


Scenario Based Testing of Advanced Driver Assistance Systems





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- Masters in Power Electronics and Bachelors in Electrical & Electronics
- Working in Software development and verification for the last 7 years
- Has several publications on model based development and testing

- Introduction
- What are ADA systems?
- Demand for efficient methods of development
- Model Based Development with Scenario Based Testing – A solution
- Scenario Based Testing
- Advantages of SBT over Traditional Testing
- A Case Study
- Features of prototype tool for SBT
- Summary
- Q&A

Advanced Driver Assistance System

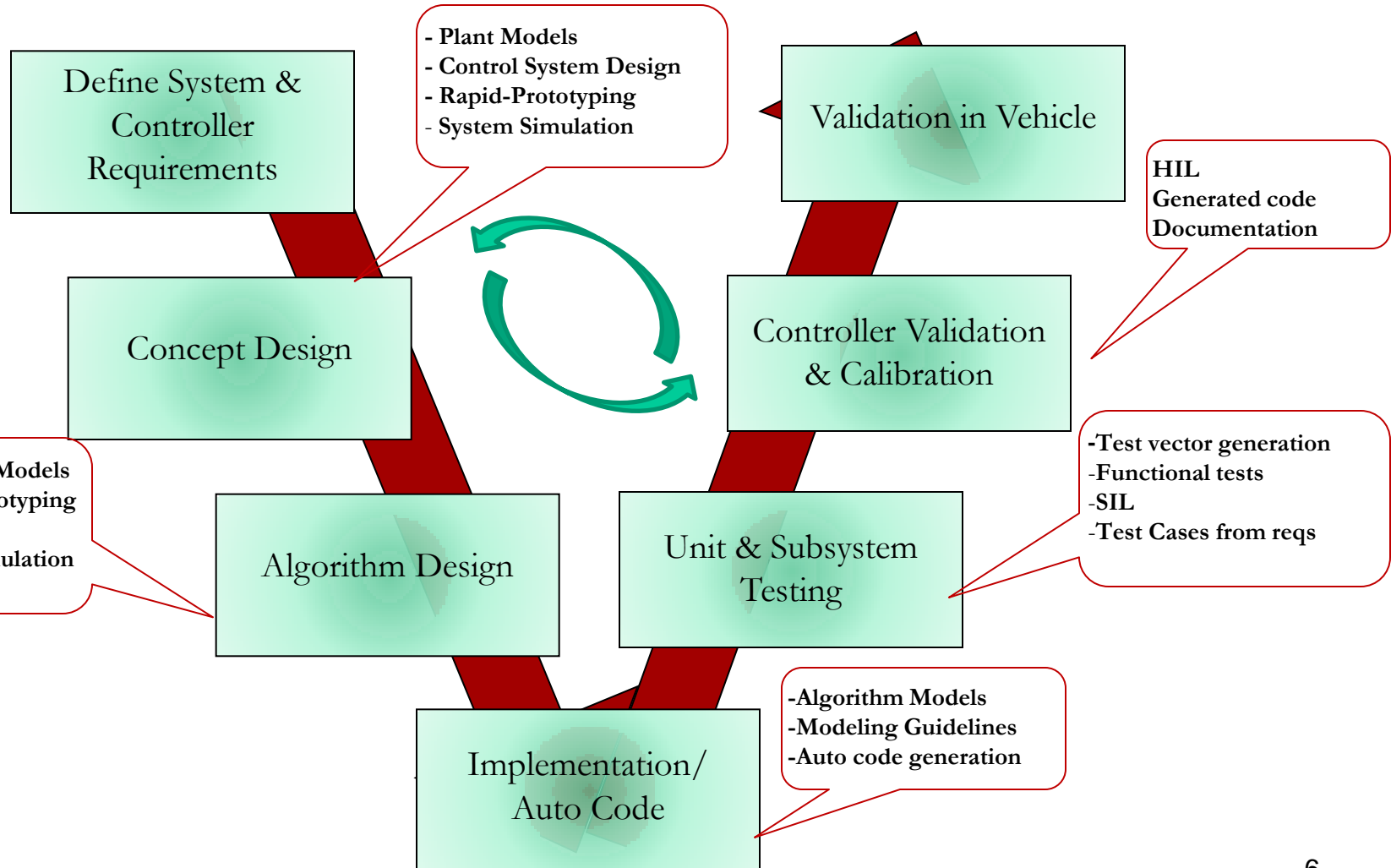


- Helps driver to avoid or mitigate an accident
- Depending on the significance and timing of the threat, these systems will:
 - **ALERT** the driver to an impending danger
 - **WARN** if there is no driver reaction and
 - **ASSIST** or ultimately **INTERVENE**
- Existing systems: Lane Departure Warning, Collision Preparation System and Forward Collision Warning
- Challenges to Penetrate Market
 - Customer acceptance and understanding
 - Expectations to meet high requirements

- Development of ADAS starts with functional specs
- An Example Requirement:
 - Sic 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.
 - Safety critical – error free code
 - Exhaustive testing at each integration phase
 - Costs & Time to Market
- Traditional Design Life Cycle
 - Design information in text form – difficult to comprehend
 - Manual coding – more error prone and time consuming
 - Little Tracking to Change Requests
 - Test Vector & Test Case creation – Huge Effort
 - Discovery of design errors late in design cycle – Delays
- Need for efficient methods of development & validation to address these issues
- Model Based Development complemented with Scenario Based Testing – A solution

Model Based Development

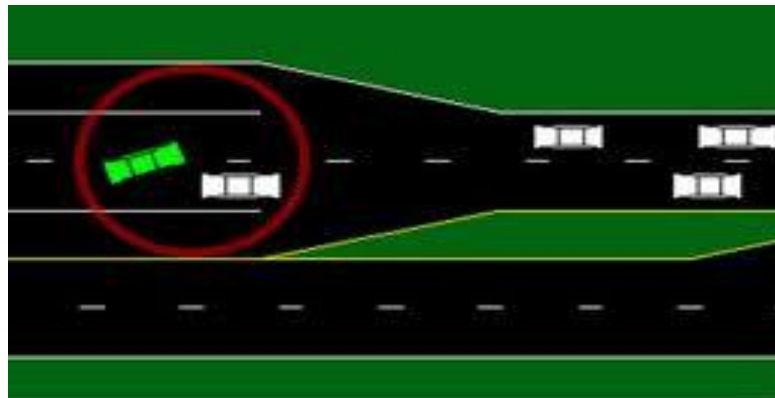
- Single design environment
- Developers can evaluate multiple options, predict system performance
- Possibility of accurate production code generation



- Largest share of testing done at model level
- Executable models - the main source of information
- Test information at model level can be reused at SIL & HIL
- At every integration phase verification takes place
- Verification only confirms compliance with the specification
- Verification must assure that integration with other subsystems does not have any negative side-effect.
- It is therefore important to perform validation of the integrated system against its functional requirements
- Scenario complemented with MBD can be a solution for testing safety systems

Scenario Based Testing

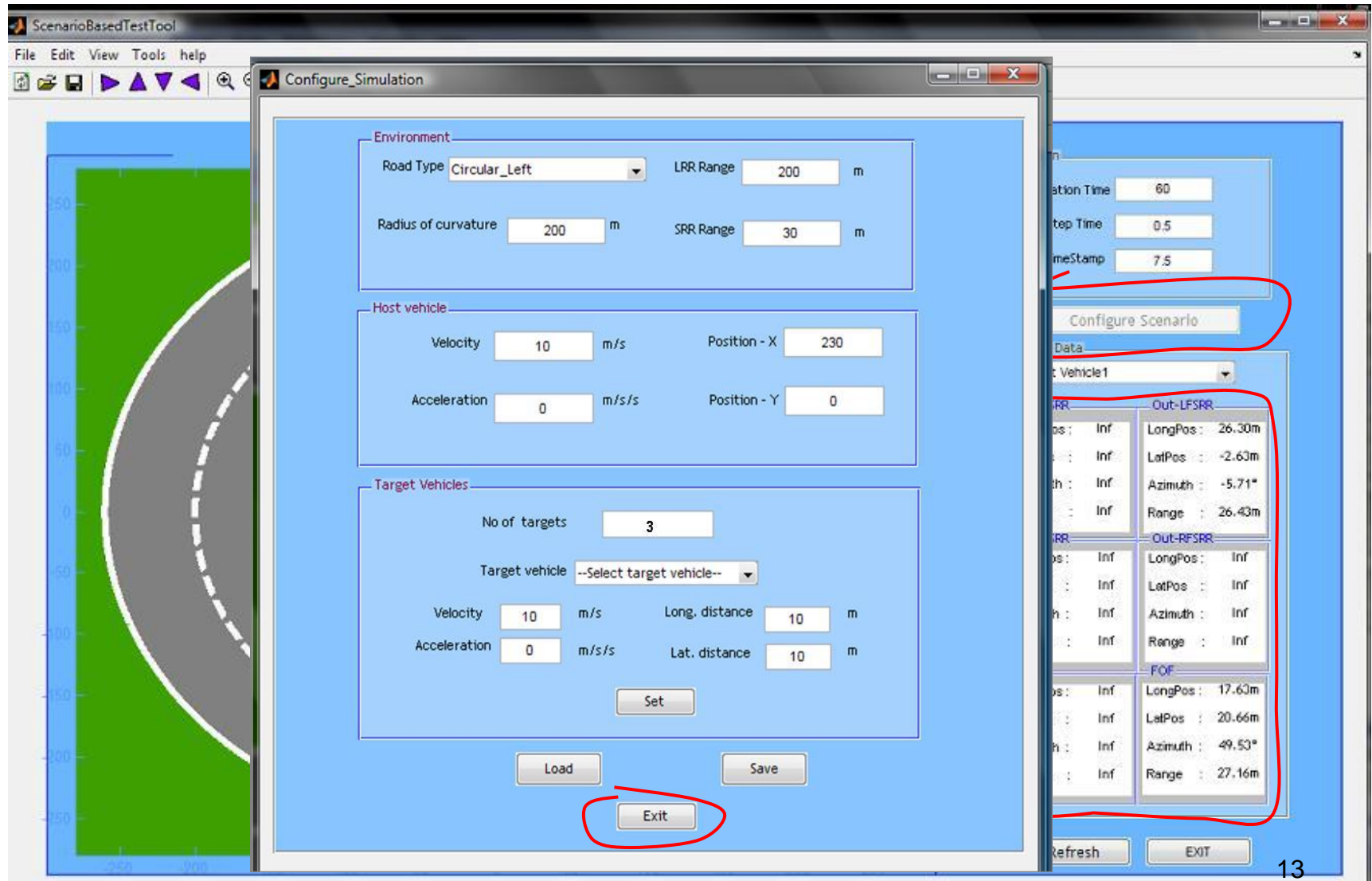
- A scenario is used to help a person think through a complex problem or system
- Ideal scenario test has characteristics....
 - A scenario test is based on a story or a sequence of events about how the application is used, including information about the motivations of the other systems or people around
 - The story involves a complex use of the application or a complex environment or a complex set of data.
 - The test results are easy to evaluate.



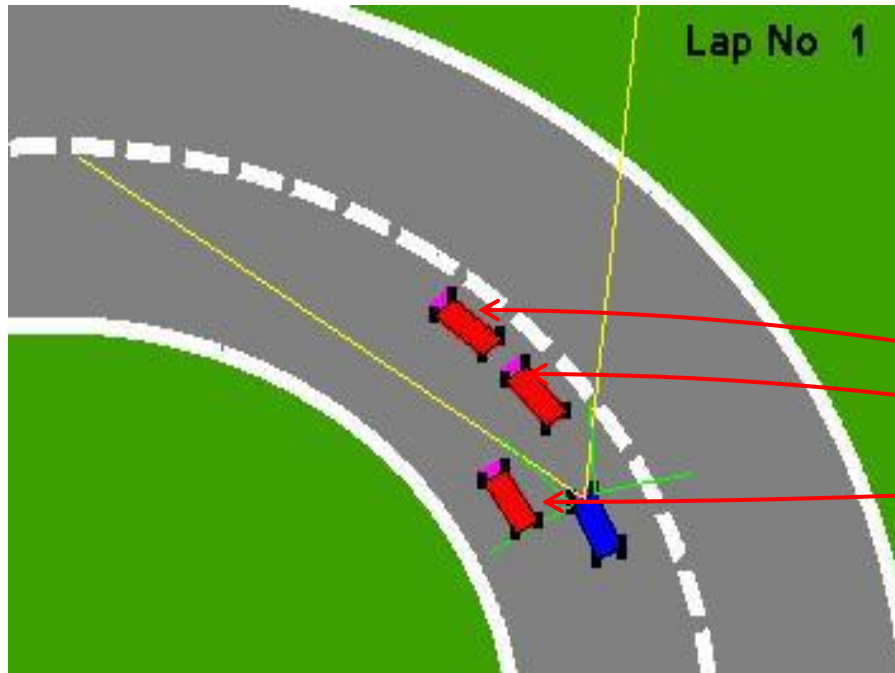
- Learn the product early in testing
- Connect testing to requirements specifications
- Expose failures to deliver desired benefits
- Expert use of the application
- Pop-up requirements-related issues, which might involve reanalyzing already defined requirements
- Surfacing not-yet-defined requirements

- Scenario Based Testing of Sensor Fusion & Object Detection
- 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

Case Study



Case Study



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

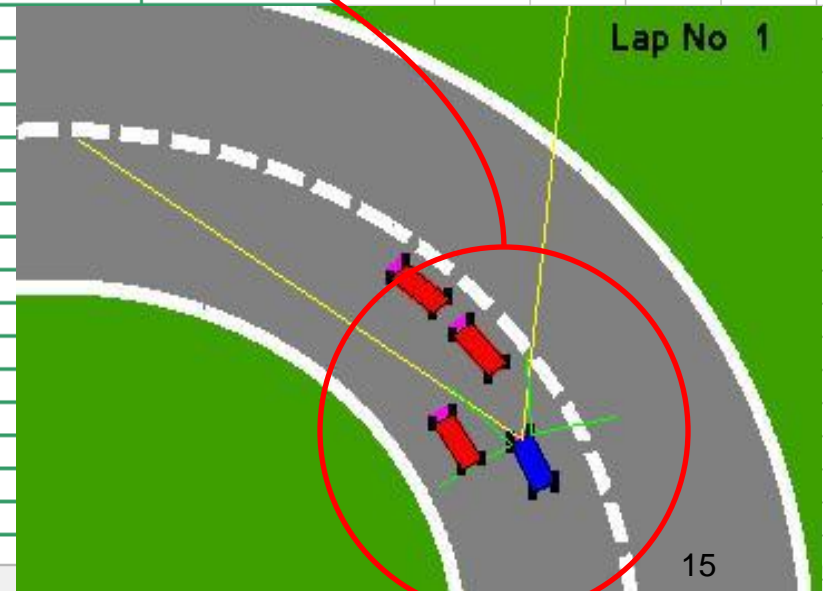
LRR		FOF	
LongPos :	45.19m	LongPos :	47.44m
LatPos :	-0.69m	LatPos :	-0.69m
Azimuth :	-0.88°	Azimuth :	-0.83°
Range :	45.20m	Range :	47.45m

Results – Case Study

GZ26		fx 2															
	DP	DQ	DR	DS	DT	FW	GM	GS	GW	GX	GY	GZ	HA	HB			
1	next_seg	length_of	data_lat	veh_LaneS	Veh_TimeToLnCross	Fus_NmValTargts	Fus_ObjA_LongPos	Fus_ObjA_Type	Fus_ObjA_DynProp	FusTrkBRR	FusTrkBRR	FusTrkBRR	FusTrkBRR	FusTrkBRR	FusTrkBRR	FusTrkBRR	
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	14.83997738	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										

Lap No 1

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A Scenario Based Testing Tool

- A prototype is done as proof of 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

- ADA Systems
- Why Traditional Development Process not a solution
- Model Based Development
- SBT based on Models
- Advantages of SBT
- A Case Study
- A tool developed for SBT

Thank you for your interest!

Any Questions?



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