Paving the Road with Automation

Erik Martinez Luna

Texas Department of Transportation & Penn State University

Advisor: Panos Giannakis

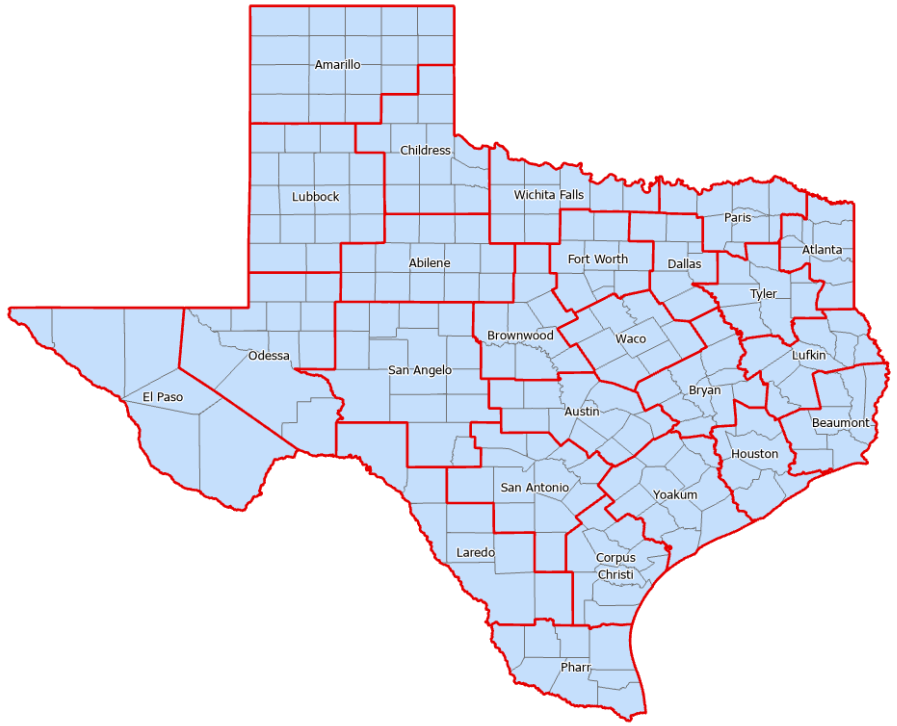
October 25, 2023

Presentation Objective

- Texas Department of Transportation (TxDOT) Background
- Geospatial Roadway Inventory Database (GRID) Background
  - What is it
  - Why is it important
  - Opportunities for improvement
- GRID Workflow Enhancement
  - KG Roadbed Attribution Builder (KRAB)

TxDOT Background

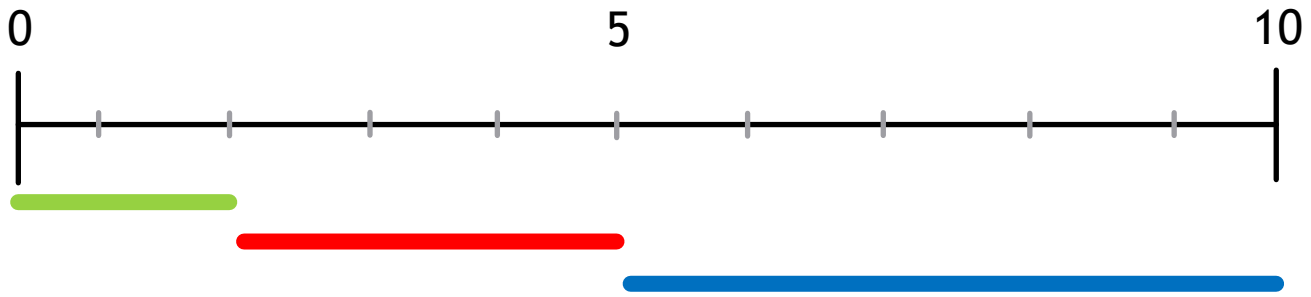
- Maintains Texas Roadway System
  - Roughly 80,000 miles of on-system roads
  - Network divided into 25 Districts
- Transportation Planning and Programming is responsible for geometry, asset attribution and reporting
  - Network maintained using a proprietary software known as the Geospatial Roadway Inventory Database (GRID)



GRID Background

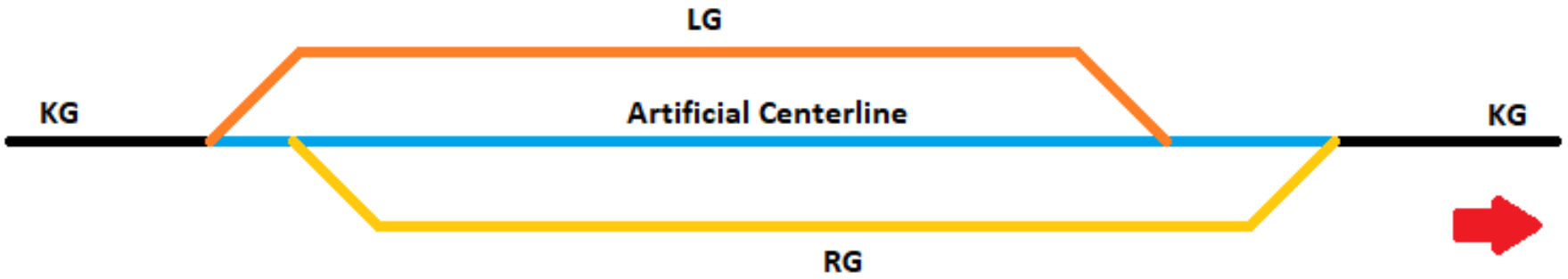
- Stores descriptive data such as physical and categorical information
  - Each data type (aka asset) stored in individual tables
  - Assets are recorded along a route using a linear referencing system (LRS)
- Two methods of updating asset attribution
  - Through GUI within GRID Portal
  - Extract, Transform and Load (ETL) of bulk packets
- Roadbed attribution updates are required when route geometry has been edited

Linear Referencing System Explained

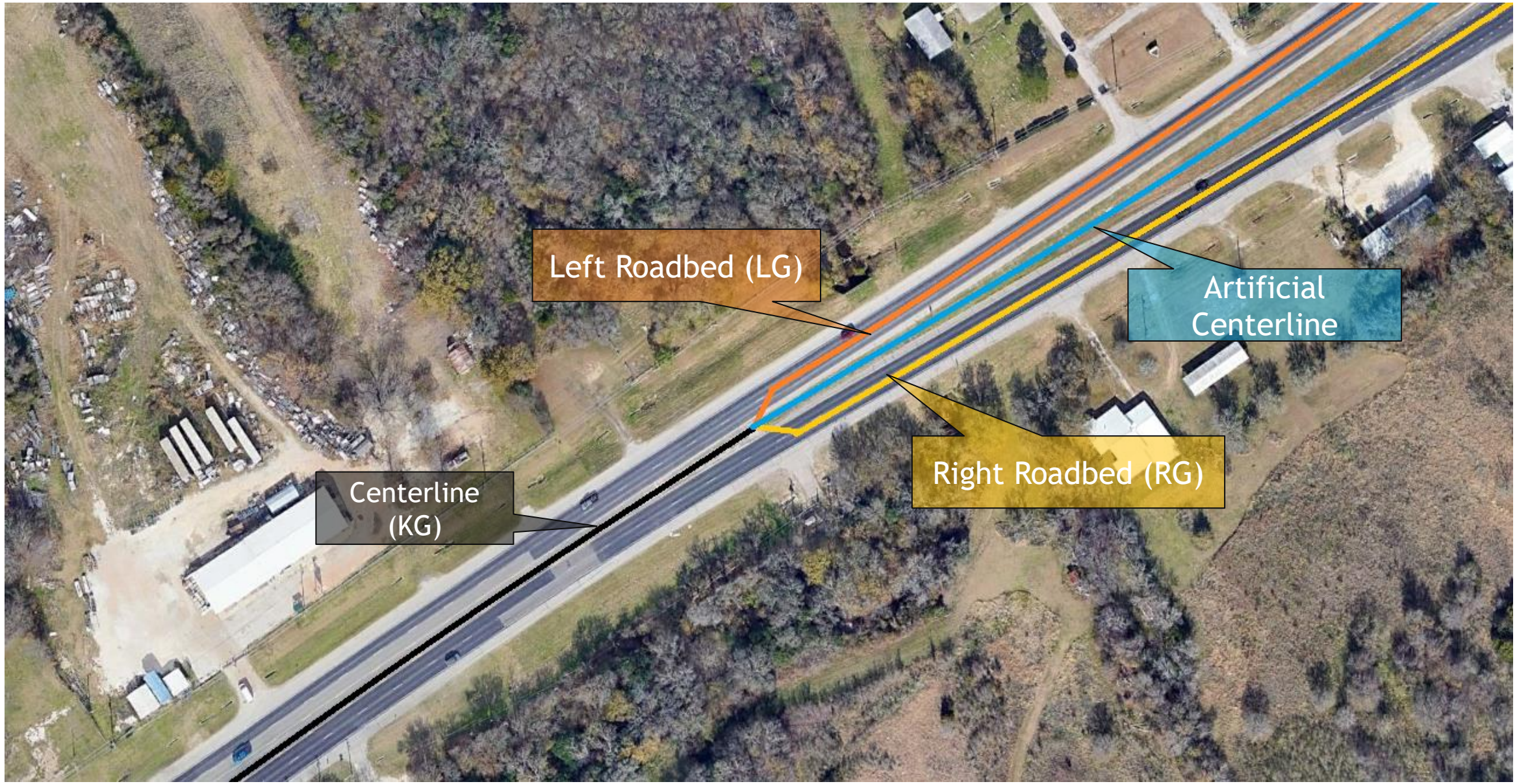


ASSET ID	BEGIN MEASURE	END MEASURE	ASSET TYPE
1	0	2	Green
2	2	5	Red
3	5	10	Blue

Basic Roadway Model



KG – Centerline
LG – Left Roadbed
RG – Right Roadbed


Left Roadbed (LG)
Artificial Centerline
Right Roadbed (RG)
Centerline (KG)

Why maintaining GRID data is Important

- Roadbed Attribution Accuracy
- Support other TxDOT projects and efforts
- Meet Federal reporting requirements

Inefficiencies with current attribution workflow

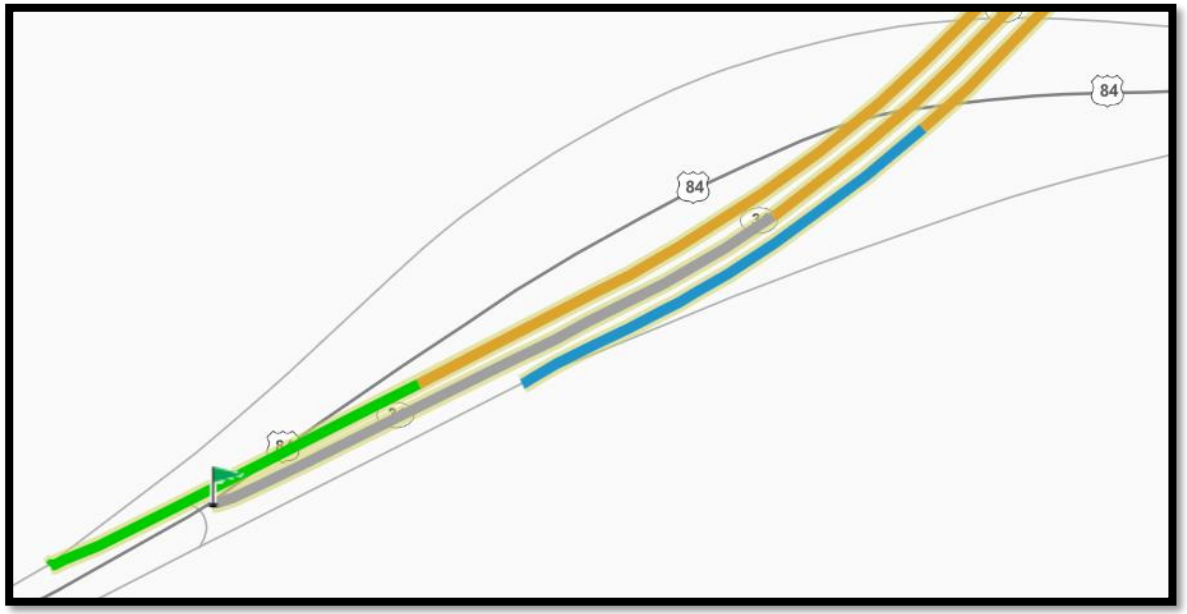
- No automated functionality within GRID to transfer attribution from one roadbed to artificial centerline
- Attribution of artificial centerline is time costly and increases likelihood of introduction of human error within database

In an Ideal World

- Why not just copy the attribution from right roadbed and paste them within an ETL Packet?
  - Each roadbed has their own independent LRS

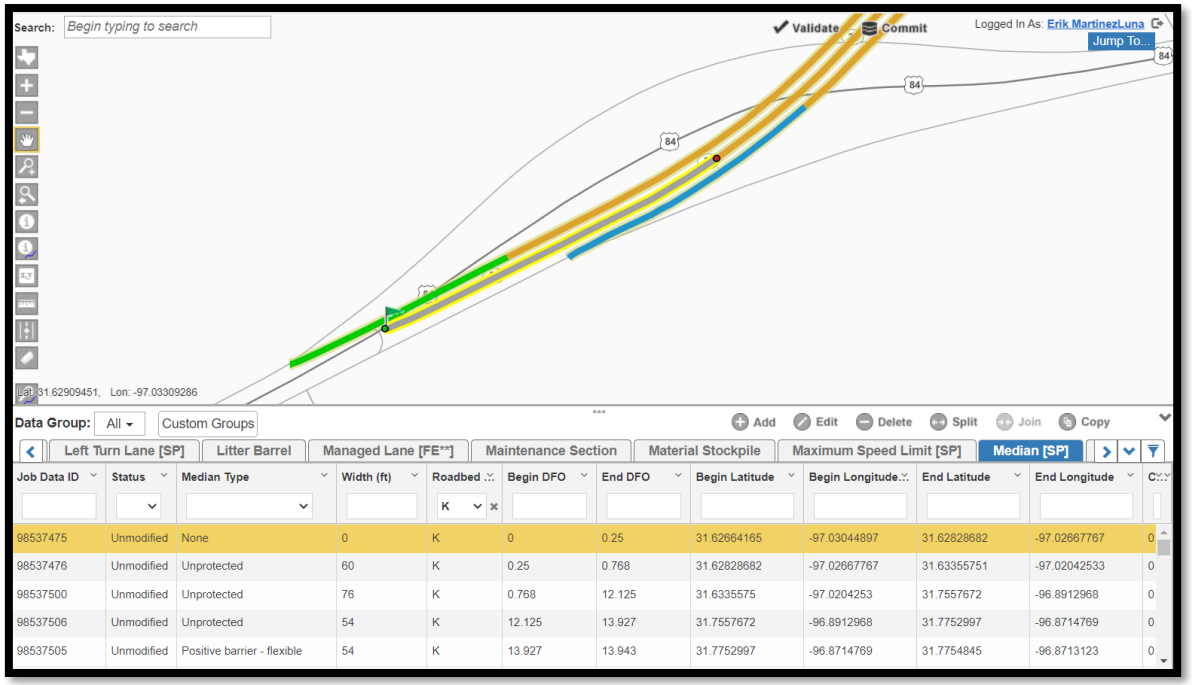
GRID Job Example – SH 31 Median Asset

- SH 31 Centerline Review
  - First artificial centerline is incorrectly classified as ‘No Median’ and 0 ft width
  - Needs to mirror right or left roadbeds



Working a GRID Job

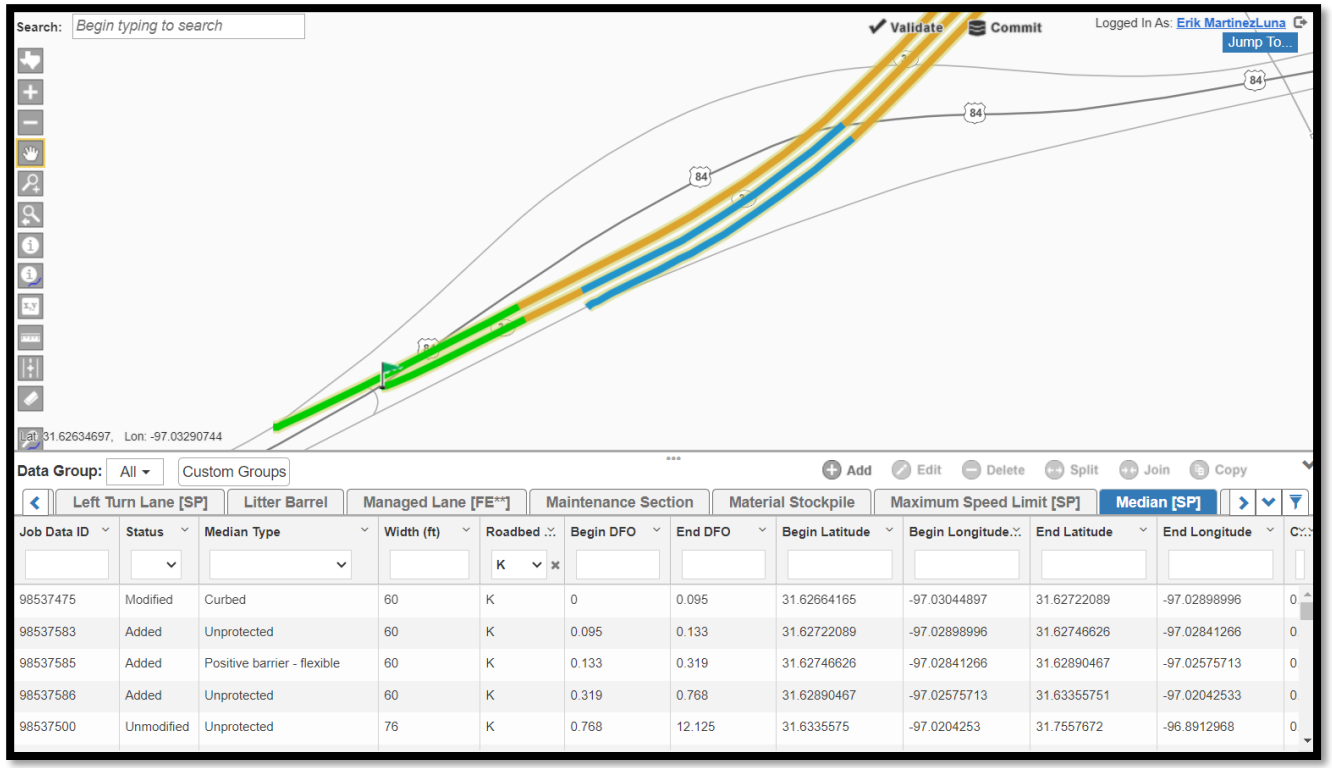
- Create job selecting SH0031 for attribution Editing
- Select the Median Table
- Verify asset type on right and left roadbed



Job Data ID	Status	Median Type	Width (ft)	Roadbed	Begin DFO	End DFO	Begin Latitude	Begin Longitude	End Latitude	End Longitude	C
				K							
98537475	Unmodified	None	0	K	0	0.25	31.62664165	-97.03044897	31.62828682	-97.02667767	0
98537476	Unmodified	Unprotected	60	K	0.25	0.768	31.62828682	-97.02667767	31.63355751	-97.02042533	0
98537500	Unmodified	Unprotected	76	K	0.768	12.125	31.6335575	-97.0204253	31.7557672	-96.8912968	0
98537506	Unmodified	Unprotected	54	K	12.125	13.927	31.7557672	-96.8912968	31.7752997	-96.8714769	0
98537505	Unmodified	Positive barrier - flexible	54	K	13.927	13.943	31.7752997	-96.8714769	31.7754845	-96.8713123	0

Working a GRID Job

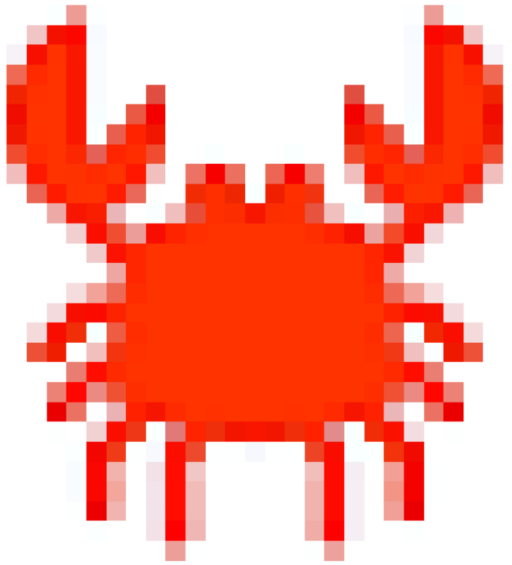
- Copy attribution from roadbeds to centerline
- Merge potential records with the same attribution values if able



Job Data ID	Status	Median Type	Width (ft)	Roadbed	Begin DFO	End DFO	Begin Latitude	Begin Longitude	End Latitude	End Longitude	C
				K							
98537475	Modified	Curbed	60	K	0	0.095	31.62664165	-97.03044897	31.62722089	-97.02898996	0
98537583	Added	Unprotected	60	K	0.095	0.133	31.62722089	-97.02898996	31.62746626	-97.02841266	0
98537585	Added	Positive barrier - flexible	60	K	0.133	0.319	31.62746626	-97.02841266	31.62890467	-97.02575713	0
98537586	Added	Unprotected	60	K	0.319	0.768	31.62890467	-97.02575713	31.63355751	-97.02042533	0
98537500	Unmodified	Unprotected	76	K	0.768	12.125	31.6335575	-97.0204253	31.7557672	-96.8912968	0

GRID Workflow Enhancement - KRAB

- KG Roadbed Attribution Builder (KRAB)
  - A custom python application automating the attribution of artificial centerlines using existing left and right roadbed attribution
- Application integrated with existing ETL tools with ArcGIS Pro developed by TxDOT
- Main Goal
  - Lower time to attribute routes within GRID



Querying and Data Extraction

- Initiate TxDOT's inhouse asset retriever to generate a GDB with selected assets
- Query GRID for main lane attribution, attribution measures, geometry and coordinate information

Extracted Roadbed Coordinate and Measure Table

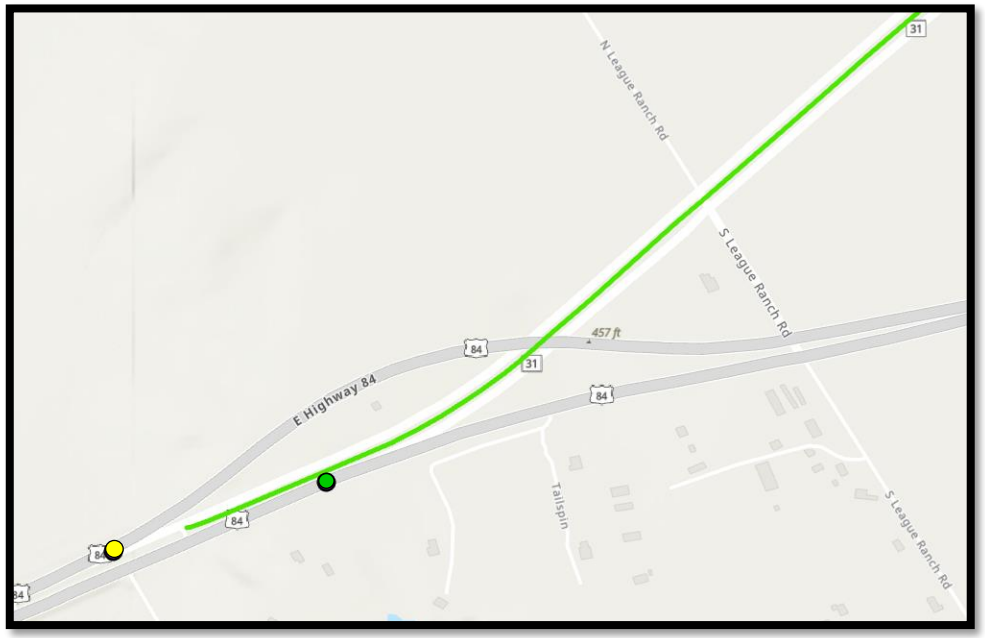
	RDBD_GMTRY_LN_ID	NAME	BEGIN_LAT	BEGIN_LON	END_LAT	END_LONG	ROADBED	RDWAY_STAT_TYPE_ID	BEGIN_DFO	END_DFO
1	1628640070	SH0031	31.62732497	-97.02835848	31.89628644	-96.72835468	R	5	0.133	26.074
2	1631059424	SH0031	31.90416214	-96.71245643	32.04387929	-96.53963106	R	5	27.146	41.274
3	1631059466	SH0031	32.10567142	-96.38347591	32.11687978	-96.33122303	R	5	53.059	56.234
4	1631145606	SH0031	32.11845416	-96.32074604	32.13090303	-96.24500018	R	5	56.864	61.392
5	1631145610	SH0031	32.1341971	-96.2223522	32.1480944	-96.0894871	R	7	62.739	70.629
6	1631145616	SH0031	32.15113161	-96.08048207	32.16505738	-96.03846109	R	5	71.196	73.841
7	1631145620	SH0031	32.17563718	-95.99185599	32.19443398	-95.90891205	R	5	76.684	81.716
8	1631145626	SH0031	32.22782761	-95.81091421	32.27469177	-95.75658344	R	5	87.923	92.469
9	1631145632	SH0031	32.28096672	-95.74016097	32.30129306	-95.62464225	R	5	93.534	100.442
10	1631145638	SH0031	32.297282	-95.52353607	32.30578335	-95.49049472	R	5	106.645	108.751
11	1631145642	SH0031	32.31419151	-95.45501683	32.33134599	-95.38689903	R	5	110.91	115.141
12	1631145646	SH0031	32.41743329	-94.84598172	32.42460895	-94.83832374	R	5	148.067	148.745
13	1631145656	SH0031	32.43490295	-94.82756923	32.4402209	-94.82123275	R	5	149.673	150.197

Extracted Roadbed Attribution Table

	GID	ROUTE	ASSET_LN_BEGIN_LAT	ASSET_LN_BEGIN_LON	ASSET_LN_END_LAT	ASSET_LN_END_LON	MDN_TYPE_ID	RDBD	ASSET_ID	WIDTH_MS	ASSET_LN_BEGIN_DFO_MS	ASSET_LN_END_DFO_MS
1	1690848005	1319	33.25454834	-96.73247498	33.2622117	-96.73293532	1	K	107011291	0	0	0.531
2	1691971288	700	31.82529747	-106.41315377	31.80462093	-106.43509649	1	K	1002361653	0	0	2.423
3	1691971290	700	31.82512458	-106.41314954	31.8087371	-106.43588404	1	K	1002361655	0	0	2.296
4	1691971292	700	31.82577174	-106.42163846	31.7951703	-106.42087266	1	K	1002361657	0	0	2.109
5	207143	700	29.46986257	-100.95222741	29.47171226	-100.95507756	1	K	1002360855	0	0	0.227
6	207322	700	29.45916832	-100.94665947	29.46522351	-100.95873034	1	K	1002360857	0	0	0.839
7	1652832020	702	29.33442359	-98.45512112	29.33417314	-98.45406729	1	K	1002361272	0	0	0.166
8	1652832022	702	29.33341879	-98.45453552	29.33188321	-98.45445071	1	K	1002361273	0	0	0.229
9	211760	702	30.72113003	-98.39125995	30.72461766	-98.38471613	1	K	1002360858	0	0	0.515
10	211761	702	30.72452711	-98.38489593	30.72486668	-98.38423337	1	K	1002360859	0	0	0.056
11	211762	702	30.7248802	-98.38423651	30.72506249	-98.38375488	1	K	1002360860	0	0	0.033

End points to identify measures along centerline

Geometry Endpoints of Left and Right



- Right Roadbed Geometry Endpoint
- Left Roadbed Geometry Endpoint

Attribution Endpoints of Left and Right

- Right Roadbed Asset Begin/Endpoint
- Left Roadbed Asset Begin/Endpoint

DFO Measures for Each Roadbed Attribution on the KG

Right Roadbed

OBJECTID *	BEGIN_DFO ▲	END_DFO	RB_RG	ASSET_RG	SEG_ID	WIDTH_MS_RG
2	0.133	0.32	RG	5	0	60
1	0.32	0.736	RG	2	0	60
3	0.736	12.069	RG	2	0	76
5	12.069	13.918	RG	2	0	54
7	13.918	14.437	RG	5	0	54
6	14.437	25.879	RG	5	0	45
4	25.879	26.065	RG	2	0	45
8	27.145	27.198	RG	2	1	45

Left Roadbed

OBJECTID *	BEGIN_DFO ▲	END_DFO	RB_LG	ASSET_LG	SEG_ID	WIDTH_MS_LG
6	0	0.094	LG	3	0	60
7	0.094	0.491	LG	2	0	60
2	0.491	12.059	LG	2	0	76
3	12.059	13.862	LG	2	0	54
5	13.862	14.434	LG	2	0	54
4	14.434	25.879	LG	5	0	45
1	25.879	26.065	LG	2	0	45
8	27.145	27.196	LG	2	1	45

Right and Left Attribution Tables Overlay

OBJECTID *	SEG_ID *	BEGIN_DFO ▲	END_DFO	RB_RG	ASSET_RG	WIDTH_MS_RG	RB_LG	ASSET_LG	WIDTH_MS_LG
12	0	0	0.094			0	LG	3	60
15	0	0.094	0.133			0	LG	2	60
14	0	0.133	0.32	RG	5	60	LG	2	60
13	0	0.32	0.491	RG	2	60	LG	2	60
3	0	0.491	0.736	RG	2	60	LG	2	76
4	0	0.736	12.059	RG	2	76	LG	2	76
5	0	12.059	12.069	RG	2	76	LG	2	54
6	0	12.069	13.862	RG	2	54	LG	2	54

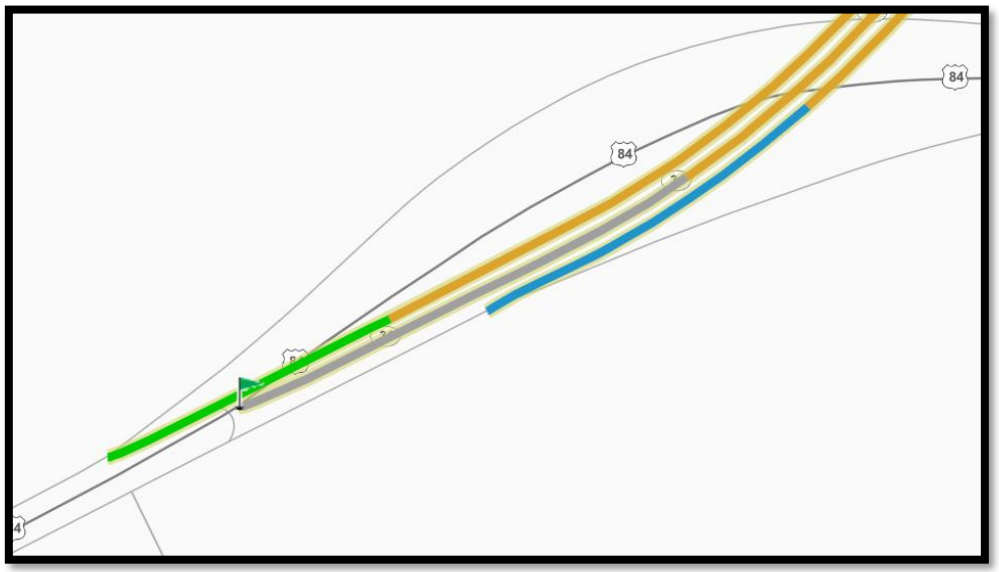
Processed Attribution Table

OBJECTID *	ROUTE *	BEGIN_DFO ▲	END_DFO	ASSET	WIDTH_MS	GID
18	SH0031	0	0.094	3	60	1631059288
12	SH0031	0.094	0.133	2	60	1631059288
25	SH0031	0.133	0.32	5	60	1631059288
13	SH0031	0.32	0.736	2	60	1631059288
16	SH0031	0.736	12.069	2	76	1631059288
10	SH0031	12.069	13.918	2	54	1631059288
24	SH0031	13.918	14.437	5	54	1631059288
22	SH0031	14.437	25.879	5	45	1631059288

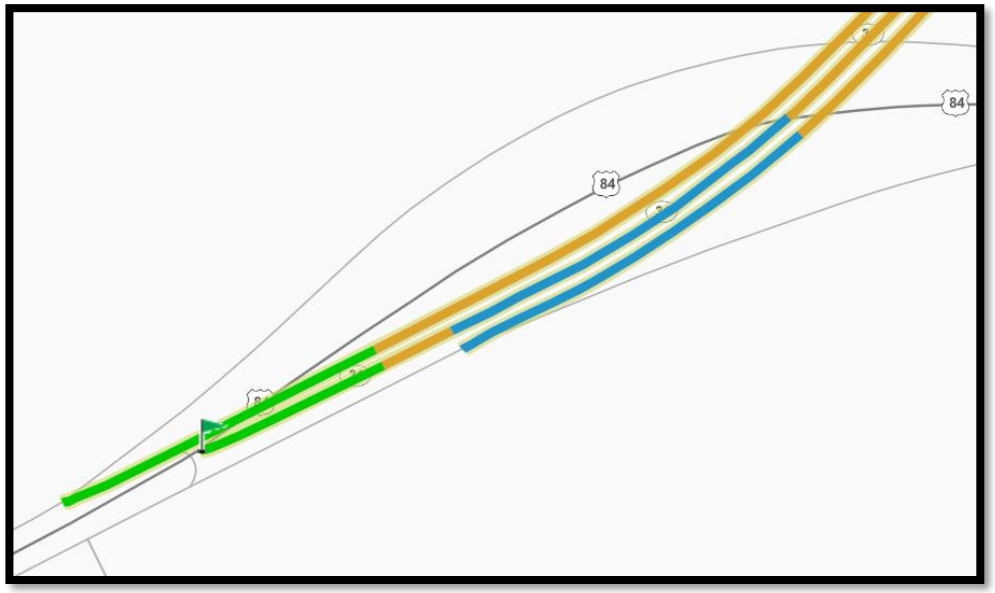
Prepping and Pushing ETL Packet

- Using the ‘Master Bounds’, attribution along identified measure extents are marked as ‘DELETE’ to be removed from the database
- Generated artificial centerline attribution are then pushed into ETL packet
- Finally, KRAB will dissolve records by merging neighboring records with same attribution values
  - If asset IDs of record’s marked as ‘DELETE’ can be salvaged, KRAB will recycle these IDs by reassigning them to the correct generated attribution

Before KRAB



After KRAB



None
Unprotected
Curbed
Positive Barrier - Flexible

KRAB's Future

- Further Debugging required for niche route models
  - Currently KRAB has the functionality to identify, remove and report routes with errors after processing
- Functionality to attribute Right/Left roadbeds based on centerline

Summary

- Importance of accurate data
  - Support TxDOT project and future endeavors
  - Obtain federal funding
- Inefficiencies with current workflow
  - Attribution of artificial centerline is time costly and increases likelihood of introduction of human error within database
- GRID Workflow Enhancement
  - Automate the attribution of the artificial centerline by using left and right roadbed attribution within ETL packets.

Questions?

- For further questions, you can contact me at:
  - Erik.martinezluna@txdot.gov