

AVL Embedded Software Model-Based Design Platform Based on MATLAB and Simulink

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Public

Outline





- 1. Company use-cases introduction
- 2. In-house tool platform overview
- 3. Technical challenges and innovative solutions

Overview AVL Powertrain Controls Business Fields









Passenger Cars







Commercial Vehicle



Software and function development



Locomotive

Construction



Agriculture



Power Plants

What is "AVLab"?



Project B083229 🛛 🗮

AVLab (~AVL+MATLAB) describes the tool platform developed at AVL PTE Controls for supporting Model-Based Embedded Software Development in MATLAB and Simulink.





"AVLab" Approach and Philosophy



- Do not make, if you can buy state-of-the-art tool covering our needs
- Build toolchain/interfaces between existing tools (glue tools) to have an *integrated* seamless toolchain
- Don't be dependent but flexible (open platform)
- Cover/support all standard tool landscape/customer scenarios with least effort
- Component-based approach
- Support processes/methods
- Standardization
- Proxy for best practices
- Re-use oriented



AVL Customer Toolchain Use Cases







AVLab Users

AVLab has a strong in-house user basis (**188** users).





AVLab supports the MBD development process in several AVL PTE affiliates around the world.







AVLab Advantages

Before AVLab:

- Too many tools, too complex
- Local project specific solutions/scripts (fill missing feature)
- High Cost and time delay because of tools
- Effort to link tools
- Multiplied maintenance and effort by project
- Developer without guidance





With AVLab:

- Shorter development time
- Increased efficiency and productivity (oneclick solutions)
- Better quality
- Best practices proxy/levelling up
- Easy re-use
- One standard workflow/one way (from start to end/continuity)
- One platform (tool linked together/seamless toolchain)





Development Levels and Test Platforms



List of Challenges



We will present our current answers to some of following questions/challenges:

- How to ensure Traceability to the System-Under-Test?
- How to support Data Management for both Embedded Coder and TargetLink?
- How to handle Calibration Data for a component and Test Cases?
- How to handle simulation data in a lean way to reduce out of memory issues but still ensure test results consistency?
- How to push the limits of full ASW System simulation on MATLAB and Simulink?
- How to support component aggregation in MATLAB and Simulink in a semiautomatic way?
- How to ensure consistency between all development artefacts?
- How to ensure test continuity between different test platform (example MiL/SiL -> HiL)? [re-use and Back-to-Back]

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Lean Specification Data management

Test Specification Data are handled in single files.

One directory per Test Case.

Test Cases directory contains

- Specification data (stimuli, calibration file)
- Evaluation data (plot config, assessment script, reference signals)





<u>Advantages</u>:

- Allows direct access to information (example Test Case calibration)
- Straightforward re-use of test cases
- Traceability Test Case Item to test case data (source traces in Integrity) with suspect/impact analysis

AV

Lean Modular Simulation Data management

Simulation Data

- Simulation Data is split from Configuration Data and saved in a separated file
- Simulation Data belonging to a Test Session are packed/ zipped together for test run consistency
- If the System-Under-Test is unchanged (checksum), Data are merged. Else reset.

Advantages:

- Ensure consistency
- Lean memory usage for evaluation
 - Only result data from one Test Case is loaded simultaneously.
 - Only the necessary signals are loaded. (mat-file API)
- Supports Simulation Parallelization





Component Aggregation







Project Interface to build/aggregate components

- Build/update model (using library or model reference)
- Build data files (flat included or referenced)
 - For TargetLink also .dd files are merged
- Build calibration file (flat included or referenced)



Semi-automatic: scheduling has to be finished manually.

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		19 -	else
		20 -	warning('DocNoxMdl.dom not found!');
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		22 -	end



Traceability & Consistency Challenge

In automotive SPICE 3.0 special focus on traceability and consistency.



Example: Test Report and Test Results shall reference to the revision of the System-

Under-Test.

Traceability System-Under-Test (SUT)



Challenge:

Assure all test work products are traceable to their tested objects. "<u>What</u> was tested?"

Summary of solutions

1. Display revision as Expanded Keywords Properties (Model, ASCII Files)



- 2. Download revisions from Version Management Repository and run test against downloaded unmodified revisions (redirect path to download location)
- 3. Tracing revision in working Sandbox/on the fly; marking of weak (=modified) revision traces
- 4. Solution 3 + automatic repair of weak revision traces

Traceability System-Under-Test (Solution 4)

Solution 4: Run against working files and gather on the fly suspect/weak trace information + checksum information

Repair Weak revision traces





Artefacts Consistency Check



Goal:

 While looking at a collection of artefacts, be able to check if they are consistent together.

Problematic examples/pitfalls:

- Are the test artefacts (e.g. Test Report, Test Results) consistent with the data label definition?
- Was the delivered model tested?
 - = Is the test configuration in the delivery consistent with the one used for testing?
- Is the documentation up-to-date = consistent with the delivered model revision?
- Is the Test Report consistent with the deliverables?

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Artefacts Consistency Check - tracing

Label Repository



Action Examples:

- Generate Documentation
- Write Test Report
- Run Test Session
- ADD Update
- Generate Code

• ...

Traces are available as text (in file header) and hidden as file properties.



Artefact Consistency Check/ Matrix - Report

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5	ScrCtlr\mdl_test\ScrCtlr_Test.mdl	1.7	1.2	1.8	B083229.7.1.0	fixed		1.2.0	software	ScrCtlr	
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5	ScrMdl\mdl_test\ScrMdl_Test.mdl	1.23	1.18	1.23	B083229.7.2.0	draft	2.5.0	software	ScrMdl	
5	ScrMdl\mdl_test\ScrMdl_TestReport.docx	1.24	1.11	1.19	B083229.7.2.0	draft	2.3.0	software	ScrMdl	
7	ScrMdl\src_test\ScrMdl_TestReport.docx		1.11	1.19	B083229.7.2.0	draft	2.4.0	software	ScrMdl	
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Outlook / Roadmap

2015: Major Milestones:

- Interface to Integrity Test Management
- Review / Consistency Module

Hot Topics: AUTOSAR, MultiCore Support Continuity towards HiL, Virtual Integration Platform

2016: Continuous Integration (Review)

Conclusion



AVL Powertrain Controls uses an open standard internal platform to support and improve its model-based software development process.

It is purely implemented in MATLAB and Simulink and connects many tools together.

It tries to face many challenges for achieving high quality and provide a seamless toolchain with best practice state-of-the-art solutions to its users.

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Ob8_StBsgTqAbseMin_P	Local	Parameter	Boolean		1	0
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THANK YOU



Backup Slides



www.avl.com

MATLAB/Simulink ADD Interface

Synchronize Tool

- One-click ADD Update (ADD to MATLAB: data synchronization)
- ADD2Simulink: Synchronization ADD<-> Simulink
- Consistency Check
- Seamless Integration

AVLab Export Help						
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BSOF_TqBsgDynMax	Input	Online	float32	Nm	1	1
BSOF_TqBsgDynMin	Input	Online	float32	Nm	1	1
BSOF_TqBsgQstatMax	Input	Online	float32	Nm	1	1
BSOF_TqBsgQstatMin	Input	Online	float32	Nm	1	1
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ObB_StBsgTqAbsvMin_P	Local	Parameter	Boolean	-	1	0
ObB_StBsgTqDynMax_P	Local	Parameter	Boolean	-	1	0
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ObB_StBsgTqQstatMax_P	Local	Parameter	Boolean	-	1	0
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Public

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Simulink Model and



Data Management – Labels Dictionary



Calibration Files Handling

- Default Global Calibration File under **mdl test**/<compname>.dcm
- Tear-down
- Test Case calibration files:
 - <TCid> Cal.m (extracted from Data.m; only .Value)
 - full.dcm is rewritten after run for documentation and traceability
 - => this allows handling of TC calibration variation as Delta in an M-File











Lean Simulation Data Handling



Only result data from one TestCase is loaded simultaneously. With matfile API, only the necessary signals are loaded.



Prerequisite: Standard Component Structure

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Model Template with Operating System

*	Model_template/	OpS	Sys/AVLOpSys			
	Step Size			0.001		
	Туре		Angle/Recurrence	Trigger		0,8
1	Recurrence	-	0.01	Function Call	-	್ಗೆ
2	Rising Edge	-	-	Function Call	-	A3/1
3	Angle based	-	180	Function Call	-	AV Lab
4	Recurrence	-	0.01	Function Call	-	
5	Falling Edge	-	-	Function Call	•	wove up
6	Recurrence	-	0.01	Function Call	•	
						Move Down
						Add
						Delete



Support Closed-loop Test with Plant Model

Component Aggregation (Model)





Scheduling is Semi-automatically created at aggregation



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Standard Component File Structure







CM Plan at Project/ ASW Sys Level with 3 levels architecture. Level 1 = Aggregation Level

System-Under-Test Definition









Traceability System-Under-Test (Solution 1)

Display revision information as Expanded Keywords Properties



Model Prone	rties		8	3
Main Callbacks	History Description			
Created by: -		Last saved by:	\$Author: Valero-Bertrand, Diego RGB (VALEROD) \$	
Created on: -		Last saved on:	\$Date: 2010/12/09 11:47:27MEZ \$	Simulin
🗹 Read Only		Model version:	\$Revision: 1.5 \$	Model

If file is modified after Check-out/ Get, contained revision information is obsolete. This information can not be used as consistent trace to the VM repository.



Traceability System-Under Test (Solution 2)

Solution 2: Download SUT files and run test session against them without modifying local version in one batch



Traceability System-Under-Test (Solution 3)



Solution 3: Run against working files and gather on the fly suspect/weak trace information

2.2 Test Environment

Information is necessary to guarantee the reproducibility of test results.

	AVLab 2.6.0.1			evaluation tool
	k 8.2 (R2013b)	MATLAB/Simulink		ation environment
	AVLib			
	working			Revision
	<u>MiL</u> fixed			/lode
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weak trace	.28 (modified)	<u>1.</u>	LamSpBas_test.mdl	MUT
	<u>1.26</u>		LamSpBas_Data.m	Data File
	1.5		LamSpBas.dcm	Calibration File



<u>Advantages</u>:

- No need for download and SUT redirectCan be checked automatically (at review,
- Can be checked automatically (at review, checkpoint...)





Parallel Execution





Parallel Simulation Example 3 Children MATLAB Instances



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