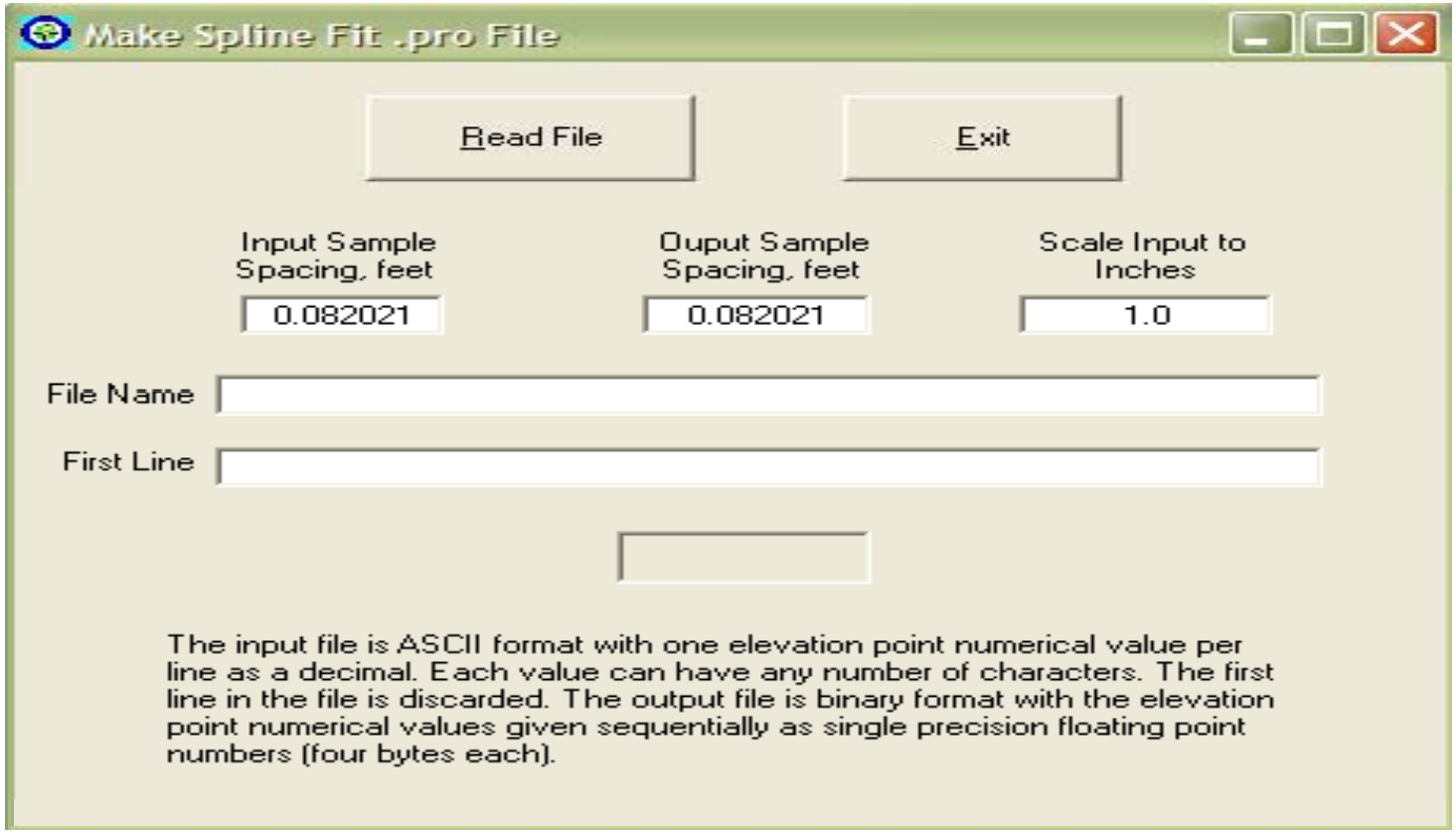
Current File Conversion Program (for “*.pro”)



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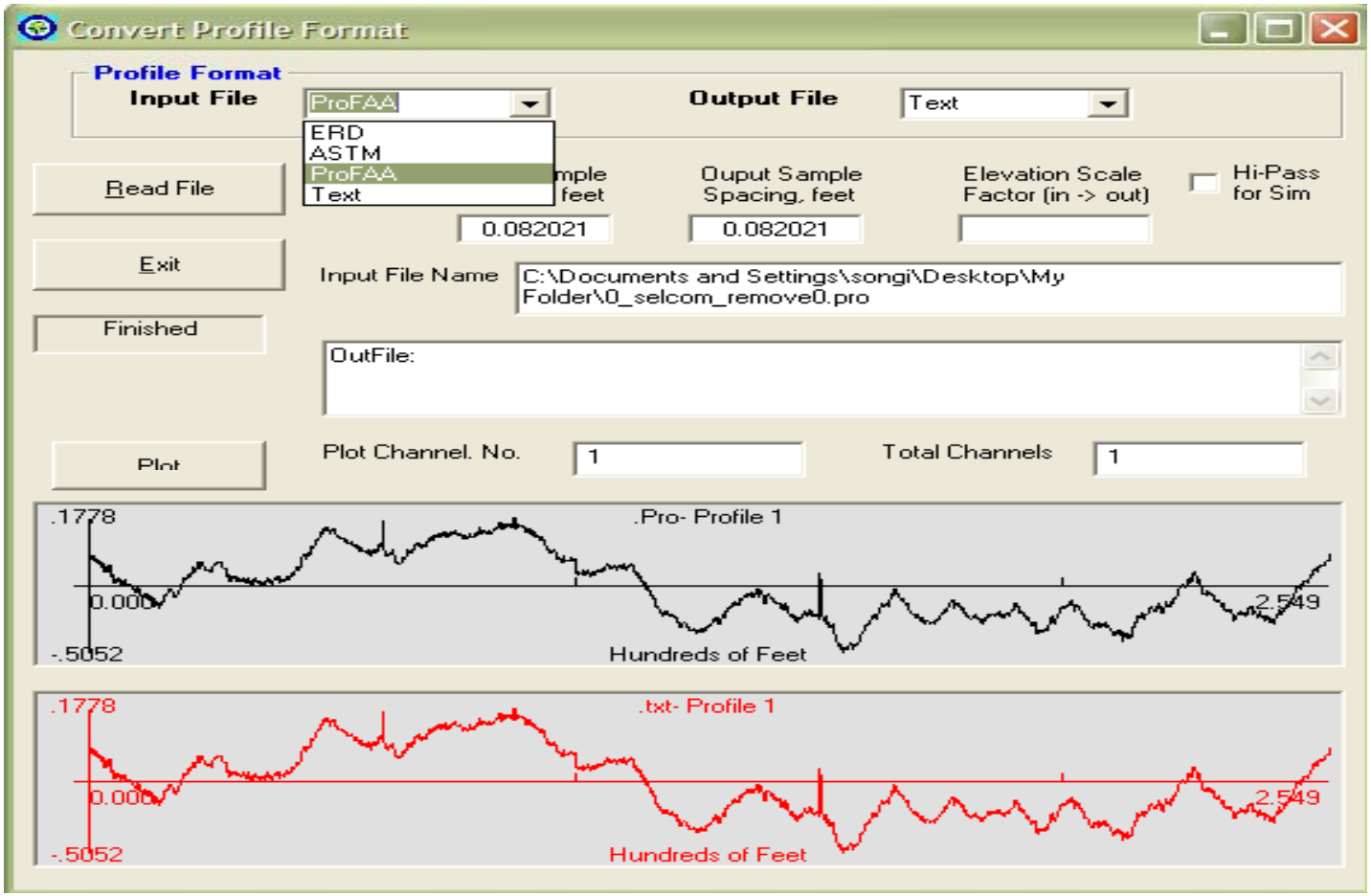
New File Conversion Program



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New File Conversion Program

- Multiple file format conversions
  - “*.erd”, “*.ppf”, “*.pro”, and “*.txt”
- Text box to select a profile channel
- Instant profile plots to confirm the conversion before analysis

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Indexes from Straightedge Type Measurements

- (Regular) Straightedge Index
- Rolling Straightedge Index
- Boeing Bump Index
- Profilograph Index

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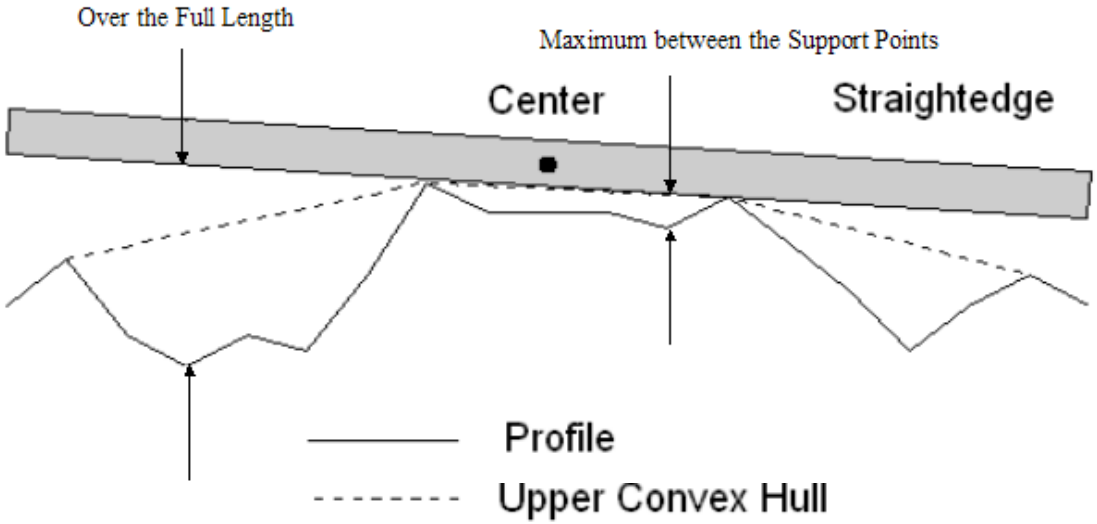
Straightedge Index



- Maximum Deviation Over the Full Length
- Maximum Deviation between the Support Points
- An Unique Feature of ProFAA

Straightedge Index Specs

	FAA	ICAO	USACE
Length (AC)	**16-foot**	**9.8-foot**	**12-foot**
Full or Between	**Full**	**Full**	**Between**
Length (PCC)	**16-foot**	**9.8-foot**	**12-foot**
Full or Between	**Full**	**Full**	**Full**
Reference	**AC150/5370-10**	**ICAO Annex 14**	**UFGS-02749** **UFGS-02753** **UFGS-02751N**

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Straightedge Simulation

- Optional selections for measuring methods (Full length or Between) and straightedge length (5 to 250 feet)
- Straightedge places at every data points and average of the maximum deviation at each point becomes straightedge index

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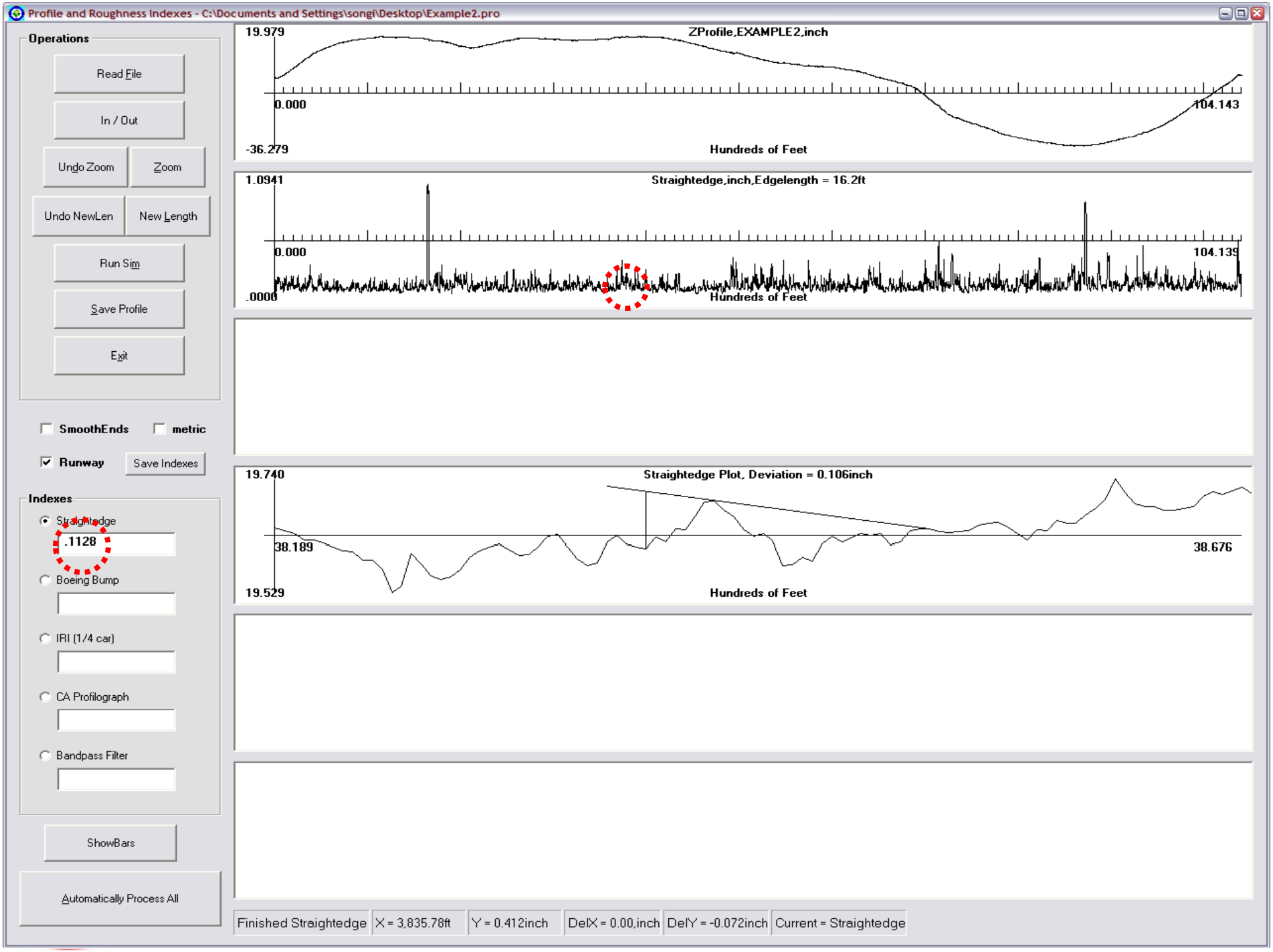
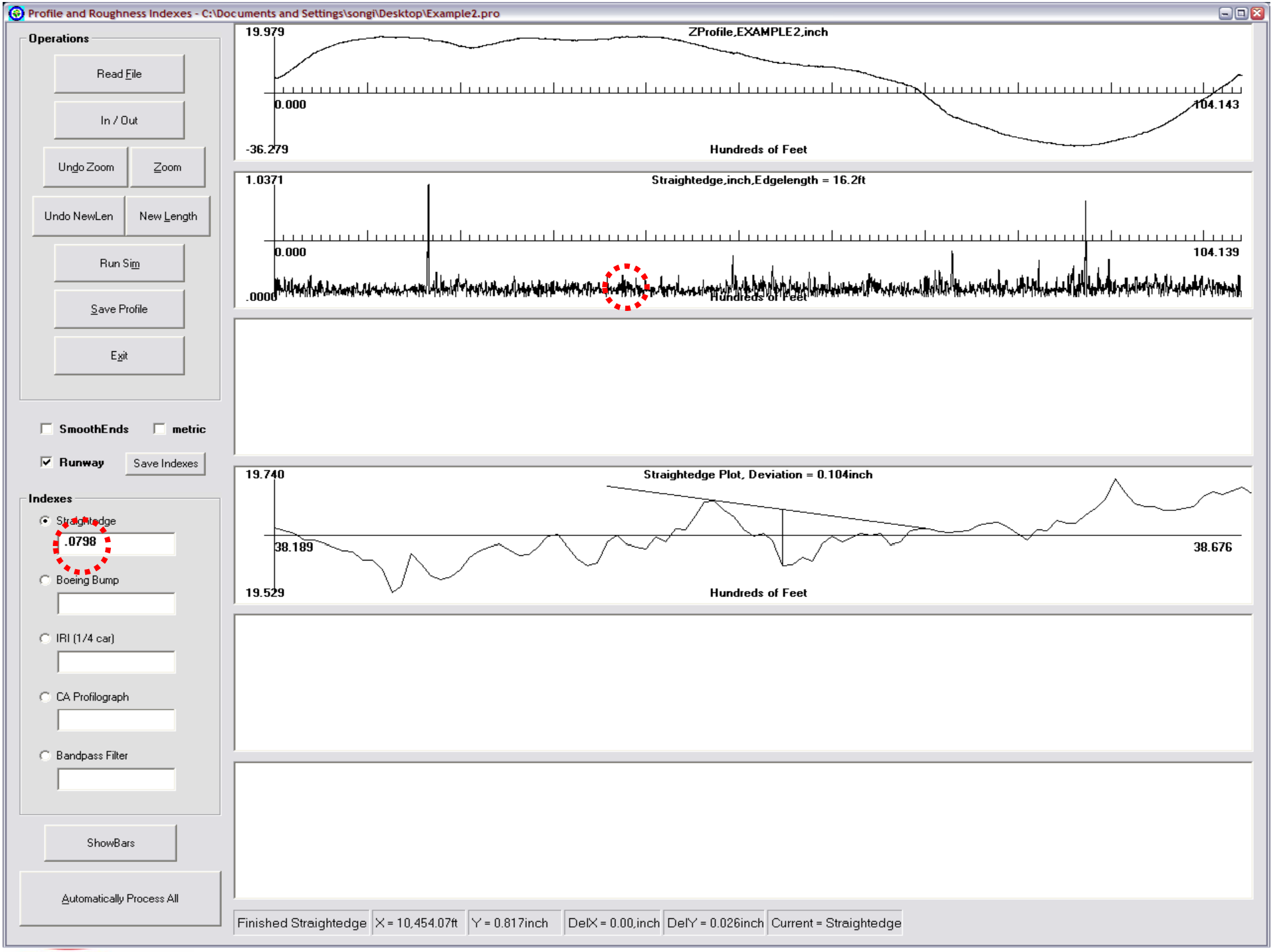

Profile and Roughness Indexes - C:\Documents and Settings\songi\Desktop\Example2.pro
Operations
Read File
In / Out
Undo Zoom
Zoom
Undo NewLen
New Length
Run Sim
Save Profile
Exit
SmoothEnds
metric
Runway
Save Indexes
Indexes
Straightedge
.1128
Boeing Bump
IRI (1/4 car)
CA Profilograph
Bandpass Filter
ShowBars
Automatically Process All
19.979
ZProfile,EXAMPLE2,inch
0.000
104.143
-36.279
Hundreds of Feet
1.0941
Straightedge,inch,Edgelength = 16.2ft
0.000
104.139
.0000
Hundreds of Feet
19.740
Straightedge Plot, Deviation = 0.106inch
38.189
38.676
19.529
Hundreds of Feet
Finished Straightedge
X = 3,835.78ft
Y = 0.412inch
DelX = 0.00,inch
DelY = -0.072inch
Current = Straightedge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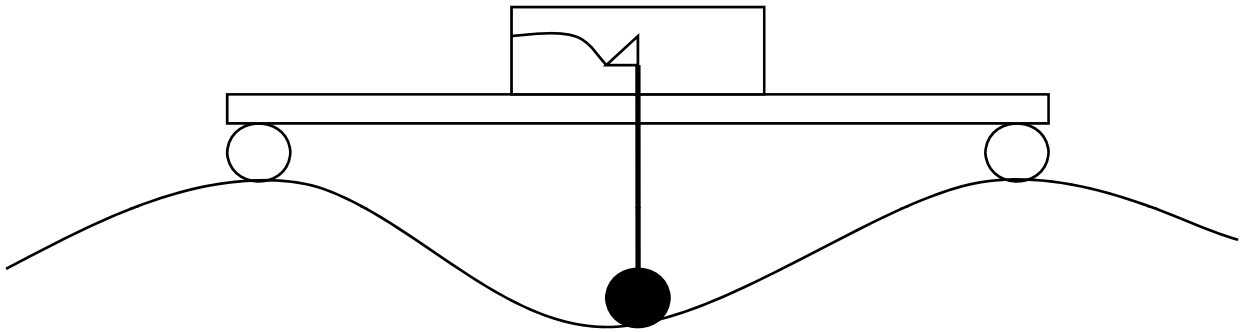
Runway
Save Indexes
Indexes
Straightedge
.0798
Boeing Bump
IRI (1/4 car)
CA Profilograph
Bandpass Filter
ShowBars
Automatically Process All
19.979
ZProfile,EXAMPLE2,inch
0.000
104.143
-36.279
Hundreds of Feet
1.0371
Straightedge,inch,Edgelength = 16.2ft
0.000
104.139
.0000
Hundreds of Feet
19.740
Straightedge Plot, Deviation = 0.104inch
38.189
38.676
19.529
Hundreds of Feet
Finished Straightedge
X = 10,454.07ft
Y = 0.817inch
DelX = 0.00,inch
DelY = 0.026inch
Current = Straightedge

Rolling Straightedge



- Recording wheel is located at the center of straightedge
- A couple of “rolling” wheels are placed at both ends
- Straightedge travels on pavement surface

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Rolling Straightedge Simulation

- CA profilograph simulation function in ProFAA was modified
- Twelve supporting wheels are replaced by two
- 10-foot straightedge length and 0.7-foot recording wheel diameter

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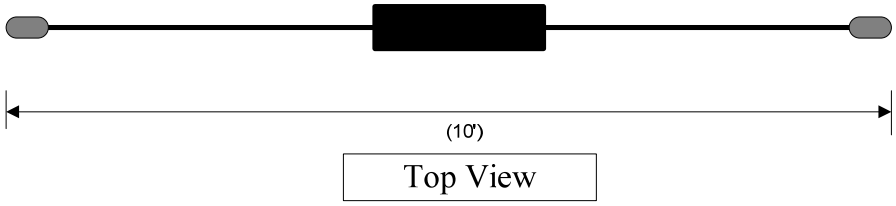
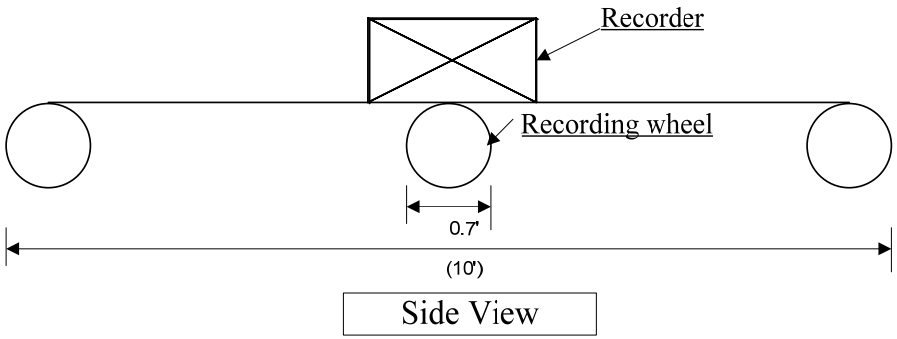
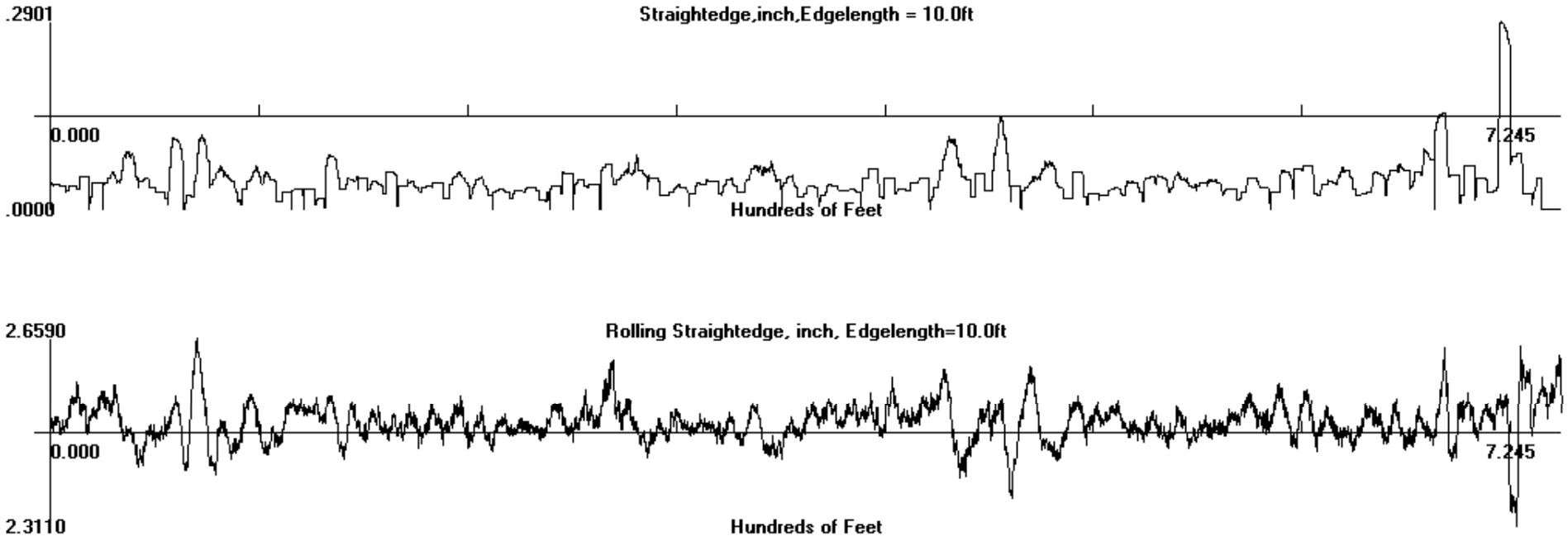
Rolling Straightedge in ProFAA





$$R(x) = (\sum_{i=1}^{N} C_i P_i(x - d_i)) - P_r(x - d_r)$$

Straightedge and Rolling Straightedge



- Rolling Straightedge
  - Measurement Point: Center of the Straightedge by Recording Wheel
  - Two Supporting Wheels at Both Ends

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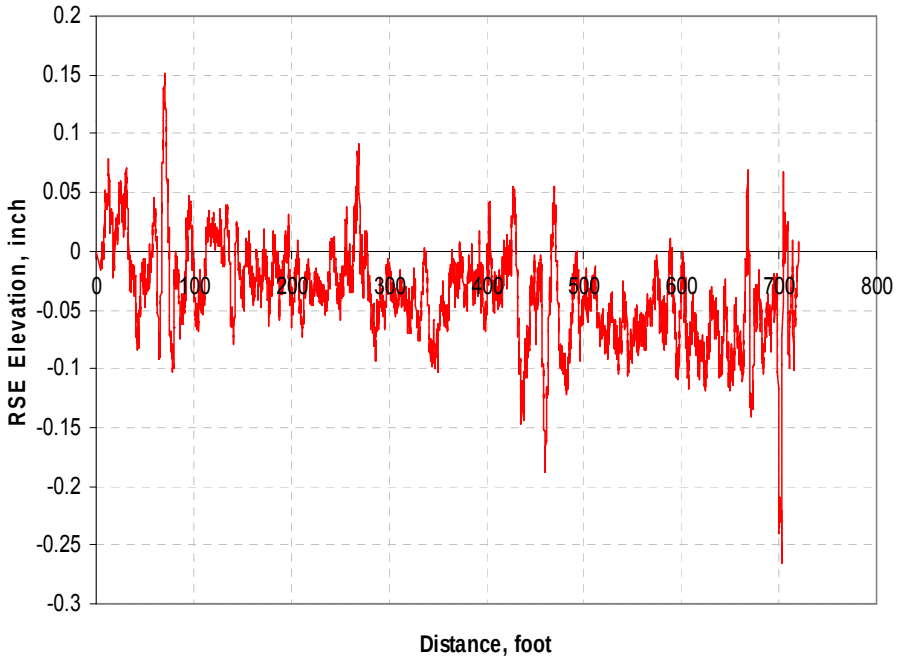
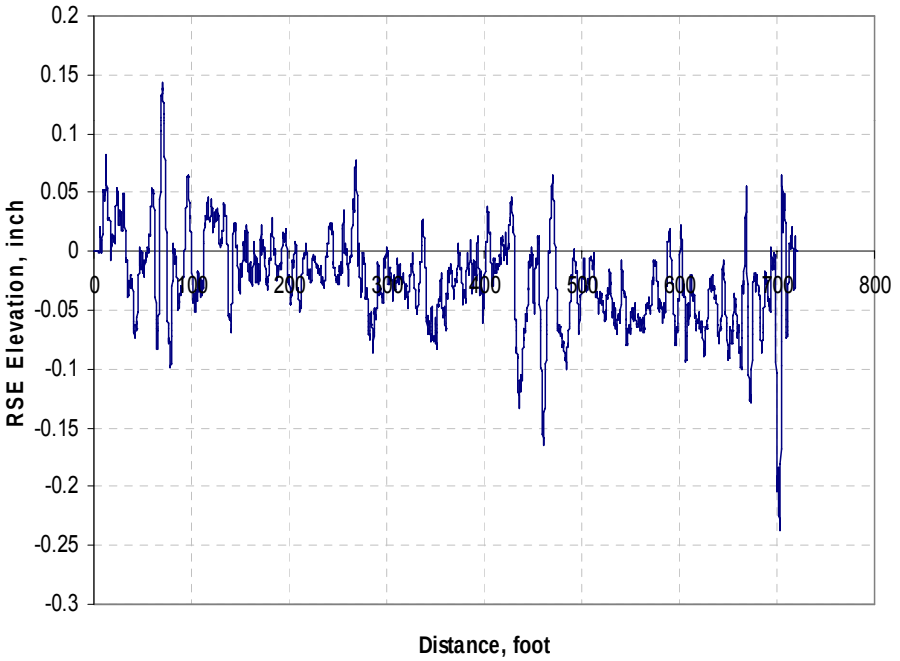
Rolling Straightedge Simulation Comparisons

ProFAA



ProVAL



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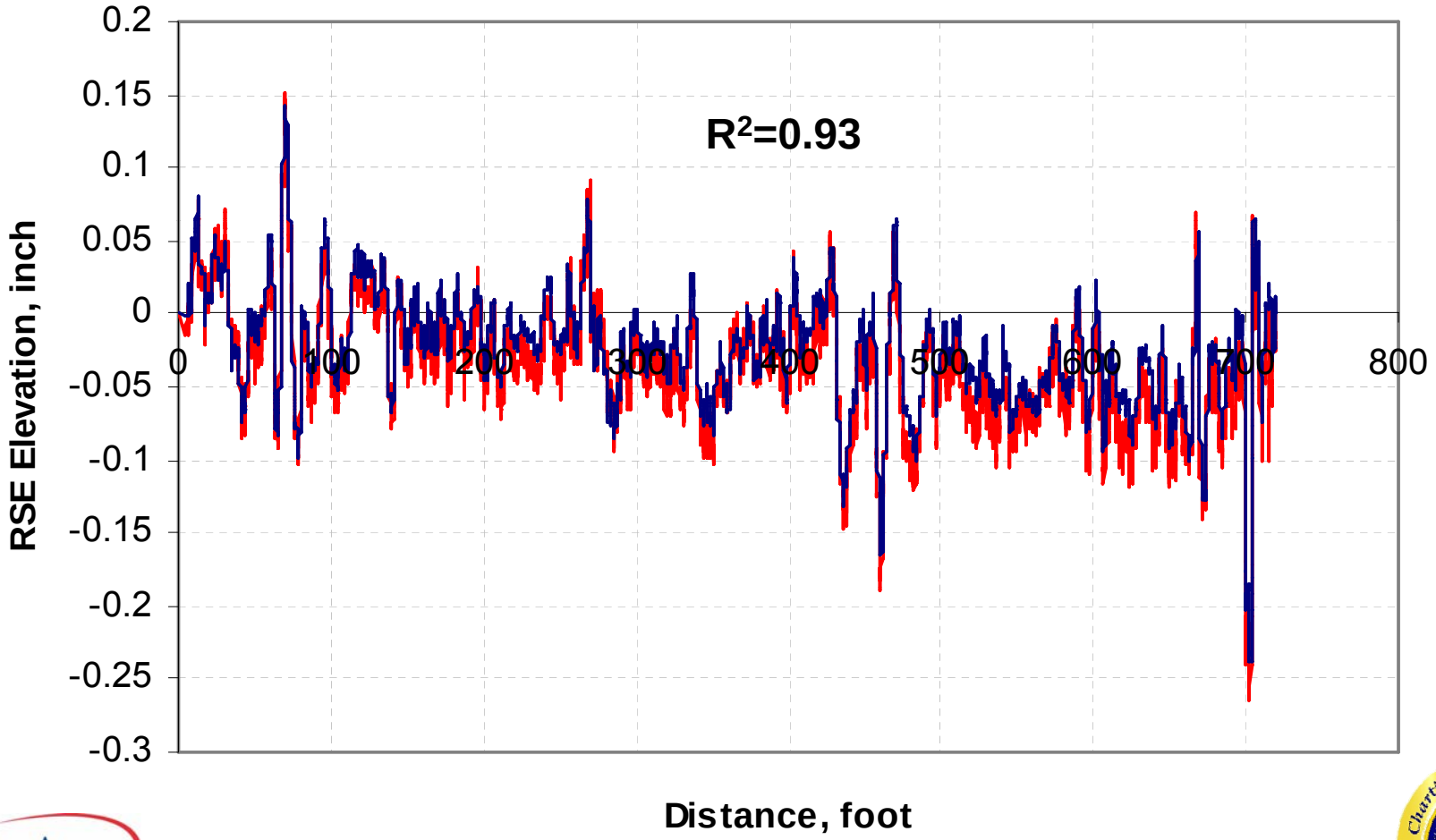
Rolling Straightedge Simulation Comparisons (Cont'd)



Boeing Bump Index

- Defined in terms of bump height versus wavelength for individual disturbances
- Construct a straightedge between two points on the elevation profile of a runway and to compare the ratio: (measured bump height) / (limit of acceptable bump height)
- Currently, Straightedge length is variable from 1 m to 60 m
- Draft Advisory Circular 150/5380-9: “Guidelines and Procedures for Measuring Airfield Pavement Roughness”

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Boeing Bump Index Computation

- Step 1: compute the bump height and bump length
- Step 2: compute the limit of acceptable bump height (lower limit criteria curve)
- Step 3: compute the ratio (measured bump height) / (limit of acceptable bump height)
- Step 4: take the largest of all values computed in step 3 (Boeing Bump Index) for the selected sample point
- Step 5: Repeat steps 1 through 4 for all sample points in the profile

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Boeing Bump Index Computation

- Step 1: compute the bump height and bump length
- Step 2: compute the limit of acceptable bump height (lower limit criteria curve)
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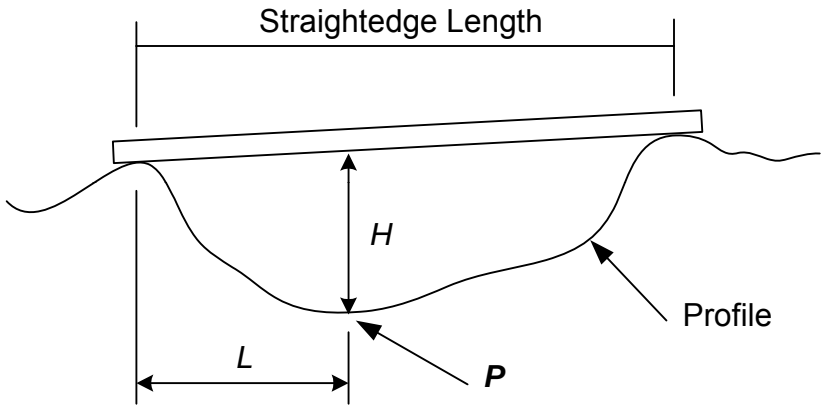
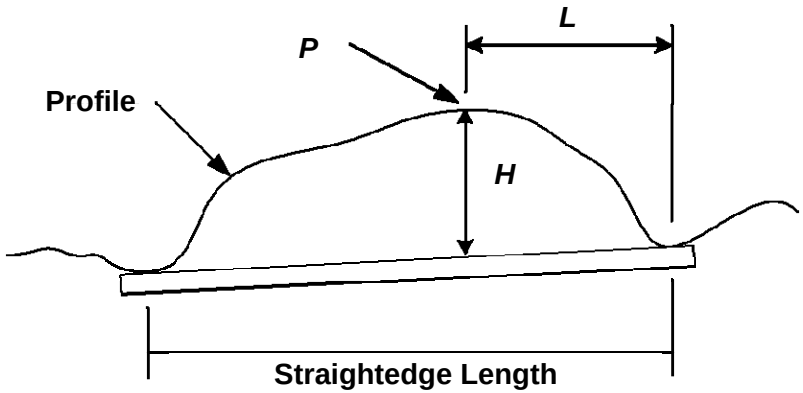
Step 1:
Bump Length (L) & Bump Height (H)





Boeing Bump Index Computation

- Step 1: compute the bump height and bump length
- Step 2: compute the limit of acceptable bump height (lower limit criteria curve)
- Step 3: compute the ratio (measured bump height) / (limit of acceptable bump height)
- Step 4: take the largest of all values computed in step 3 (Boeing Bump Index) for the selected sample point
- Step 5: Repeat steps 1 through 4 for all sample points in the profile

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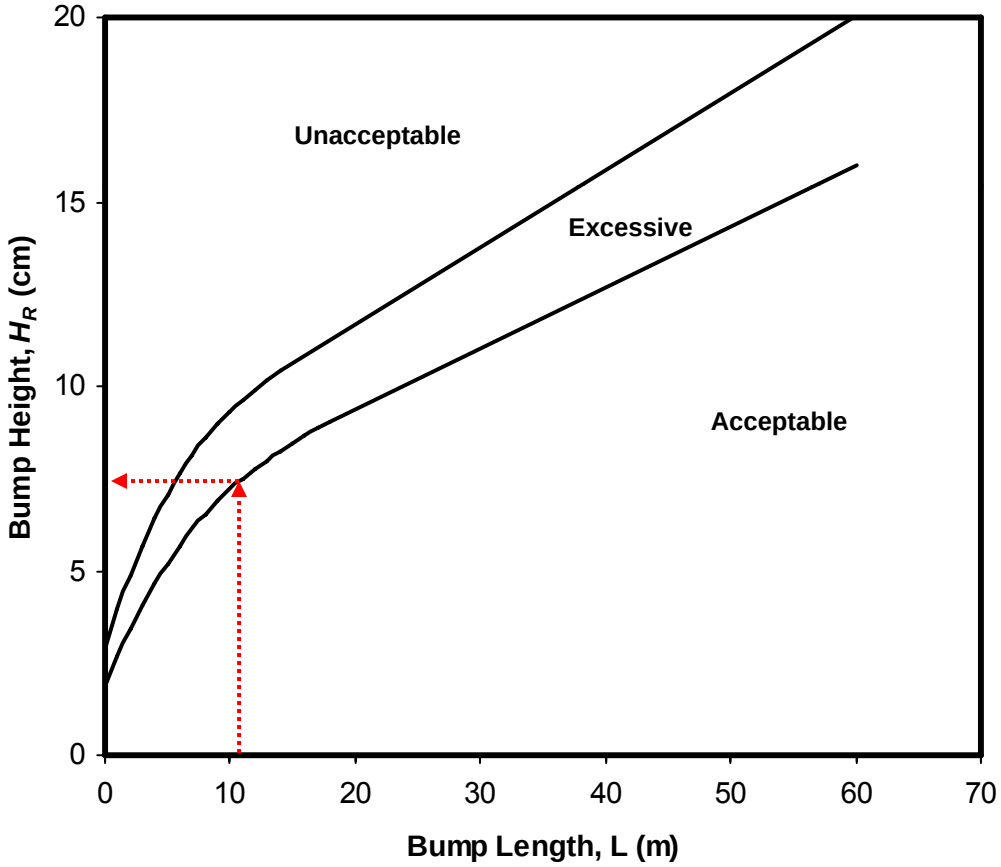
Step 2:
Acceptable Bump Height (H_R)



Boeing Bump Index Computation

- Step 1: compute the bump height and bump length
- Step 2: compute the limit of acceptable bump height (lower limit criteria curve)
- Step 3: compute the ratio (measured bump height) / (limit of acceptable bump height)
- Step 4: take the largest of all values computed in step 3 (Boeing Bump Index) for the selected sample point
- Step 5: Repeat steps 1 through 4 for all sample points in the profile

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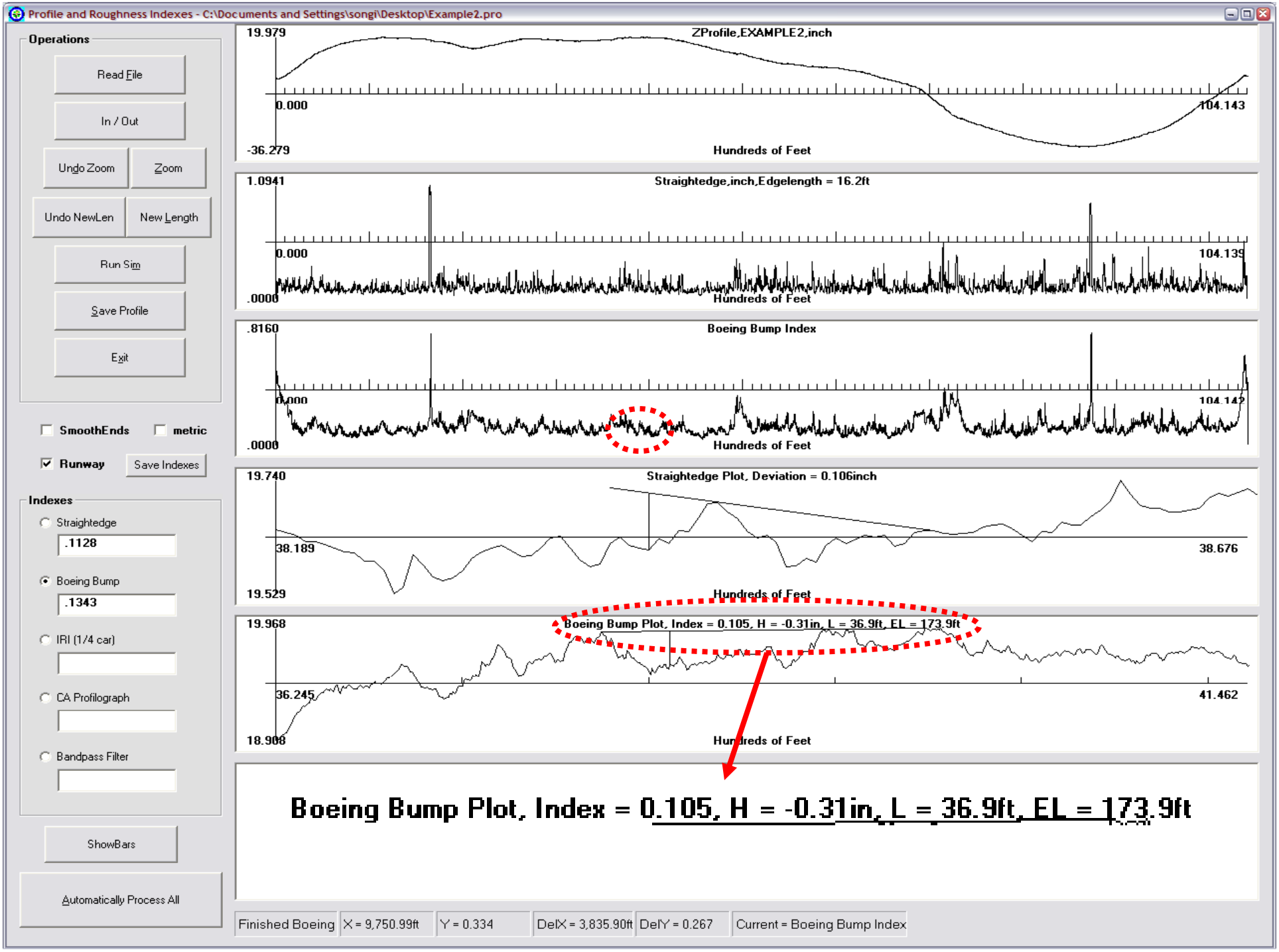
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In / Out
Undo Zoom
Zoom
Undo NewLen
New Length
Run Sim
Save Profile
Exit
SmoothEnds
metric
Runway
Save Indexes
Indexes
Straightedge
.1128
Boeing Bump
.1343
IRI (1/4 car)
CA Profilograph
Bandpass Filter
ShowBars
Automatically Process All
19.979
ZProfile,EXAMPLE2,inch
0.000
104.143
-36.279
Hundreds of Feet
1.0941
Straightedge,inch,Edgelength = 16.2ft
0.000
104.139
.0000
Hundreds of Feet
.8160
Boeing Bump Index
0.000
104.142
.0000
Hundreds of Feet
19.740
Straightedge Plot, Deviation = 0.106inch
38.189
38.676
19.529
Hundreds of Feet
19.968
Boeing Bump Plot, Index = 0.105, H = -0.31in, L = 36.9ft, EL = 173.9ft
36.245
41.462
18.908
Hundreds of Feet
Boeing Bump Plot, Index = 0.105, H = -0.31in, L = 36.9ft, EL = 173.9ft
Finished Boeing
X = 9,750.99ft
Y = 0.334
DelX = 3,835.90ft
DelY = 0.267
Current = Boeing Bump Index

CA Profilograph Simulation

- Previously, measured and simulated CA profilograph profiles using ProFAA were compared
- Equation: $R(x) = (\sum_{i=1}^{N} C_i P_i(x - d_i)) - P_r(x - d_r)$
- Pavement Type: PCC
- Different Pavement Conditions
- Correlation Coefficient: 0.9173 – 0.9570

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Bump Template

- The procedure for manually determining bump height from a template and a Profilograph paper trace is defined in various documents
- ASTM E 1274-03, “Standard Test Method for Measuring Roughness with a Profilograph,”
- ACPA Publication TB-006.0-C, “Constructing Smooth Concrete Pavements,” 1990, provides more detail on manipulating and positioning the bump template
- NCHRP Report 1-31, “Smoothness Specifications for Pavements,” 1997

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Bump Height and Width Specs for Template

Agency	Bump	
	Height, inch (mm)	Width, ft (m)
FAA	0.4	25
ASTM	-	25
ACPA	0.4	25
FHWA Website	0.3 / 0.4	25 (7.5)
Idaho	0.3 (8)	25 (8)
Indiana	0.3 (7.62)	25
Iowa	0.5	25
Kansas	0.4	25
South Dakota	0.3 (8)	25 (8)
Texas	0.3 (7.62)	25 (7.62)
Saskatchewan, CA	0.315 (8)	24.9 (7.6)
Alberta, CA	0.315 (8)	24.6 (7.5)

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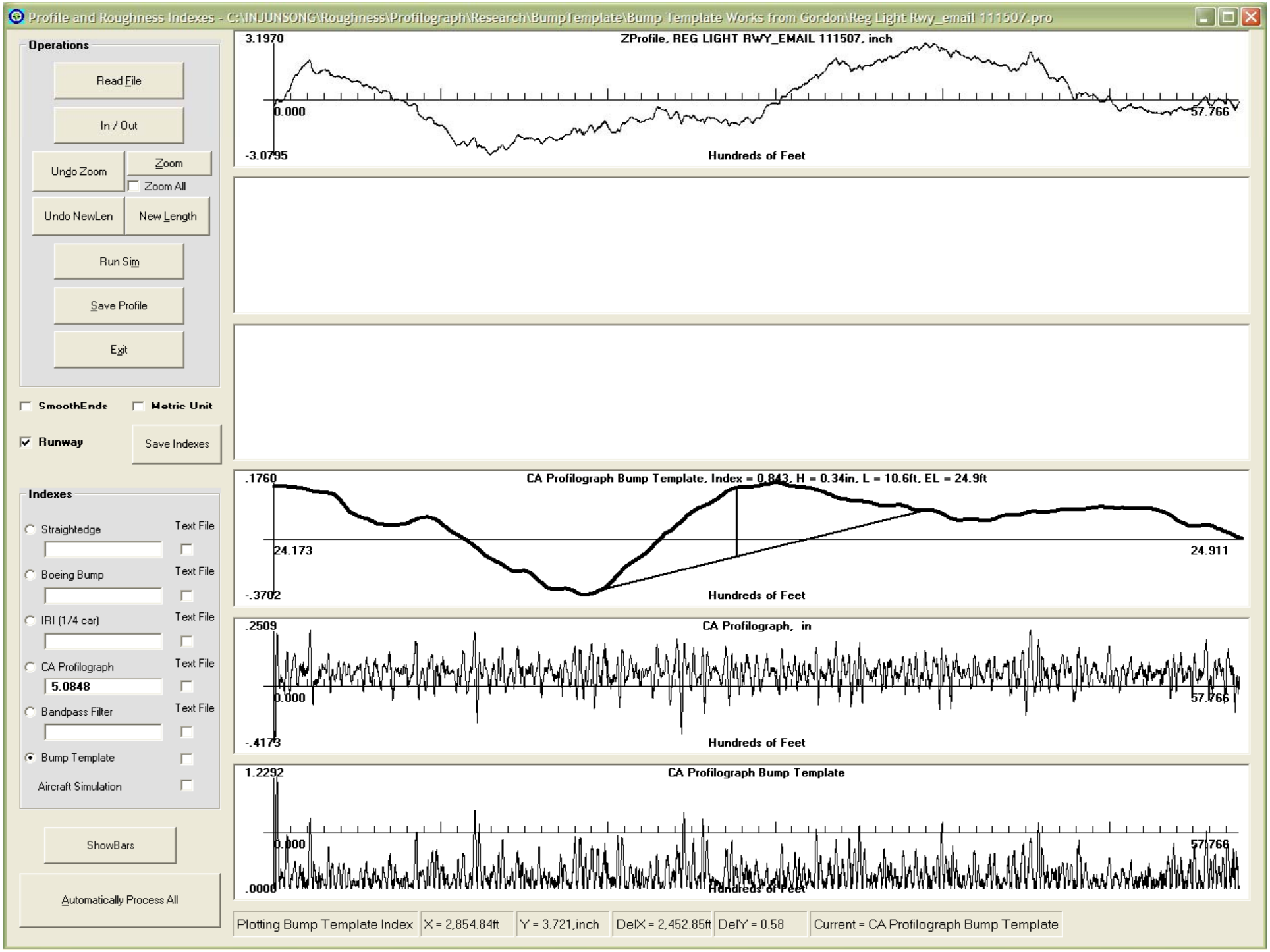
Profile and Roughness Indexes - C:\INJUNSONG\Roughness\Profilograph\Research\BumpTemplate\Bump Template Works from Gordon\Reg Light Rwy_email 111507.pro
Operations
Read File
In / Out
Undo Zoom
Zoom
Zoom All
Undo NewLen
New Length
Run Sim
Save Profile
Exit
SmoothEnds
Metric Unit
Runway
Save Indexes
Indexes
Straightedge
Boeing Bump
IRI (1/4 car)
CA Profilograph
5.0848
Bandpass Filter
Bump Template
Aircraft Simulation
Text File
ShowBars
Automatically Process All
3.1970
ZProfile, REG LIGHT RWY_EMAIL 111507, inch
0.000
57.766
-3.0795
Hundreds of Feet
.1760
CA Profilograph Bump Template, Index = 0.843, H = 0.34in, L = 10.6ft, EL = 24.9ft
24.173
24.911
-.3702
Hundreds of Feet
.2509
CA Profilograph, in
0.000
57.766
-.4173
Hundreds of Feet
1.2292
CA Profilograph Bump Template
0.000
57.766
.0000
Hundreds of Feet
Plotting Bump Template Index
X = 2,854.84ft
Y = 3.721,inch
DelX = 2,452.85ft
DelY = 0.58
Current = CA Profilograph Bump Template

Thank You

- ProFAA & MakeSplineFit
  - http://www.airporttech.tc.faa.gov/pavement/25rough.asp

- Injun Song
  - Email: Injun_song@sra.com

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