



GOVERNMENT/INDUSTRY MEETING

Executive Leadership Provided By



January 18-20, 2022 | Washington, DC or Online
[sae.org/glm](https://www.sae.org/glm)

*This meeting is co-located with 

Refining Testable Cases and Scenarios for Evaluating Level 3 Through Level 5 Automated Driving System Concepts

Project Overview



TRANSPORTATION INSTITUTE
VIRGINIA TECH.

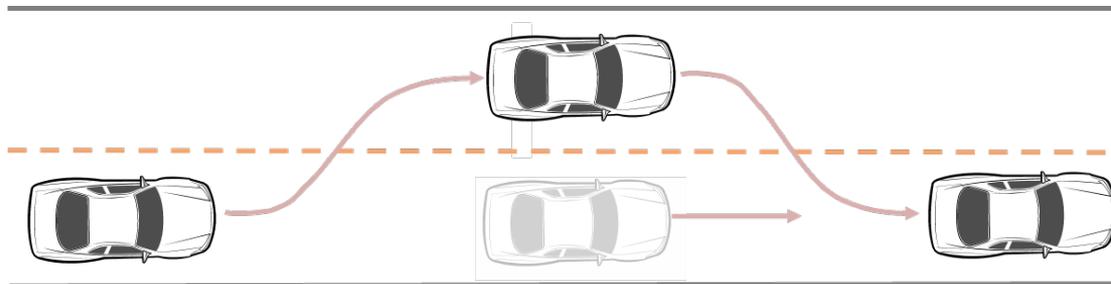
Refining Testable Cases and Scenarios for Evaluating L3 - L5 ADS Concepts

Purpose:

Develop a *method* to guide the design and selection of cases to test the performance of an Automated Driving System (ADS) - using *lane change scenario* data for *piloting purposes*.

Objectives:

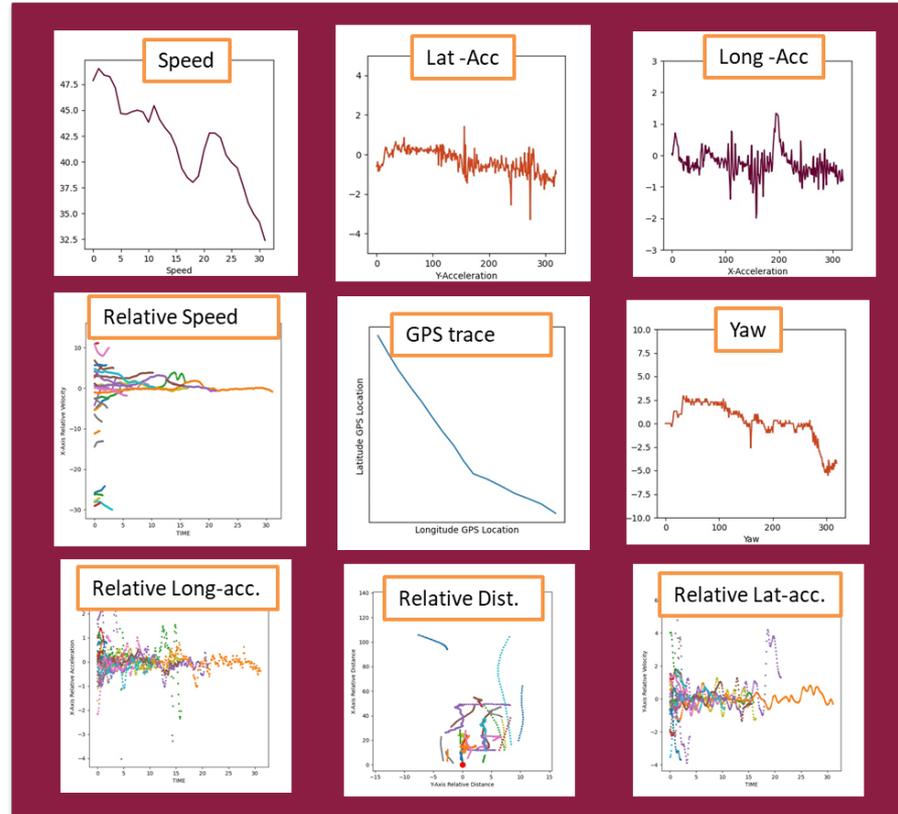
- Develop a model-based feature representation of multivariate driving scenario data to further define testable cases.
- Apply previous testable cases framework to identify ADS test cases and quantify the relationship and boundaries between test cases.



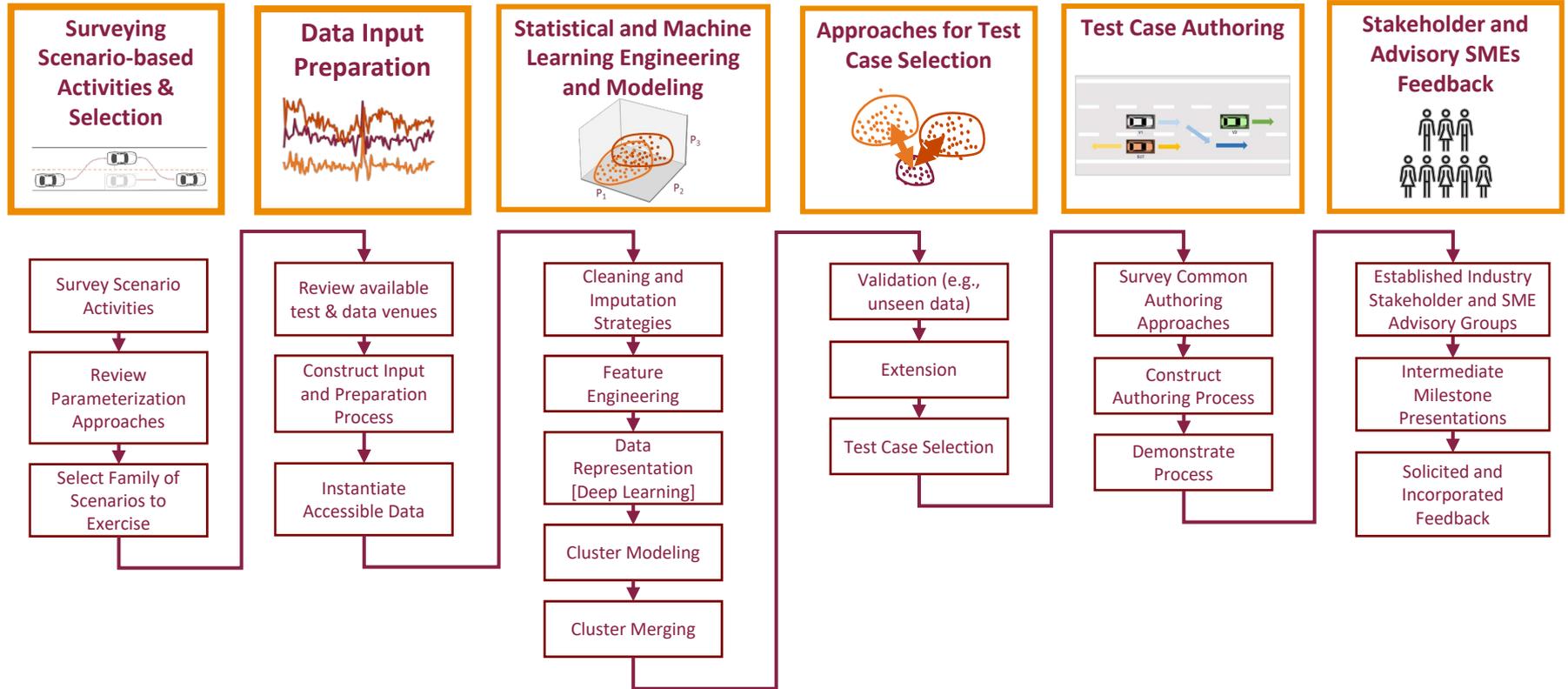
Refining Testable Cases and Scenarios for Evaluating L3 - L5 ADS Concepts

Project Motivation:

- Data Breadth
- Data Scale
- Data Science



Project Overview

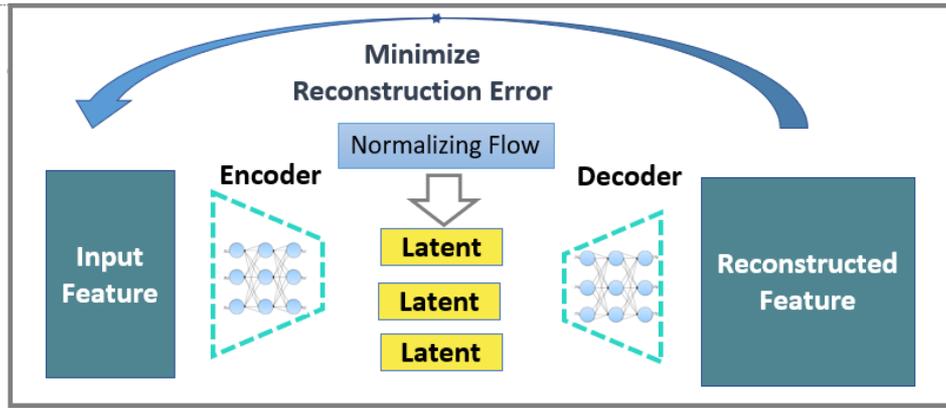


Scenario Sources for Statistical Models

	Venue	Approximate Count	Description	
Naturalistic	NDS	500,665	Routine lane changes greater than 31 mph	Nominal Criticality
	NDS	435	Routine lane changes, located in random samples	
	Public ADS	306	Lane changes in proximity of automated driving system	
Public ADS Source	NDS	5003	Routine merges	
	Test Track	567	Routine lane changes	
Test Track	NDS	919	Cut-ins	
	Simulation	10,799	3 core cases X 3600 simulated variations	
CISS with EDR	NDS	1394	Near-crashes	
Simulation	Test Track	5	Event avoidance lane changes	
	NDS	53	Crashes	
	CISS	145	CISS EDR cases	
		520,291	Total	

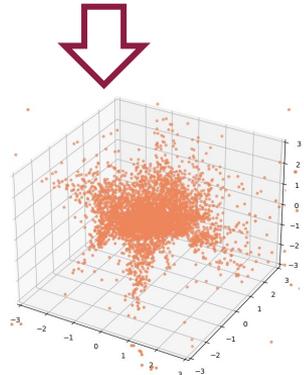
Note: Tables were intentionally populated with more units than would be used (1) to learn more from the import and preparation task and (2) to provide more options for downstream processes.

Cluster Modeling Workflow

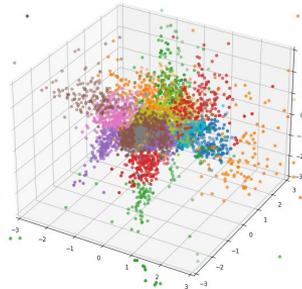


Models Considered

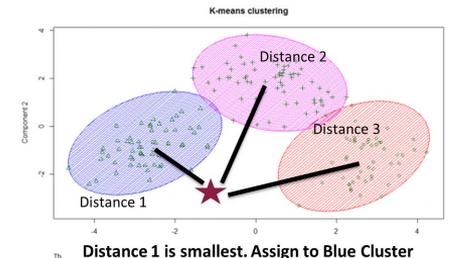
1. Variational Auto Encoder (VAE-NF)
2. Principal Component Analysis (PCA)
3. Fast Independent Component Analysis (Fast-ICA)
4. Kernel-PCA
5. t-distributed stochastic neighbor embedding (tSNE)
6. Truncated Singular Value Decomposition (TSVD)
7. Spectral Embedding (SE)



Clustering



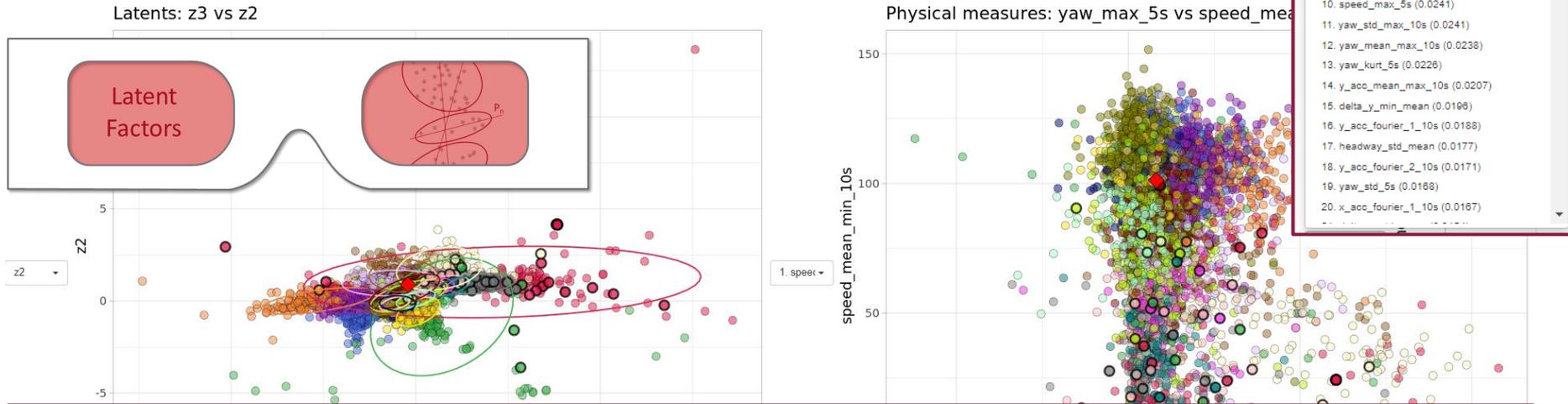
Validation and Extension



Relating Latent Factors to Engineered Features

Venue types: NDS
 Maneuver types: 3 items selected
 Severity types: 3 items selected
 Clusters: 19 items selected
 Enter case ID: 91568
 Draw ellipses: Yes No
 Brush Function: Select Zoom
 Update plots

Cluster scatter plots



Type Variable Name

1. speed_mean_min_10s (0.059) ✓
2. speed_min_5s (0.0478)
3. speed_mean_5s (0.0435)
4. yaw_max_5s (0.0393)
5. yaw_rv_5s (0.0367)
6. speed_mean_max_10s (0.0318)
7. yaw_bpv_5s (0.0285)
8. yaw_skew_5s (0.0261)
9. delta_y_mean_min (0.0246)
10. speed_max_5s (0.0241)
11. yaw_std_max_10s (0.0241)
12. yaw_mean_max_10s (0.0238)
13. yaw_kurt_5s (0.0228)
14. y_acc_mean_max_10s (0.0207)
15. delta_y_min_mean (0.0196)
16. y_acc_fourier_1_10s (0.0188)
17. headway_std_mean (0.0177)
18. y_acc_fourier_2_10s (0.0171)
19. yaw_std_5s (0.0168)
20. x_acc_fourier_1_10s (0.0167)

The database structure, data standardization functions, and analysis tool created by the team provide data traceability and human interpretability to the cluster modeling workflow

Cluster

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 20
- 31
- 32

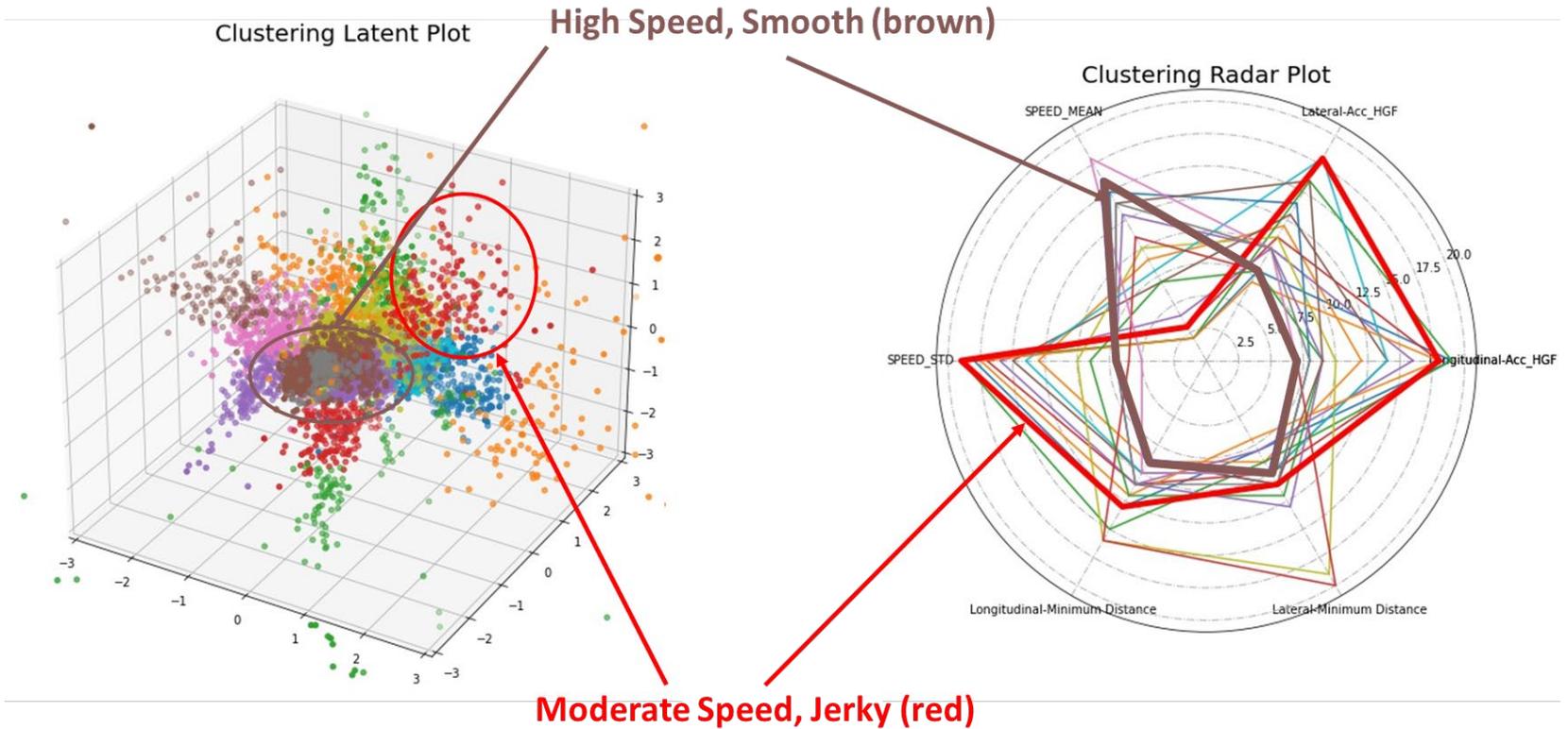
Selection: Unselected

Cluster

- 0
- 1
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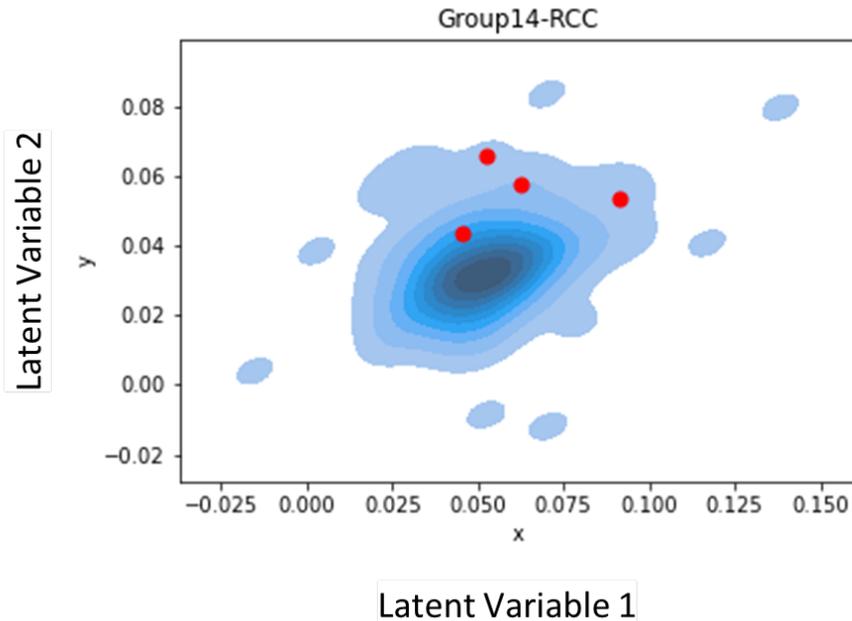
Selection: Unselected

Clustering to Test Cases



Clustering to Test Cases

Moderate speed, jerky



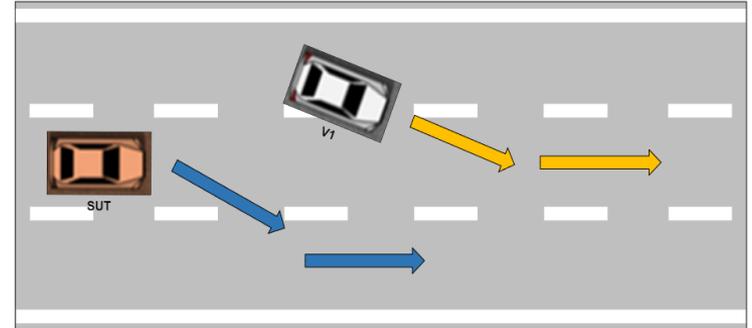
High density: More likely to happen
Low density: Less likely to happen

● : safety-critical events

- Certain feature combinations occur more frequently than others
- Safety-critical events tend to occur on low-density regions

Test Case Authoring

The SUT is traveling straight on a multi-lane highway with V1 ahead in left adjacent lane. As V1 initiates lane change into SUT's path, SUT responds.



SUT	A (to Right) Event 1	B (Straight)
V1	A (to Right) Event 1	B (Straight)
Road Type	Three-lane Highway	
Weather	Clear, Afternoon	
Time	▶	

Contact Info

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NHTSA Contract #: DTNH2214D00328L
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Thank You!