UDOT's MAP Message Experiences

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Building MAP Messages for Intersections

- Introduction to MAP Messages.
- UDOT's experience with MAP Messages.
- MAP Message creation tools and methodology.
- Lessons Learned.
- The need for MAP Guidance.
- Future Needs.

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What is a MAP Message

- SAE J2735 Standard
  - Defines the data structure of a MAP message.
  - Contains detailed information about an intersection or roadway.
  - Approaches, Lanes, Lane Geometry, Lane Movements.

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How a MAP is Message Used

- Road Side Unit (RSU) broadcasts a MAP message using wireless communications.
- MAP message is broadcast once per second by the RSU.
- An Onboard Unit (OBU) receives the MAP message and uses the intersection or roadway geometry contain in the message to determine the vehicle's location in the intersection or roadway.

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MAP Construction

- Inputs
  - Intersection data (approaches, lane IDs, lane node points, lane widths, lane movements, crosswalks, signal group IDs, etc.).
- Outputs
  - Text/ASCII files which contain the intersection/roadway information (NMAP file or JSON file).
  - MAP message payload (binary file).

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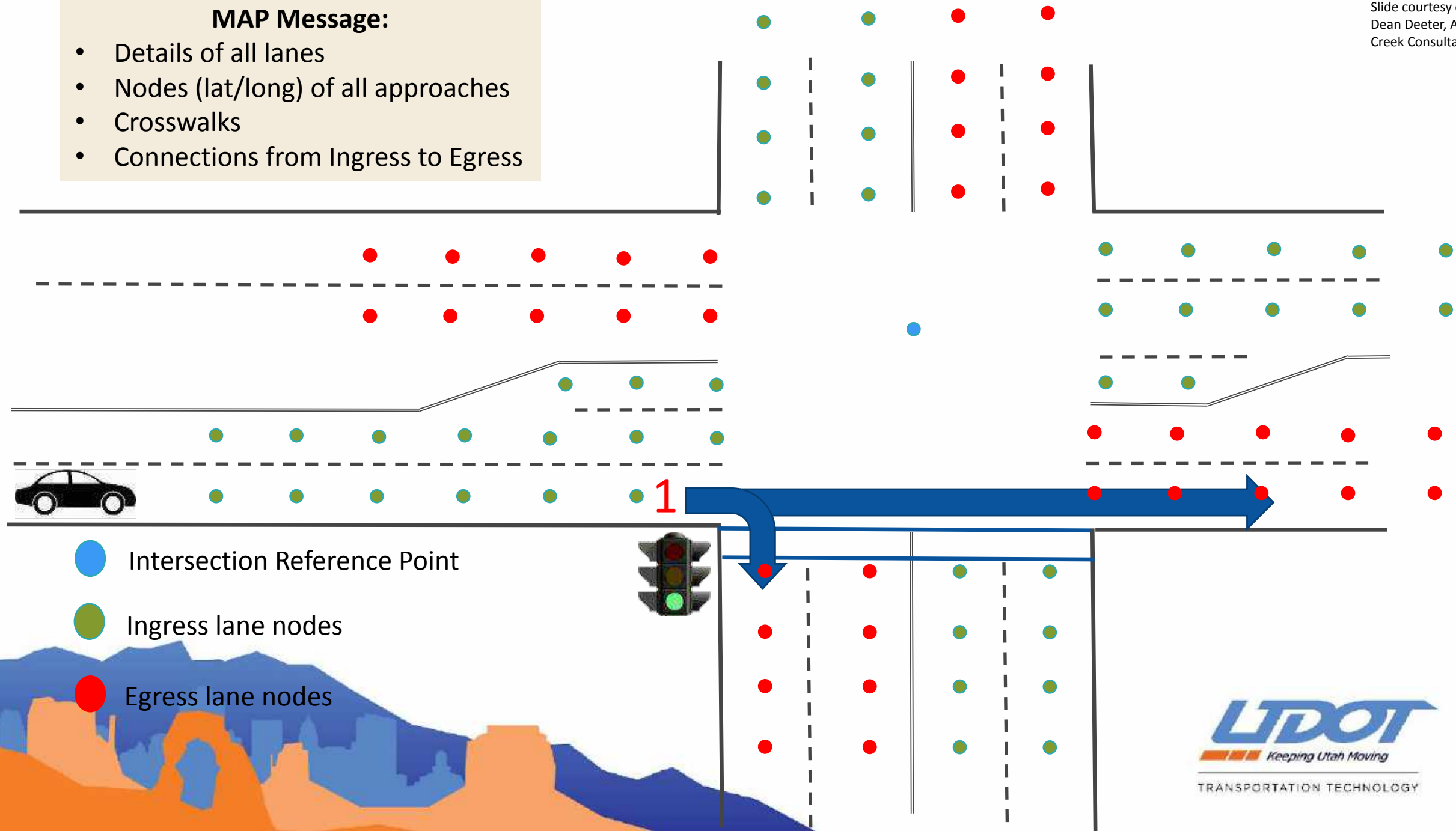
MAP Message:

- Details of all lanes
- Nodes (lat/long) of all approaches
- Crosswalks
- Connections from Ingress to Egress

Slide courtesy of Dean Deeter, Athey Creek Consultants



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Utah DOT Experiences with MAP Messages

- Over 300 Intersection MAP messages created to date
- Tools Used:
  - ESRI ArcMap
  - Microsoft Excel
  - In-house developed software
  - Utah Geographic Resource Center (6-inch resolution aerial imagery)
  - Field Surveys of intersections for Verification of MAP Message data.
  - USDOT MAP Creation Tool (https://webapp.connectedvcs.com/isd)
- Challenges:
  - J2735 standard can be difficult to understand.
  - MAP message creation documentation was sparse.
  - MAP message creation lacked guidance.

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In the beginning…NMAP Files

- Multimodal Intelligent Traffic Signal System (MMITSS) required an NMAP file for intersection geometry. The NMAP is used to create a MAP message.
- Create road intersection reference point and lane nodes in ArcMap using Google imagery.
- Export reference point and lane node data and coordinates (latitude, longitude) to a Microsoft Excel worksheet.
- Add additional road intersection information to spreadsheet required for NMAP file format.
- In-house developed software reads the spreadsheet and creates the NMAP file.
- Validate the NMAP file by processing it with an NMAP Parser / Validation application.
- NMAP file is now ready to used by the MMITSS software.

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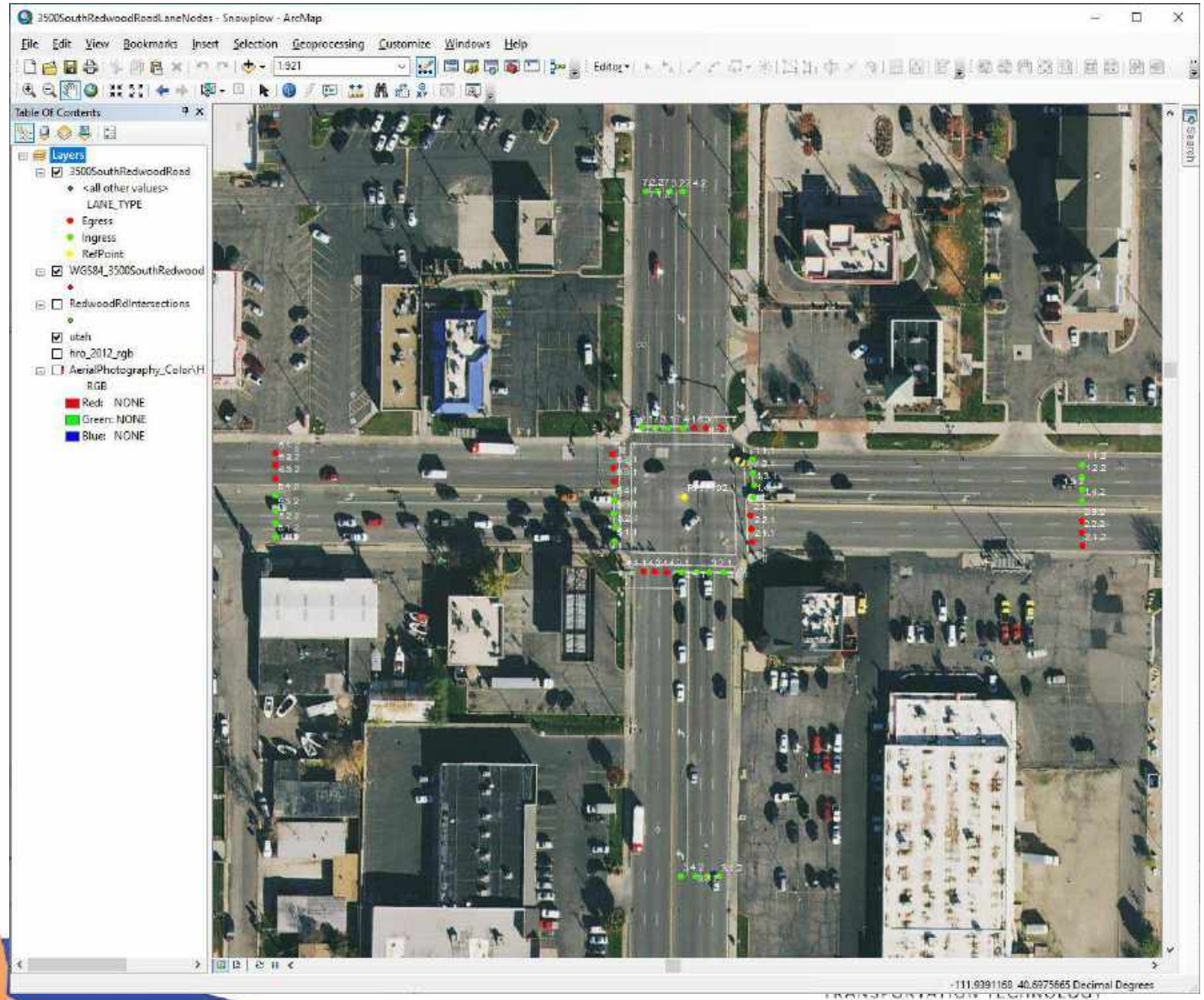
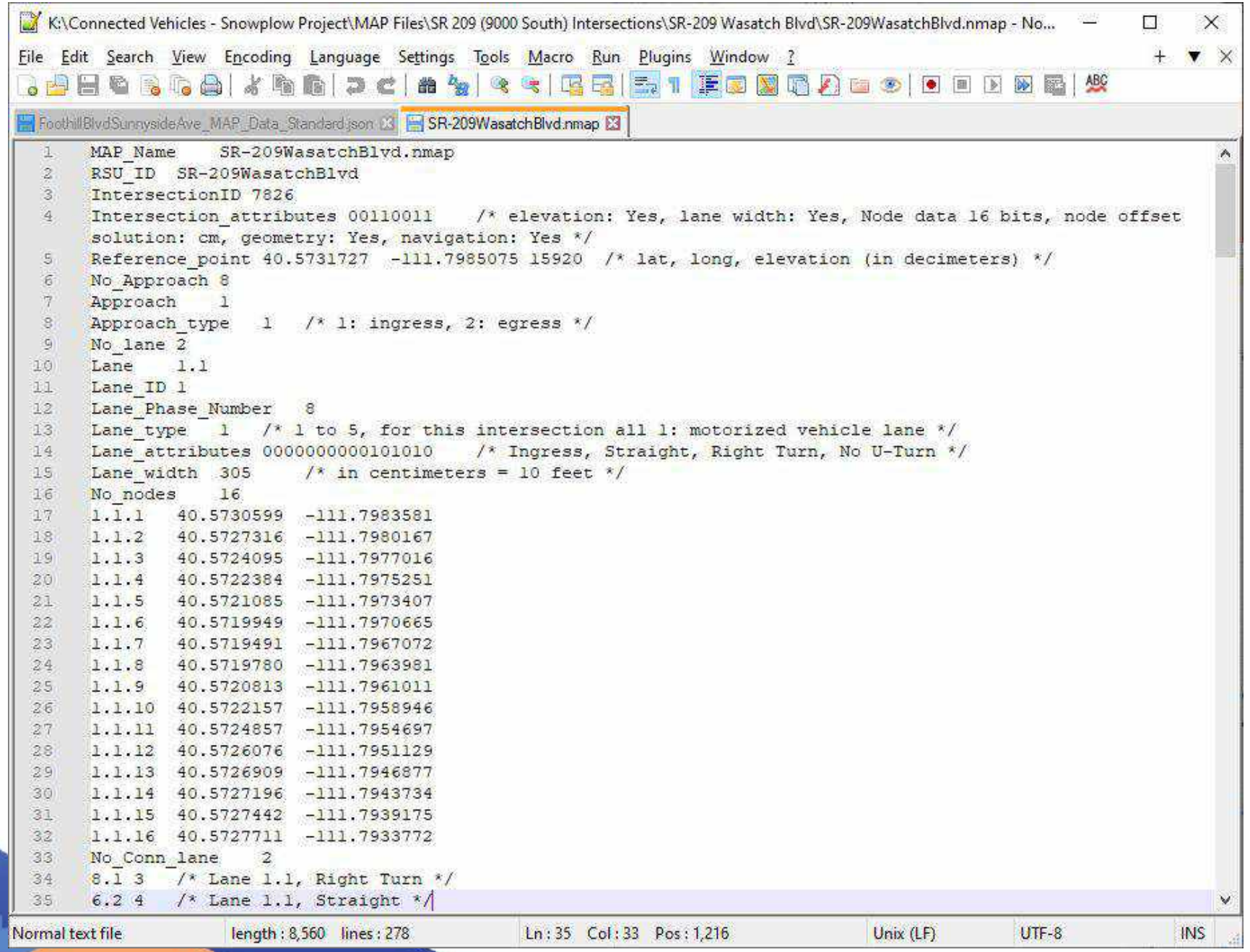
Creating intersection MAP node points using ESRI ArcMap



NMAP File


K:\Connected Vehicles - Snowplow Project\MAP Files\SR 209 (9000 South) Intersections\SR-209 Wasatch Blvd\SR-209WasatchBlvd.nmap - No...
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
FoothillBlvdSunnysideAve_MAP_Data_Standard.json
SR-209WasatchBlvd.nmap
1 MAP_Name SR-209WasatchBlvd.nmap
2 RSU_ID SR-209WasatchBlvd
3 IntersectionID 7826
4 Intersection_attributes 00110011 /* elevation: Yes, lane width: Yes, Node data 16 bits, node offset solution: cm, geometry: Yes, navigation: Yes */
5 Reference_point 40.5731727 -111.7985075 15920 /* lat, long, elevation (in decimeters) */
6 No_Approach 8
7 Approach 1
8 Approach_type 1 /* 1: ingress, 2: egress */
9 No_lane 2
10 Lane 1.1
11 Lane_ID 1
12 Lane_Phase_Number 8
13 Lane_type 1 /* 1 to 5, for this intersection all 1: motorized vehicle lane */
14 Lane_attributes 0000000000101010 /* Ingress, Straight, Right Turn, No U-Turn */
15 Lane_width 305 /* in centimeters = 10 feet */
16 No_nodes 16
17 1.1.1 40.5730599 -111.7983581
18 1.1.2 40.5727316 -111.7980167
19 1.1.3 40.5724095 -111.7977016
20 1.1.4 40.5722384 -111.7975251
21 1.1.5 40.5721085 -111.7973407
22 1.1.6 40.5719949 -111.7970665
23 1.1.7 40.5719491 -111.7967072
24 1.1.8 40.5719780 -111.7963981
25 1.1.9 40.5720813 -111.7961011
26 1.1.10 40.5722157 -111.7958946
27 1.1.11 40.5724857 -111.7954697
28 1.1.12 40.5726076 -111.7951129
29 1.1.13 40.5726909 -111.7946877
30 1.1.14 40.5727196 -111.7943734
31 1.1.15 40.5727442 -111.7939175
32 1.1.16 40.5727711 -111.7933772
33 No_Conn_lane 2
34 8.1 3 /* Lane 1.1, Right Turn */
35 6.2 4 /* Lane 1.1, Straight */
Normal text file length : 8,560 lines : 278 Ln : 35 Col : 33 Pos : 1,216 Unix (LF) UTF-8 INS

Using the USDOT MAP Message Building Tool

- The USDOT Mapping Tool allowed MAP messages to be built much faster than the ESRI ArcMap method.
- JSON file and binary file were created by the mapping tool.
- MAP message validation tool.

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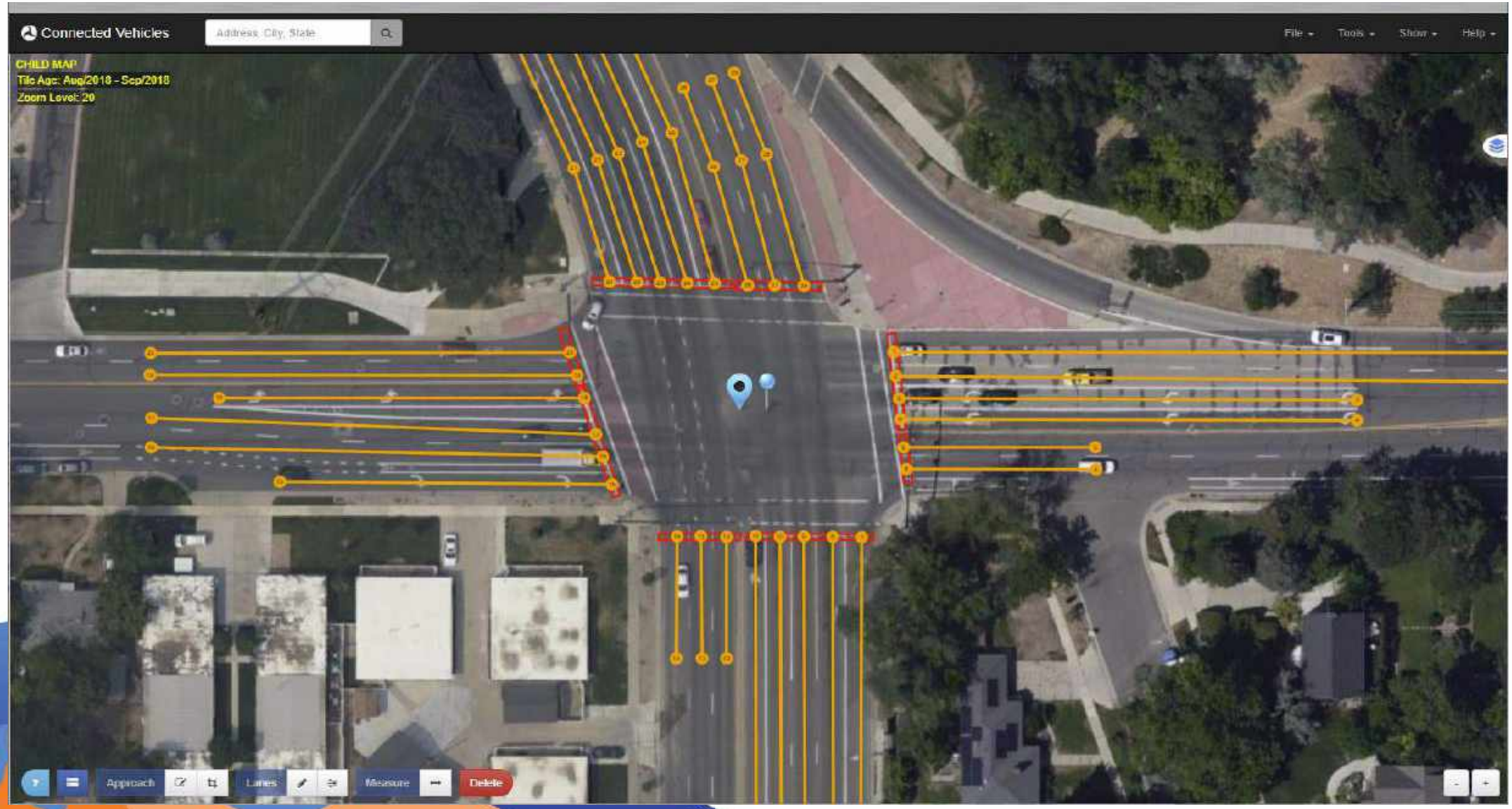
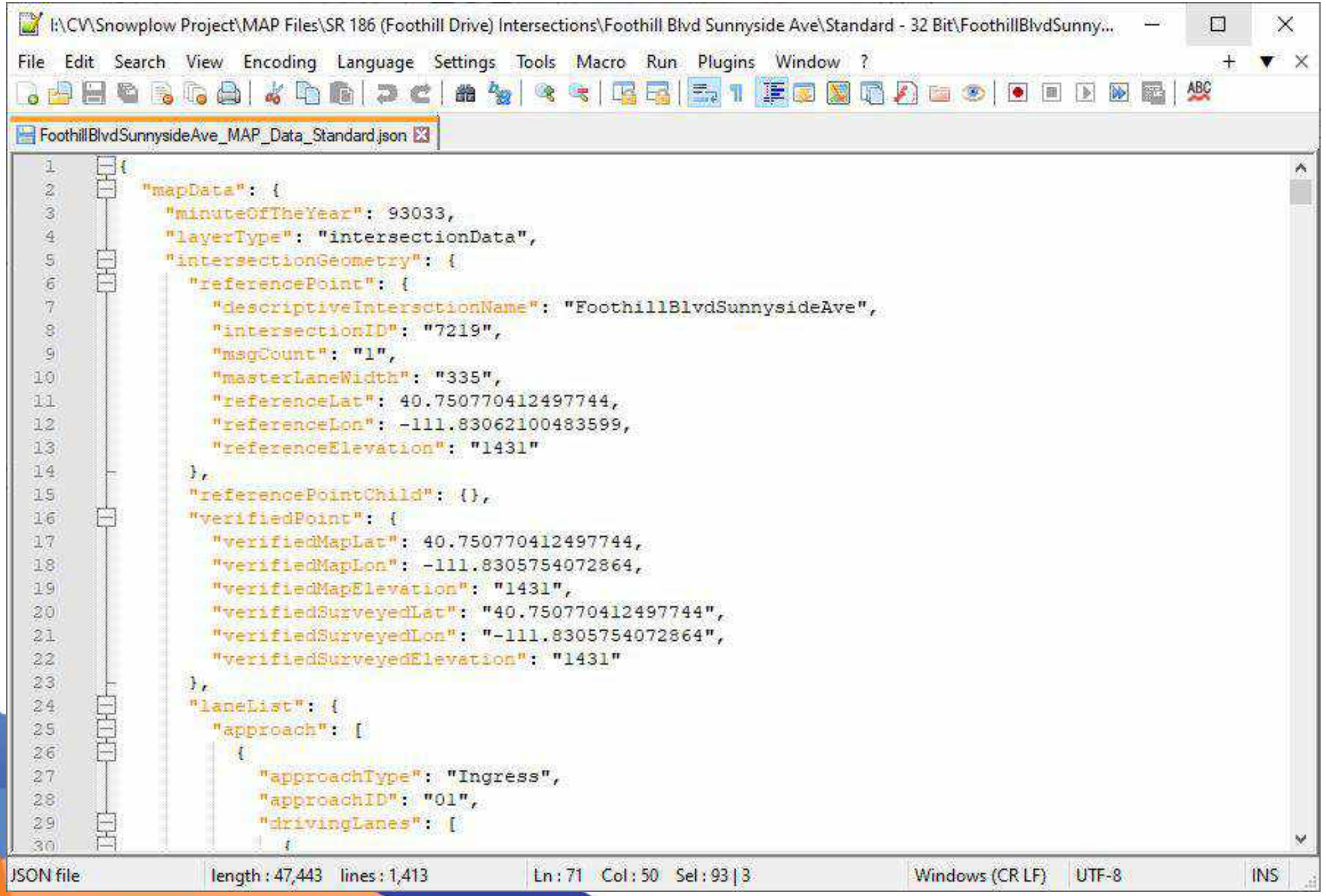
USDOT MAP Tool



JSON MAP File



MAP Message Creation Issues

- Intersections or roadways that are under construction.
- Aerial imagery that is out of date or of poor resolution.
- MAP message accuracy.

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Road Intersection under Construction

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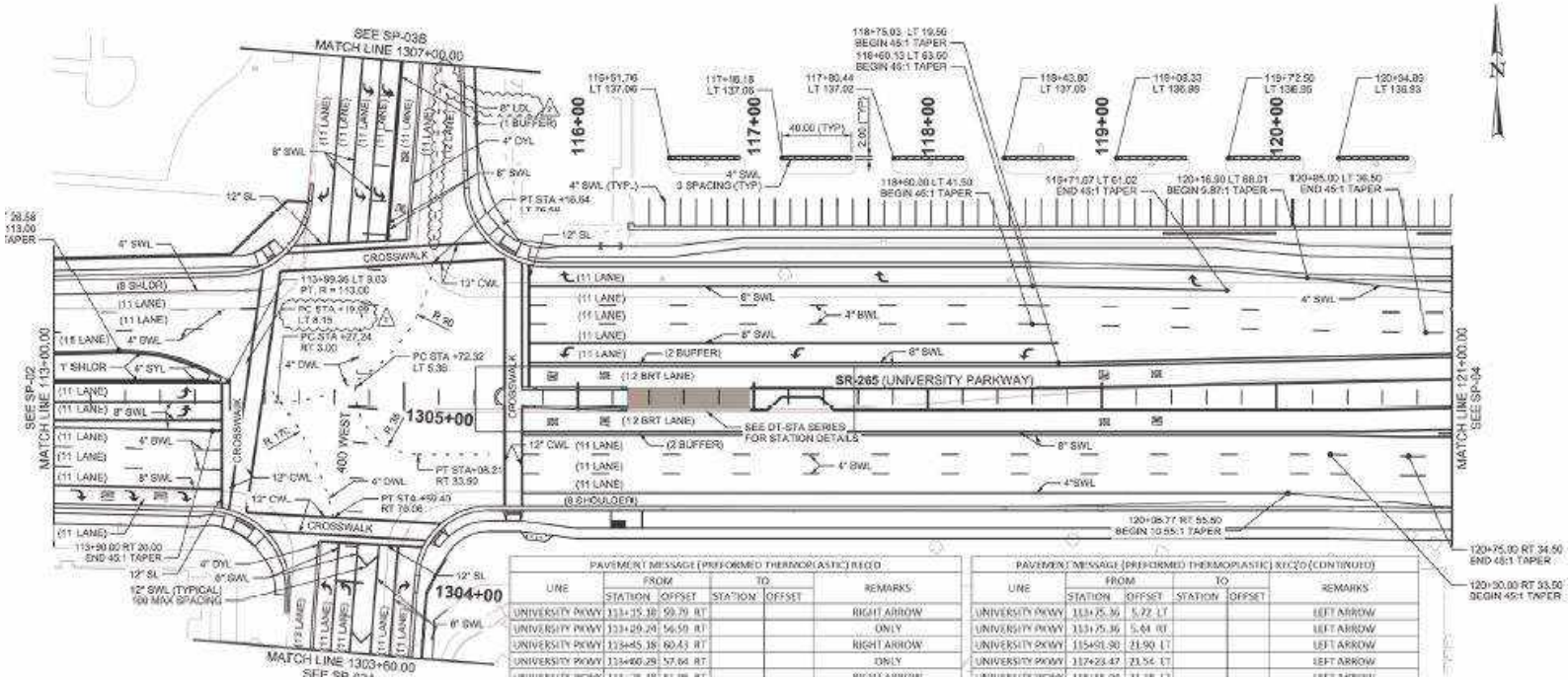
Road Intersection under Construction



Intersection Plan Set

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Road Intersection under Construction

KML File Overlay Created from Intersection Plan Set

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Lessons Learned

- Good informative documentation is a must. Much time was spent determining what needed to be in the MAP message file: where information for the attribute bit field attributions could be found; how many lane nodes should be created for each lane; and other “gotcha’s”. Searching on the internet was done to obtain the above mentioned information along with making phone calls to people. Better documentation could have solved these problems and lessened the learning curve on how to create a MAP message.

- MAP message payload size is limited to approximately 1450 bytes. This size limitation issue required the number of lane nodes to be kept at a minimum. Computed lanes should be used to reduce the number of lane nodes. Node points for road curves can be challenging in that they increase the number of nodes for the intersection or roadway.

- The manual workflow process has given insight into how the process could be sped up using software to automate many of the tasks in creating MAP messages.

- Imagery for intersections under construction can be obtained from local drone imagery.

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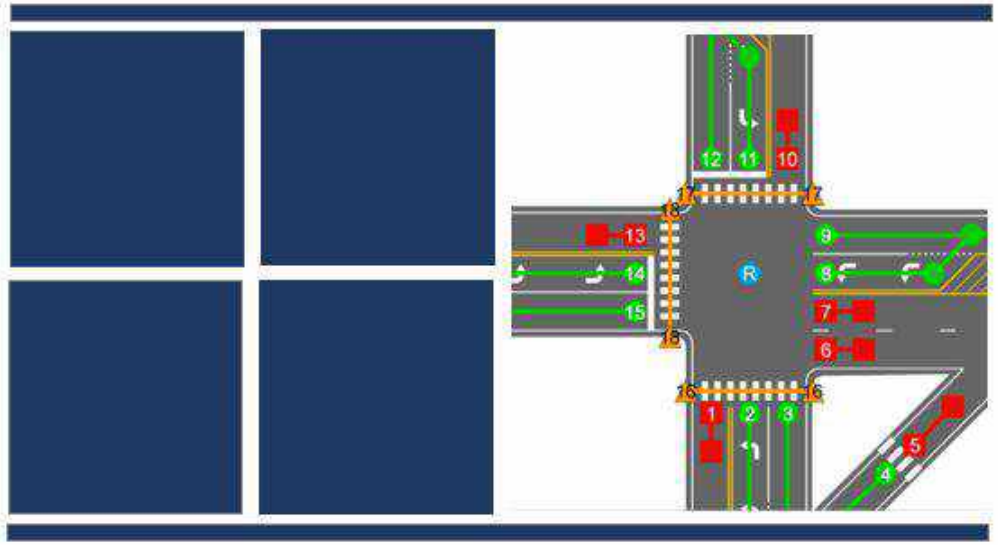
CV PFS MAP Guidance Document

- Accessing the MAP Guidance
- Original and all revisions available on the CV PFS Website at:
- https://engineering.virginia.edu/cv-pfs-resources#accordion688161



Creation of a Guidance Document for MAP Preparation

MAP GUIDANCE DOCUMENT

FINAL – Revision #2

February 2022

Prepared for:

The Connected Vehicle Pooled Fund Study
(University of Virginia Center for Transportation Studies

Prepared by:

Athey Creek Consultants, LLC and Synesis Partners, LLC

Structure of the MAP Guidance

Two up-front sections summarize the Guidance to support readers through the document

1. Definition of 7 Steps to creating MAP messages

- Intended to support MAP Creators in each step
- Majority of Guidance is in Steps 1 & 3
- Steps indicated in header to guide user through the document

Document Size – 103 pages
Number of Figures – 35
Number of Guidance Statements – 62

Step 1:
Assemble Data

Step 2:
Determine Verified Point Marker

Step 3:
Place Nodes and Create MAP Content

Step 4:
Visual Validation

Step 5:
Convert to J2735 Format

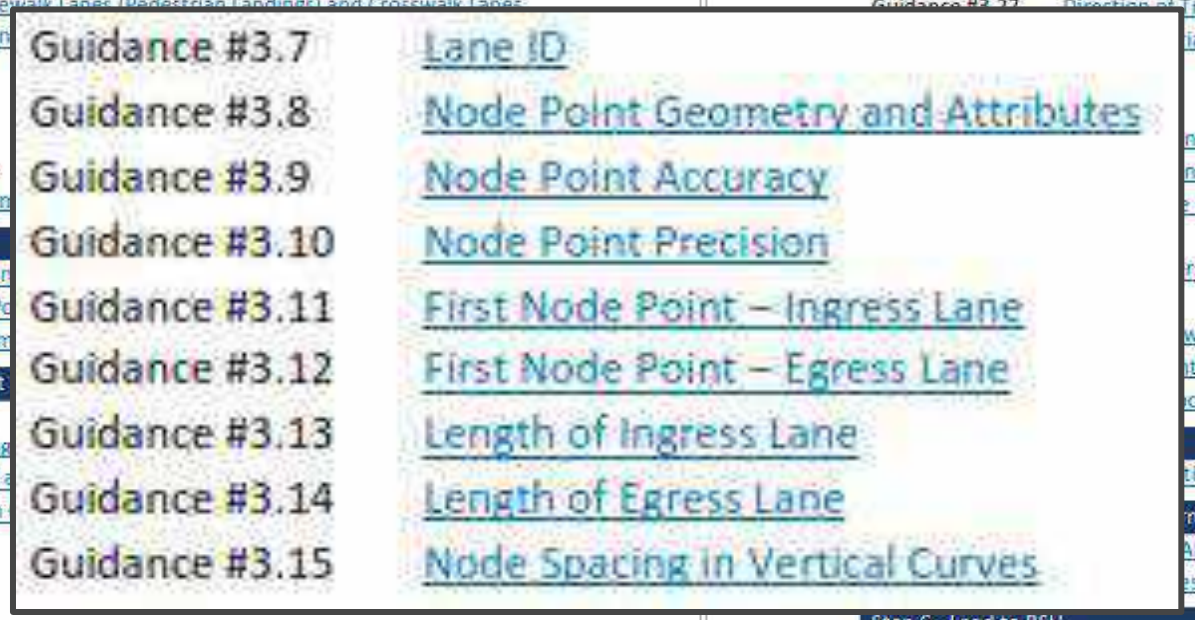
Step 6:
Load to RSU

Step 7:
Field Validation

Slide courtesy of
Dean Deeter, Athey Creek Consultants

Table 2: Listing of MAP Guidance by MAP Creation Step

Step 1 – Assemble Data	
Guidance #1.1	Understanding of Minimum Required Elements of the MAP Message
Guidance #1.2	MAP Message and Intersection Revision Counters
Guidance #1.3	Intersection Reference Identification (ID): Road Regulator ID
Guidance #1.4	Intersection Reference ID: Intersection ID
Guidance #1.5	Intersection Geometry
Guidance #1.6	Lane Width
Guidance #1.7	Lane ID
Guidance #1.8	Direction of Travel
Guidance #1.9	Connections Between Motor Vehicle Lanes
Guidance #1.10	Crosswalk Lanes
Guidance #1.11	Connections Between Sidewalk Lanes (Pedestrian Landings) and Crosswalk Lanes
Guidance #1.12	Phase Numbering and Sign
Guidance #1.13	Lane Use Variations
Guidance #1.14	Reference Point
Guidance #1.15	Computed Lanes
Guidance #1.16	Allowed Lane Maneuvers
Guidance #1.17	Geodetic Reference Syste
Step 2 – Determine Verified Point Market	
Guidance #2.1	Selection of a Verified Poi
Guidance #2.2	Precision of the Verified Po
Guidance #2.3	Determination and Implem
Step 3 – Place Nodes and Create MAP Content	
Intersection Descriptors	
Guidance #3.1	Incrementing MAP Messag
Guidance #3.2	Intersection Reference ID a
Guidance #3.3	Incrementing Intersection
Guidance #3.4	Reference Point
Intersection Lane Geometry	
Guidance #3.5	Lane Width
Guidance #3.6	Speed Limits
Guidance #3.7	Lane ID
Guidance #3.8	Node Point Geometry and Attributes
Guidance #3.9	Node Point Accuracy
Guidance #3.10	Node Point Precision
Guidance #3.11	First Node Point – Ingress Lane
Guidance #3.12	First Node Point – Egress Lane
Guidance #3.13	Length of Ingress Lane
Guidance #3.14	Length of Egress Lane
Guidance #3.15	Node Spacing in Vertical Curves
Guidance #3.16	Node Spacing in Horizontal Curves
Guidance #3.17	Node Placement for Through Lane Splits into Through Lane and Turn Lane
Guidance #3.18	Non-Signalized Intersections
Guidance #3.19	Flyover Lanes
Guidance #3.20	Parking Lanes
Guidance #3.22	Node Offsets
Guidance #3.22	Crosswalks
Guidance #3.23	Turning Lanes: Channelization and Traffic Islands
Guidance #3.24	Turning Lanes: Egress Merge Lanes
Guidance #3.25	Turning Lanes: Mid-Block Left-Turn Lanes
Guidance #3.26	Turning Lanes: Two-Way Left-Turn Lanes
Lane Use Descriptions	
Guidance #3.27	Direction of Travel
	iations
	nections and Maneuvers – Motor Vehicle Lanes
	nections – Sidewalk Lanes to Crosswalk Lanes
	Maneuvers
	rsections in Close Proximity
	way – Multiple Signals Per Approach
	ntersections
	d Streets with Parking Lanes
	tion
	mat
	AE J2735 Format
	essage Completeness and Structure
Step 6 - Load to RSU	
Guidance #6.1	Load to RSU
Step 7 – Field Validation	
Guidance #7.1	Field Validation



Slide courtesy of Dean Deeter, Athey Creek Consultants

Future Needs

- Best Practices Guide for creating MAP Data.
  - Connect Vehicle Pooled Fund Study - Map Guidance Document.
  - The MAP Guidance Document is used by contractors hired by UDOT to build intersection MAP messages.
- Methodology for automating MAP Data messages / file creation.
  - Creating MAP messages is very labor intensive.
- Validation of MAP Data Messages / files.
  - Connect Vehicle Pooled Fund Study - Connected Intersection Message Monitoring System (CIMMS)
- Up-to-date base maps and aerial imagery.
- RTCM Corrections Message.

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