AVOIDING THE DISTRESS OF SIDEWALKS ASSESSMENTS

FLORIDA ASSOCIATION OF COUNTY ENGINEERS & ROAD SUPERINTENDENTS

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INTRODUCTION

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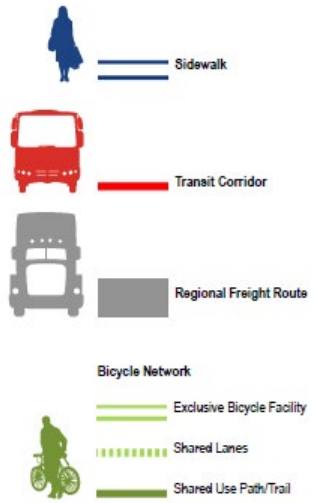
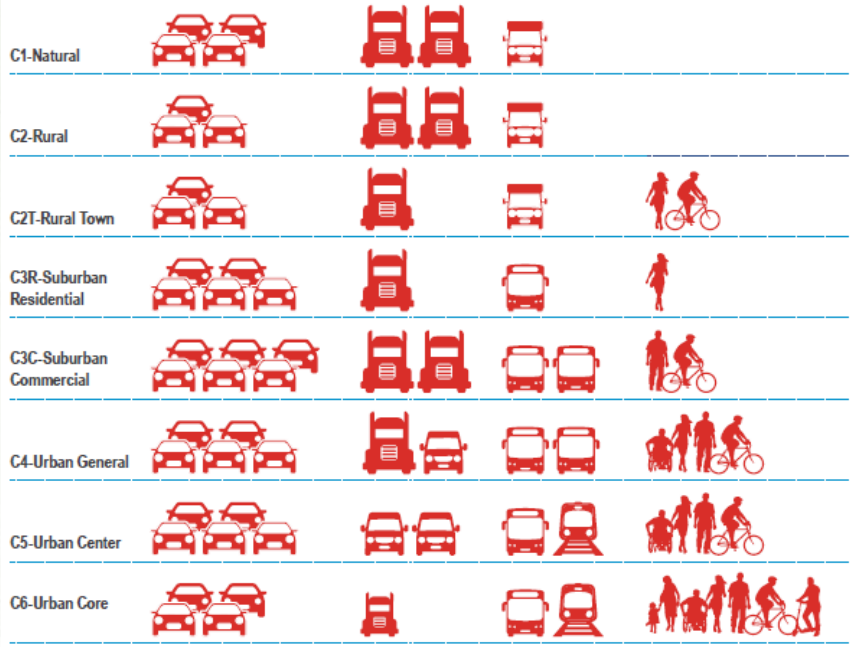
ASSESSMENT PURPOSE and APPROACH

- Condition Inventory of:
  - Pavement areas, edge of pavement, and markings
  - Roadside assets
  - Curbing
  - Trees in right of way
  - Sidewalks and bike lanes
- Americans with Disabilities/Accessibility
  - Ramps
  - ADA Assessments
- Complete Streets
  - Beyond a sidewalks assessment, the purpose includes necessary data to support roadways designed and operated for pedestrians, bicyclists, motorists and transit riders of all ages and abilities

ASSESSMENT PURPOSE and APPROACH

- Data for Target Zero objectives
  - Corridors with higher speeds and transit frequency have highest likelihood of pedestrian and bicycle crashes
- Data collected from sidewalks gives the perspective of the pedestrian and/or bicyclist in interactions with traffic or obstructions
- Zones
  - Frontage
  - Pedestrian
  - Furnishing
  - Curb
  - Roadway Realm
- Context Classifications and design approach





SIDEWALK DATA COLLECTION

gEN 1

- Conduct inspections and accurate mapping of sidewalks and their surroundings
- Sensor technology later supporting geospatial (GIS) processes
- Asset management data for issuance of future maintenance/rehabilitation work orders
- Collect design quality data quickly, cost-effectively
- Observe conditions with lidar, imagery and sidewalk profiler
- Linear referenced sidewalk data with the asset management system's roadway segments
- Geographic coordinates for GIS mapping for use in planning activities
- Overall Condition Index (OCI) to classify sidewalks most needing repair
- Collection rate ~ 36+ *sidewalk miles a day, 1-person, one system!*

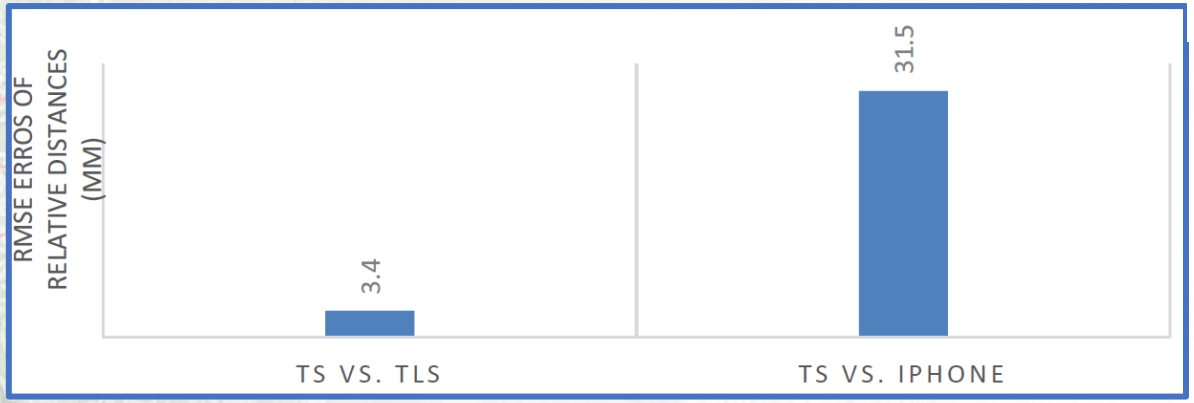
SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

- What about these?
- Testing indicate accuracies*:
  - Absolute accuracies of ± 3 cm (1”) horizontally
  - ± 7mm (0.25”) vertically,
  - Relative accuracy of ± 3 cm (1”).
  - Measuring range - iPhone has a maximum range of 5 m (16.4’)
  - For large scenes multiple passes (frames) are required, new frames required for large angular displacements
  - With only a distance range of 5 m, the iPhone is limited to smaller scale projects
- These results were only achieved after:
  - Establishing a control network of 24 targets at sub-millimeter geometric accuracy
  - Use of real-time 3D mapping package for consumer mobile devices

*https://conferences.lib.unb.ca/index.php/tcrc/article/view/645/113

SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

- What about these?
  - Labor intensive fielding efforts to conduct an inventory
  - Algorithm is necessary to adjust the camera positions for those estimated by the phone's SLAM system
  - Very intensive back-office processing for large areas, such as a countywide assessment *and mapping-grade data*
  - Comparisons
    - TS = Total Station (precise survey grade instrument)
    - TLS = Terrestrial Lidar Scanner (4 tenths of an inch)
    - iPhone
    - Survey control by TS and comparison to well defined target locations



SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

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- Safety and control
- Speed and efficiency
- Clean energy, quiet and non-intimidating to pedestrians
- Affordability to our clients and WGI for operation, as compared to labor-intensive fielding collections
- Electric standup vehicle (ESV), height, width, weight, visibility considerations
- Dependability of ESV - military, police grade vehicle
- Form-factor comparable to mobility scooters made sense
- Adaptability allows human interactions with multiple sensors and controller configuration
- Quick charging with auxiliary power
- Multisensor integration with positioning and orientation systems

SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

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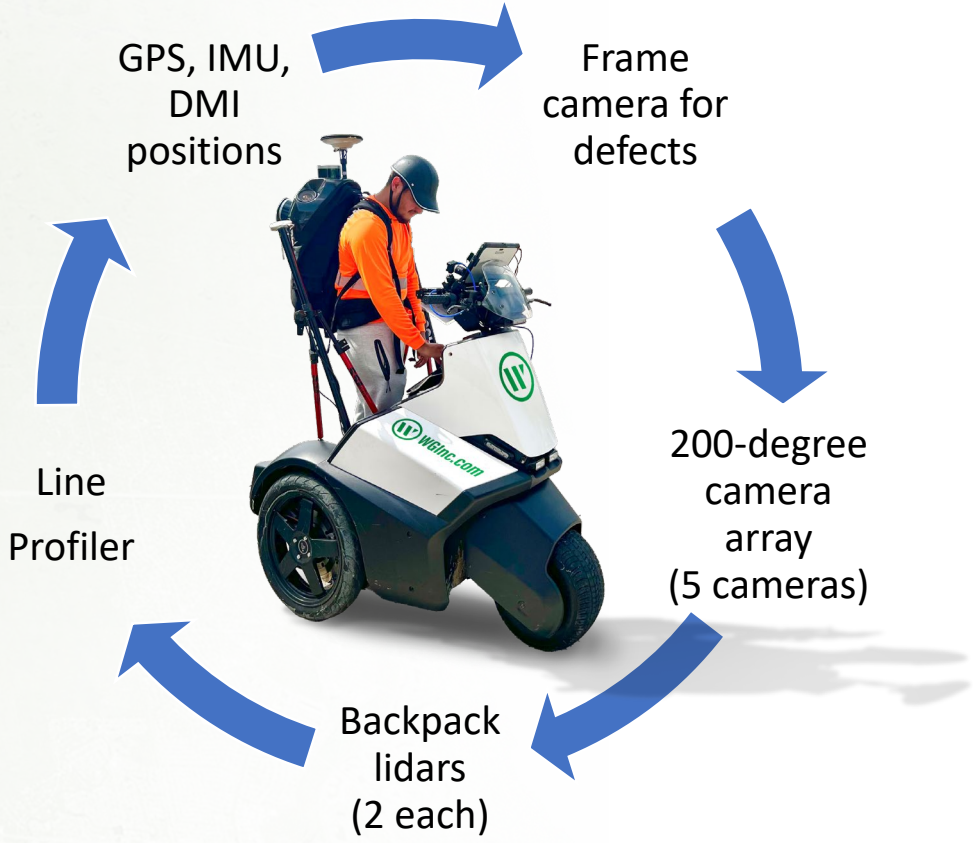
- Identify edges and defects along the sidewalk.
- Imagery collected using multiple cameras on the ESV
- Close-range, survey-grade on the ESV
- IMU for slope and tilt (lidar and profiler IMUs)
- Keypad used to record a GPS coordinate location using preloaded hot keys for many defect types
- IMU supplements GPS for sensor trajectories
- GPS of image photocenters collected by front and back and side facing cameras



SIDEWALK DATA VISUALIZATIONS

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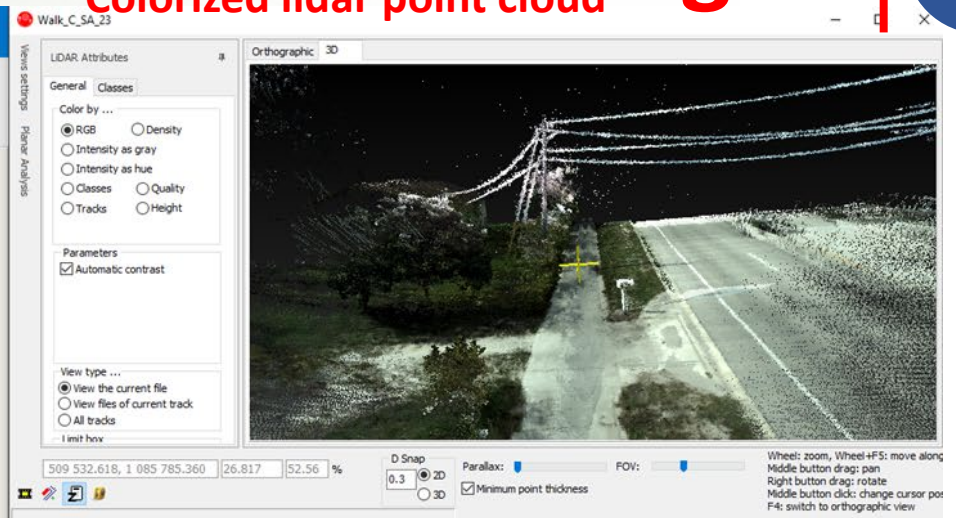
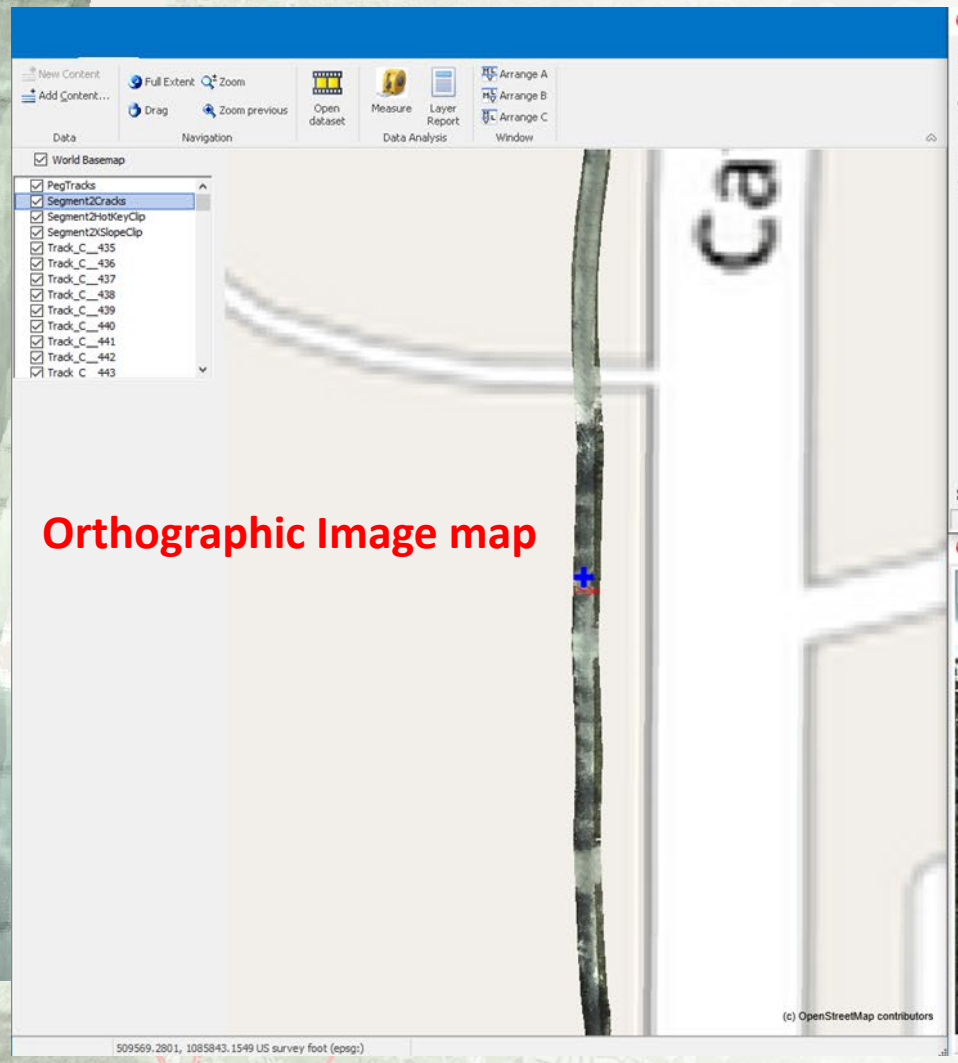
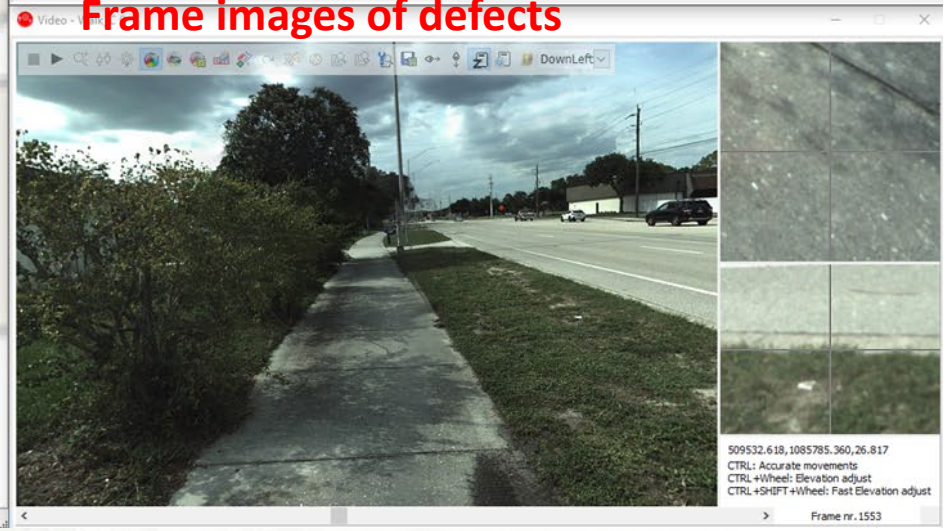
Colorized lidar point cloud



Orthographic Image map



Frame images of defects



AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS

SIDEWALK DATA COLLECTION

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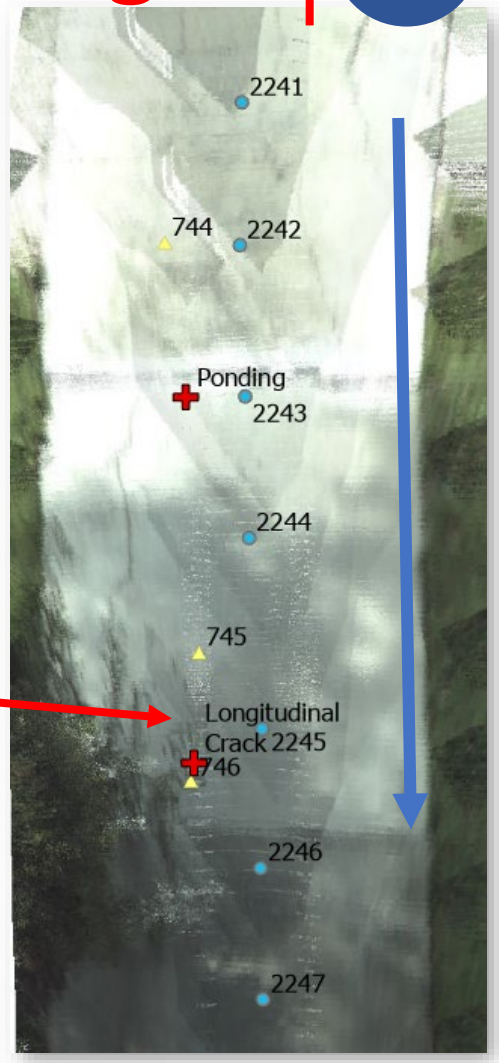
- Attribution for sidewalk segments includes photocenters for all images
- Using imagery, the sidewalk defects can be reviewed for defect type

Image from the rear facing camera. (Point labeled 2245)

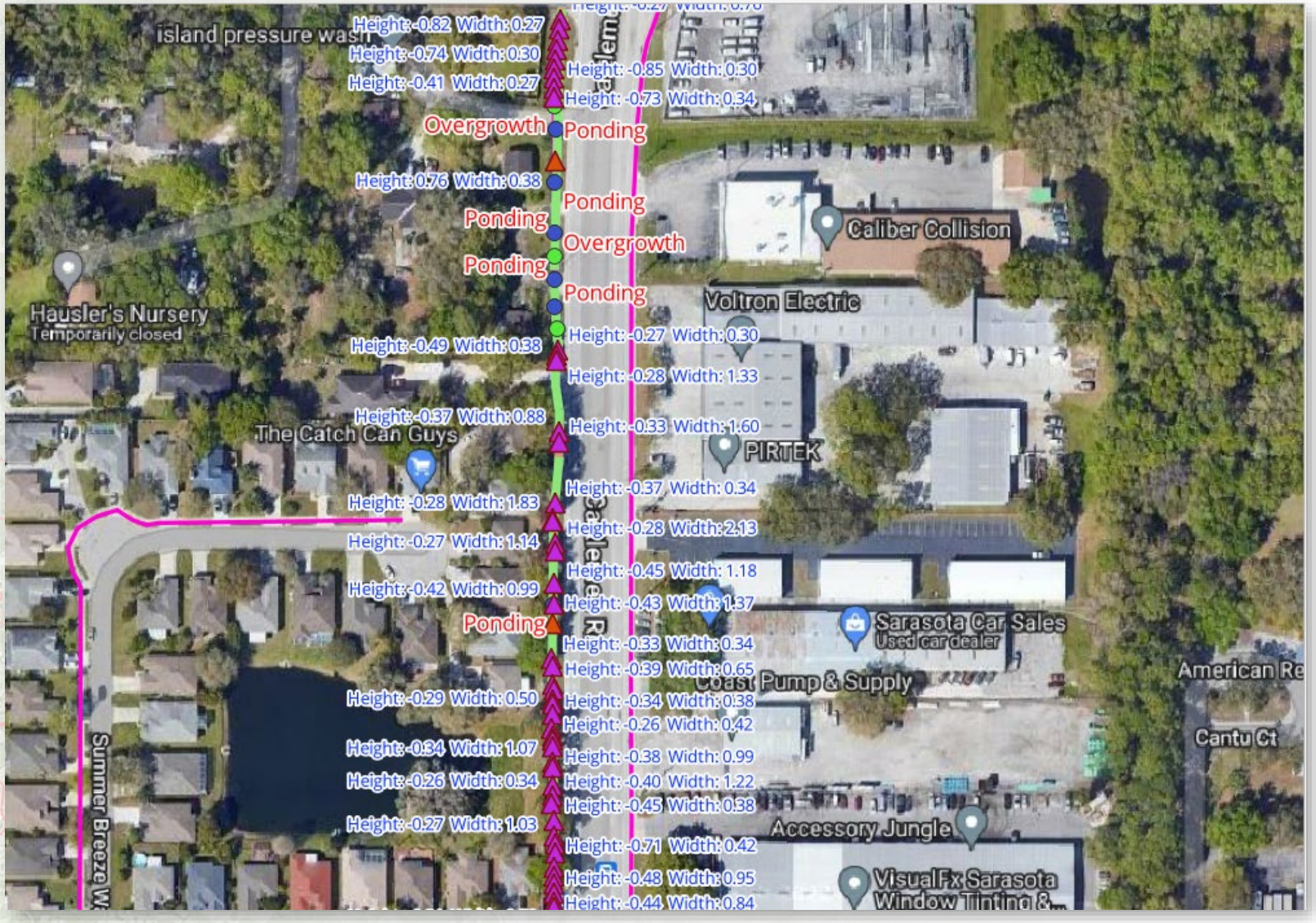


SIDEWALK DATA ANALYSIS

Example:

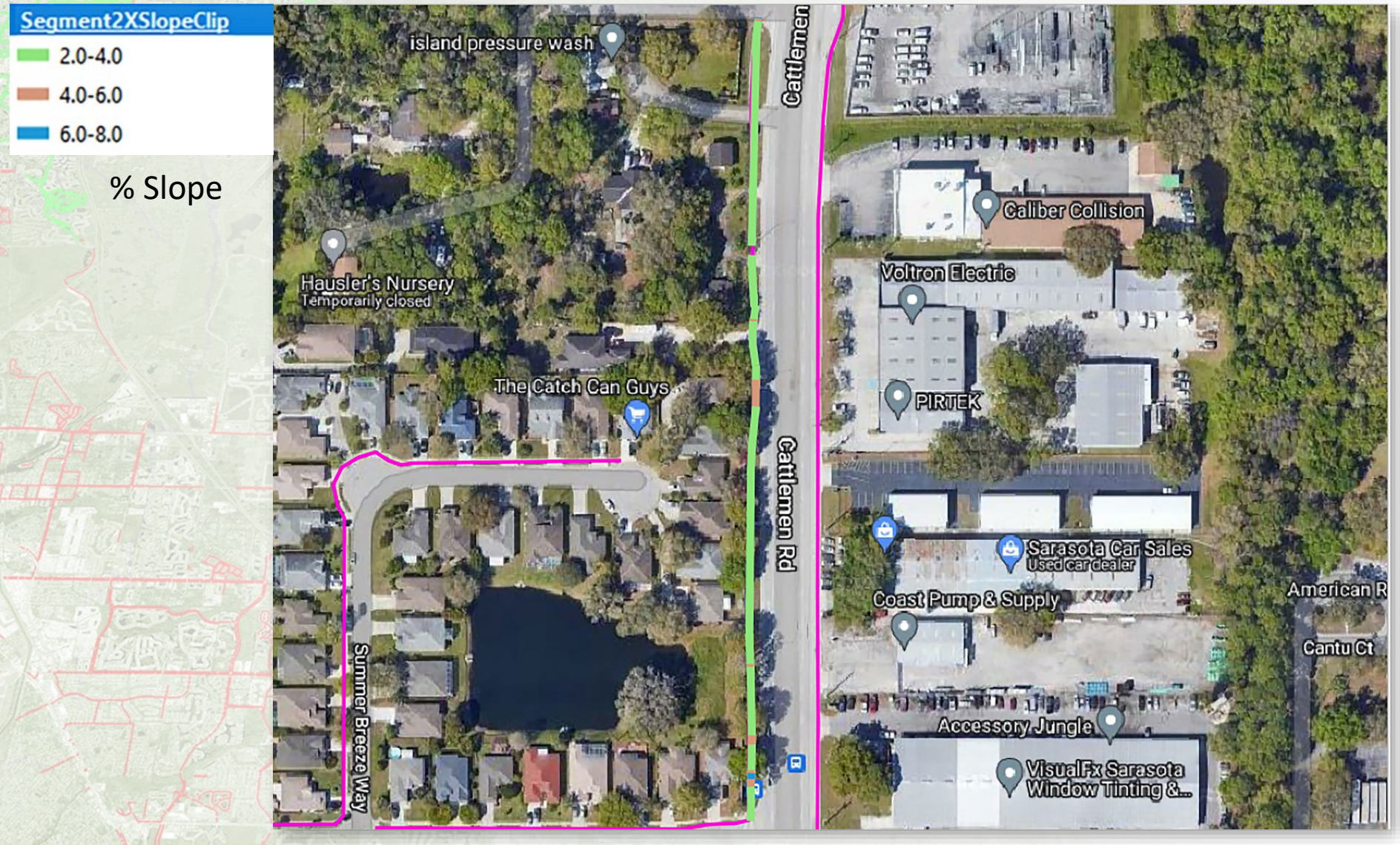
- **Profile length 1.325 miles**
- **Horizonal scale is compressed**
- **From POB a small hill begins +/- 1 mile**
- **From POB, first defect is at 15.5’ 0.37” deep 0.95” wide**

SIDEWALK DATA ANALYSIS



AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS

SIDEWALK DATA ANALYSIS



AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS

SIDEWALK DATA ANALYSIS METHODOLOGY

- **Identify defect types**
- **Criteria for severity, categories and defect weights**
- **Assign Defects categories and sub-categories to segments**
  - *Larger weights applied to greater severity.*
  - *Number of panels counted based on defect criteria*
  - *Sidewalk OCI calculated for the segment*
- **Representation in GIS for needed repairs and used with asset management for planning and remedies**
- **Sidewalk OCI ratings necessary for programming repairs** *(e.g., ADA compliance)*
- Communities need to have a multiple prong approach to meeting ADA criteria

Defect	Severity (Weight)
Crack/Opening < 0.25	3
Crack/Opening 0.25 < 0.5	10
Crack/Opening => 0.5	25
Vertical Displacement 0.25 < 0.5	3
Vertical Displacement 0.5 < 1.0	10
Vertical Displacement => 1.0	30
Pedestrian Access Route Width < 4 ft	10
Slab Width < 5 ft	5
Cross slope >2%	10
Logitudinal Slope >5%	10
Drop Off Hazard	10
Overgrowth	1
Spalling/Scalling <25% of panel	2
Spalling/Scalling 25% <50% of panel	5
Spalling/Scalling 50% <75% of panel	8
Ponding	5
Obstruction	30

Inspections determine the number of panels with each defect.

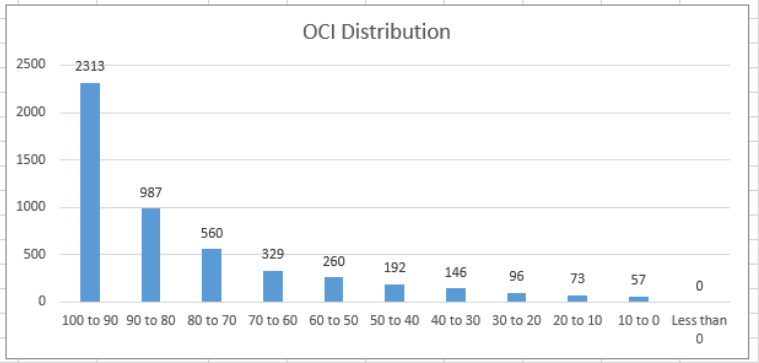
- Weighted Defect Score (WDS) = Number of Panels * Weight
- WDS over sidewalk length (WDSOSL) = (WDS) / (Sidewalk Length)
- Sidewalk OCI = 100 - (WDSOSL)

SIDEWALK DATA ANALYSIS OCI TOOL

Defect	Severity (Weight)
Crack/Opening < 0.25	0.2
Crack/Opening 0.25 < 0.5	0.5
Crack/Opening => 0.5	1
Vertical Displacement 0.25 < 0.5	0.2
Vertical Displacement 0.5 < 1.0	0.5
Vertical Displacement => 1.0	1
Pedestrian Access Route Width < 4 ft	2
Slab Width < 5 ft	0.025
Cross slope 3% < 4%	0.2
Cross slope 4% < 5%	1
Cross slope > 5%	3
Logitudinal Slope >5%	2
Drop Off Hazard	5
Overgrowth	5
Ponding	5
Obstruction	5
vertical clearance obstruction	5
Spalling	5
Longitudinal Crack	5
Width >4	5

Adjust Weights here to see how it affects the entire data set.

OCI Min	0.26118
OCI Max	100
OCI Median	88.3341
OCI Average	80.47877
Std Dev	21.7807
Mode	100



- **Output in Excel**

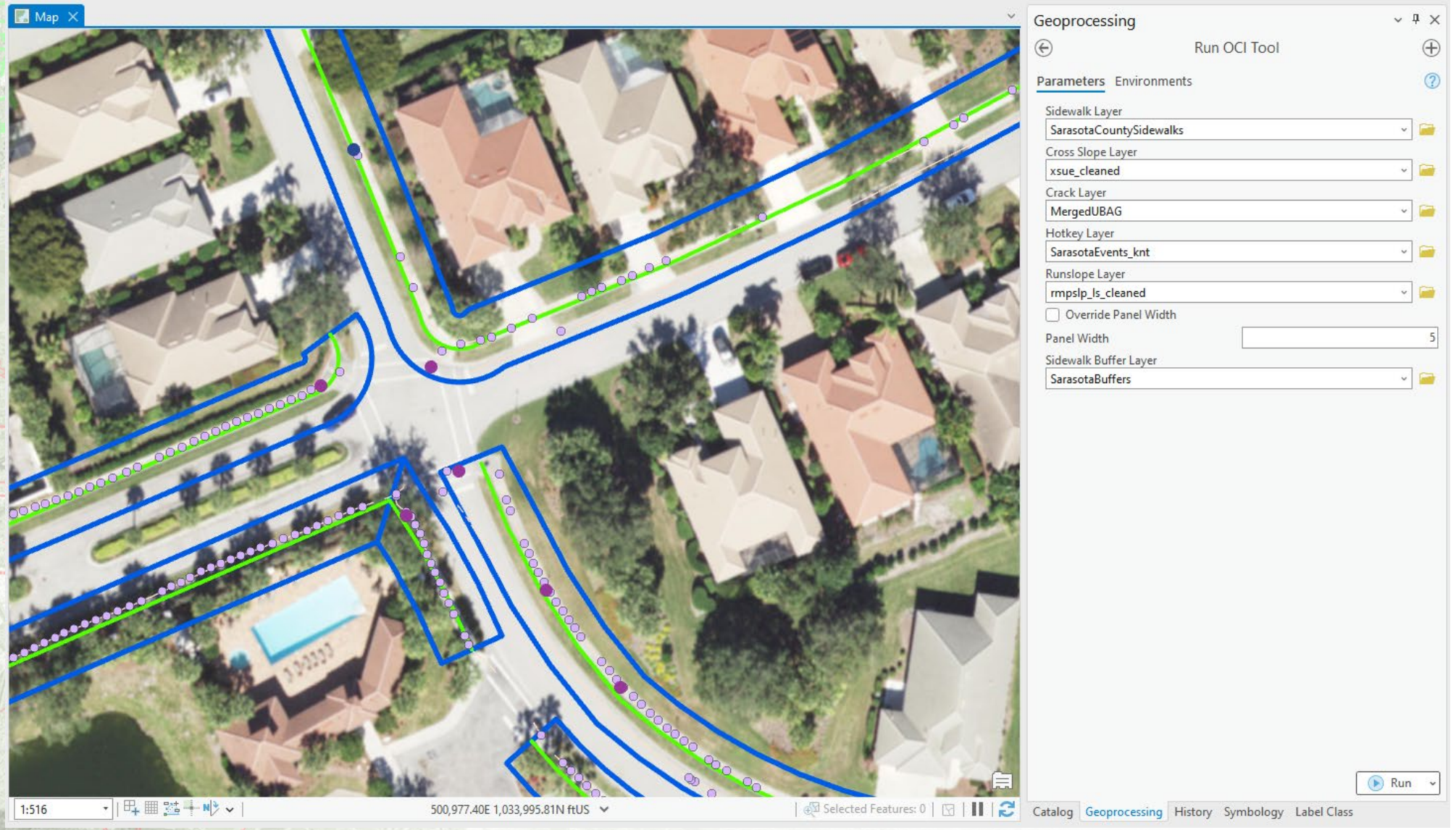
18	19	20	21	22	23	EXCEL FORMULA				
0.5	0.5	0.5	0.5	0.25	0.5					
Ponding	Obstruction	vertical clearance obstruction	Spalling	Longitudinal Crack	Width >4	Defect Count	TotalWeightedDefectScore	WDS	WDS/Length	OCI
0	1	0	0	0	0	0	53	2.565	135.945	0.187	99.813
0	1	0	0	1	0	0	45	3.53	158.85	0.7416	99.258
0	0	0	0	2	0	0	72	3.98	286.56	0.5545	99.446
5	0	0	4	1	0	0	60	7.04	422.4	1.3241	98.676
0	0	0	1	0	1	1	69	3.725	671.025	1.5643	98.436
1	0	0	0	0	0	0	5	0.62	3.1	0.0754	99.925
0	0	0	0	0	0	0	42	1.64	68.88	0.3322	99.668
0	0	0	0	0	0	0	41	2.54	104.14	0.8606	99.139
0	0	0	0	0	0	0	93	4.64	431.52	0.8267	99.173
0	0	0	0	0	0	0	56	2.92	163.52	0.8885	99.112
0	0	0	0	0	2	0	4	0.535	2.14	0.0156	99.984
0	0	0	0	0	0	0	14	0.87	12.18	0.1887	99.811
0	0	2	0	0	0	0	41	2.325	95.325	0.3896	99.61
0	0	0	0	0	0	0	72	2.84	204.48	0.5146	99.485
0	0	0	0	18	132	0	236	45.13	10650.68	2.5572	97.443
0	0	0	0	3	2	0	223	13.04	2907.92	2.9206	97.079
0	0	0	0	0	0	0	197	7.77	1530.69	1.3203	98.679
0	0	0	0	0	1	0	321	12.065	3872.865	1.8534	98.141
0	0	0	0	0	4	0	118	5.465	644.87	1.2028	98.797
0	0	0	0	0	0	0	25	0.97	24.25	0.1752	99.825
0	0	0	0	0	2	0	70	3.37	235.9	0.4613	99.539
0	0	0	0	0	0	0	16	0.74	11.84	0.1434	99.857
0	0	0	0	0	0	0	46	1.8	82.8	0.4579	99.542
1	0	0	2	0	3	0	182	9.355	1811.81	2.9571	97.043
0	0	0	1	0	0	0	139	6.7	1333.3	1.3716	98.628
4	0	0	2	0	0	0	30	5.015	150.45	0.3155	99.084
0	0	0	0	0	0	0	239	16.7	3991.3	6.3809	93.619
0	0	0	3	0	1	0	280	12.155	3403.4	2.6687	97.331
0	0	0	0	0	0	0	104	4.44	461.76	0.7211	99.279
0	0	0	0	1	0	0	289	14.64	4230.96	3.6205	96.379
0	0	0	0	0	0	0	129	5.295	683.055	1.4471	98.553
0	0	0	0	0	0	0	127	7.33	930.91	2.5905	97.409
0	0	0	0	0	0	0	23	1.49	34.27	0.2714	99.729
0	0	0	0	0	0	0	131	4.915	643.865	0.9595	99.04
0	0	0	0	0	0	0	42	2.2	92.4	0.7187	99.281
2	1	0	0	1	3	0	580	26.445	15338.1	8.0419	91.958
0	0	0	0	2	1	0	24	2.11	50.64	0.0921	99.908
0	0	0	0	0	0	0	104	4.905	510.12	1.4666	98.533
1	0	0	0	1	5	0	240	17.265	4143.6	3.7217	96.278
1	0	0	0	0	2	0	379	23.22	8800.38	9.1696	90.83
0	0	0	0	0	3	0	99	4.73	468.27	1.0101	98.99
0	0	0	0	0	7	0	204	11.07	2258.28	5.5587	94.441
3	0	0	0	0	7	0	129	13.435	1733.115	4.3248	95.675

14	1165.05	8	417	2	2	16	19	1	0	0	0	32	2	1	0	1	0	0	0	0	0	0
15	995.65	6	166	3	75	27	59	45	1	0	0	2	2	1	0	3	0	0	0	0	3	2
16	1158.82	6	193	1	60	21	47	34	1	0	0	29	4	0	0	0	0	0	0	0	0	0
17	2082.83	5	417	2	36	31	101	28	2	0	0	51	5	1	0	1	0	0	0	0	0	1
18	536.16	6	89	0	32	18	43	5	2	0	0	11	3	0	0	0	0	0	0	0	0	4
19	135.36	5	27	0	8	4	11	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
20	511.34	8	64	0	25	8	25	5	3	0	0	2	0	0	0	0	0	0	0	0	0	2
21	82.57	5	17	0	6	2	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	180.81	5	36	0	16	6	18	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0
23	612.7	5	123	6	51	29	55	31	0	0	0	2	1	1	0	0	1	0	0	0	2	0
24	972.06	5	194	3	63	15	73	8	0	0	0	34	2	0	0	0	0	0	0	0	1	0
25	164.33	5	33	0	4	5	6	2	1	0	0	3	1	0	0	1	1	4	0	0	2	0
26	625.51	5	125	0	2	115	20	97	0	0	0	5	0	0	0	0	0	0	0	0	0	0
27	1275.28	4	319	5	113	11	97	31	1	0	0	6	5	6	1	0	0	0	0	0	3	0
28	640.38	5	128	3	35	5	32	9	2	0	0	14	2	0	0	0	2	0	0	0	0	0
29	1168.6	5	234	7	98	37	92	49	1	0	0	0	0	0	3	1	0	0	0	0	1	0
30	472.01	5	94	1	41	14	32	22	2	0	0	14	3	0	0	0	0	0	0	0	0	0
32	359.35	5	72	2	30	24	29	26	1	0	0	7	4	1	3	0	0	0	0	0	0	0
33	126.26	5	25	0	3	8	3	6	2	0	0	1	0	0	0	0	0	0	0	0	0	0
34	671.03	5	134	0	39	15	39	14	1	0	0	20	3	0	0	0	0	0	0	0	0	0
35	128.57	5	26	0	15	6	5	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
36	1907.28	5	381	2	221	57	200	78	2	0	0	5	3	4	1	0	2	1	0	0	1	3
37	550.06	5	110	2	2	5	9	0	0	0	0	0	0	3	0	0	0	0	0	0	2	1
38	347.83	5	70	2	34	11	26	20	1	0	0	5	1	3	0	0	1	0	0	0	0	0
39	1113.36	8	139	0	4	101	28	77	0	0	0	11	5	7	1	0	0	0	0	0	1	5
40	953.73	8	120	0	5	158	82	81	0	0	0	35	10	4	0	1	1	0	0	0	0	2
41	463.6	6	77	2	32	14	36	12	0	0	0	0	0	0	0	0	0	0	0	0	0	3
42	406.26	5	81	2	65	14	47	34	0	0	0	13	4	15	3	0	0	0	0	0	0	7
43	400.74	5	80	2	24	8	16	13	5	0	0	3	3	35	7	3	3	0	0	0	0	7

AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS

SIDEWALK DATA ANALYSIS OCI TOOL

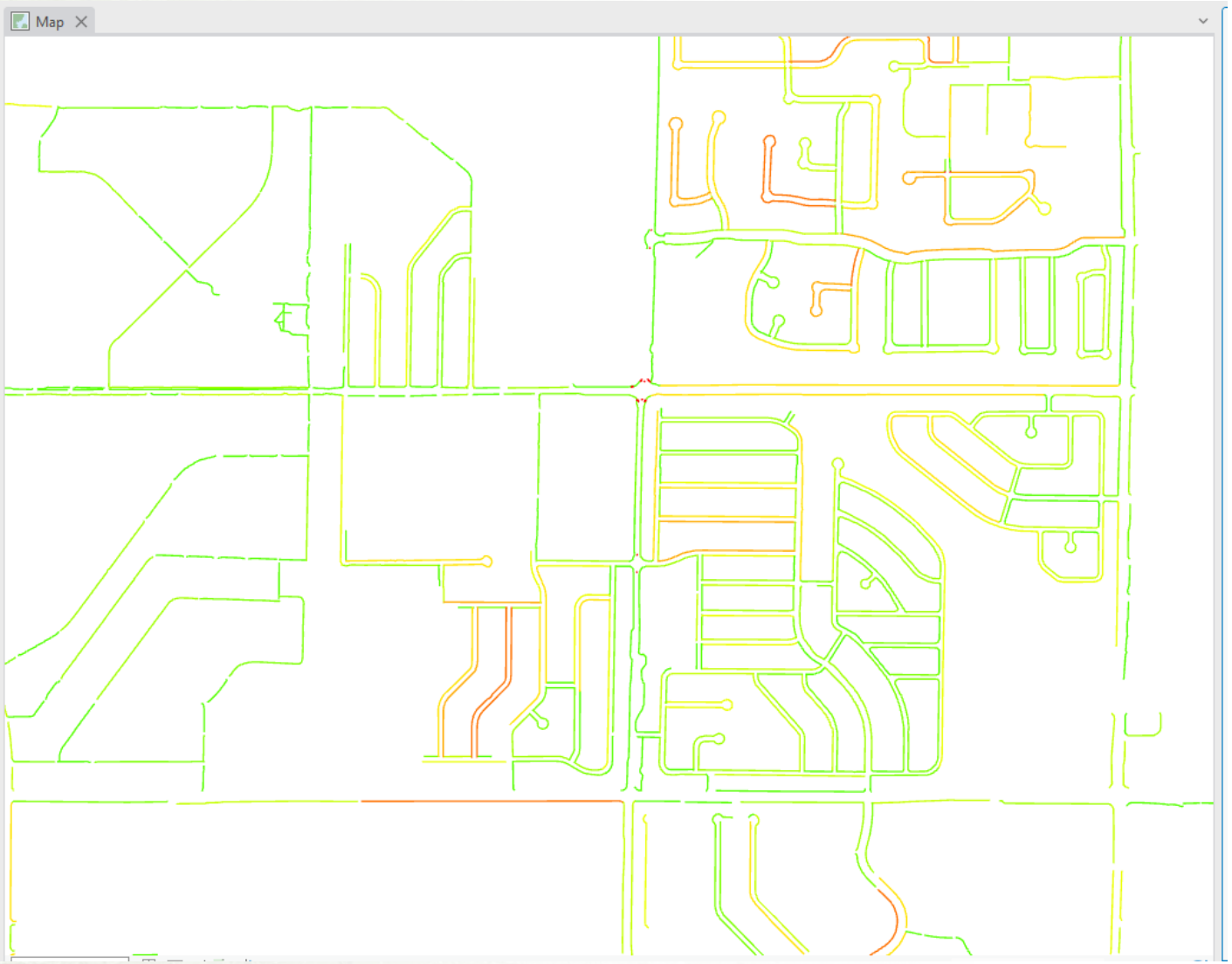
- **ArcGIS Pro based OCI Tool**



AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS

SIDEWALK DATA ANALYSIS RESULTS

- GIS Results
  - Heatmap
  - Additional Analysis



SIDEWALK DATA ANALYSIS

- **LiDAR for:**
  - *Widths, obstructions, drop-off locations*
  - *Pedestrian access*
- **Profiler for:**
  - *Slope and cross slope,*
  - *Crack width and depth*
  - *Panel separation*
- **Data is georeferenced**
- **Office reviews to create GIS features**
- **System assigns OCI for the defined sidewalk segments**

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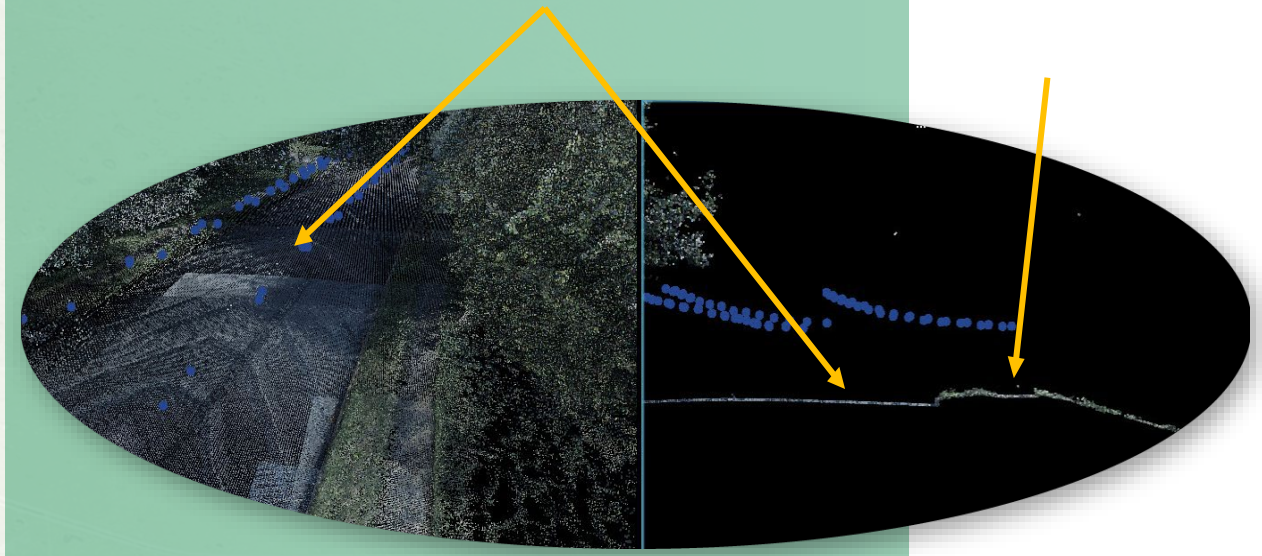
✓ • Methodology for sidewalk conditioning rating



COLORIZED LiDAR POINT CLOUD AND PROFILE

SIDEWALK DATA ANALYSIS

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- **Complimentary technology, surpassing basic data needs**
  - *Safe and efficient*
  - *High benefits with superior value*

AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS

SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

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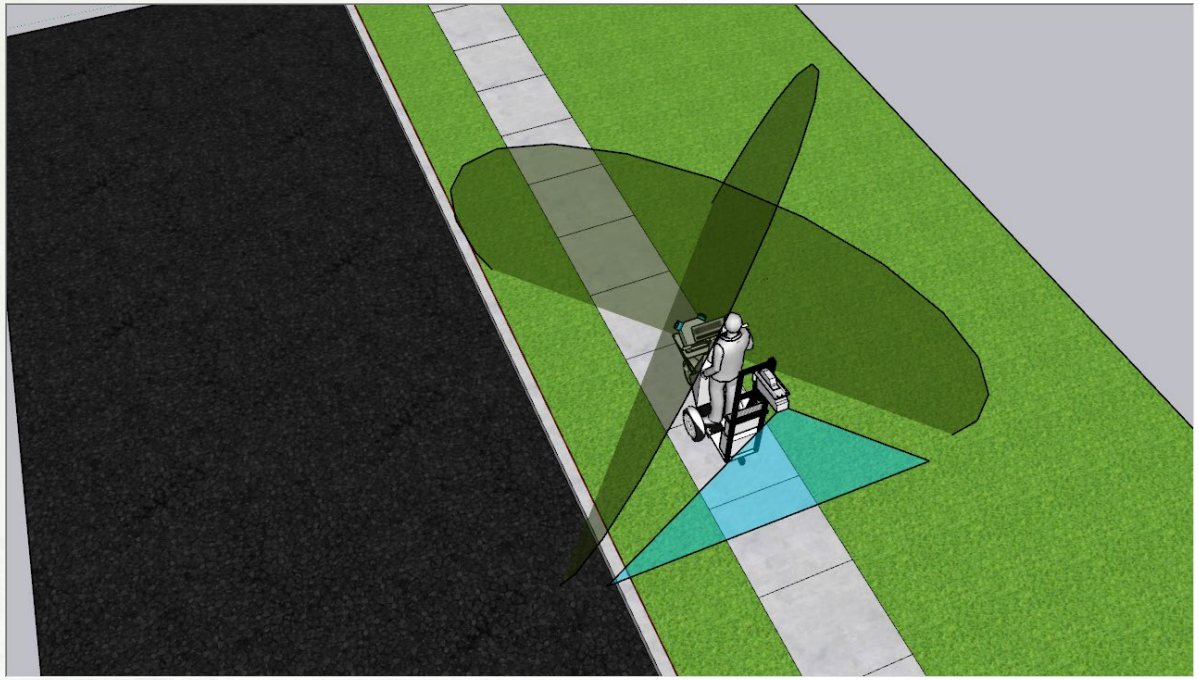
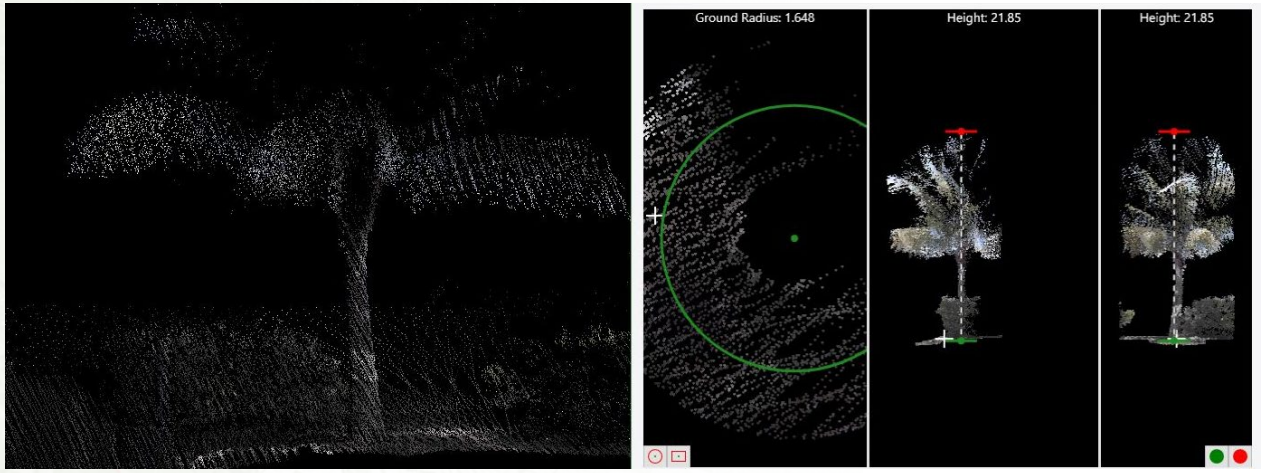
- Profiler is wide scan angle vs. single line scan, optimal height
- Imagery collected using multiple cameras mounted on the ESV
- Cross-scanning/dual scanning lidar mounted on the ESV
- Fix-mounted lidars eliminating operator fatigue
- A high-precision mapping-grade IMU integrated with profiler and lidars
- Panoramic 360° camera
- ESV has more power and longer range
- Full asset inventory capability for all assets (e.g., mapping grade system for structure FFE and addresses, utilities)



SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

gEN 2

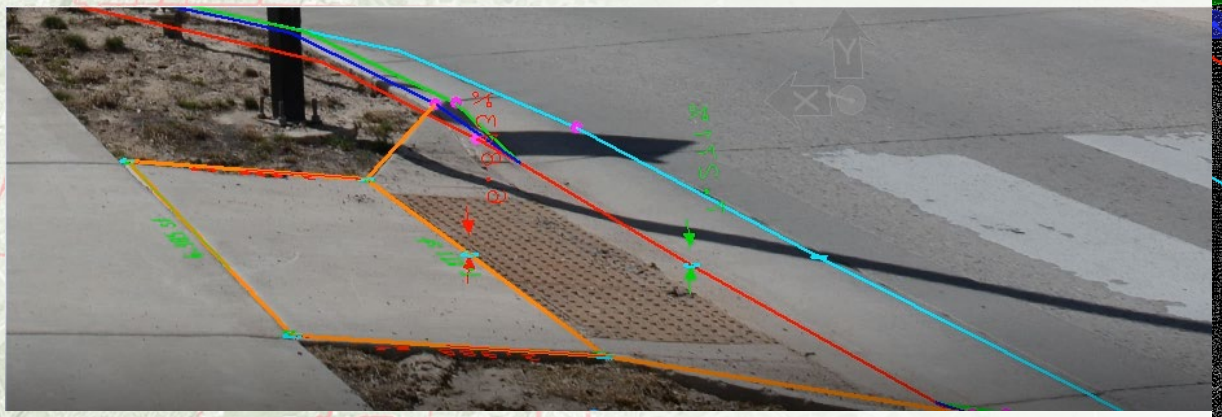
- Mapping grade data
  - Laser's range and precision accuracy of 10 mm (0.40") at 100 meters (0.62 mile) with 600,000 pulses per second.
  - 250 scan lines / second and up to 600 kHz pulse repetition rate.
  - Imagery and lidar data are abundantly useful for a myriad of purposes (e.g., tree inventories in right of way)
- Sidewalk distresses:
  - Extremely high-density laser system used at close range
  - Measurement accuracy (including depth) of 1 mm.

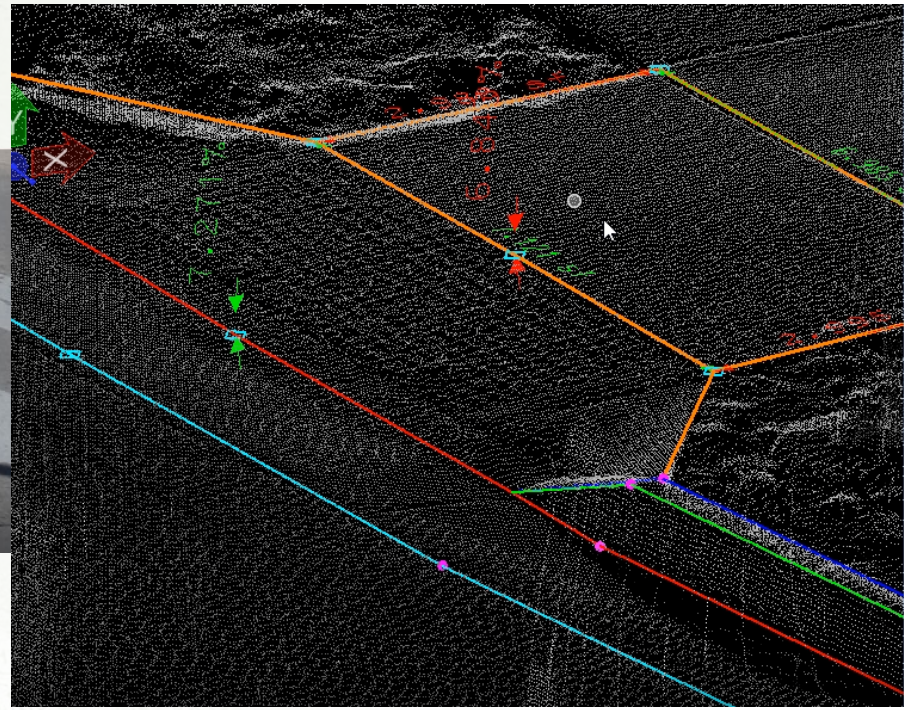


SIDEWALK COLLECTION SYSTEM CONSIDERATIONS

gEN 2

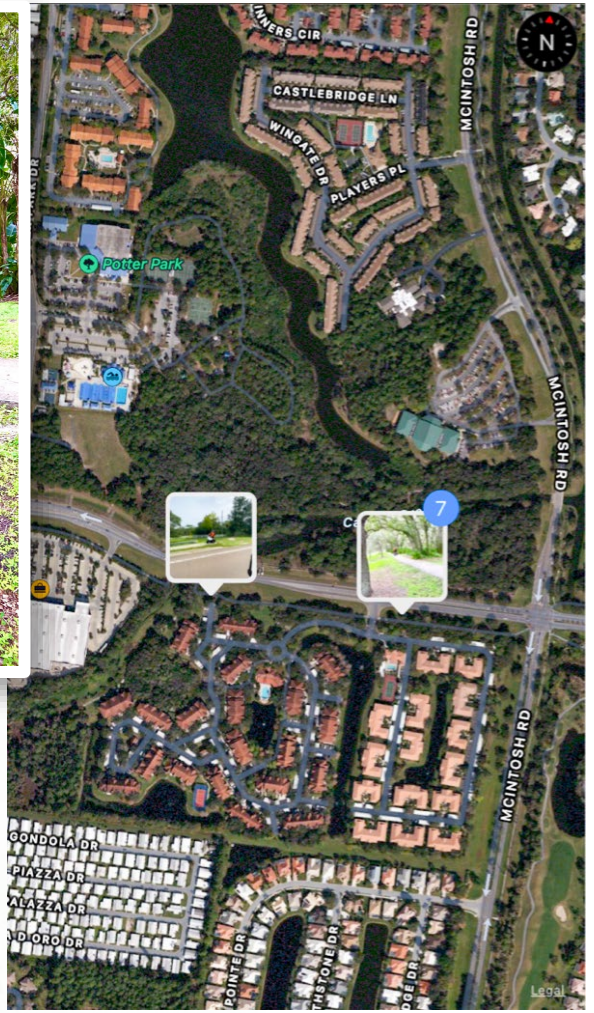
- ADA ramp measurements and self assessments are “low-lying fruit”
- WGIGEO.tech platform provides independent viewing and measurement from lidar data, includes ArcGIS plugin and Mobile app if doing field visitations
- 3rd party AR option for integrations with lidar point cloud data
- Data is provided for client-generated measurements, reporting, GIS and asset management integrations





WGI's GEOSPATIAL SERVICES

- Surveying and Mapping
- Geographic Information Systems
- Asset Management Collections
- Subsurface Utility Engineering
- Aerial LiDAR/Imagery Collection and Processing
  - *Manned Aircraft*
  - *UAS*
- Terrestrial LiDAR Collection and Processing
  - *Mobile*
  - *Static*
- Hydrographic Surveying
- Pavement Condition Surveying



AUTOMATED DATA COLLECTION for SIDEWALKS ANALYSIS


WGI
GEOSPATIAL
Thank You
Any Questions?