Pavement Stitching and Data Transformation for Airports and Concrete Surveys

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14 October 2022

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Outline

- Define the Challenge
  - Airport Surveys
  - Concrete Rehab Surveys
- Solution
  - 2D/3D Image Stitching
  - Data Transformation
  - Data Exports
- Real project example

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Collecting complete surface data on a wide pavement:

- Lower resolution and one pass (e.g. LIDAR)
- Higher resolution and multiple passes

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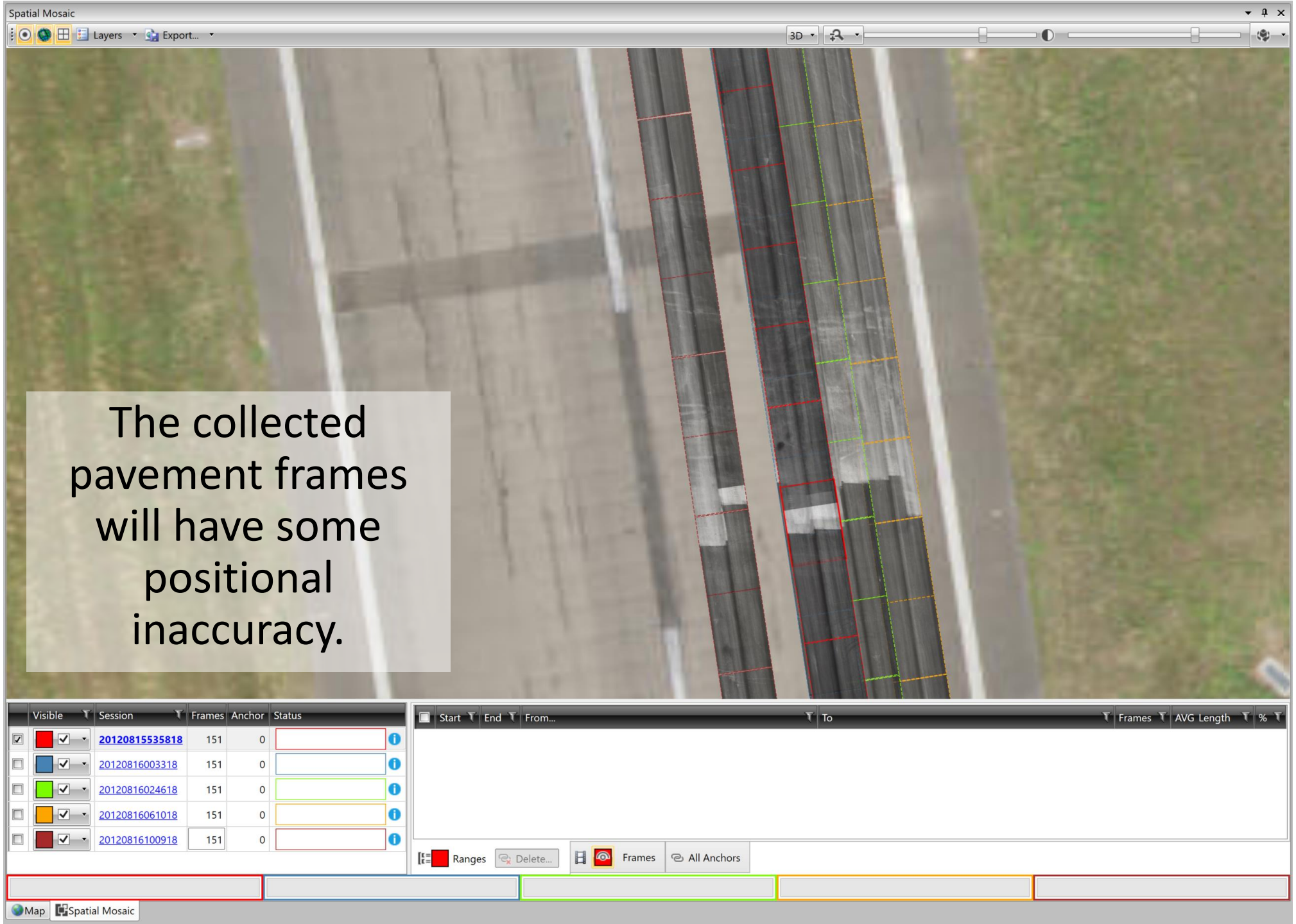

The collected pavement frames will have some positional inaccuracy.

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Houston Airport (IAH), from Airport Improvement

Many airports have detailed slab inventories that have been tied down to ground control

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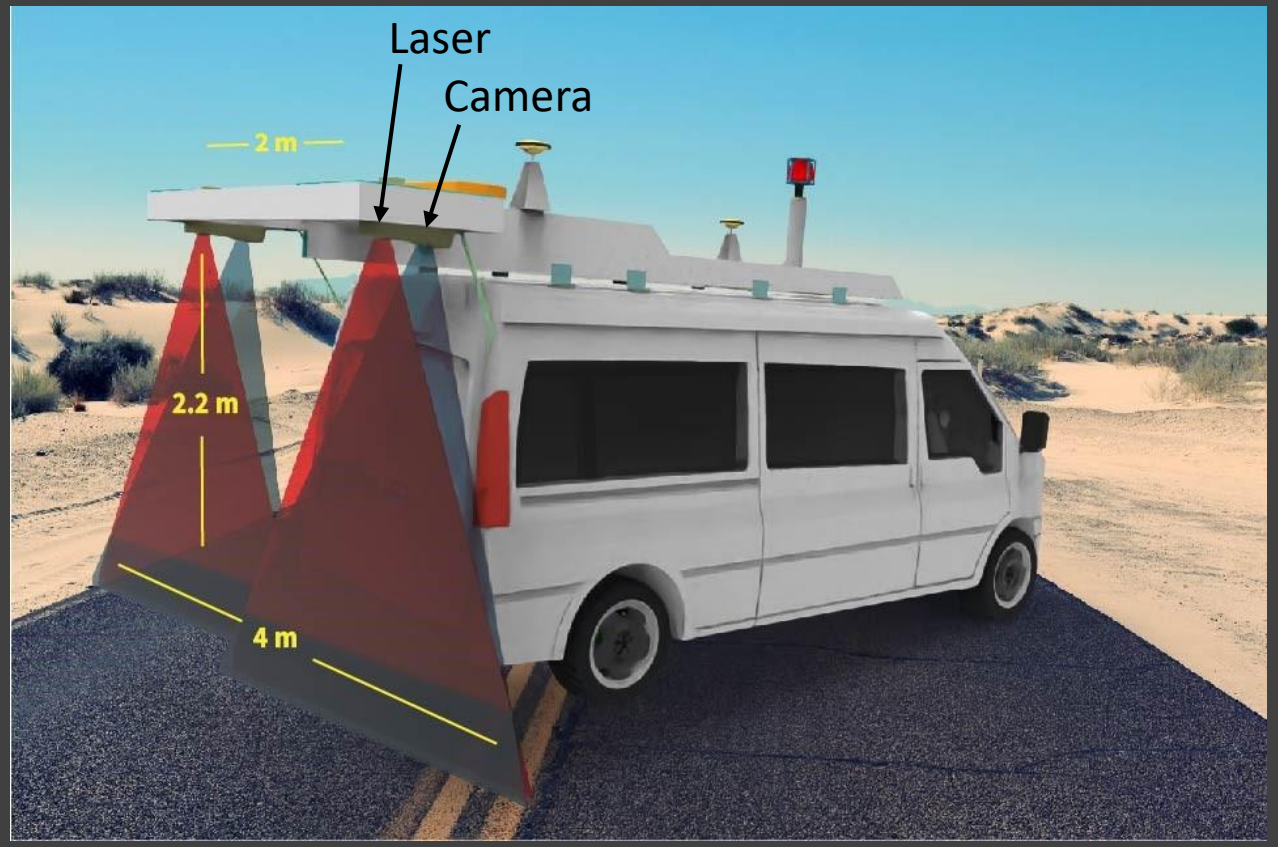
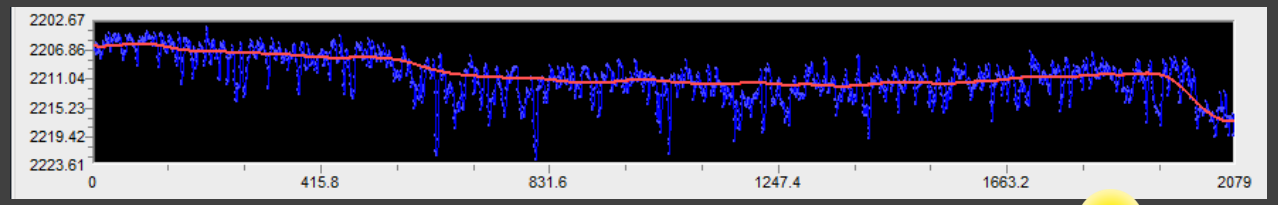
LCMS-2 Data Transformation

- Not just images
- We also have:
  - Joints
  - Fault heights
  - Surface defects including cracks
  - Classified distresses
  - Annotations

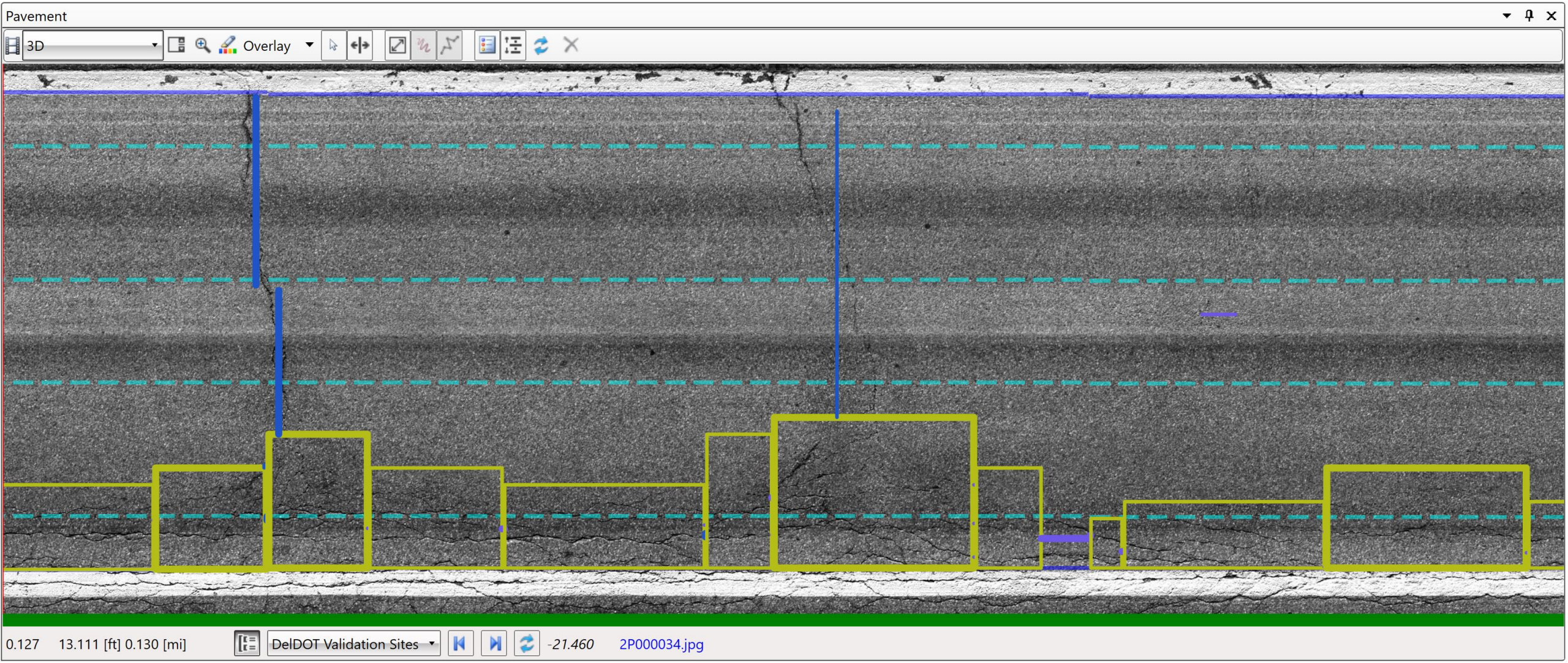
LCMS-2 Working Principle

- Not the same as LIDAR
  - No spinning mirror
  - No moving parts
- Laser illuminates line on pavement
- Camera takes pictures of the line rapidly, triggered by vehicle forward motion
- The individual profiles are stitched together into a 3D surface
- 0.25mm vertical accuracy
- 0.05mm vertical resolution





Extracted and rated data should be transformed



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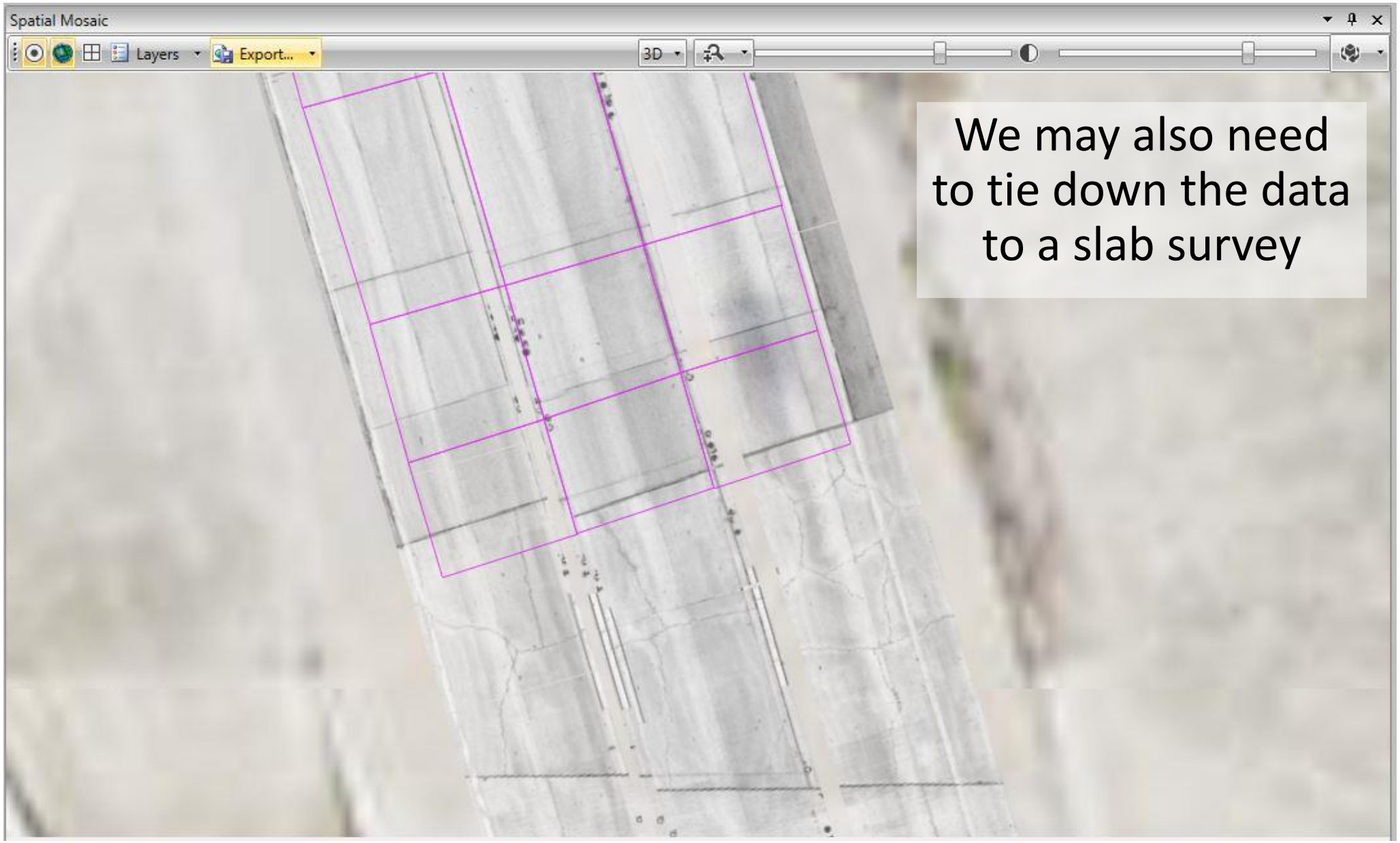
Treatment decisions (i.e. slab repairs)

StartChainage [mi]	EndChainage [mi]	Site Name	DistressType	Severity	PavementType	StartLatitude	StartLongitude
2.496	2.494	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Full Slab, Full Depth Replacement	JCP	30.25049908	-81.59560289
2.494	2.493	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Full Slab, Full Depth Replacement	JCP	30.25049908	-81.59560289
2.493	2.490	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Full Slab, Full Depth Replacement	JCP	30.25049908	-81.59560289
2.488	2.487	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal + Grind OR Full Depth Replacement	JCP	30.25041768	-81.59551764
2.487	2.485	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Full Slab, Full Depth Replacement	JCP	30.25041768	-81.59551764
2.485	2.484	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal + Grind OR Full Depth Replacement	JCP	30.25041768	-81.59551764
2.484	2.483	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25037704	-81.59547498
2.480	2.479	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25033635	-81.59543240
2.479	2.478	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25033635	-81.59543240
2.477	2.475	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25029570	-81.59538968
2.475	2.474	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25029570	-81.59538968
2.474	2.473	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Full Slab, Full Depth Replacement	JCP	30.25029570	-81.59538968
2.473	2.471	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25025504	-81.59534708
2.471	2.470	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25025504	-81.59534708
2.470	2.468	SOUTHBOUND - MAINLINE - LANE 1 (LEFT)	Slab Repair	Clean and Seal	JCP	30.25021431	-81.59530446



We may also need to tie down the data to a slab survey

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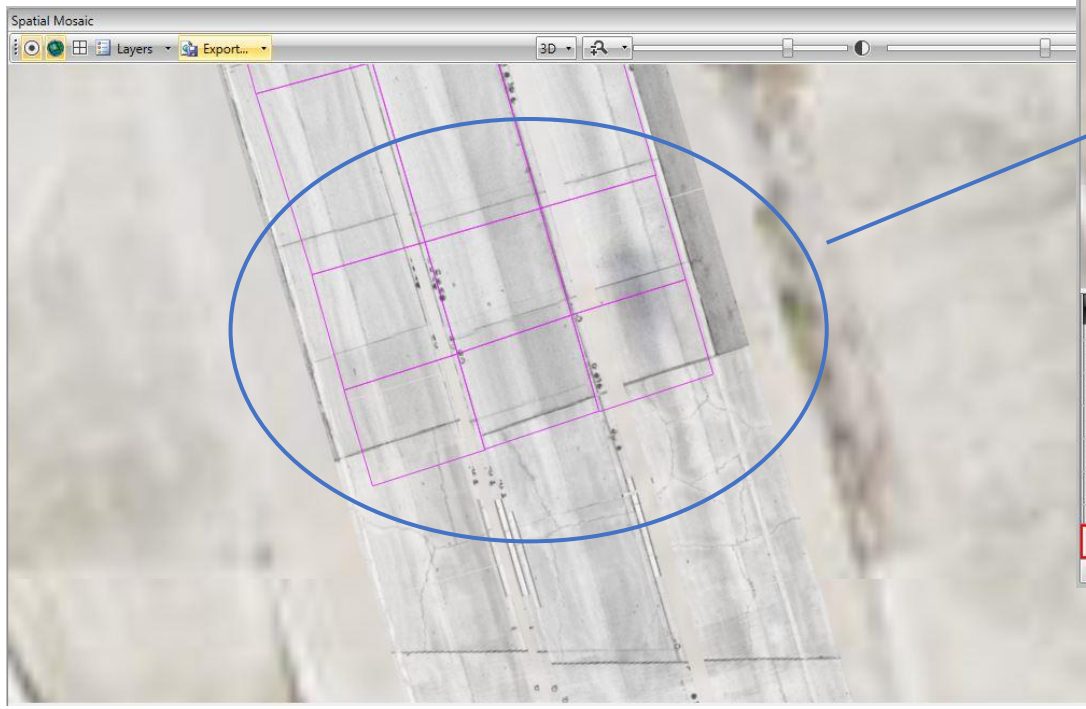
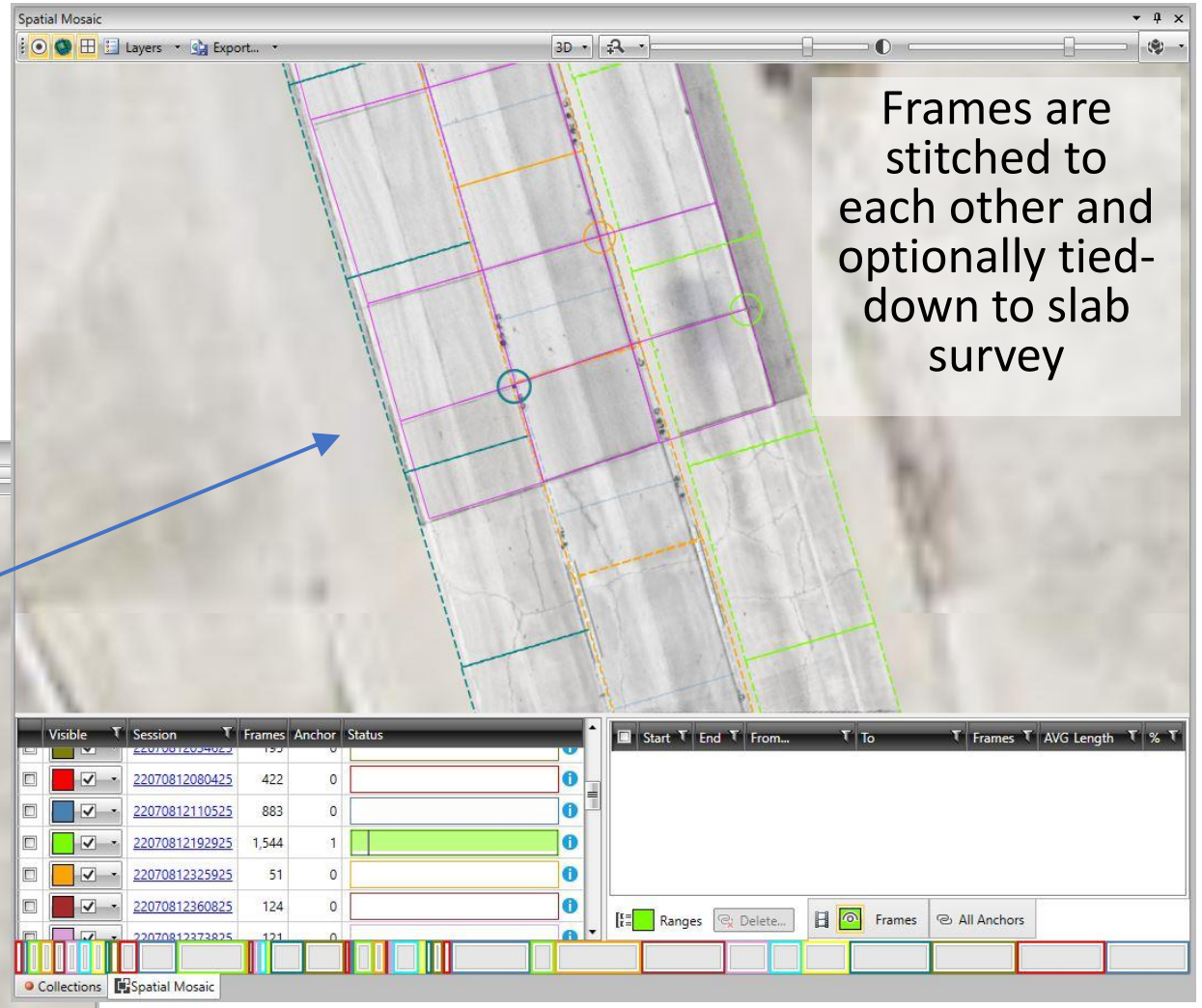
Connect™ Solution

Works with any LCMS data as long as GPS is embedded in FIS files or linked to DMI from another source





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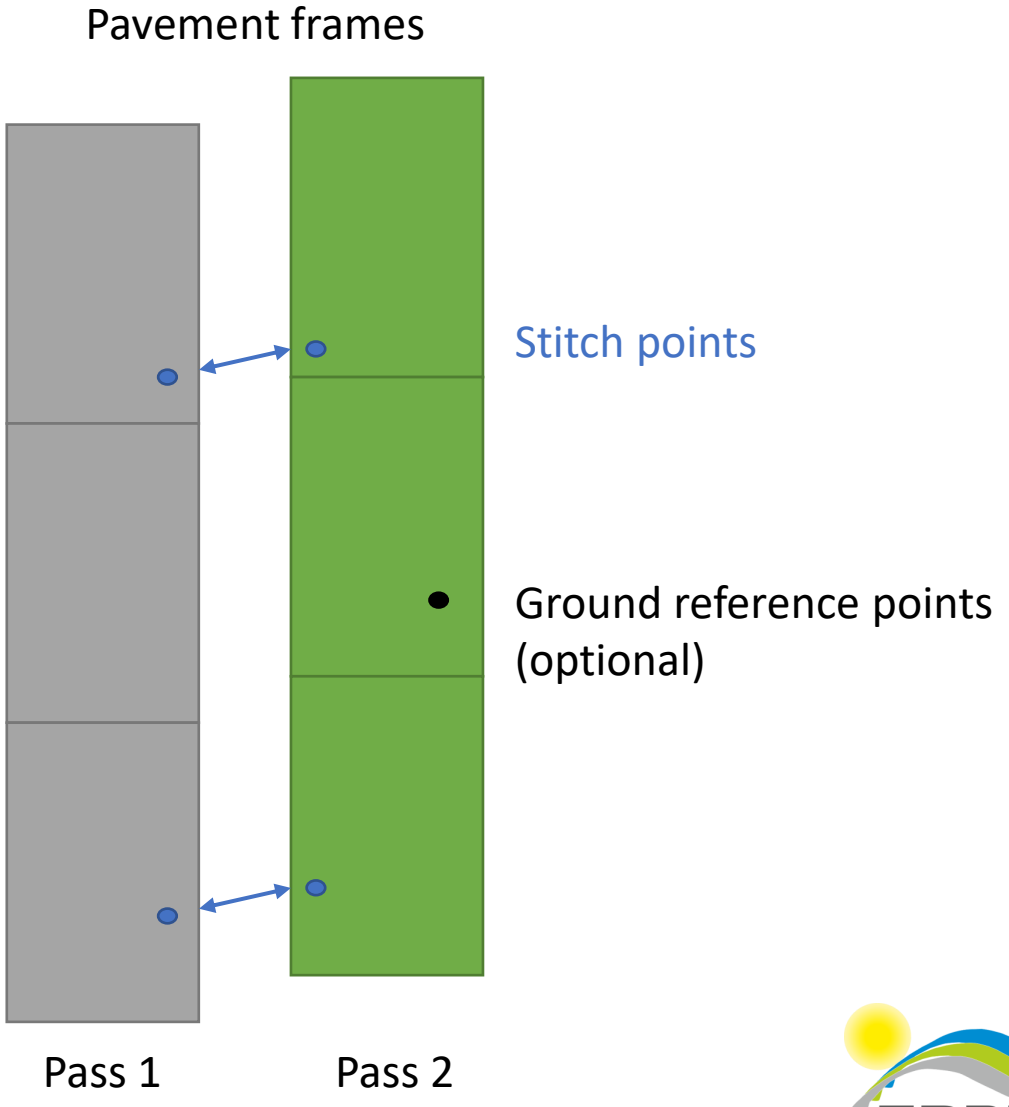
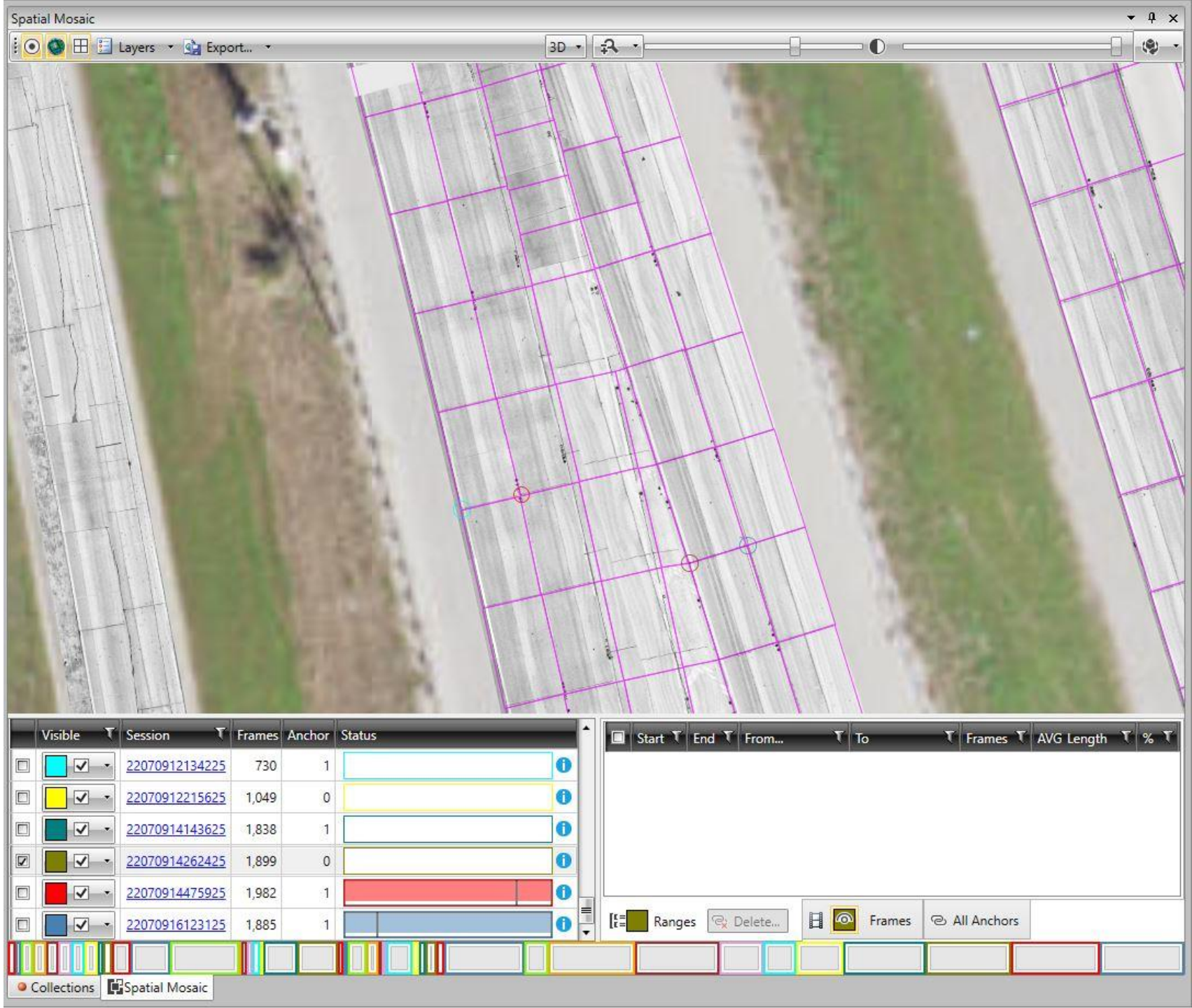
Transformation Process

1. Select stitch points to join adjacent sessions based on common features
2. Join to ground reference points if available
3. Convert all frame data to geospatial format
4. Apply modified affine transformation to images and data
5. Aggregate and export by region(s) of interest



Step-by-Step

Example: Adding stitch/tie points for second last session

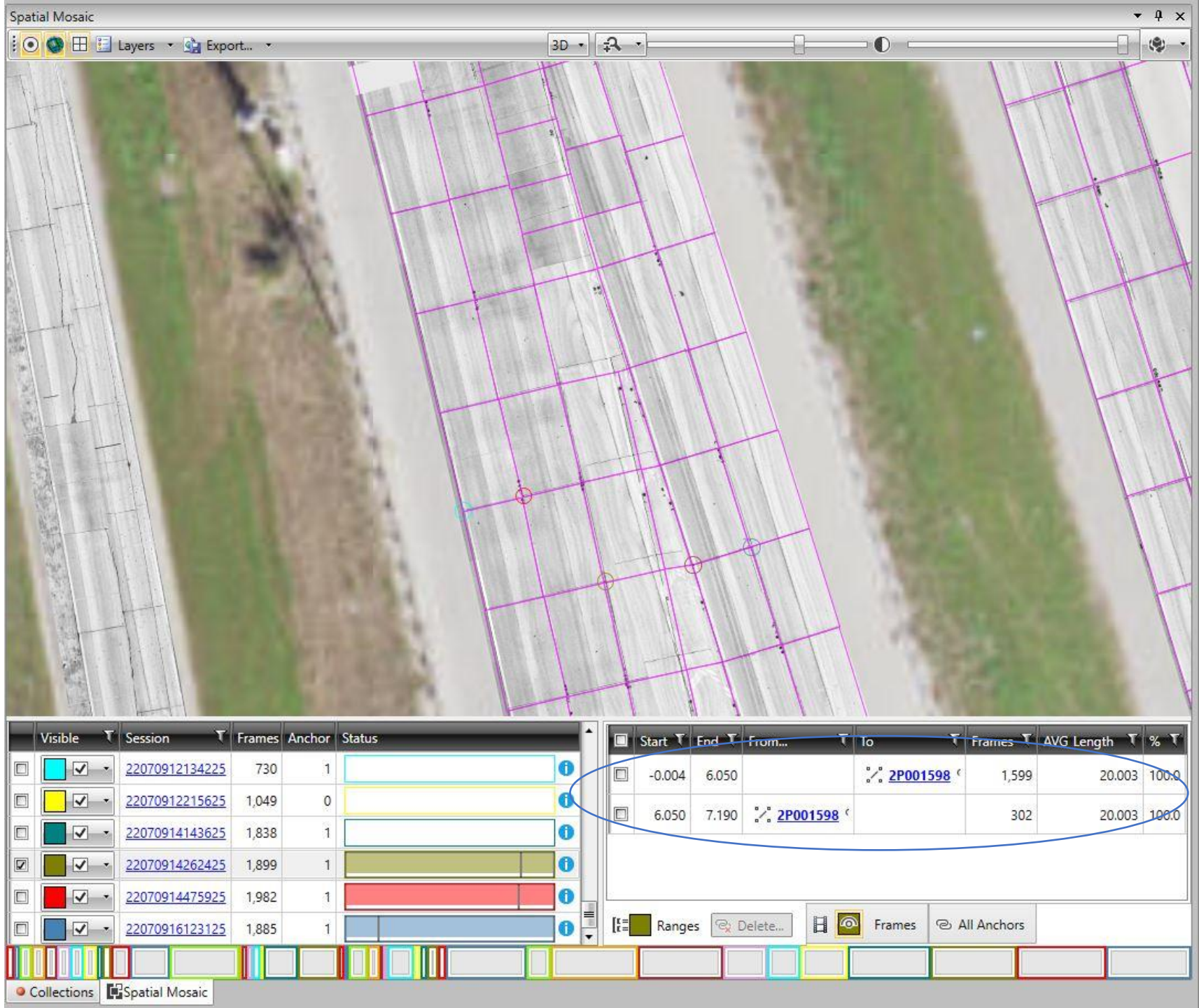


Step-by-Step

Example: Adding stitch/tie points for second last session

Link is created

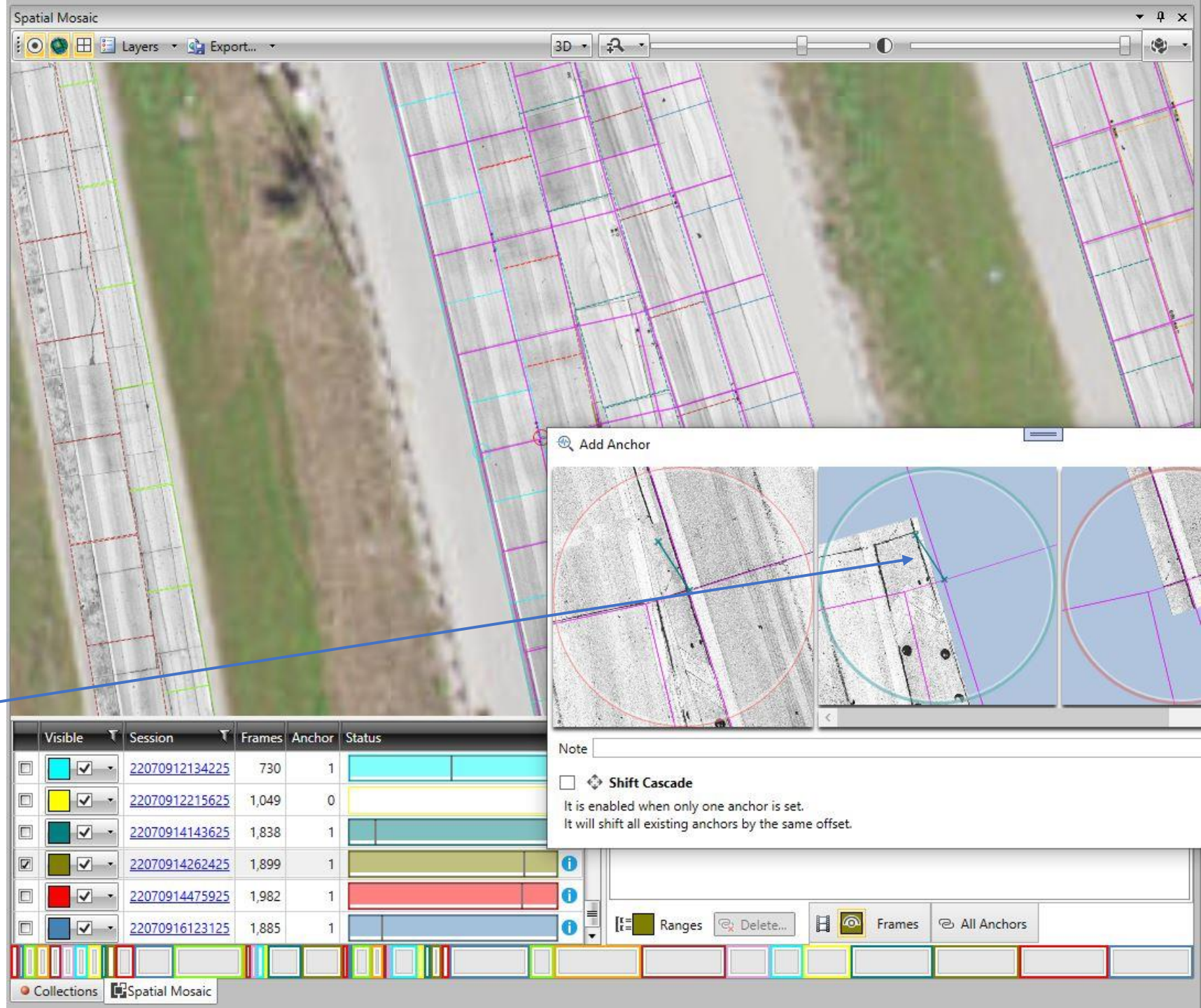
Session shifts and warps



Step-by-Step

Example: Adding stitch/tie points for last session

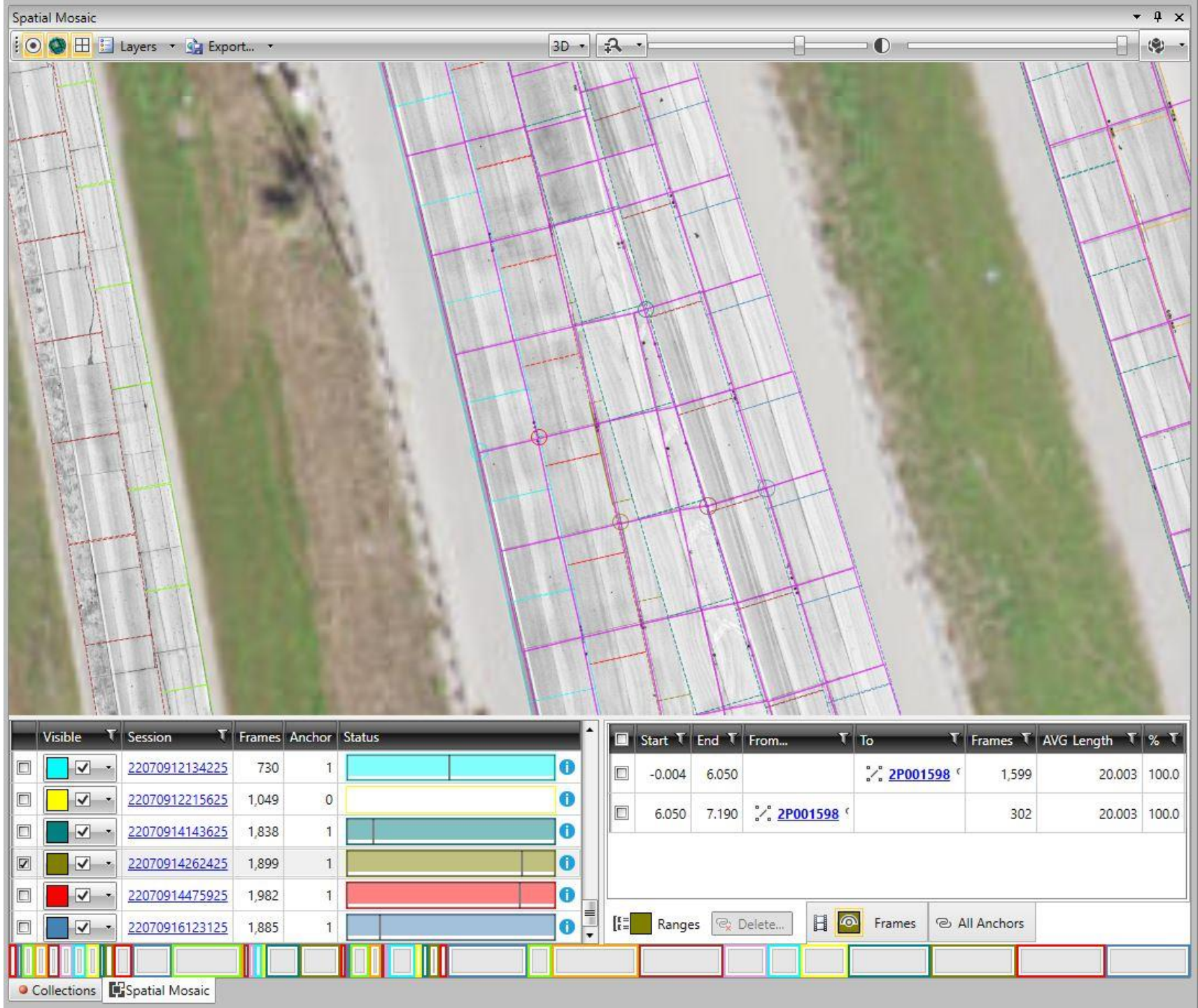
This session must be shifted down and to the right to match slab survey



Step-by-Step

Example: Adding stitch/tie points for last session

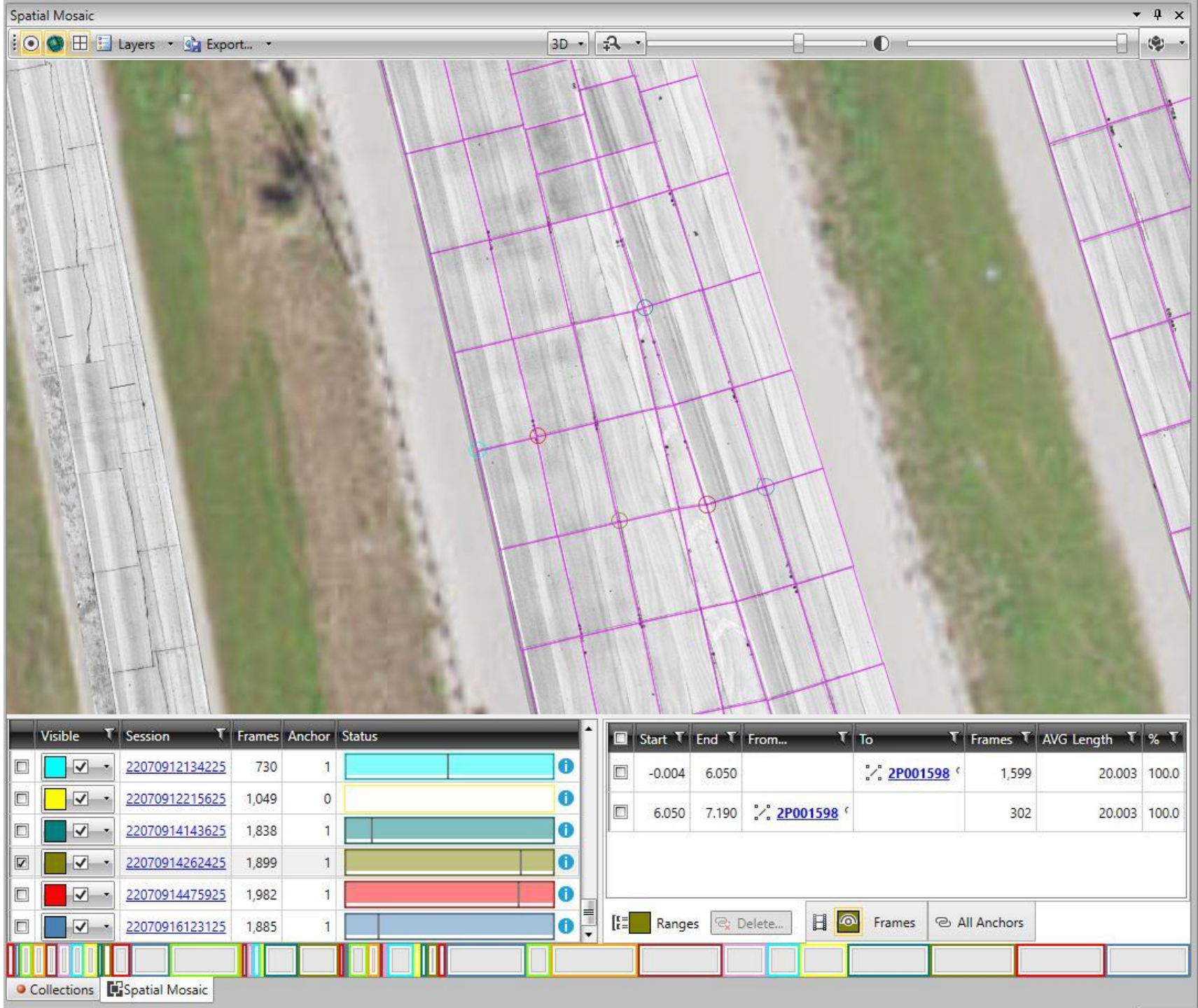
All sessions are now aligned to each other and to slab survey



Step-by-Step

Example: Adding stitch/tie points for last session

Hide LCMS frame lines and leave slab definition only

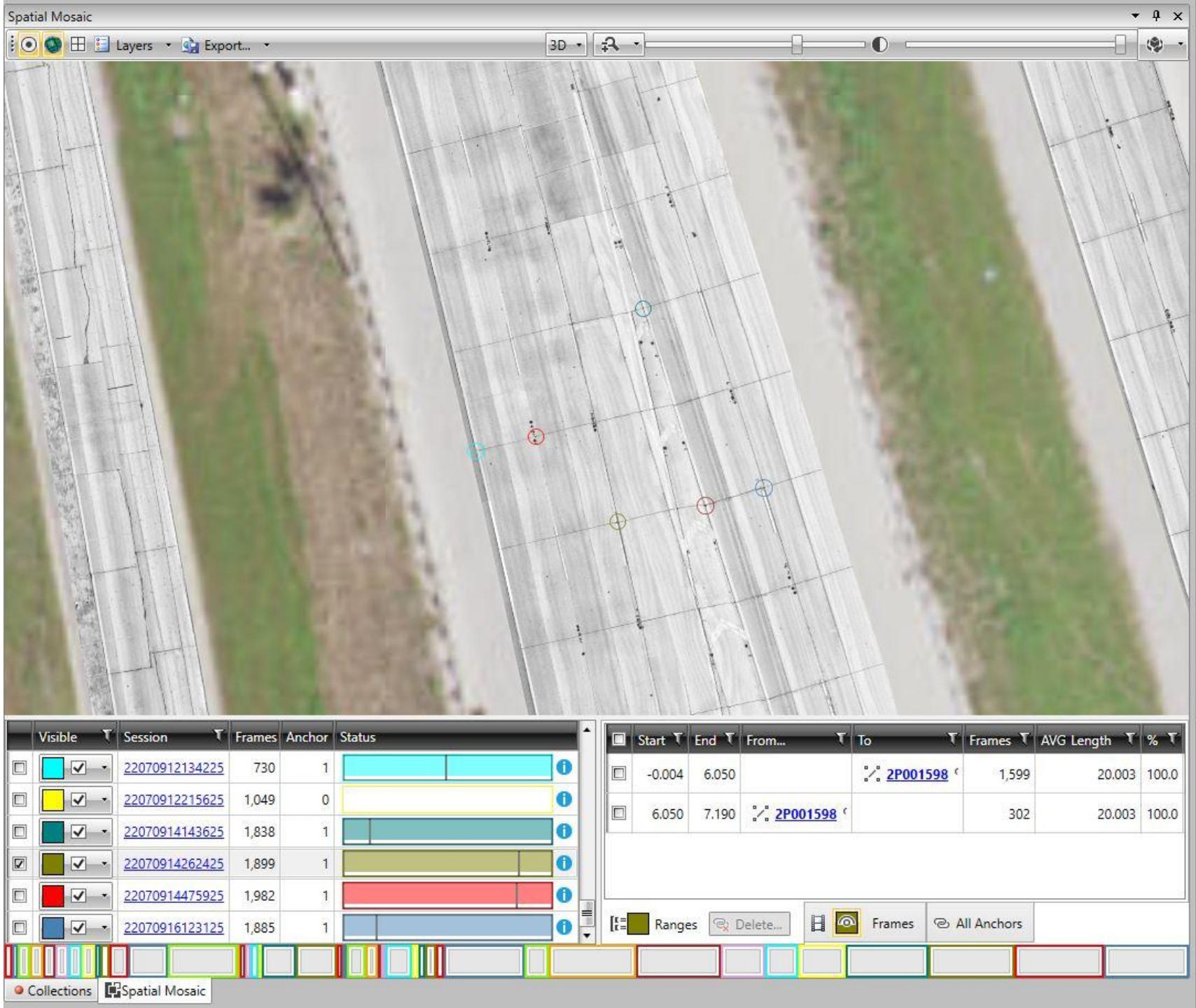


Step-by-Step

Example: Adding stitch/tie points for last session

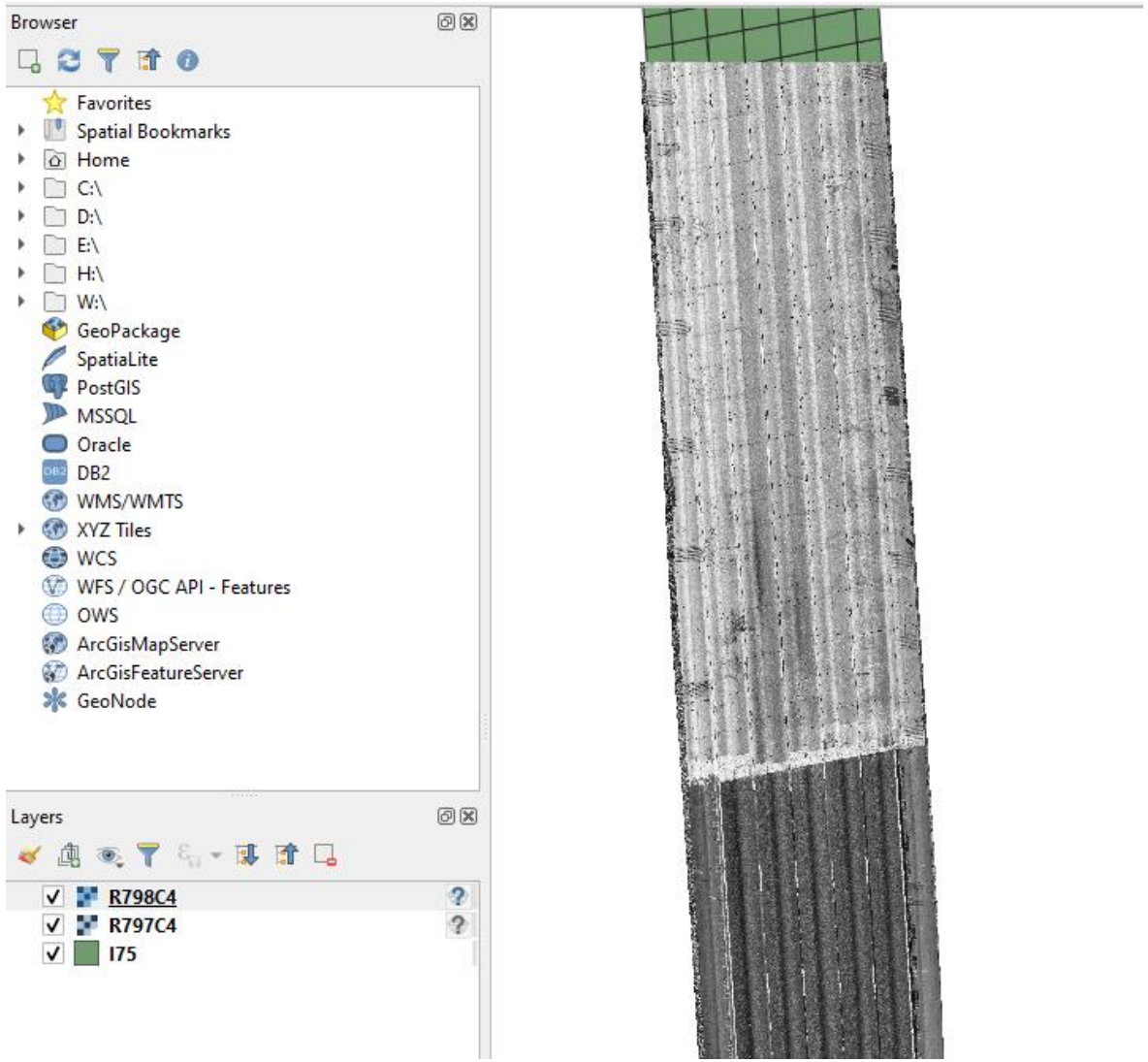
Hide slab definition

The transformation is complete

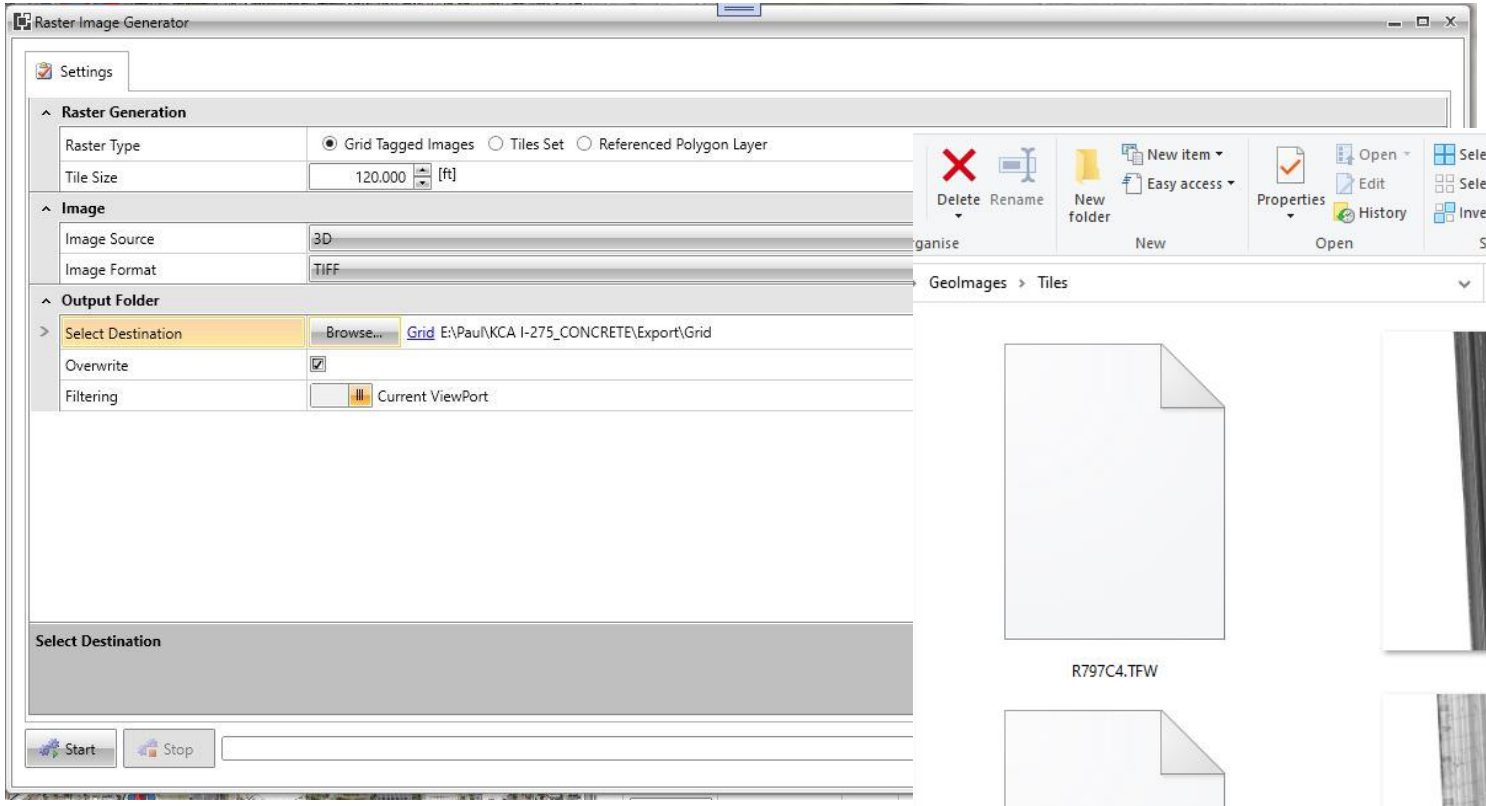


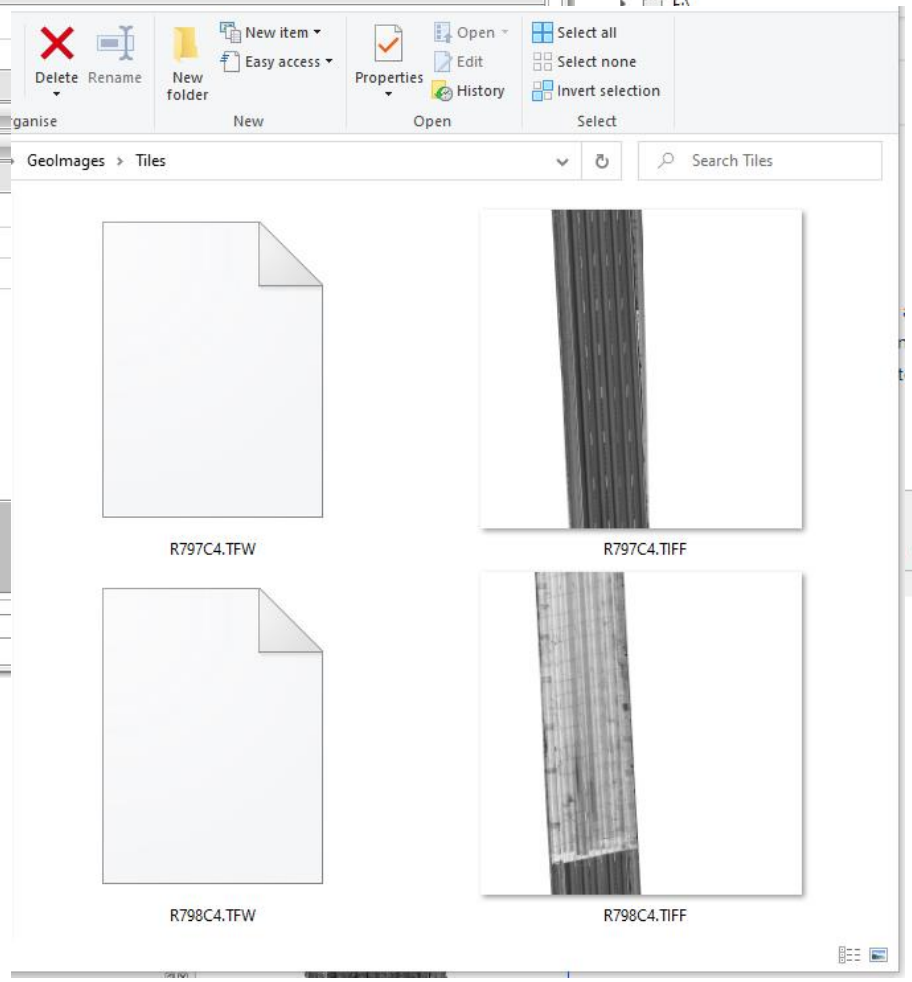
Outputs

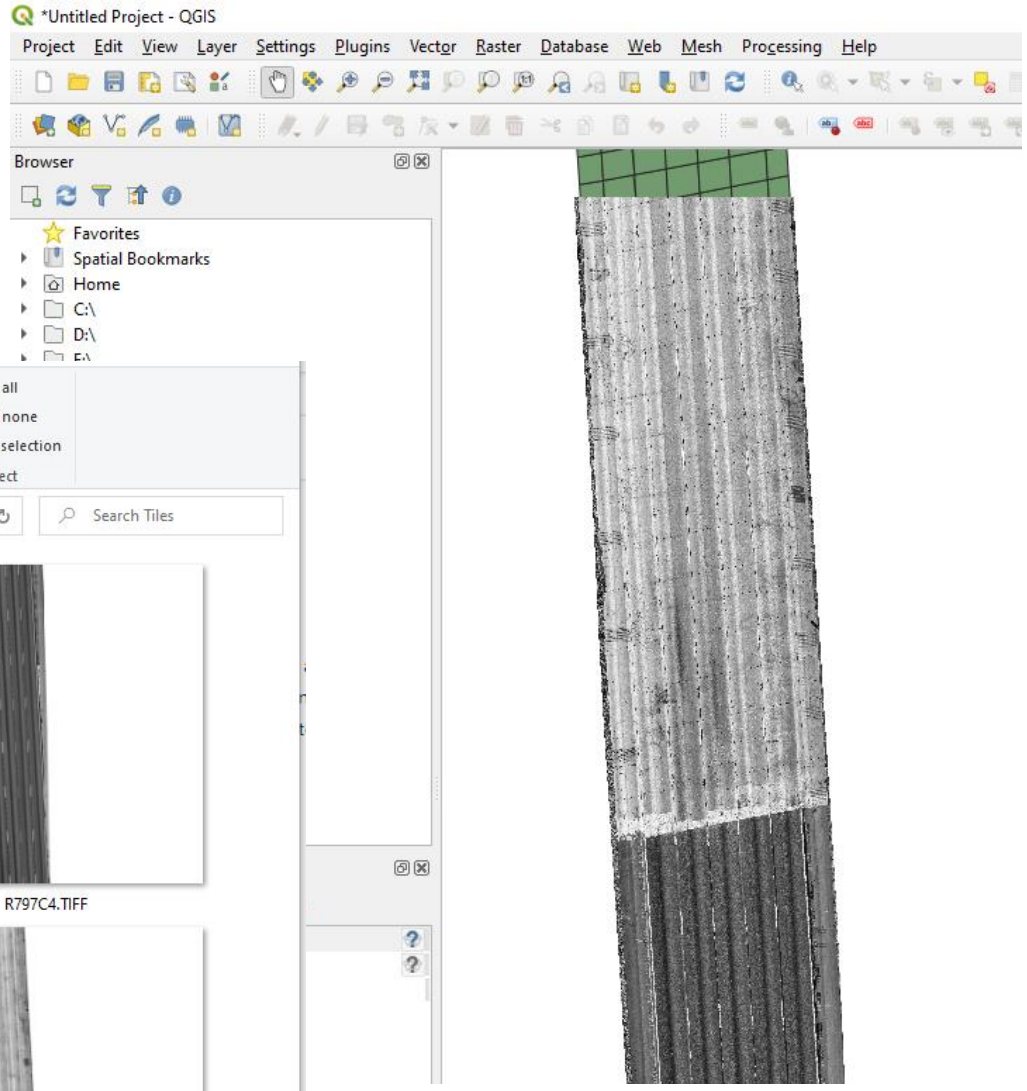
- Raster images for the entire area
- Raster images for areas defined by polygons (e.g. individual slabs)
- Vector data
  - Pavement distresses (e.g. ASTM D5340, D6433) trimmed to polygons
  - Distresses aggregated by and associated to polygons
  - Annotations (e.g. treatment decisions) linked to polygons



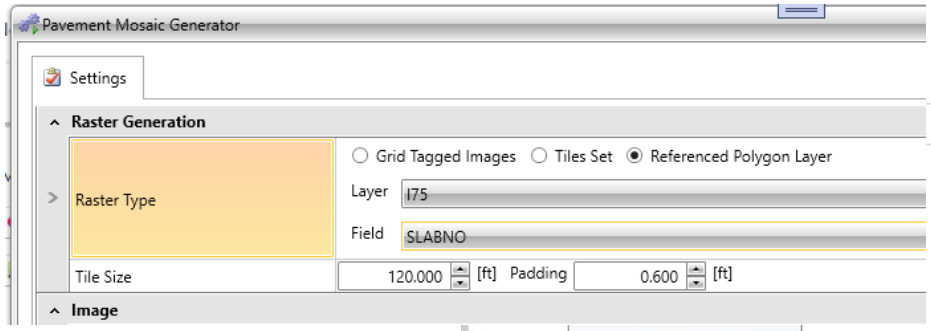
Raster Image Generation

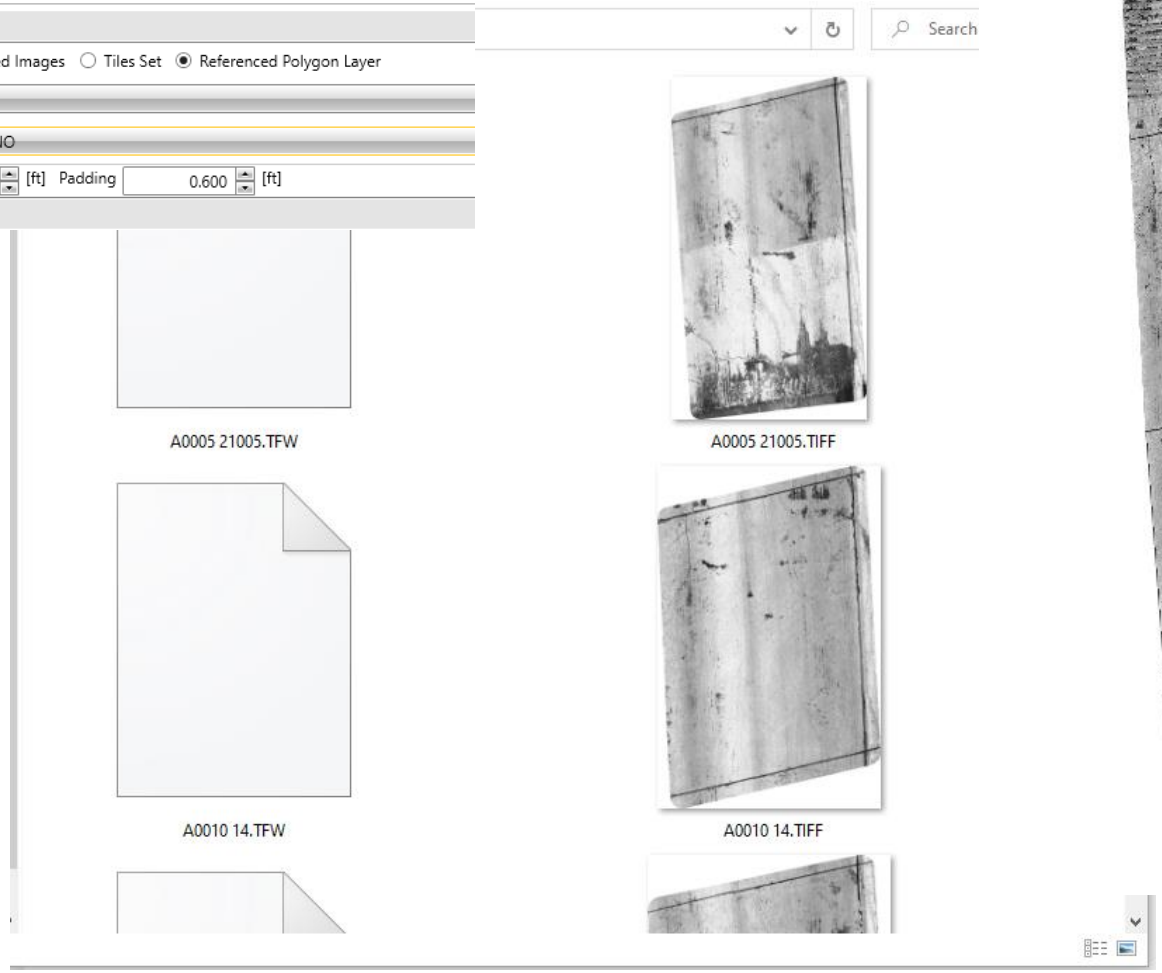


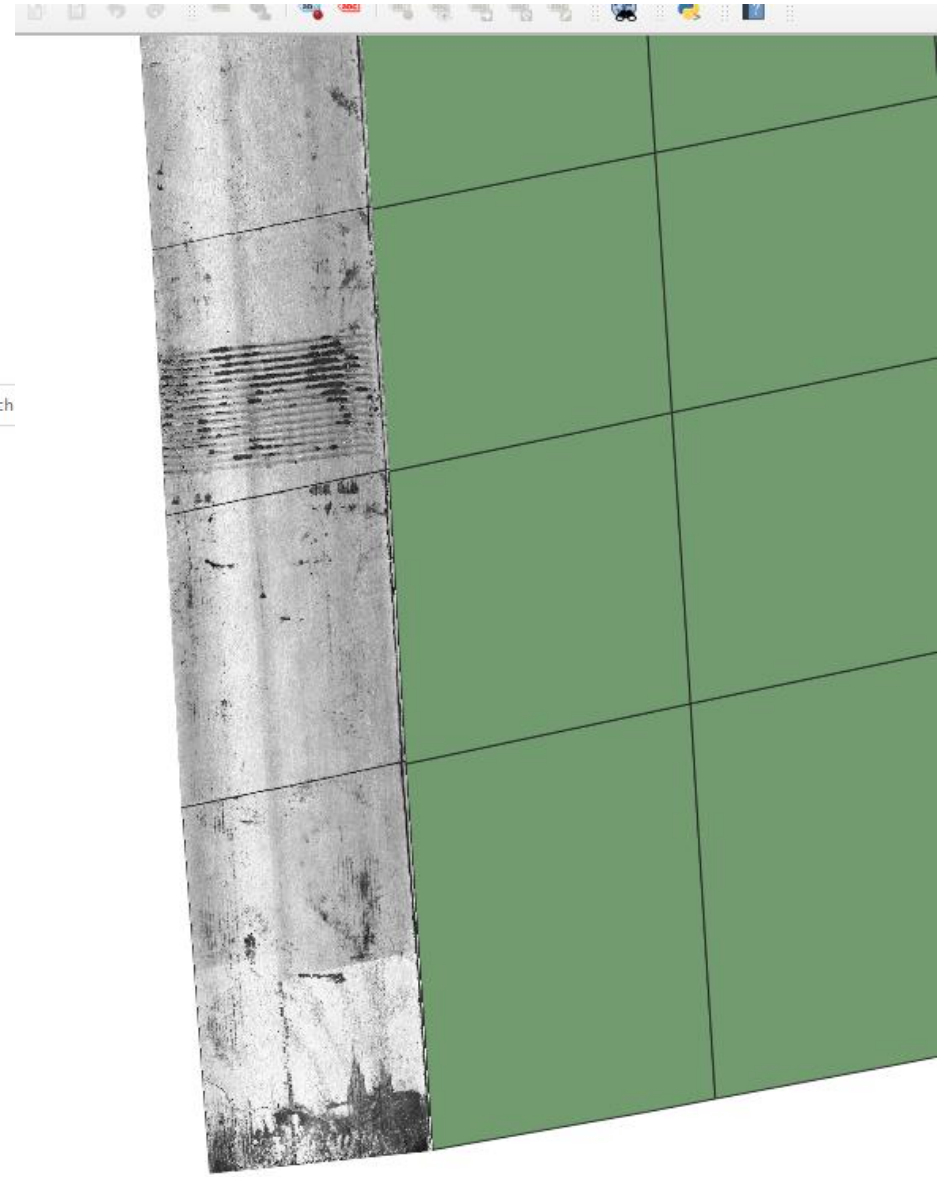




Pavement Tile Generation







Pavement Tile Generation

This image is a composite of 5 LCMS frames

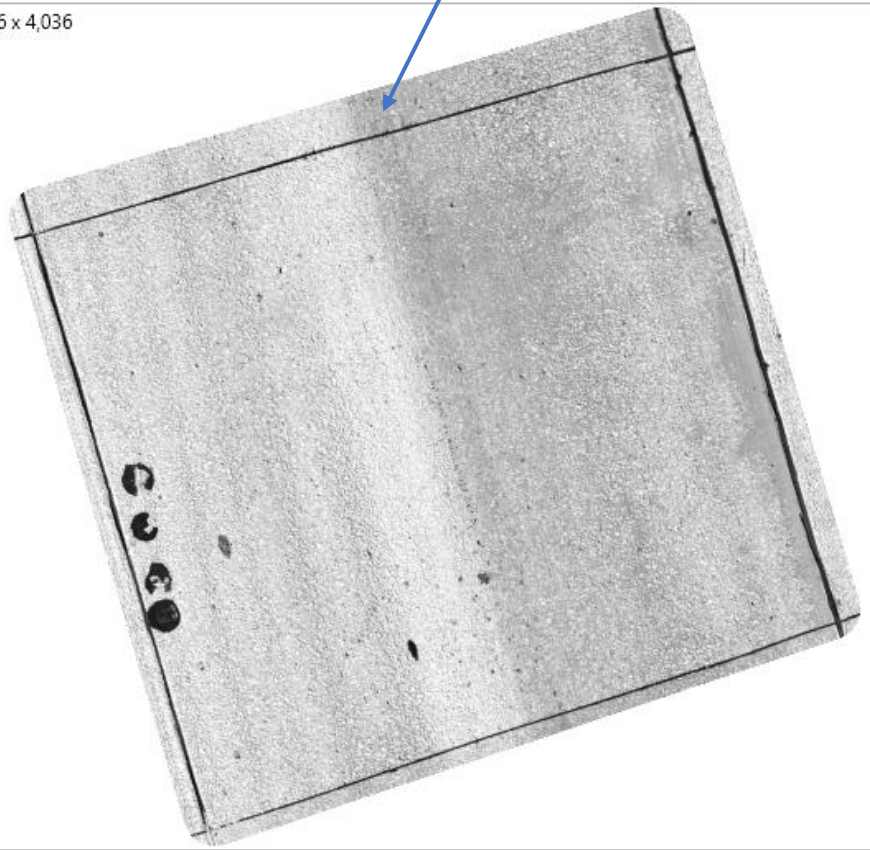
Add buffer around slab to show joint context

Raster Image Generator

Settings | Show Preview

		ID	Area	Frames	Coverage	Image	Size (KB)	Duration
		A0005 4	119.202	5	99.95	A0005 4.TIFF	24,355	00:00:10.1
		B0005 5	121.291	5	100.00	B0005 5.TIFF	23,775	00:00:10.0
		C0005 7	119.570	4	90.96	C0005 7.TIFF	24,284	00:00:10.0
		A0010 10	140.711	5	100.00	A0010 10.TIFF	25,472	00:00:10.1
☑		B0010 11	137.734	5	100.00	B0010 11.TIFF	25,329	00:00:17.6
		C0010 12	132.669	6	90.10	C0010 12.TIFF	25,086	00:00:17.2
		A0015 16	227.516	6	99.98	A0015 16.TIFF	12,629	00:00:15.5
		B0015 17	227.136	6	100.00	B0015 17.TIFF	10,007	00:00:16.6
		C0015 18	226.399	6	90.75	C0015 18.TIFF	20,466	00:00:05.8
		F0005 21	140.018	5	100.00	F0005 21.TIFF	22,747	00:00:05.5
		A0020 24	225.057	6	99.99	A0020 24.TIFF	19,875	00:00:05.9
		B0020 26	229.384	6	100.00	B0020 26.TIFF	19,673	00:00:05.7
		C0020 28	227.304	6	92.33	C0020 28.TIFF	5,587	00:00:06.2
		F0010 29	199.756	6	99.87	F0010 29.TIFF	23,646	00:00:06.9
		A0025 32	222.784	6	99.97	A0025 32.TIFF	19,778	00:00:06.3
		B0025 34	226.420	6	100.00	B0025 34.TIFF	19,642	00:00:06.8
		C0025 35	188.792	4	93.57	C0025 35.TIFF	22,579	00:00:05.5
		C0030 38	73.723	5	93.54	C0030 38.TIFF	18,821	00:00:05.3
		A0030 41	228.963	6	99.94	A0030 41.TIFF	19,535	00:00:04.9

4,096 x 4,036



Start | Stop

20 / 20 (100.00%) Processed - 17 Generated

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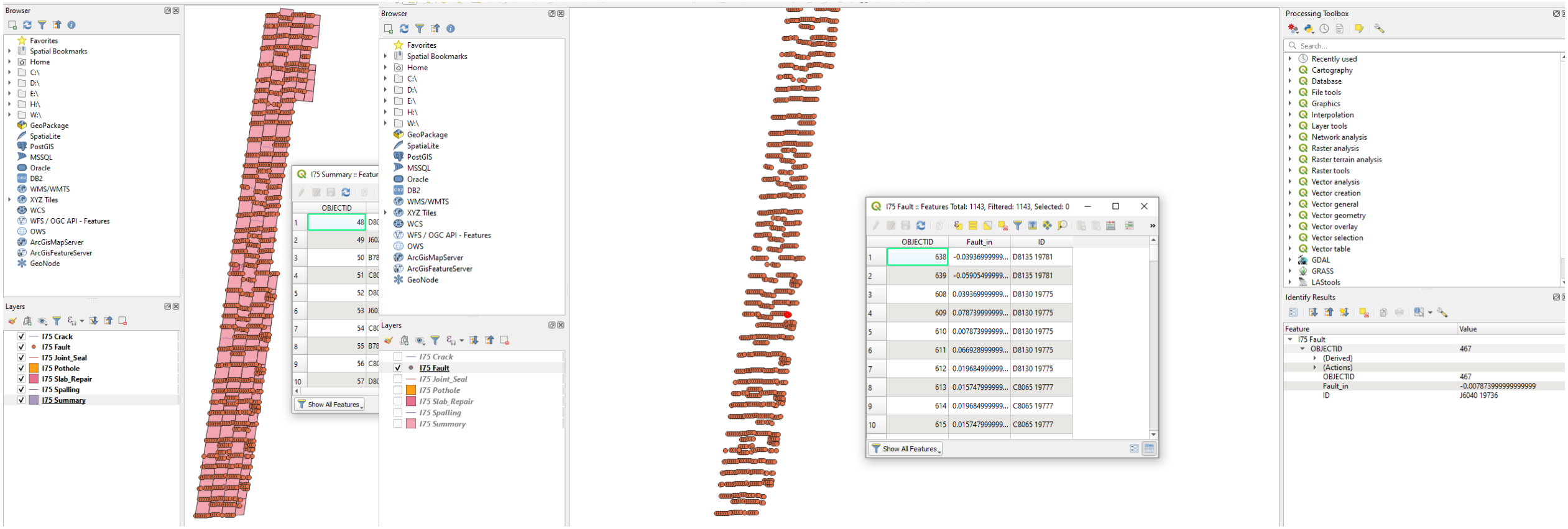
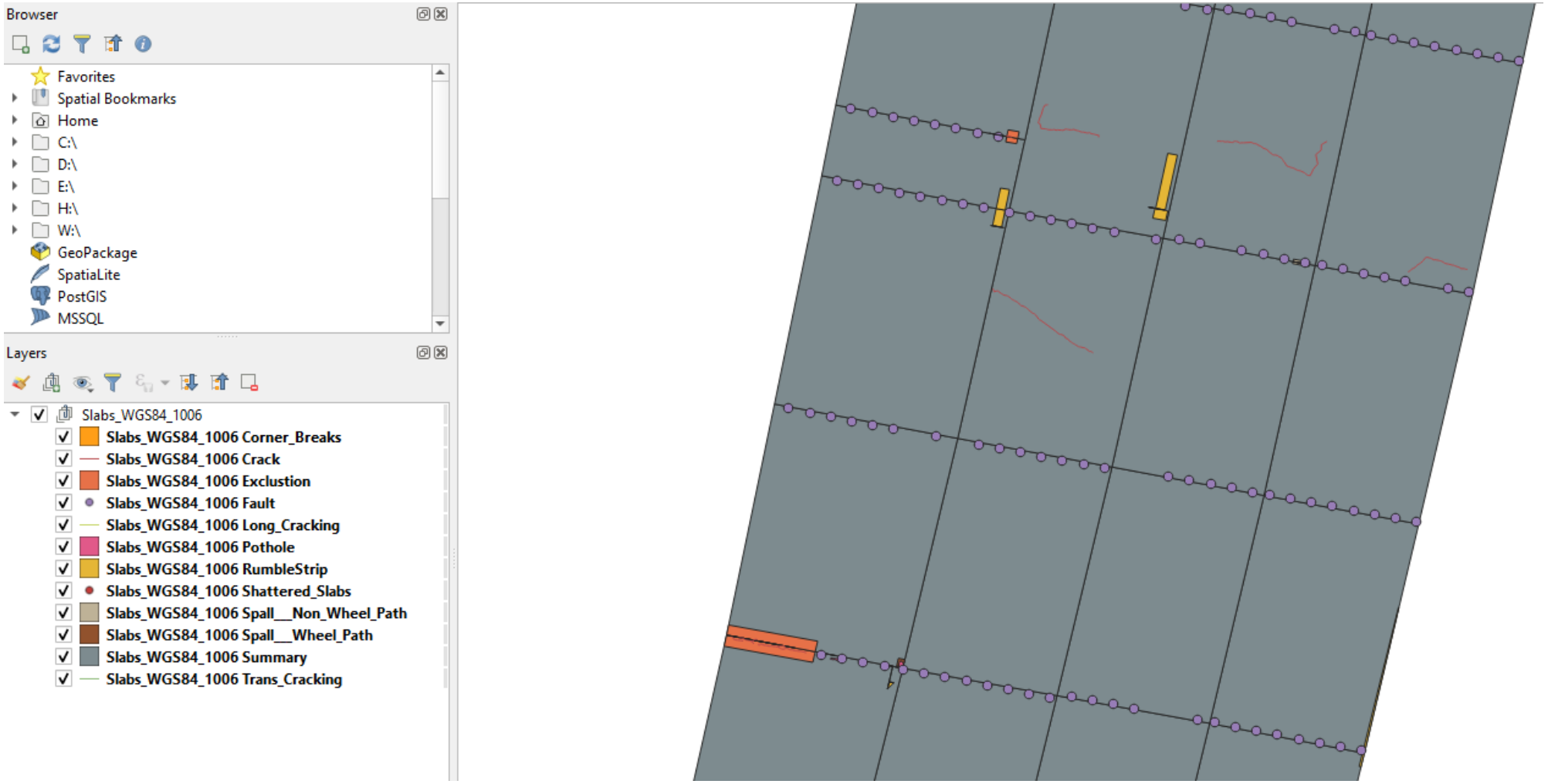
Vector Layer Generation

All distresses, faults, and annotation layers are preserved and translated/rotated to follow frames



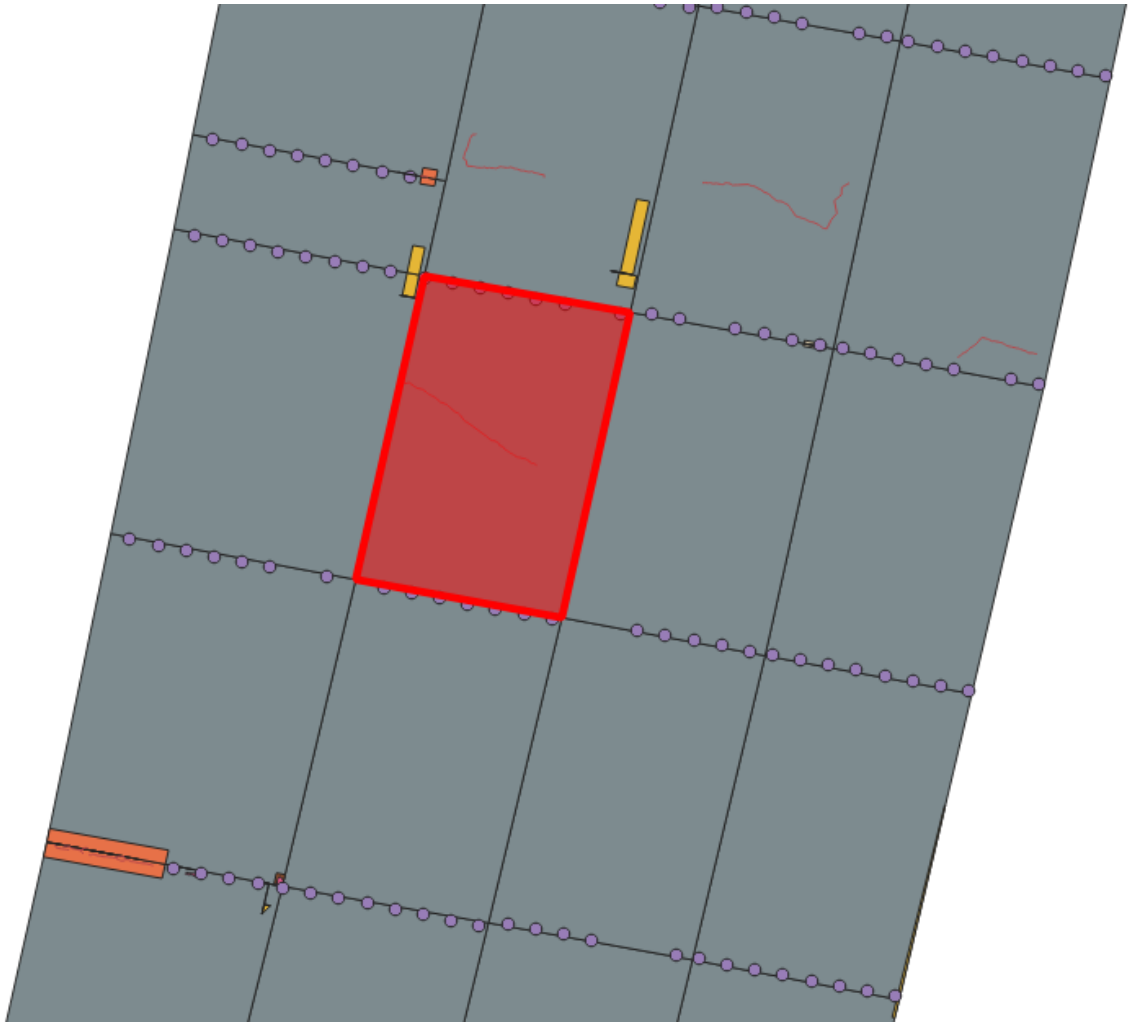
Vector Layer Generation

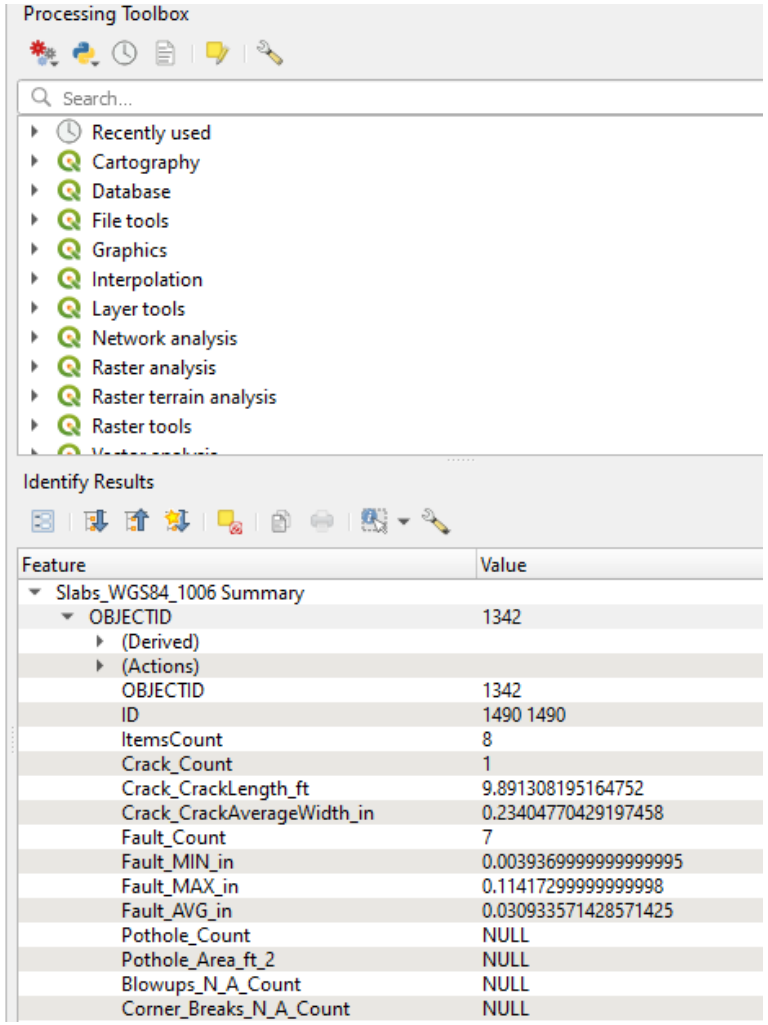
All distresses, faults, and annotation layers are preserved and translated/rotated to follow frames



Vector Layer Generation

All data is trimmed and aggregated to slab definition (or any other polygon); overlaps are eliminated using precedence rules





I-275 Rehab Survey in Florida, USA

- Survey all lanes on concrete sections selected by FDOT for treatment (~4-8 km sections)
- Measure cracking and rate other distresses from LCMS data as normal
- Apply stitching and transformation process
- Automatically apply FDOT criteria to recommend appropriate repair strategy for each slab

SLAB REPAIR AND REPLACEMENT CRITERIA

DISTRESS PATTERN	SEVERITY/DESCRIPTION		REPAIR METHOD	REFERENCE
CRACKING				
Longitudinal	Light	<1/8", no faulting, spalling <1/2" wide	None	Figure 10.2
	Moderate	1/8" <width <1/2", spalling <3" wide	Clean and Seal	Figure 10.2
	Severe	width >1/2", spalling >3" faulting >1/4"	Replace	Figure 10.3
Transverse	Light	<1/8", no faulting, spalling <1/2" wide	None	Figure 10.2
	Moderate	1/8" <width <1/2", spalling <3" wide	Clean and Seal	
	Severe	width >1/2", spalling >3" faulting >1/4"	Replace	Figure 10.3, 10.4 and 10.5
Corner Breaks	A corner of the slab is separated by a crack that intersects the adjacent longitudinal and transverse joint, describing an approximate 45° angle with the direction of traffic.		Full Depth	Figure 10.4 and 10.5
Intersecting Random Cracks (Shattered Slab)	Cracking patterns that divide the slab into three or more segments.		Full Depth	Figure 10.3 and 10.4
JOINT DEFICIENCIES				
Spall Nonwheel Path	Light	spall width <1 1/2", < 1/3 slab depth, <12" in length	None	Figure 10.4 and 10.5
	Moderate	1 1/2" <spall width <3", < 1/3 slab depth, <12" in length	None	Figure 10.4 and 10.5
	Severe	spall width >3" or length >12"	Full Depth	Figure 10.4 and 10.5
Spall Wheel Path	Light	spall width <1 1/2", <than 1/3 slab depth, <12" in length	None	Figure 10.4 and 10.5
	Moderate	1 1/2" <spall width <3", < 1/3 slab depth, <12" in length	Full Depth	Figure 10.4 and 10.5
	Severe	spall width >3" or length >12"	Full Depth	Figure 10.4 and 10.5
SURFACE DETERIORATION				
Pop Outs Nonwheel Path	Small pieces of surface pavement broken loose, normally ranging from 1 to 4 in. diameter and 1/2 to 2 in. in depth.			
	Light	Not deemed to be a traffic hazard	Keep under observation	
	Severe	Flying debris deemed a traffic hazard	Full Depth	Figure 10.4
Pop Outs Wheel Path	Small pieces of surface pavement broken loose, normally >3" diameter and 2" in depth.			
	Light	Deemed to be a traffic hazard	Full Depth	Figure 10.4
	Severe	Flying debris deemed a traffic hazard	Full Depth	Figure 10.4
MISCELLANEOUS DISTRESS				
Faulting	Elevation differences across joints or cracks.			
	Light	Faulting <4/32"	None	
	Moderate	4 <Faulting <16/32"	Grind	
	Severe	Faulting >16/32"	Grind	
Lane To Shoulder Drop-Off	Light	0 <drop-off <1"	None	N/A
	Moderate	1" <drop-off <3"	Build Up	
	Severe	drop-off >3 "	Build Up	
Water Bleeding Or Pumping	Seeping or ejection of water through joints or cracks.		Install appropriate drainage, edge drain, permeable subbase, reseal joints, etc.	N/A
Blowups	Upward movement at transverse joints or cracks often accompanied by shattering of the concrete.		Full Depth	Figure 10.3 and 10.4

FDOT DESIGN STANDARDS 2013

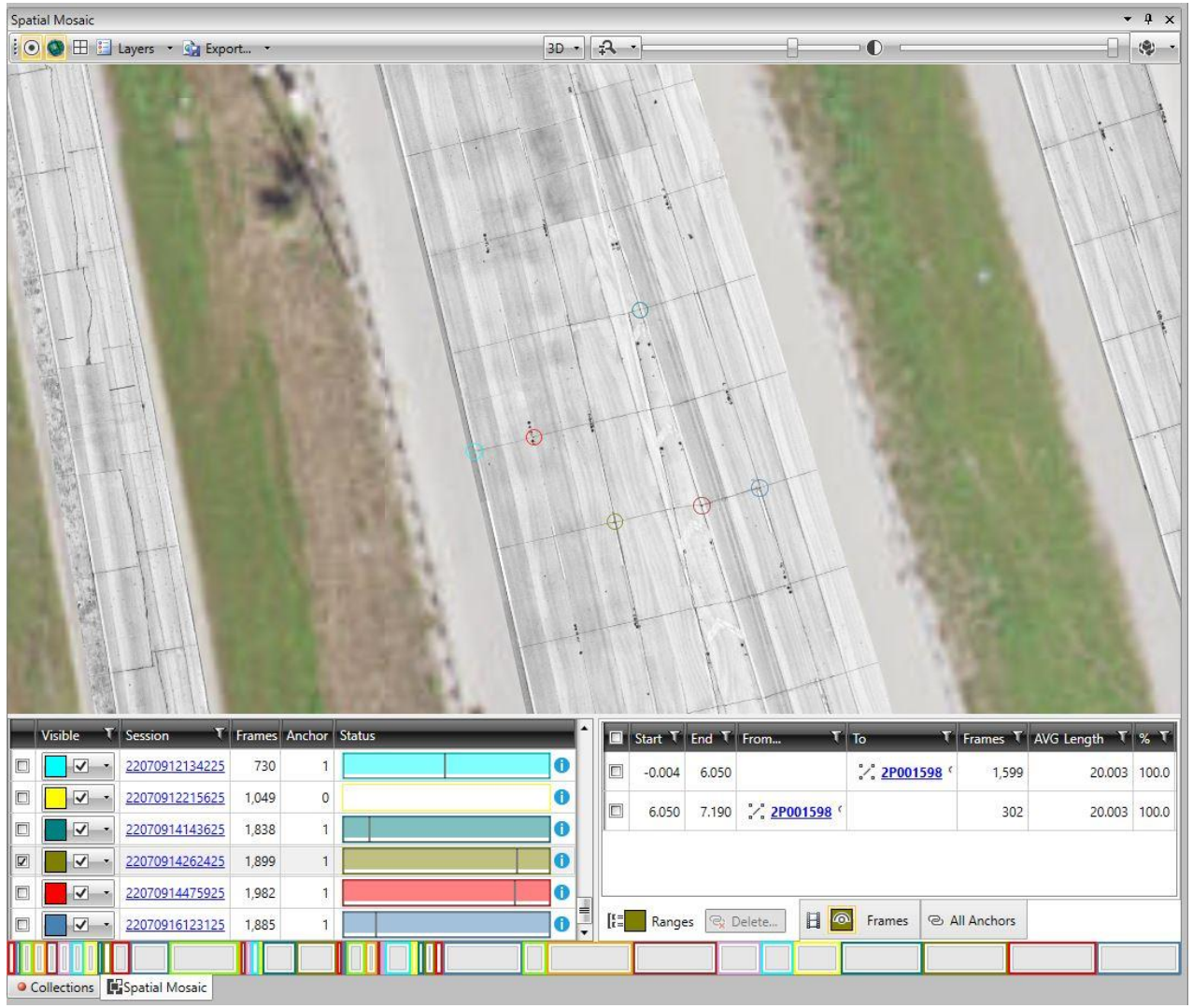
CONCRETE SLAB REPLACEMENT

I-275 Rehab Survey in Florida, USA

- Rehab treatments are selected by software following FDOT treatment matrix
- Treatments are associated with each slab and exported as a spatial layer (GDB, SHP)
- Engineers conveniently load defects *and* recommended treatments in GIS or CAD software
  - ArcGIS, QGIS, etc.
  - AutoCAD, Microstation, etc.

Recap

- For any LCMS system, Connect™ software can be used to stitch any multi-pass or multi-lane data
- Data can be tied down to ground reference data
- Raster images can be exported by section or by area defined by a polygon
- Vector data is preserved and transformed to match



Questions?

Contact us:
https://www.internationalcybernetics.com/contact-us

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