Creation of a Guidance Document for MAP Preparation Phase 3

May 6, 2025

CV PFS In-Person Meeting

CV PFS MAP Guidance



Guidance Document for MAP Message Preparation

FINAL – Revision #3 March 2024

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

SPaT Message:

- From the Signal Controller
- Current Signal Status for each approach
- Expected time of next signal phase change
- Whether pedestrian cross walks are activated
 - Others





MAP Message:

- Details of all lanes ٠
- Nodes (lat/long) of all approaches •
- Crosswalks •
- Connections from Ingress to Egress ٠









Ingress lane nodes

Egress lane nodes

MAP Message:

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







- Vehicle Lat/long matches node points in Lane 1
- Vehicle identifies as traveling in Lane 1
- Pays attention to SPaT status for Lane 1





First Node Point – Ingress Lanes

Overview:

•

•

•



Channelization and Traffic Islands



Channelization and Traffic Islands



Contents of the MAP Guidance

Table 2: Listing of MAP Guidance by MAP Creation Step

Guidance #3.12

Guidance #3.13

Guidance #3.14

Guidance #3.15

Length of Ingress Lane

Length of Egress Lane

Node Spacing in Vertical Curves

Node Spacing in Horizontal Curves

able 2. Listing of MA	r dudance 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 Signal Groups
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 Systems
Step 2 – Determine	e Verified Point Market
Guidance #2.1	Selection of a Verified Point Marker
Guidance #2.2	Precision of the Verified Point Marker Coordinates
Guidance #2.3	Determination and Implementation of Displacement Distance/Direction
Step 3 – Place Nod	es and Create MAP Content
Intersection Descri	iptors
Guidance #3.1	Incrementing MAP Message Revision Counter
Guidance #3.2	Intersection Reference ID and Road Regulator ID
Guidance #3.3	Incrementing Intersection Geometry Revision Counter
Guidance #3.4	Reference Point
Intersection Lane (Geometry
Guidance #3.5	Lane Width
Guidance #3.6	Lane ID
Guidance #3.7	Node Point Geometry and Attributes
Guidance #3.8	Node Point Accuracy
Guidance #3.9	Node Point Precision
Guidance #3.10	First Node Point – Ingress Lane
Guidance #3.11	First Node Point – Egress Lane

Guidance #3.17 Non-Signalized Intersections Guidance #3.18 Flyover Lanes Guidance #3.19 Parking Lanes Guidance #3.20 Node Offsets Guidance #3.21 Crosswalks Guidance #3.22 Turning Lanes: Channelization and Traffic Islands Guidance #3.23 Turning Lanes: Egress Merge Lanes	
Guidance #3.18 Flyover Lanes Guidance #3.19 Parking Lanes Guidance #3.20 Node Offsets Guidance #3.21 Crosswalks Guidance #3.22 Turning Lanes: Channelization and Traffic Islands Guidance #3.23 Turning Lanes: Egress Merge Lanes Guidance #3.24 Turning Lanes: Egress Merge Lanes	
Guidance #3.19 Parking Lanes Guidance #3.20 Node Offsets Guidance #3.21 Crosswalks Guidance #3.22 Turning Lanes: Channelization and Traffic Islands Guidance #3.23 Turning Lanes: Egress Merge Lanes Guidance #3.24 Turning Lanes: Egress Merge Lanes	
Guidance #3.20 Node Offsets Guidance #3.21 Crosswalks Guidance #3.22 Turning Lanes: Channelization and Traffic Islands Guidance #3.23 Turning Lanes: Egress Merge Lanes Guidance #3.24 Turning Lanes: Egress Merge Lanes	
Guidance #3.21 Crosswalks Guidance #3.22 Turning Lanes: Channelization and Traffic Islands Guidance #3.23 Turning Lanes: Egress Merge Lanes Guidance #3.24 Turning Lanes: Egress Merge Lanes	
Guidance #3.22 <u>Turning Lanes: Channelization and Traffic Islands</u> Guidance #3.23 <u>Turning Lanes: Egress Merge Lanes</u>	
Guidance #3.23 Turning Lanes: Egress Merge Lanes	
and when a sub-sub-sub-sub-sub-sub-sub-sub-sub-sub-	
Guidance #3.24 <u>Turning Lanes: Mid-Block Left-Turn Lanes</u>	
Guidance #3.25 Turning Lanes: Two-Way Left-Turn Lanes	
Lane Use Descriptions	
Guidance #3.26 Direction of Travel	
Guidance #3.27 Lane Use Variations	
Guidance #3.28 Lane Types	
Connections and Signal Groups	
Guidance #3.29 Defining Connections and Maneuvers – Motor Vehicle Lanes	
Guidance #3.30 Defining Connections – Sidewalk Lanes to Crosswalk Lanes	
Guidance #3.31 Allowed Lane Maneuvers	
Other	
Guidance #3.32 Multiple Intersections in Close Proximity	
Guidance #3.33 Pre-Signals	
Guidance #3.34 Divided Highway – Multiple Signals Per Approach	
Guidance #3.35 Jug Handle Intersections	
Guidance #3.36 Neighborhood Streets with Parking Lanes	
Step 4 - Visual Validation	
Guidance #4.1 <u>Visual Validation</u>	
Step 5 - Convert to SAE J2735 Format	ĺ
Guidance #5.1 Convert to SAE J2735 Format	
Guidance #5.1 Convert to SAE J2735 Format Guidance #5.2 Test MAP Message Completeness and Structure	
Guidance #5.1 Convert to SAE J2735 Format Guidance #5.2 Test MAP Message Completeness and Structure Step 6 - Load to RSU	
Guidance #5.1 Convert to SAE J2735 Format Guidance #5.2 Test MAP Message Completeness and Structure Step 6 - Load to RSU Guidance #6.1	
Guidance #5.1 Convert to SAE J2735 Format Guidance #5.2 Test MAP Message Completeness and Structure Step 6 - Load to RSU Load to RSU Guidance #6.1 Load to RSU Step 7 - Field Validation Load to RSU	

Table 1: Listing of M/	AP Guidance by MAP Creation Step		Guidance #3.17 Non-Signalized Intersections						
Step 1 – Assemble	e Data		Guidance #3.18 Flyover Lanes						
Guidance #1.1	Understanding of Minimum Required Element	s of the MAP Message	Guidance #3.19 Parking Lanes						
Guidance #1.2	MAP Message and Intersection Revision Count	ters	Guidance #3.20 Node Offsets						
Guidance #1.3	Intersection Reference Identification (ID): Road	d Regulator ID	Guidance #3.21 Crosswalks						
Guidance #1.4	Intersection Reference ID: Intersection ID		Guidance #3.22 Turning Lanes: Channelization and Traffic Islands						
Guidance #1.5	Intersection Geometry	Guidance #3.7	Node Point Geometry and Attributes						
Guidance #1.6	Lane Width	Guidance 115.7	Node Forne deorneery and Attributes						
Guidance #1.7	Lane ID								
Guidance #1.8	Direction of Travel	Guidance #3.8	Node Point Accuracy						
Guidance #1.9	Connections Between Motor Vehicle Lanes								
Guidance #1.10	Crosswalk Lanes	Guidance #2 0	Node Point Precision						
Guidance #1.11	Connections Between Sidewalk Lanes (Pede	Guidance #5.9	Node Point Precision						
Guidance #1.12	Phase Numbering and Signal Groups								
Guidance #1.13	Lane Use Variations	Guidance #3.10	First Node Point – Ingress Lane						
Guidance #1.14	Reference Point		The troad for the ingrees Land						
Guidance #1.15	Computed Lanes	Culdence #2.11	Einst Made Daint - Eansea Lana						
Guidance #1.16	Allowed Lane Maneuvers	Guidance #3.11	First Node Point – Egress Lane						
Step 2 – Determin	e Verified Point Market								
Guidance #2.1	Selection of a Verified Point Marker	Guidance #3.12	Length of Ingress Lane						
Guidance #2.2	Precision of the verified Point Marker Coor								
Stop 2 - Place Nor	des and Croate MAD Content	Guidance #3-13	Length of Egress Lane						
Intersection Desc	rintors	Guidance no.10	Eength of Egress Eune						
Guidance #3.1	Incrementing MAR Message Revision Count	0 1 1 1 1 1 1 1							
Guidance #3.2	Intersection Reference ID and Road Regulat	Guidance #3.14	Node Spacing in Vertical Curves						
Guidance #3.3									
Guidance #3.4	Reference Point	Guidance #3 15	Node Spacing in Horizontal Curves						
Intersection Lane	Geometry		Noue Spacing in honzontal curves						
Guidance #3.5	Lane Width								
Guidance #3.6	Lane ID	_	Step 7 – Field Validation						
Guidance #3.7	Node Point Geometry and Attributes		Guidance #7.1 Field Validation						
Guidance #3.8	Node Point Accuracy								
Guidance #3.9	Node Point Precision								
Guidance #3.10	First Node Point – Ingress Lane								
Guidance #3.11	First Node Point – Egress Lane								
Guidance #3.12	Length of Ingress Lane								
Guidance #3.13	Length of Egress Lane								
Guidance #3.14	Node Spacing in Vertical Curves								
Guidance #3.15	Node Spacing in Horizontal Curves								
Guidance #3.16	Node Placement for Through Lane Splits into T	hrough Lane and Turn Lane							

Reminder about MAP Guidance Revision #3

- Completed March 2024 and posted on the CV PFS webpage
 - <u>https://engineering.virginia.edu/sites/default/files/Connected-Vehicle-PFS/Resources/MAP%20Guidance%20Document%20-</u> %20Revision%203%20FINAL.pdf
- Revision updates
 - Node placement for through lane splits into through lane and turn lane
 - Ongoing monitoring and validation, including the Connected Intersections Message Monitoring System (CIMMS)

Today's Discussion

• Project extended through July 31, 2025

- Update on MAP message topics and Issues for Guidance Revisions
- Update on Support in Preparing for Transition from SAE 2735 MAP to SAE 2945/A Road Geometry and Attributes (RGA) Standard

MAP Guidance Topics

- MAP Validation
- Request for input on any Additional Changes

MAP Validation

- CTI 4501 identifies a requirement that MAP message node points be accurate to within .2 Meters
- It is not possible to guarantee this with the current version of the USDOT MAP Creation Tool
- To establish trust with OEMs, a validation process was needed
 - This was a focus of the UDOT SMART Grant that we updated on in December









Specification (developed by CAMP and incorporated into CTI efforts that Blaine updated on)

- Defines the data needed.
- Does not preclude other trusted sources of lane marking positions (e.g., surveying, GIS, etc.)

Data Element	Format
Intersection ID	Integer (Road Authority ID will replace)
Intersection Name	String
Lane Type	Ingress, Egress, Xwalk
MAP Lane Id	Integer
Sequence Number	Integer
Lane Line Position Points	WGS 84 Datum
- latitude – Left edge, Right edge	degrees (7 decimal)
- longitude – Left edge, Right edge	degrees (7 decimal)
- elevation – Left edge, Right edge	meters (1 decimal)
Lane marker type	Lane, Crosswalk
Distance to Stop bar (Point 0)	Meters (2 decimal)

Other parameters in the specification:

- Data pairs representing the edges of each approach lane
- Initial data pair at upstream edge of the stop bar and, if present, crosswalk
- Data pairs extend upstream at least the distance of the advance notification range
- Maximum spacing between data pairs no greater than 2 meters

Specification has been tested at intersections in Michigan and Utah

- LiDAR scans in each location
- Discussions about automating the MAP creation (at least the nodes) vs. validating adjusting

Data in CSV from LiDAR Scan Points

Intersection	D: 81									
Intersection	MPalymeouth Rd	& Huron Pkwy	, Ann Arbor, M							
Scan Date/Ti	r 20 24-06-19-	10:57:00								
LaneType	LaneID	Sequence	lat_1	lon_1	elev_1	lat_2	lon_2	elev_2	Distance	LaneMarker
ingress	10	1	42.3027357	-83.704444	275.8	42.3027355	-83.704405	275.9	0	Lane
ingress	10	2	42.3027537	-83.704444	275.8	42.3027535	-83.704405	275.8	2	Lane
ingress	10	3	42.3027717	-83.704444	275.8	42.3027715	-83.704405	275.9	4	Lane
ingress	10	4	42.3027897	-83.704444	275.8	42.3027895	-83.704405	275.8	6	Lane
ingress	10	5	42.3028077	-83.704444	275.8	42.3028075	-83.704405	275.8	8	Lane
ingress	10	6	42.3028257	-83.704444	275.8	42.3028256	-83.704405	275.8	10	Lane
ingress	10	7	42.3028437	-83.704443	275.8	42.3028436	-83.704406	275.8	12	Lane
ingress	10	8	42.3028617	-83.704443	275.7	42.3028616	-83.704406	275.8	14	Lane
ingress	10	9	42.3028797	-83.704444	275.8	42.3028796	-83.704405	275.8	16	Lane
ingress	10	10	42.3028977	-83.704445	275.8	42.3028976	-83.704405	275.8	18	Lane
ingress	10	11	42.3029157	-83.704445	275.7	42.3029156	-83.704406	275.8	20	Lane
ingress	10	12	42.3029337	-83.704446	275.7	42.3029336	-83.704406	275.8	22	Lane
ingress	10	13	42.3029517	-83.704446	275.7	42.3029516	-83.704407	275.8	24	Lane
ingress	10	14	42.3029697	-83.704447	275.7	42.3029696	-83.704408	275.8	26	Lane
ingress	10	15	42.3029877	-83.704447	275.7	42.3029875	-83.704409	275.8	28	Lane
ingress	10	16	42.3030056	-83.70445	275.7	42.3030055	-83.704411	275.8	30	Lane

LaneType = ingress/egress

LaneID = Lane id from MAP data

lat_x, lon_x = Latitude and longitude of lane boundary

elev_x = Elevation of scan point

Distance = Scan point distance from stop point

LaneMarker = Scanned object

Example Report of MAP Assessment – Metro Pkwy & Moravian

Α	В		С		D	E	F	G	н	I	J	К	L	M	N	0	Р	Q	R	
								*** Connecte	ed Intersection	on MAP Verific	ation Test Re	oort v2.0 ***								
Descriptior	1:																			
Lane Boundary Data File: /Users/jsp-c/myStuff/MobiTel/CAMP (CVI		VPFS + SOADS	+ UDOT Smar	t Grant)/UDC)T - Smart Gra	nt/UDOT - MA	P Assessment	/MCDR Test/I	ntersection_I	D-0-2347/Mo	ravian_Metro_	_0625_2024.cs	SV							
Intersection Name: Moravian Dr & Metro Pkwy																				
Intersection	n ID:		2347																	
LB Data File	e Date/Time	e:	2024-05-09-		12:54:02															_
MAP File Date/Time: /Users/jsp-c/myStuff/MobiTel/CAMI		Tel/CAMP (C)	VPFS + SOADS	+ UDOT Smar	t Grant)/UDC)T - Smart Gra	nt/UDOT - MA	P Assessment	/MCDR Test/I	ntersection_I	0-0-2347/202	2_01_11_18_2	24_10_cv2x0_	rx-MAP-0-234	7 converted_M	C				
Process Da	te/Time:		2025-03-07 -	15	:53:06															_
		_	1			N I. F	<<<<<<	Report of MAP	Node Point F	Requirements	s Pass/Fail and	Correspondi	ng Revised Val	ues >>>>>>>	>>	1 N 1.	Distance (m/			
	Nada	-				Node F		a da Da a	Nede Dec		- Lane width	 Device d	[Elevation -	Device d	Node	Distance for C	Surve	- MAP Len -	
Ingress	Node		Node Point		Current N	longitudo	Revised N	ode Pos	Node Pos	Lane width	Current	Kevised	Elevation	Current	Kevised	Node Dist	Radius of	Distance Det Nede (m)	Required	
Lane Id			Pos Req t					Longitude	Snint(m)	Reqt		width(cms)	Reqt	Elev(m)	Elev(m)	Curve - Requ	Curvature(m	Bet Node(m)	Length(m)	
	1	1	Fail	4	2.568/53	-82.938716	42.5687578	-82.938715	0.53	Fall	3/8	337	Pass	188.5	188.4	Pass	0	111.04		
	1	1	Fail	44	.5094495	-02.93774	42.5694465	-02.937755	0.76	PdSS	370	393	Pass	100.5	100.1	N/A	23773.06	E2 49		
	1	2	Fail	42	5701122	-02.937273	42.3097002	-02.937202	0.70	Fd55	370	375	Fass	100.3	100.2	N/A	5155.94	53.40		
	1	3	Fail	44	5702674	-82.930011	42.5701230	-82.930609	0.75	Fd55	378	356	Fass	100.5	100.2	N/A	5155.84	24.51		
	1	4	Fait	44	.5702074	-02.330337	42.370274	-02.330333	0.75	Fass	370	303	Fass D/E - 5/0	100.5	100.2	Fass	0	Z4.01	NA	
			1/1 - 0/5							1/1 - 4/1			171 - 370			171 - 270		101.241.0	NA	
	2	0	Fail	4	5687588	-82 93877	42 5687642	-82 938773	0.65	Fail	378	423	Pass	188 5	188.4	Pass	0	0		
	2	1	Fail	42	5691681	-82,938199	42,5691792	-82,938198	1.24	Fail	378	406	Pass	188.5	188.1	Fail	553.34	65.21		
	2	2	Fail	42	.5693955	-82.937815	42.5693834	-82.93789	4.59	Fail	378	8	Pass	188.5	188.1	Pass	0	40.33		
			P/F - 0/3							P/F - 0/3			P/F - 3/0			P/F - 2/1		Tot: 105.55	NA	
	3	0	Fail	42	.5685713	-82.938695	42.5685752	-82.938694	0.44	Fail	378	357	Pass	188.5	188.5	Pass	0	0		_
	3	1	Fail	42	.5686358	-82.936483	42.5686384	-82.936479	0.41	Fail	378	355	Pass	188.5	187.9	N/A	47516.99	181.28		
	3	2	Pass	42	.5686644	-82.935564	42.5686659	-82.935554	0.84	Pass	378	358	Pass	188.5	187.7	Pass	0	75.26		
			P/F - 1/2							P/F - 1/2			P/F - 3/0			P/F - 2/0		Tot: 256.54	NA	
Notes/I	Legends:																			
1. Co	lumns C. L	. I. C) Pass / -	- Fa	ail indic	ates node po	oint met/did n	ot meet the o	correspondi	ngrequirem	ent									
2 Co	lumns D F	:	M "Current" r	oro	vides valu	e currently i	n the MAP me	ssage												
4 Co	lumns F G	, <i>У</i> , I	N "Revised" r	nro	vides new	values at th	e closest con	nuted mid-n	oint of the la	ne										
5.00	lumn H "Ni	ode	Pos Shift" pr		des distar	nce from the	current node	nosition to th		monuted m	id-noint of th	elane								
6.00			- for node di	eta	inco indio	ates require	ment not ann	licable for ray	diue > 600m	moputed m										
7.00		Min.		31d			nodo point													
1.00		ulu	Sorcurvature	eι	Jinuicale	s no cuive at	inoue point													

8. Column R -- N/A -- for "MAP Len" indicates no speed limit provded for the lane to compute the MAP length

Screenshot of MAP Assessment Tool User Interface



MAP Message Adjusted with Corrections And Retested to get a "Validated" output

This is not as simple as inserting updated lat/lon values:

- Each node point is an offset from the previous node point
- MAP creators will want to maintain the USDOT MAP Creation Tool files to allow future editing through the USDOT Tool

MAP Message Adjusted with Corrections And Retested to get a "Validated" output

In Utah:

- A process is being developed (likely involving a new tool to minimize manual entry) to take the MAP node point corrections and create a new file to be inserted into the USDOT MAP Creation Tool to enable the corrected MAP files to be generated.
- This will allow the corrected nodes to be in the USDOT Tool file in the event there are additional changes to the MAP message in the future.
- This process & tool will be used in Utah for intersection validation for SMART and V2X Accelerator projects
- Proposal is to include this approach in the MAP Guidance document as an optional approach to updating and correcting MAP messages

Request for input on any Additional Changes

Soliciting Inputs for Revision #4

- Arizona V2X Accelerator Grant
- Utah V2X Accelerator Grant
- Tennessee indicated MAP creation on a recent webinar
- We invite input from others that are actively creating MAP messages to send any challenges or unique situations
 - Georgia?
 - Ohio?
 - Other states?

Next Steps for MAP Guidance

Revision #4 anticipated July 2025

- Additional details about testing, modifying, validating MAP messages
- Approach change for turn or through lanes with wide tapers
- Other lessons learned from other CV PFS member deployments:
 - Any suggestions or input?

Upcoming Panel Webinars

Occurs the third Friday from 10-11a PT (1-2p ET), as needed

- May 16, 2025
- June 20, 2025
- July 18, 2025