

Airfield Pavement Surface Characteristics with 1mm 3D Laser Imaging System

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Airfield Pavement Surface Evaluation

- Surface Characteristics
 - Macro-Texture
 - Grooving
 - Friction
- Condition Survey
 - PCI
- Roughness
 - Specific to Passenger Jet



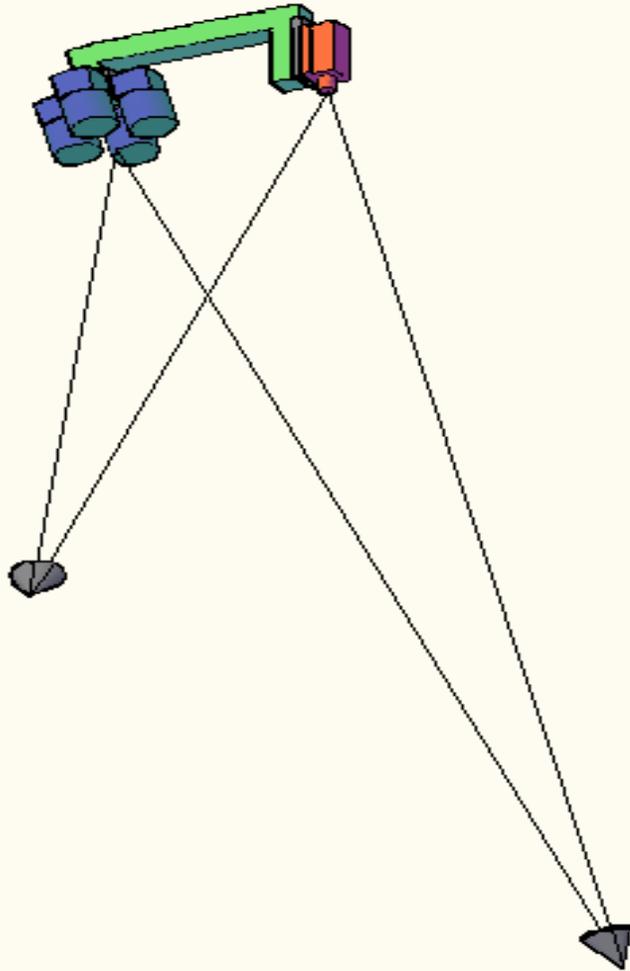
PaveVision3D for FAA NDT



3D Ultra for Deflection Trailer



Sensor Design



PaveVision3D Ultra



Virtual Pavement

- 1mm Pavement Surface in All Three Dimensions
- High-Precision IMU
- Result
 - Grades
 - Horizontal Curves
 - Cross-Slope



Applications

□ Now and 2013

- Cracking, Rutting, Macro-Texture
- Safety Analysis: High-Friction, Rumble Strips, Hydroplaning/Grooving
- Virtual Surface for Visualization

□ Future

- Longitudinal Profiling (2013)
 - Comprehensive Evaluation of Surface Distresses
 - Comprehensive Performance Metrics
-



1mm 3D Data Collected @ 60MPH

- X and Y: 1mm Resolution
- Z (vertical): 0.33mm Resolution
 - 3 Pixels for 1mm

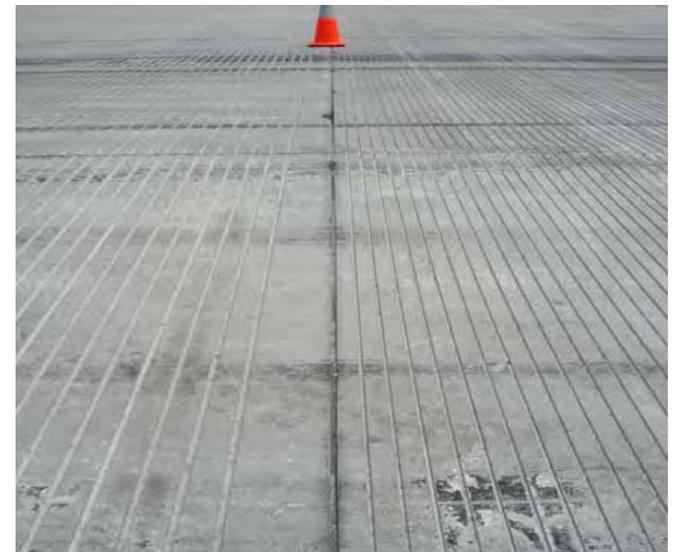
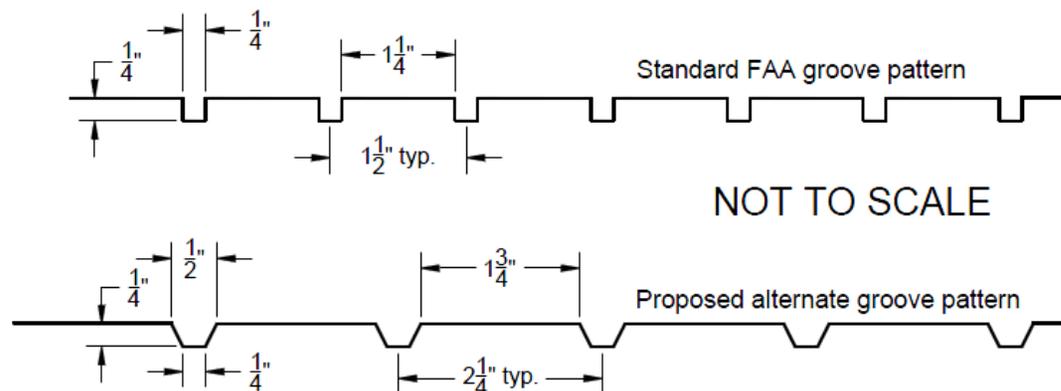


Runway Grooves

□ Rectangular Grooves

- 1/4 inch in depth by 1/4 inch (6.4mm) in width by 1 1/2 inch (38mm) center to center spacing (**AC 150/5320-12C**)

□ Trapezoid Grooves

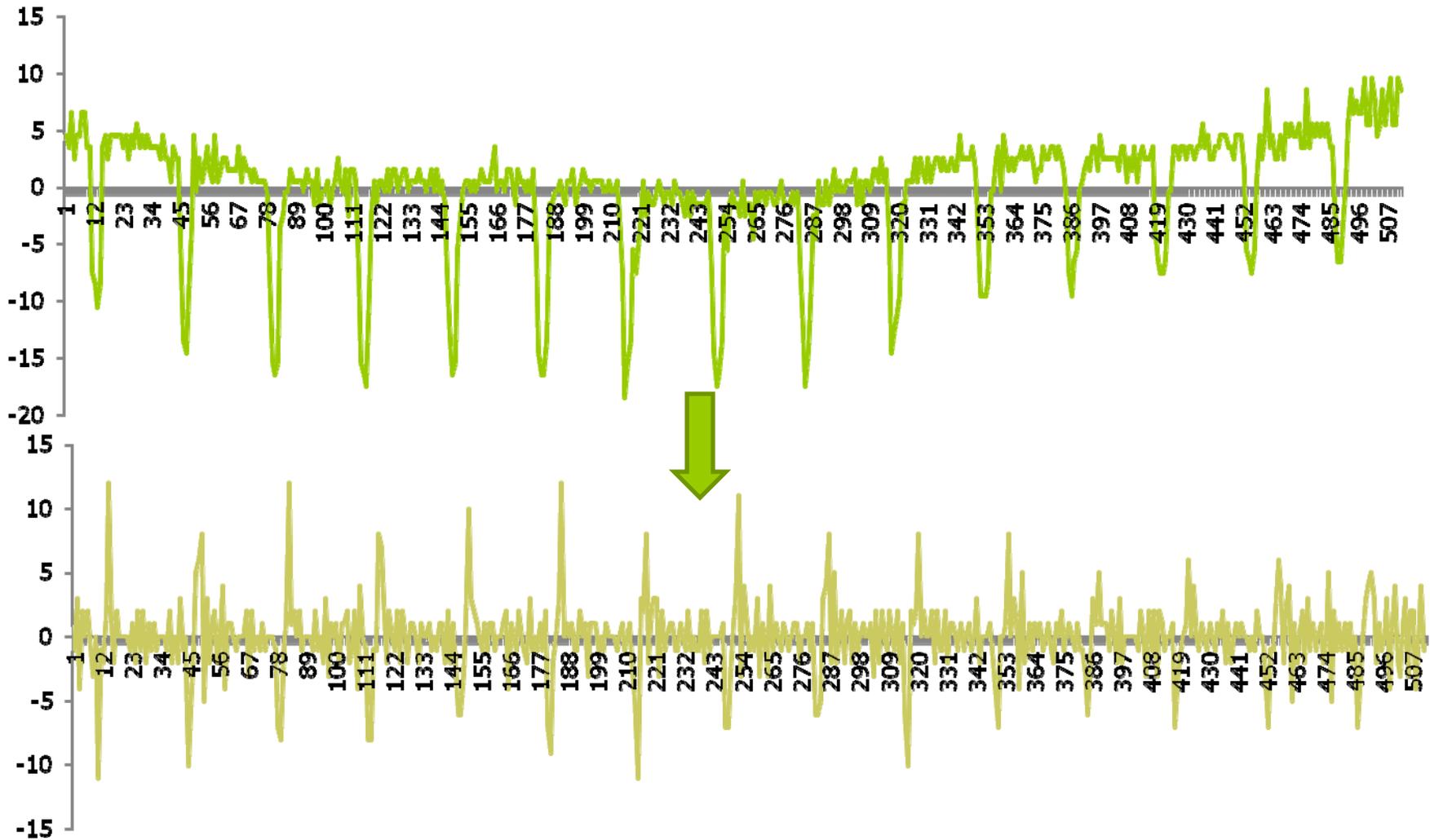


Groove Identification Procedure

- ❑ Extract the data region of interest from a 3D virtual consecutive pavement surface
- ❑ Repair data of zero values
- ❑ Use high pass filter to remove roughness
- ❑ Identify grooves and compute its depth, width, and spacing
- ❑ Find and remove joints from grooves
- ❑ Display groove and save statistical results to database table files

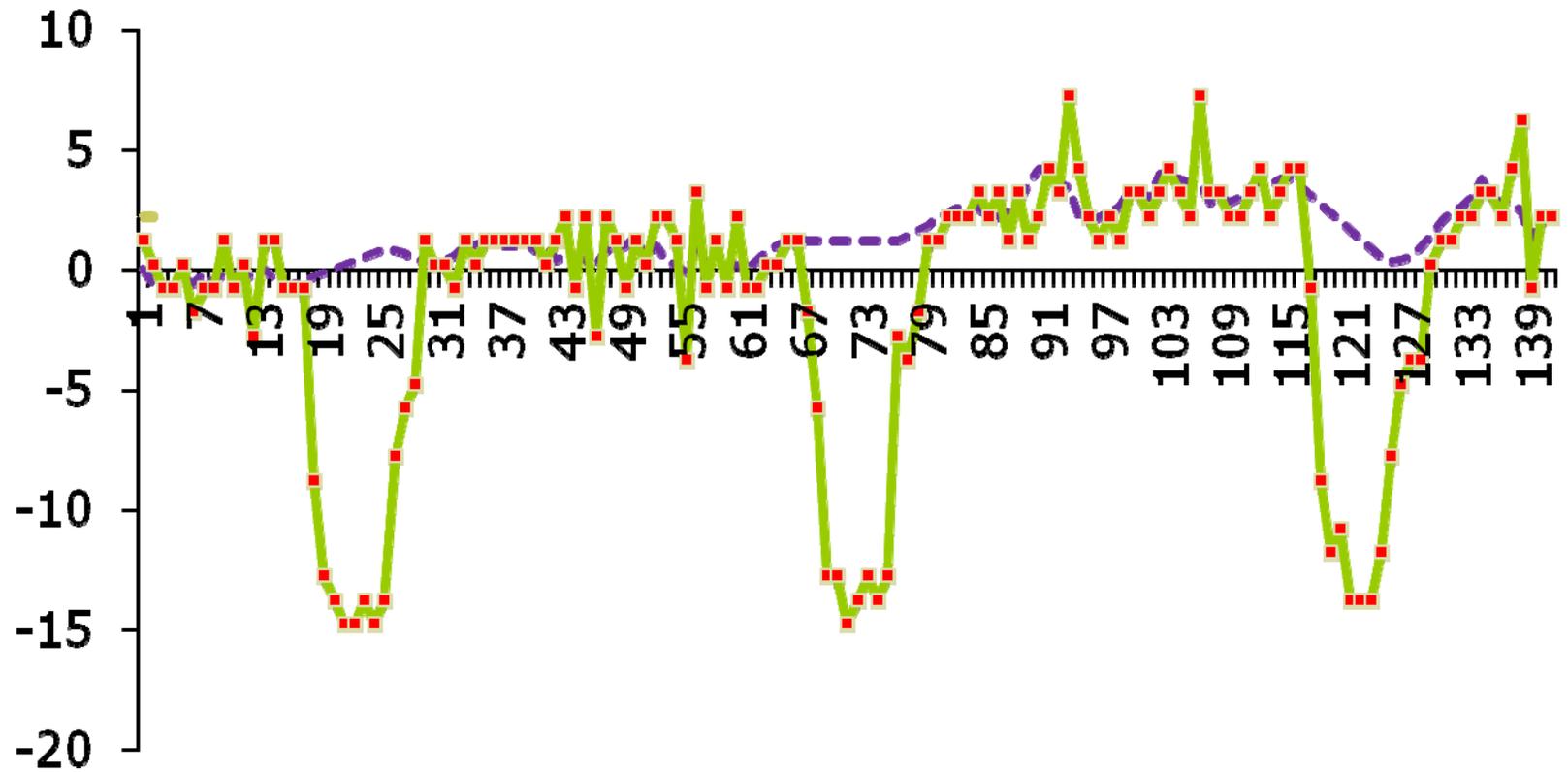


Groove and Gradient

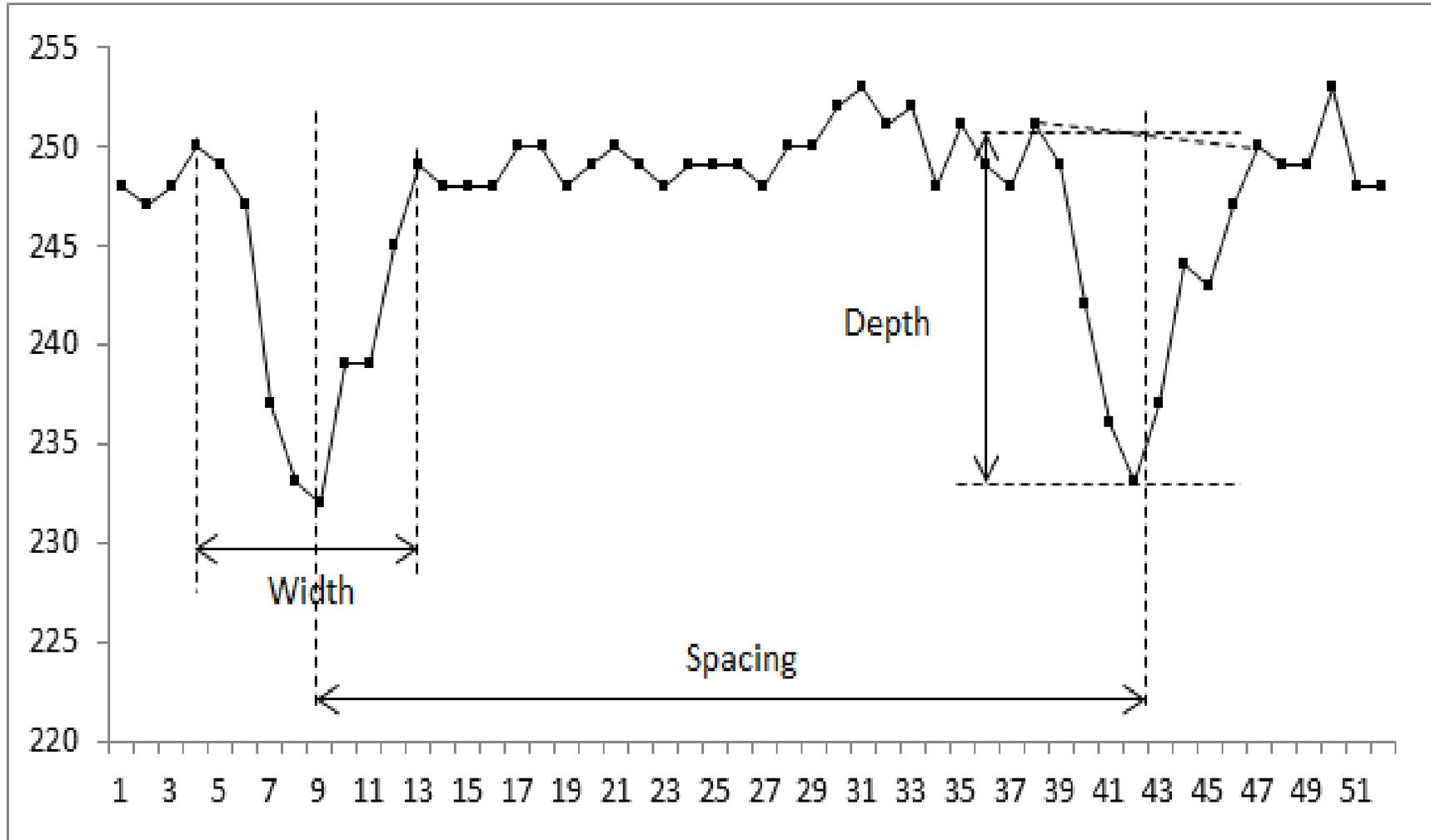


Groove Identification

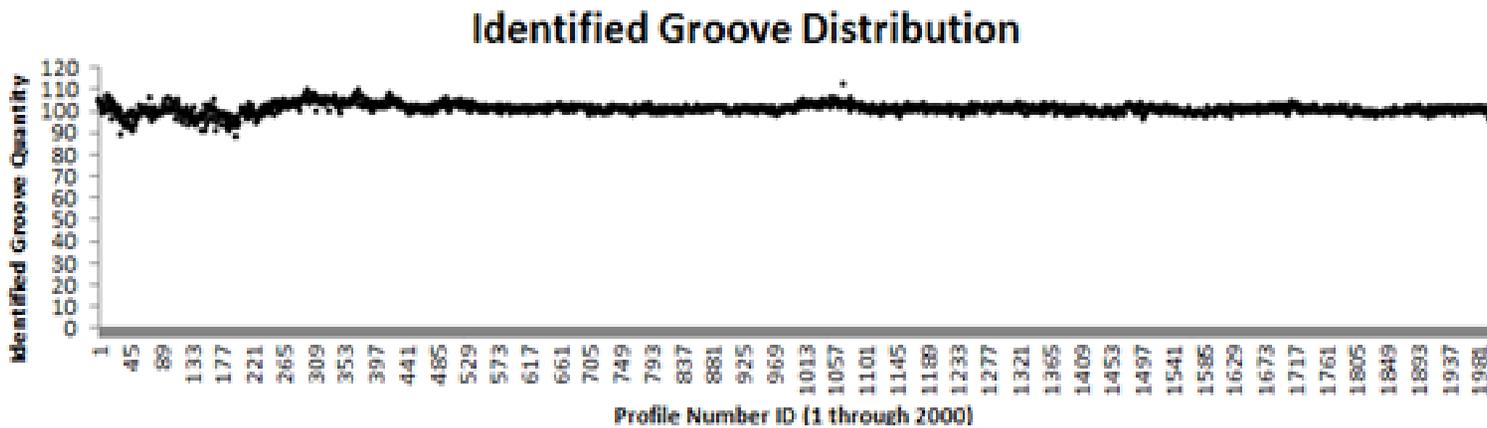
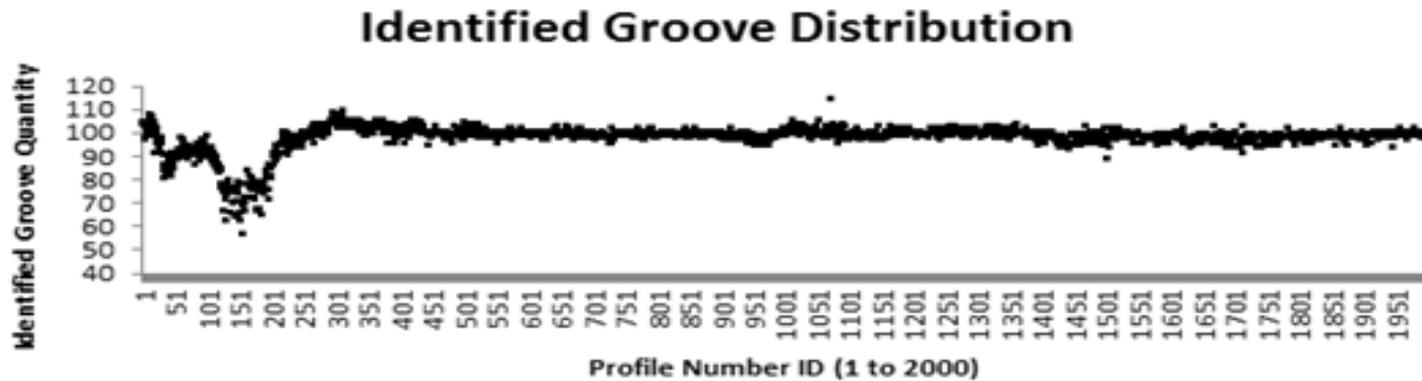
- Gradient based + Interpolation + Moving average method



Groove Dimension Calculation



Global vs. Adaptive Filtering



Groove Evaluation

- Rectangular Performance requirements - depth & width (**AC 150/5320-12C**)
 - 90%+ should be more than 3/16 in.
 - 60%+ should be more than 1/4 in.
 - 10%- should be more than 5/16 in.
- Groove quantity identification
 - Plot histogram
 - Use the highest frequency



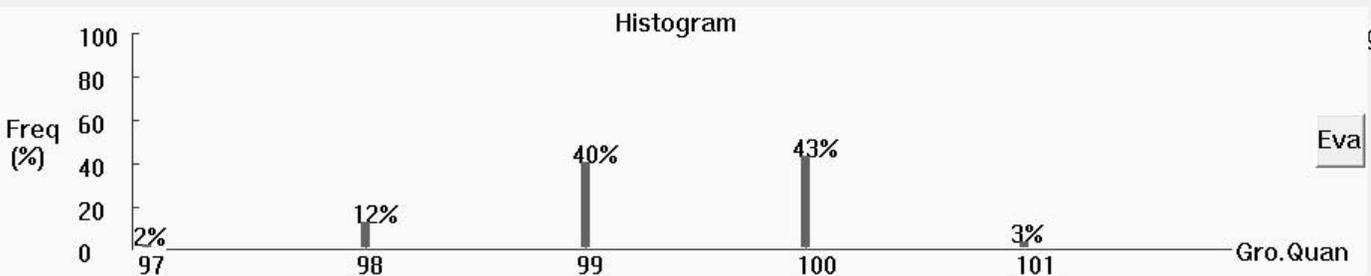
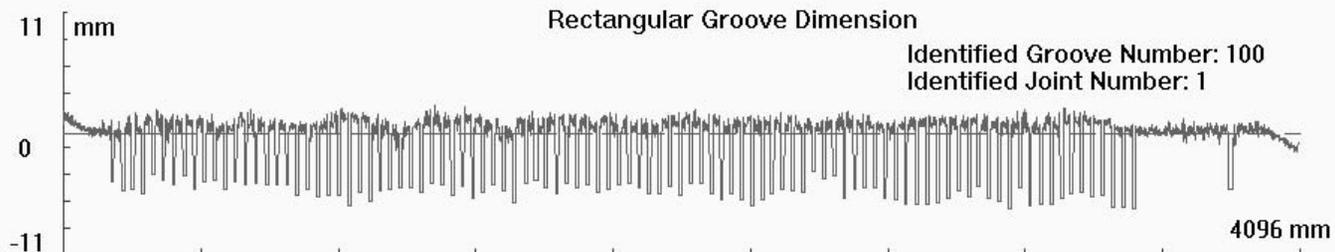
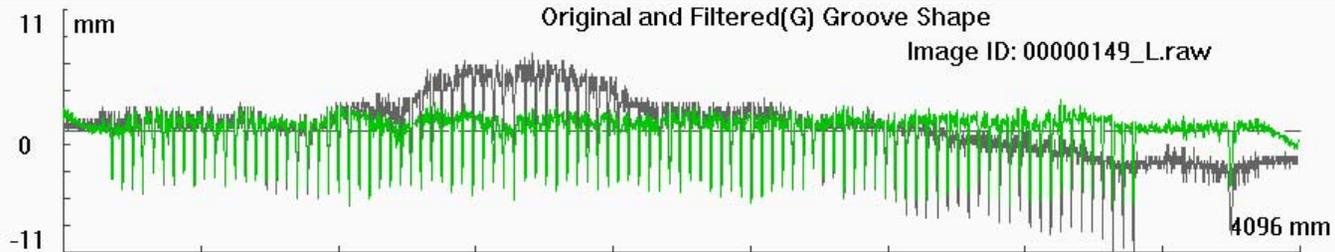
NAPTF Example

- The sample
 - 4096 mm long (eight raw image)
 - 2000 mm wide (profiles in left raw image)
 - The joint quantity: 1
 - # groove: 100



TexGroove

Input Group Open DataBase Image Quantity: 169 Section. Length: 86.528 m or 283.885 ft		Profile Sele Lane: 4000 AOI(mm): Start: 900, End: 1000		Demo 																	
Initialization Sampling Initial Img: 142, Sam.: 4096 mn Sample Quantity to be: 1		Rec.Gro Eva		Output Para <input checked="" type="checkbox"/> Depth <input checked="" type="checkbox"/> Spacing <input checked="" type="checkbox"/> Width																	
Pass Filter Low: 1040, High: 10 Cali.Coeff Verti.L: 2.5523, Verti.R: 2.5224 Samp.Lint: 1.098, Samp.Tint: 1		<table border="1"> <thead> <tr> <th>Gro.Dim</th> <th>Depth</th> <th>Width</th> <th>Recomm. Percent</th> </tr> </thead> <tbody> <tr> <td>>3/16 in.</td> <td>92.86</td> <td>100.</td> <td>>90</td> </tr> <tr> <td>>1/4 in.</td> <td>52.09</td> <td>98.83</td> <td>>60</td> </tr> <tr> <td>>5/16 in.</td> <td>7.325</td> <td>88.11</td> <td><10</td> </tr> </tbody> </table>		Gro.Dim	Depth	Width	Recomm. Percent	>3/16 in.	92.86	100.	>90	>1/4 in.	52.09	98.83	>60	>5/16 in.	7.325	88.11	<10	Stat. Info Max.Iden: 101, Min Iden: 97 STD: 1.044, Iden.Quant: 100	
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Run Pause Resume Forward Backward Close																					

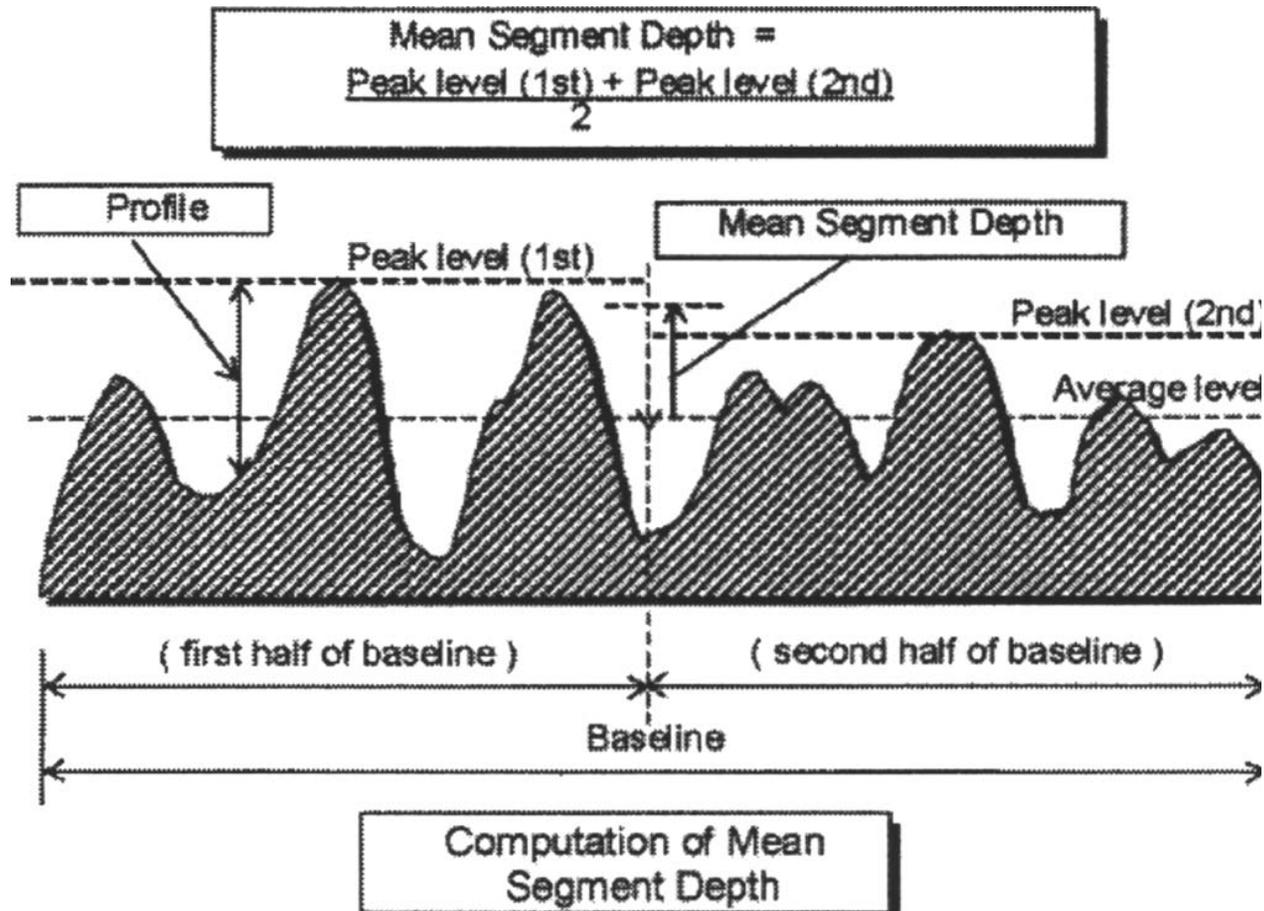


Macro-Texture MPD (ASTM E1845)

- Outlier Removal
 - Low-pass Filtering
 - Segmenting the Profile
 - Slope Suppression
 - Peak Determination
 - Determination of MPD
 - Calculation of Estimated Texture Depth (ETD)
-

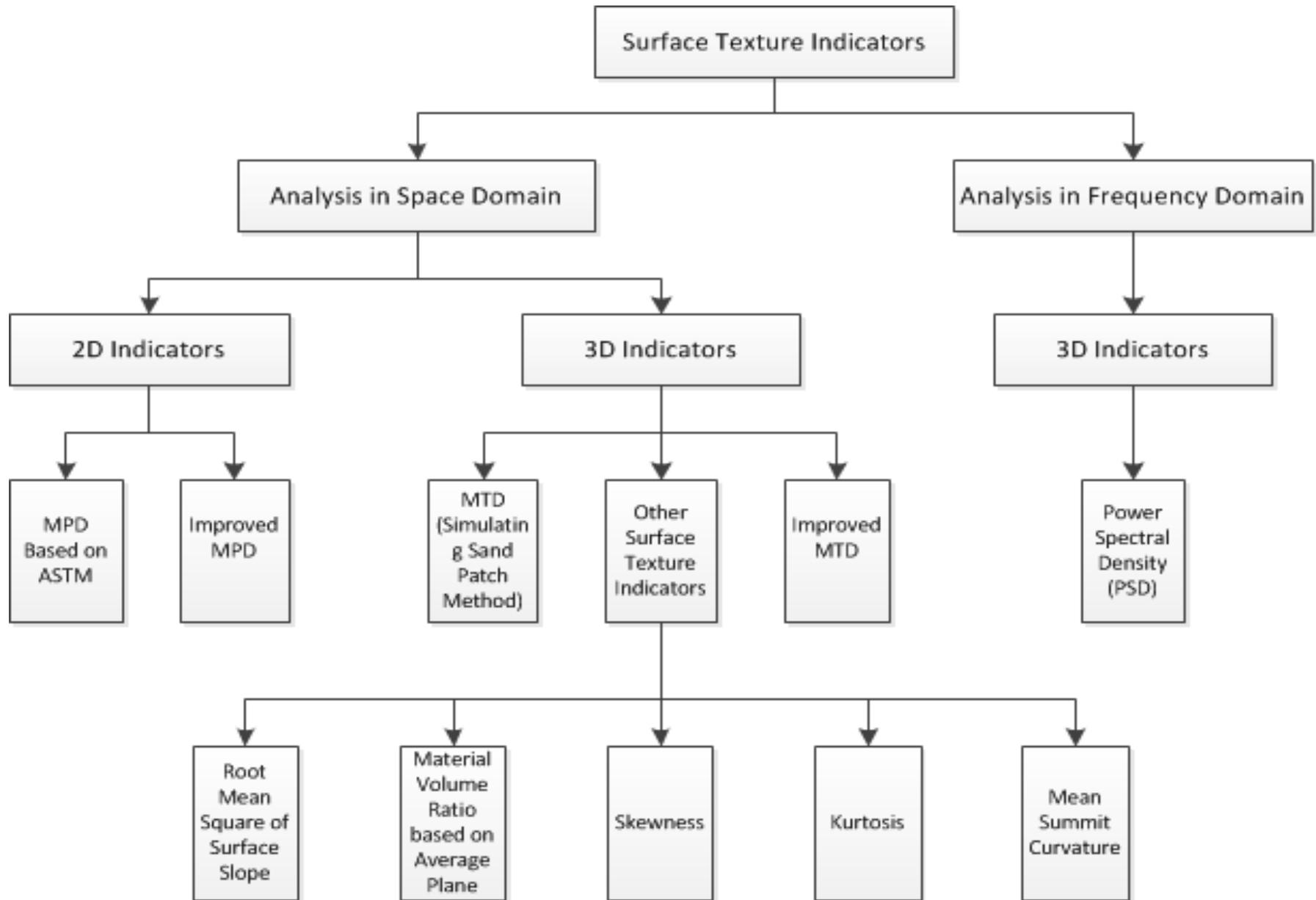


MPD Calculation (ASTM E1845)



$$\text{MPD} = \sum \text{mean segment depths} / \# \text{segments}$$

Surface Texture Indicators



Texana



Input Group

Open Database

IMG Quantity: 169
Sec.Length: 86.528 m 283.885 ft

Sample Length

Sampling

Initial IMG ID: 142
Sample 512 mm
Specify Sample Quantity: 20

Sample Width

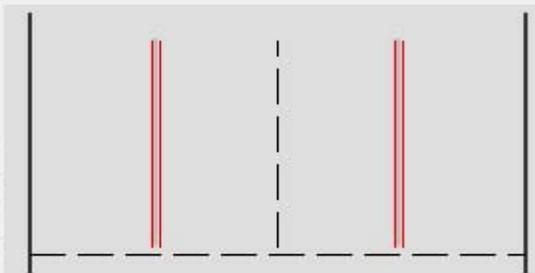
Lane Width:

4016

Start: 1006

AOI:

End: 1070



Band Filter

Low: 200
High: 20

Cali.Coeff

L.Verti: 2.5523 Longi.L: 1.11412
R.Verti: 2.5224 Longi.R: 1.11412

Outputs

- MPD MTD RMS Skewnes: Average Rougness
- Kurtosis RMS of Surface Slop PSC Angular PSC

Process

Pause

Cancel

SAMP_ID	SAMP_SIZE	IMG_RANGE	MPD	MTD	RMS	AR	RMSSS	SKEW...	KURT...
1	512 X 64	142 - 142	2.048	1.182	1.163	0.850	1.114	-0.87	5.102
2	512 X 64	143 - 143	2.579	1.449	1.501	1.144	1.283	-0.82	4.042
3	512 X 64	144 - 144	2.639	1.451	1.501	1.127	1.236	-0.81	4.061
4	512 X 64	145 - 145	2.747	1.504	1.564	1.175	1.279	-0.91	4.327
5	512 X 64	146 - 146	2.551	1.414	1.433	1.089	1.256	-0.78	4.049
6	512 X 64	147 - 147	2.640	1.484	1.538	1.156	1.280	-0.94	4.266
7	512 X 64	148 - 148	2.781	1.513	1.584	1.184	1.317	-0.87	4.300
8	512 X 64	149 - 149	1.764	1.036	0.813	0.621	1.228	-7.06	3.965
9	512 X 64	150 - 150	3.491	1.888	1.896	1.494	1.127	-0.46	3.076
10	512 X 64	151 - 151	3.482	1.944	2.005	1.580	1.157	-0.54	3.354
11	512 X 64	152 - 152	3.371	1.827	1.805	1.448	1.128	-0.27	2.689
12	512 X 64	153 - 153	3.922	2.209	2.170	1.727	1.211	-0.32	2.756
13	512 X 64	154 - 154	3.617	2.092	2.010	1.583	1.083	-0.21	2.957
14	512 X 64	155 - 155	3.603	1.946	1.885	1.501	1.193	-0.27	2.814
15	512 X 64	156 - 156	4.071	2.228	2.191	1.727	1.252	-0.24	2.785
16	512 X 64	157 - 157	1.750	0.680	0.520	0.204	0.824	7.014	5.028



Future Research

- Develop/enhance macro-texture and groove geometry measurement algorithms for the entire airfield pavement based on current FAA practice
 - Develop/enhance groove joint identification algorithms using profile based and area based approaches
 - Validate calculated texture indicators and groove characteristics by comparing with ground truth reference values and current various FAA measurement practices
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Thank You!

