SCENARIO BASED TESTING OF ADVANCED DRIVER ASSISTANCE SYSTEMS

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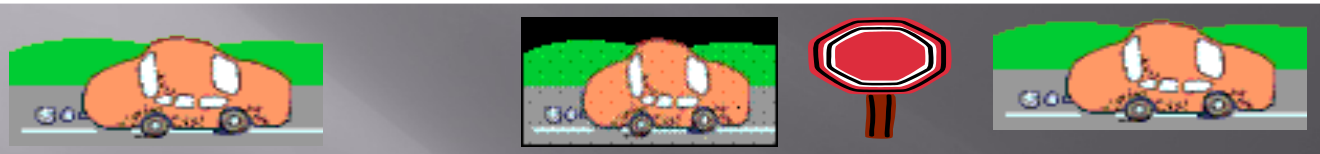
Agenda

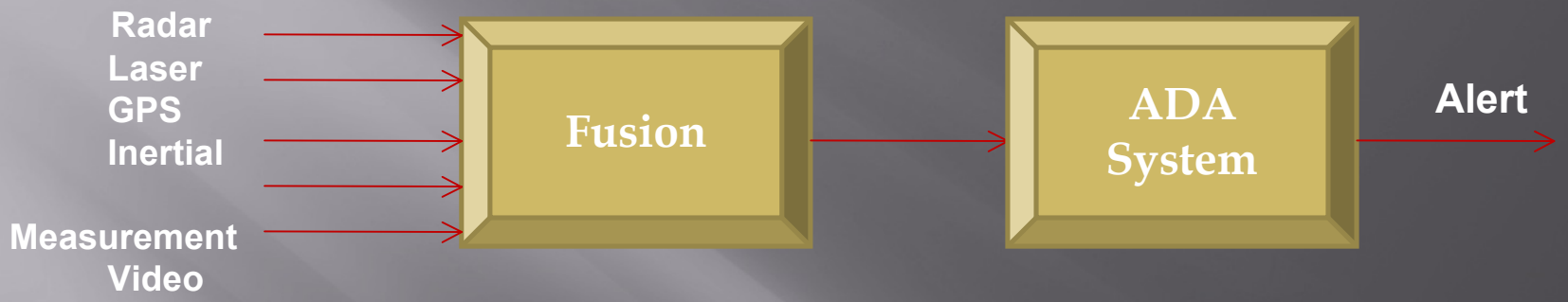
- Introduction
- Terminology
  - Advanced Driver Assistance Systems (ADA systems)
  - Sensor Fusion
  - Model Based Development
  - Model Based Testing (MBT)
- Need for Scenario Based Testing in MBT
- Present Contribution & Results
- Summary
- Q&A

Advanced Driver Assistance System



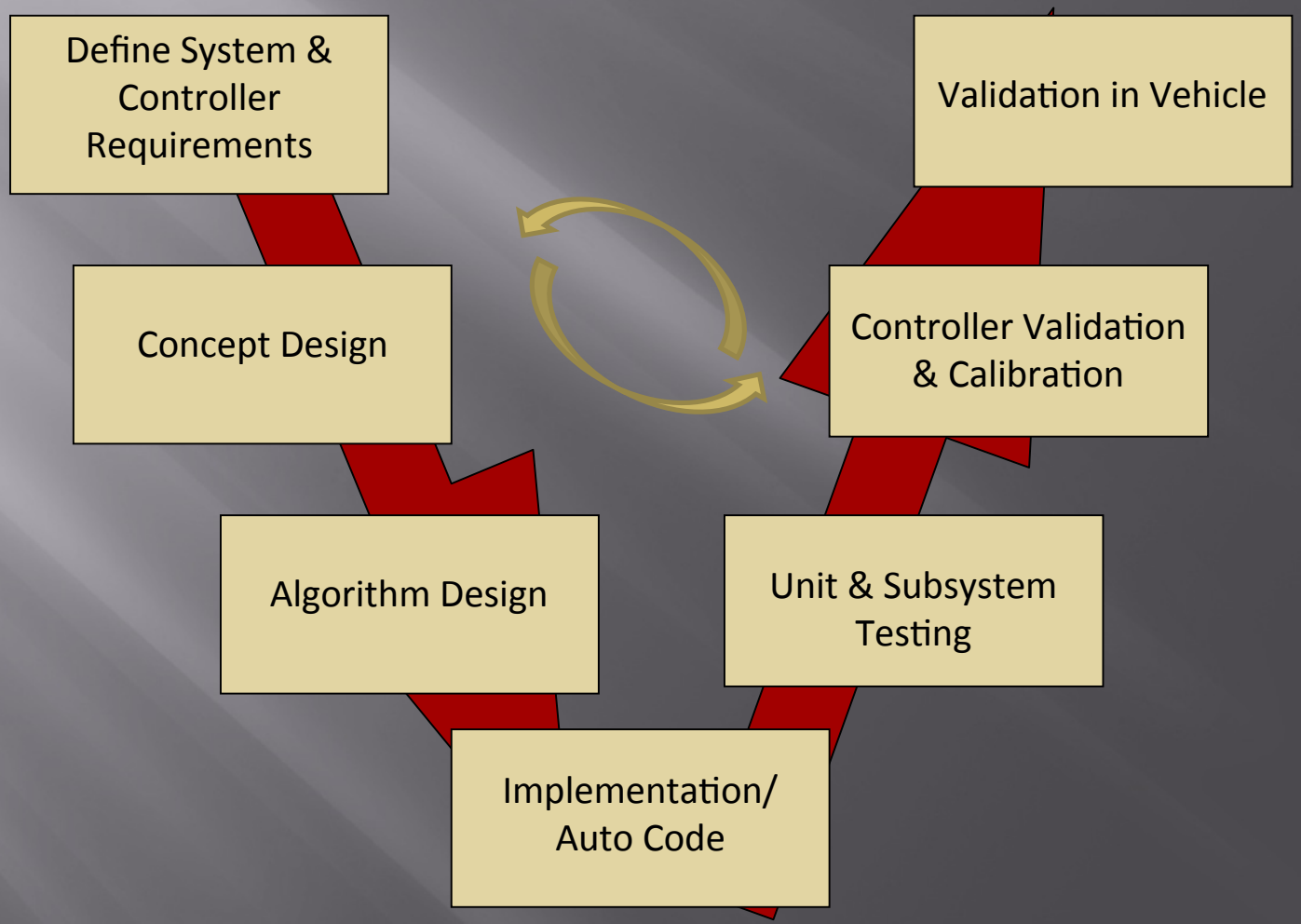
- Helps driver to avoid or mitigate an accident
- Depending on the significance and timing of the threat, these systems will:
  - **ALERT** the driver to an impending danger
  - **WARN** if there is no driver reaction and
  - **ASSIST** or ultimately **INTERVENE**
- Existing ADA systems are Lane Departure Warning, Collision Preparation System and Forward Collision Warning

Sensor Fusion Algorithm



- Sensor fusion is the combining of data from several sensors
- Fusion improves the accuracy of data by giving out a union of data from these sensors
- Examples of ambiguity or inaccuracy of data are
  - Width of an object detected is different from different sensors
  - Radar data may not be accurate in bad weather conditions
  - No of objects detected may vary based on positioning of sensors

Model Based Development



Model Based Testing

- Largest possible share of the testing is done at the model level
- Executable models as a main source of information for testing
- Test information from the model stage can be reused for subsequent testing (SIL&HIL)
- Test scenario creation from the functional specification and the requirements-based testing forms the focal point of the dynamic testing workflow
- Model test vectors to be derived from the software requirements specification according to established criteria

Need for Scenario Based Testing

- An Example Requirement:
  - Six Objects of Interest (OOI) shall be passed from the Object Selection function to the AACC function. In all cases the object may be stationary, moving in the same direction or moving in the opposite direction relative to the host vehicle.
  - OOI[2] is the nearest OOI in the adjacent lane to the left.
- Test Vector generation for such requirements is not only difficult with existing COTS tools but also is difficult to visualize from a tester's perspective
  - Assertion based testing could be a solution but tester's effort is very large in creating assertions for all possible scenarios
- Scenario based testing helps in the cases similar to above where user can create a scenario and generate test vectors

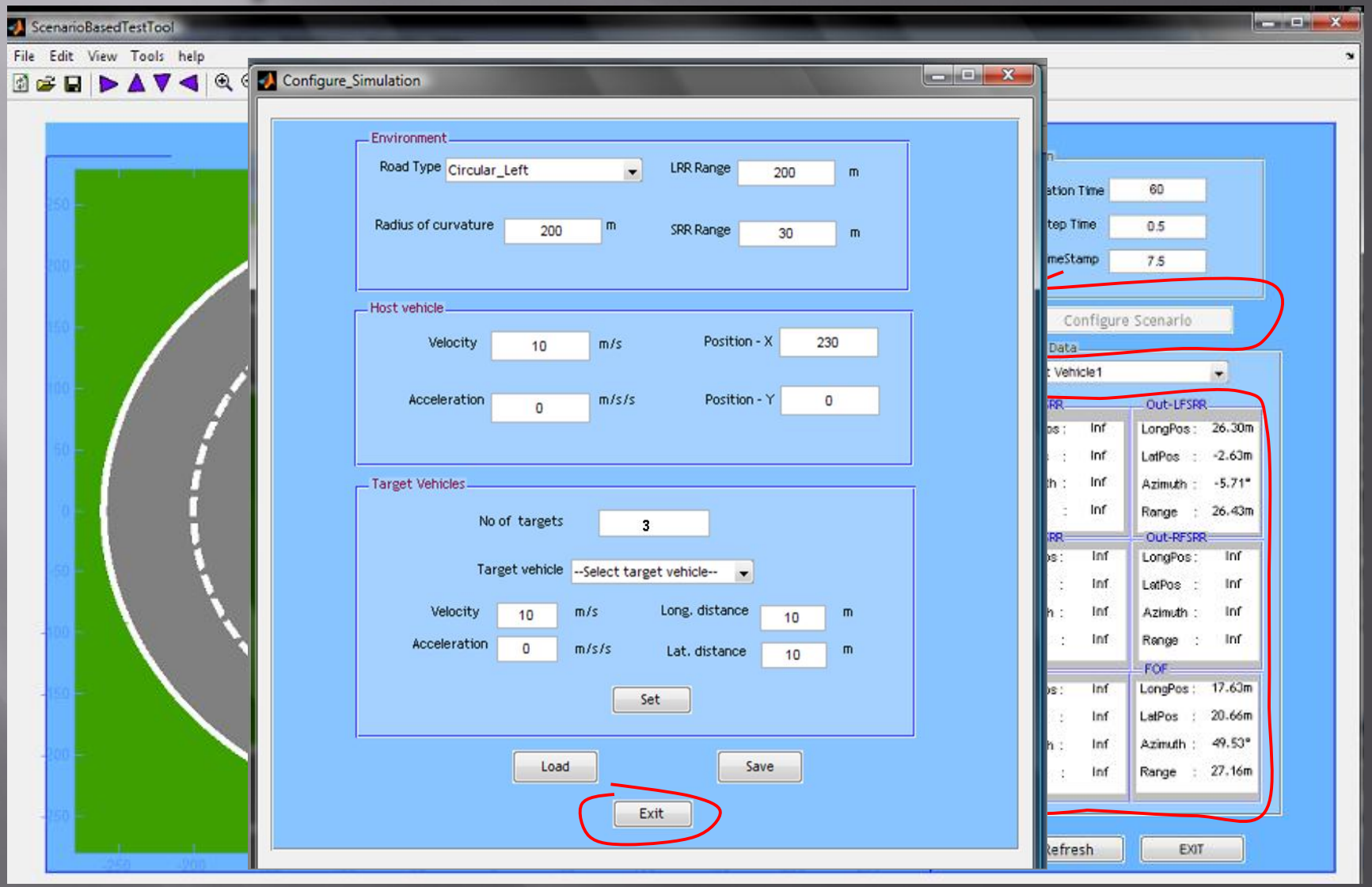
Present Contribution – A Scenario Based Testing Tool

- A prototype is done to prove the concept
- Physical system behavior is modeled
- Least Square Estimation technique is used for estimation algorithm (LSE will be replaced by Kalman filter technique in next version)
- Vehicle parameters and environmental parameters shall be configured by the user in order to run the simulation
- Test vectors are generated for the simulation duration specified by user
- Test vectors can be saved by the user in excel or mat format
- Future plan is to make the tool **configurable**

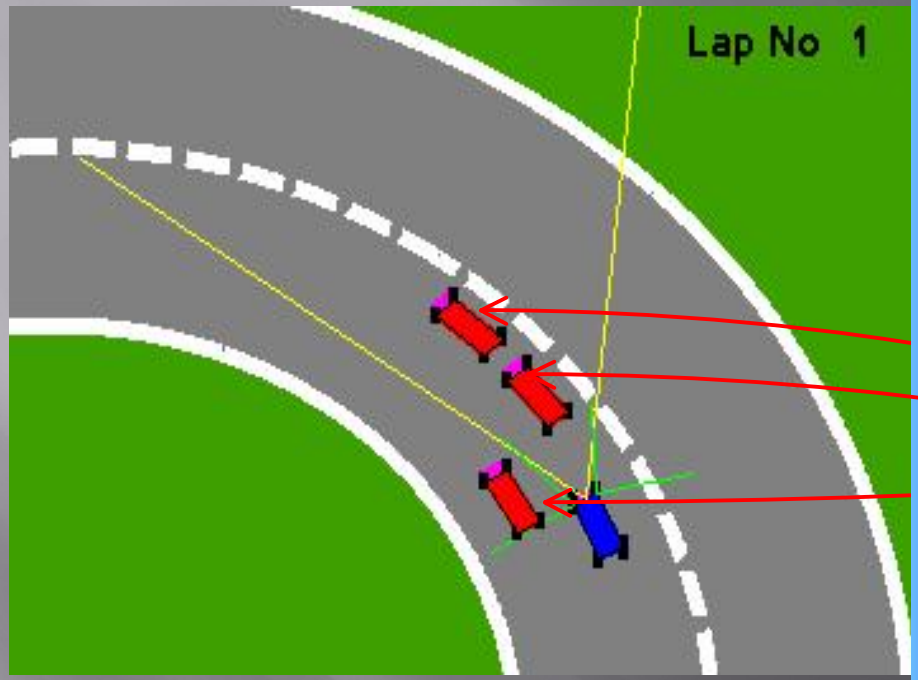
Testing Fusion Application – A Case Study

- The prototype tool is configured to test Fusion Application
- Motivation behind Choosing Fusion Algorithm:
  - Complexity
    - Testing such an application is laborious because of the large no of inputs and outputs handled by the application
    - Accurate testing can be done with defined scenarios
  - Need to use a tool which can combine both the automated test vector generation process and scenario based testing approach

Example…


ScenarioBasedTestTool
File Edit View Tools help
Configure_Simulation
Environment
Road Type Circular_Left
LRR Range 200 m
Radius of curvature 200 m
SRR Range 30 m
Host vehicle
Velocity 10 m/s
Position - X 230
Acceleration 0 m/s/s
Position - Y 0
Target Vehicles
No of targets 3
Target vehicle --Select target vehicle--
Velocity 10 m/s
Long. distance 10 m
Acceleration 0 m/s/s
Lat. distance 10 m
Set
Load
Save
Exit
Configure Scenario
Data
Vehicle1
Out-LFSRR
LongPos : 26.30m
LatPos : -2.63m
Azimuth : -5.71°
Range : 26.43m
Out-RFSRR
FOF
LongPos : 17.63m
LatPos : 20.66m
Azimuth : 49.53°
Range : 27.16m
Refresh
EXIT

Example…



View Target Data

Target Vehicle3

In-LFSRR		Out-LFSRR	
LongPos :	Inf	LongPos :	Inf
LatPos :	Inf	LatPos :	Inf
Azimuth :	Inf	Azimuth :	Inf
Range :	Inf	Range :	Inf

In-RFSRR		Out-RFSRR	
LongPos :	Inf	LongPos :	Inf
LatPos :	Inf	LatPos :	Inf
Azimuth :	Inf	Azimuth :	Inf
Range :	Inf	Range :	Inf

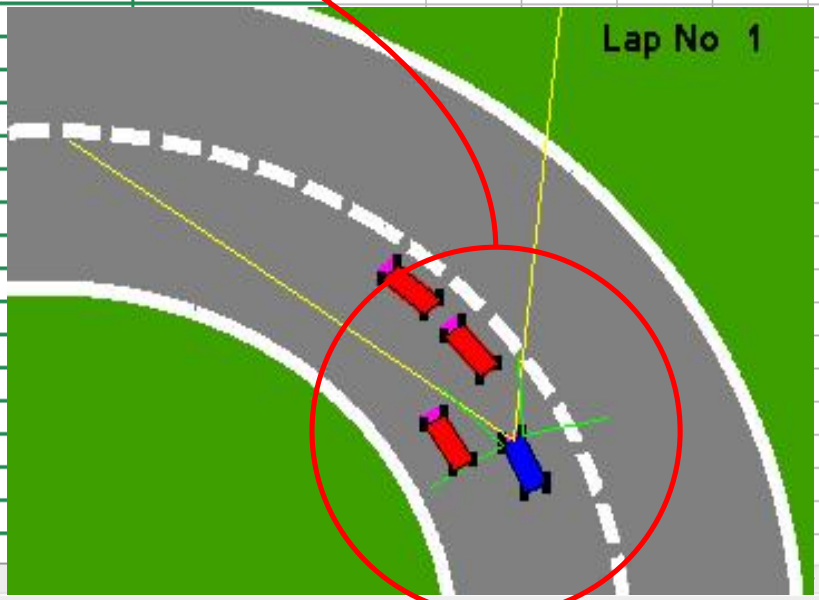
LRR		FOF	
LongPos :	45.19m	LongPos :	47.44m
LatPos :	-0.69m	LatPos :	-0.69m
Azimuth :	-0.88°	Azimuth :	-0.83°
Range :	45.20m	Range :	47.45m

Results

GZ26 fx 2

	DP	DQ	DR	DS	DT	FW	GM	GS	GW	GX	GY	GZ	HA	HB	
1	next_segm	length_of_	data_laten	veh_LaneS	Veh_TimeToLnCross	Fus_NmValTargts	Fus_ObjA_LongPos	Fus_ObjA_Type	Fus_ObjA_DynProp	FusTrkBR	FusTrkBR	FusTrkBH	FusTrkBO	FusTrkBO	FF
2	0	0	1	0	62	3	10	1	3	0	1	2	1	1	
3	0	0	1	1	62	3	10.53824826	1	3	0.033886	1	2	1	1	
4	0	0	2	1	62	3	11.07639085	1	3	0.035619	1	2	1	1	
5	0	0	3	1	62	3	11.61442238	1	3	0.037354	1	2	1	1	
6	0	0	4	1	62	3	12.15233747	1	3	0.03909	1	2	1	1	
7	0	0	5	1	62	3	12.69013071	1	3	0.040826	1	2	1	1	
8	0	0	6	1	62	3	13.22779671	1	3	0.042564	1	2	1	1	
9	0	0	7	1	62	3	13.76533008	1	3	0.044301	1	2	1	1	
10	0	0	8	1	62	3	14.30272544	1	3	0.04604	1	2	1	1	
11	0	0	9	1	62	3	14.83997736	1	3	0.047779	1	2	1	1	
12	0	0	10	1	62	3	15.37708054	1	3	0.049518	1	2	1	1	
13	0	0	11	1	62	3	15.91402952	1	3	0.051258	1	2	1	1	
14	0	0	12	1	62	3	16.45081893	1	3	0.052998	1	2	1	1	
15	0	0	13	1	62	3	16.9874434	1	3	0.054738	1	2	1	1	
16	0	0	14	1	62	3	17.52389755								
17	0	0	15	1	62	3	18.06017599								
18	0	0	16	1	62	3	18.59627335								
19	0	0	17	1	62	3	19.13218426								
20	0	0	18	1	62	3	19.66790334								
21	0	0	19	1	62	3	20.20342521								
22	0	0	20	1	62	3	20.73874452								
23	0	0	21	1	62	3	21.27385589								
24	0	0	22	1	62	3	21.80875396								
25	0	0	23	1	62	3	22.34343336								
26	0	0	24	1	62	3	22.87788874								
27	0	0	25	1	62	3	23.41211473								
28	0	0	26	1	62	3	23.94610598								
29	0	0	27	1	62	3	24.47985713								
30	0	0	28	1	62	3	25.01336284								
31	0	0	29	1	62	3	25.54661775								
32	0	0	30	1	62	3	26.07961652								

Sheet1



Summary

- Model based development
- Model based testing
- Need for scenario based testing in MBT
- A new concept or tool to realize SBT
- Tool details
- Results

QUESTIONS?