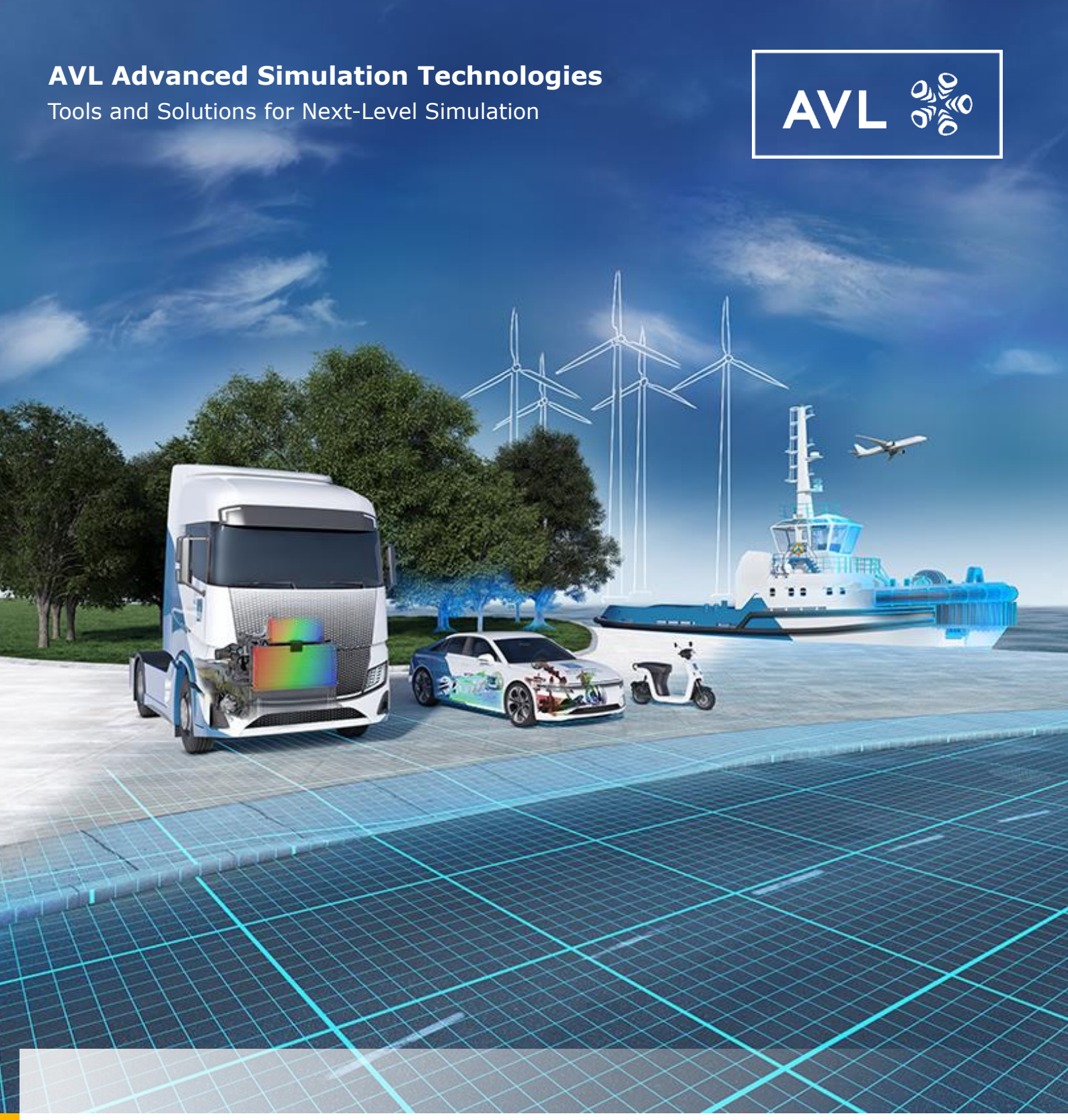
AVL Advanced Simulation Technologies
Tools and Solutions for Next-Level Simulation



Customer Services Catalogue

Software & Simulation Related Services

Training and Support | Knowledge Transfer | Project Work

www.avl.com

Overview of Basic Training courses in AST Trainings Center Austria Graz, year 2023

AVL BOOST™	AVL CRUISE™	AVL CRUISE™ M
February 21-23	January 31 - February 01	January 17-19
	September 12-13	October 03-05
AVL CRUISE™ M Engineering Enhanced EAS	**AVL CRUISE™ M BEV with HVAC**	**AVL EXCITE™ Desinger**
February 13-15	May 16-17	February 01-02
		September 18-19
AVL EXCITE™ Piston&Rings	**AVL EXCITE™ Power Unit**	**AVL EXCITE™ Timing Drive**
February 21-22	April 04-05	January 24-25
September 26-27	October 23-24	June 27-28
AVL FIRE™	**AVL FIRE™ SAMOS**	**AVL FIRE™ M**
January 24-26	March 21-22	May 09-11
November 28-30		October 16-18
Model.CONNECT™	**PreonLab™**	**AVL VSM™**
February 06-07	March 16	February 14-16
November 07-08	October 19	September 19-21

PRICING:

- For scheduled training courses held in Graz, the price is:
  - a) 450 euro per day and participant
  - b) 225 euro per day and participant for universities

- For training on request, the total price for one AST engineer for 1 full day training is:
  - a) In Graz: 1350 euro for max. 4 participants
  - b) In Europe: 2000 euro for max. 6 participants at the customer location, including travel and accommodation
  - c) The rest of the world: 5700 euro for 2 days training, including travel and accommodation
    For each additional day, 1350 euro

- Additional cost for cloud training (max. 8 users):
  - 550 euro for setting up the cloud and the introduction
  - + 60 euro per day for running the cloud
  - Software-Support costs extra

Register online: www.avl.com

Table of Content

1. Introduction

This document describes all AVL AST software product-related services offered by the customer services group (AST / CC Methodology Development & Services).

- From a Software Provider to a Solution Provider

Beside the development of easy-to-use software products, AVL AST provides the development of methods and advanced simulation solutions. The transfer of engineering and application know-how is important for an efficient use of advanced simulation technologies in daily work, in addition to training in the usage of a software tool.

- Create Values for Customers

AST offers various services in different levels to support our customers in the best way to shorten the initial phase from the first contact with our products to the effective integration and usage in the development process.

In addition, we provide services for improvement of the applied methods and for development of new simulation methods in close cooperation with the customer, up to complex project work, including simulation-measurement comparison for validation of methods, problem solving with root-cause analysis or taking over design responsibility.

- From Engineer to Engineer

All our engineers participate in method development and advanced simulation work, software training and support. This is a challenging task for all the engineers involved, but for the customer it offers the significant benefit that by getting in contact with our service group he/she is in contact with highly experienced engineers, who know their tools and their application, work in close contact with software development and can link their engineering experience with the information coming from software support of various customers.

- Our message to the customers is: "***We assist our customers in developing advanced simulation excellence***"

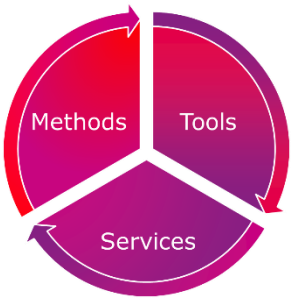
Graz, January 2022

Thomas Resch (AST CC / Head of Methodology Development & Services)

Christian Vock (AST CCSP / Customer Support Manager)

2. Overview of AST Customer Services

MORE THAN JUST A TOOL - Our Solution Approach

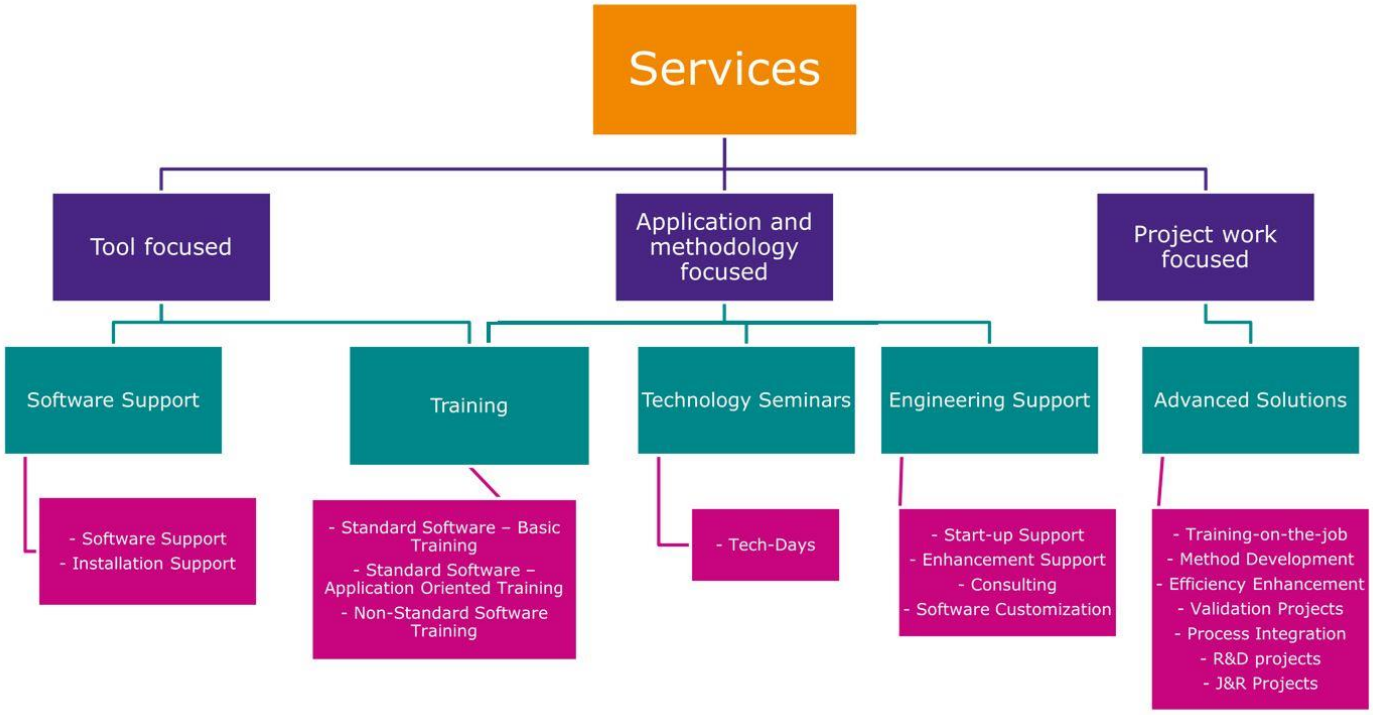


Our **methods** are grounded in the understanding of using cases. This understanding is our basis for choosing the right solution approach and defining the best workflow.
The embedded functionality in the pre-processor, solver and post-processor is the physical evidence. You can experience this in all our **tools**.
We provide **services** to train and support you, to enable you to use our solution independently and successfully with the help of validation, documentation, and training.

The customer services group comprises three modules:

- **Tool focused** – Standard Training & Software Support
- **Application and methodology focused** – Non-Standard Training, Technology Seminars & Engineering Support
- **Project work focused** – Advanced Solutions

An overview of the entire chain from basic training and standard software support via enhanced know-how transfer by technology seminars and specific engineering support up to specific advanced solutions, performed as project work, is shown in the following figure. These services are valid for AST worldwide.

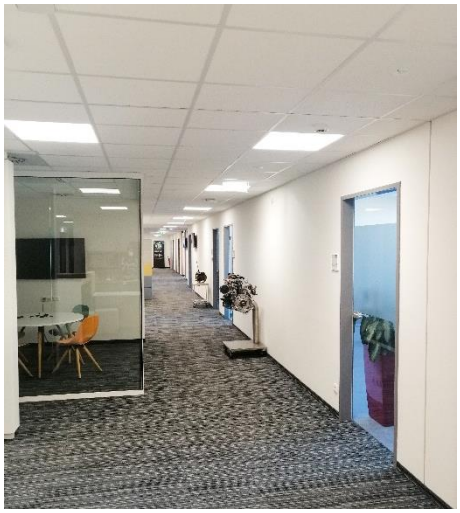


2.1 Validity of Prices and Training Content

* All **prices** given in this document, as well as the **training content**, are related to activities done by AVL AST Graz and can differ for local affiliates.

  For more details, contact your local support and sales organization.

2.2 AST Training Center



Part of the AVL Training Center in cooperation with the
AVL Skill Center and Academy at the Smart City (Graz, Austria)

- Modern-equipped and air-conditioned training rooms
- Face2face (F2F), remote and hybrid trainings
- Cloud support
- Greenroom
- Training by support and application engineers
- Hardware examples for demonstration purpose

Training at AST Training Center Graz

3. Training & Software Support

This module focuses mainly on the usage and installation of the AVL AST software tools:

- AST offers support for the *installation of software tools* in a customer-specific environment.
- AST offers for all its software products *standardized software training and customer-specific non-standard training*.
- For software-related questions, AST offers *software support* according to the AST Global Customer Support Process (CSP).

3.1 Installation Support

This module deals with the installation of our software in a customer-specific environment.

ID	Service
CC_31	Installation Support

Purpose:

The basic step is the installation of the software on a single computer or on a file server. The second step is valid for more complex installations, such as multi-processor environment on clusters.

Validity:

Basic installation is valid for all AST tools. It includes multi-processor and connection with a queuing system for the tools, which support these options.

Content:

- Software installation from the network store ready to work
- Installation performed by an AST engineer
- Customization of software interfaces according to the requirements of the queuing system

Requirements:

- Basic requirements for the system are given by AVL in advance and have to be fulfilled.
- The AVL engineer has to get administration privileges during the installation phase.

Customer Benefit:

- A fast start-up to get a valid installation running
- The best opportunity to enable the usage of all features of the software

Duration:

- Half a day for basic installation.
- The connection with a queuing system depends highly on the complexity of this system and has to be done in close cooperation between AST and system administration on the customer side. For LSF system installation, it will take approximately 1 day, for other systems around 3 days.

Price (excl. Tax): * see chapter 2.1

Installation will be done on the customer side. The price for installation by one AST engineer is:

- Basic installation: 550 euro * see chapter 2.1
- Installation in a complex system environment and the connection with a queuing system: 1350 euro per day * see chapter 2.1

Travel and accommodation will be charged separately.

Contact	
Additional Information	Responsible Sales Manager
Proposal	Responsible Sales Manager

3.2 Standard Software Training

Standard training courses are provided and performed by AST using standard training material and calculation models. AST offers **basic software training** and **application-oriented training** modules.

Training courses are available for each AVL AST software product and are provided in Graz, at AVL affiliates, or at the customer location.

The general training language is English or a local language at AVL affiliates.

Register at the AVL Homepage using the **AVL AST Training Center** to search for a course and submit an inquiry, after which you will receive a Confirmation E-Mail.

Cancellations must be made in written form 1 week before the start of the course.

Training at AVL Graz

- Training courses will take place at AST Headquarters, “Smart City” Waagner-Biro-Straße 108, A-8020 Graz, Austria.
- AST will organize accommodation for customers, if requested.
- At AVL affiliates, arrangements are to be made with the affiliates.
- Training courses held in Graz have the additional benefit for customers to get in contact with various application engineers from AVL.

Training at the Customer Location

- On-site training will be held by one engineer from AST. The customer is asked to secure a training room with equipment and necessary hardware.
- Software should be pre-installed by the customer. Additional licenses during the training can be provided by AST.

Online Training – refer to e-Learning services

- All training courses can also be held online on request.
- Software should be pre-installed by the customer. Additional licenses during the training can be provided by AST.
- Or software and licenses are used via Cloud.

Contact	
Training Content	Link to Homepage
Training Schedule	AVL Training Calendars
Training Registration	AVL Homepage

3.2.1 Basic Software Training

An overview of the handling and usage of the product is given, as well as a general introduction to the main applications. A standard model for the simulation is presented and possible applications with this model are discussed.

ID	Service
CC_321	Basic Software Training

Purpose:

- Overview on the software tool
- Enables the user to build up and run calculation models, prepared by AVL

Validity:

Basic training courses are offered for all AVL AST software products.

Content: * see chapter 2.1

- Introduction, theory, primer examples, modeling, simulation, and post-processing

Goals:

- Basic knowledge
- Capability of software handling

Customer Benefit:

- A fast and efficient way to start using the software tool

Duration:

- Depending on training (see subsequent product listing)

Price (excl. Tax): * see chapter 2.1

- For scheduled training courses held in Graz, the price is:
  a) 450 euro per day and participant
  b) 225 euro per day and participant for universities

  AVL offers fixed dates for **scheduled training courses**, typically one training course per quarter of the year. At these training courses, engineers from different companies can participate (max. 12 people).

- Alternatively, training can be held on request. For **training on request**, the total price for one AST engineer for 1 full day training is:
  - In Graz: 1350 euro for max. 4 participants
  - In Europe: 2000 euro for max. 6 participants at the customer location, including travel and accommodation
  - The rest of the world: 5700 euro for 2 days training, including travel and accommodation. For each additional day, 1350 euro.

Contact	
Information & Organization	Training Organization – Petra Pintaric (ast_training@avl.com)
Registration	link to registration (inquiry) on the AVL Homepage
Training Schedule	AVL Training Calendars

3.2.2 Application Software Training

Application training courses are also standard training courses, but focus on specific applications and are based on the knowledge given by standard basic training.

For some products, various parts of the course for different applications are offered. They can be combined individually according to the customer's requirements.

ID	Service
CC_322	Application Software Training

Purpose:

Application software training will improve the knowledge of the software tool and will train the user in the methodology of special application methods.

Validity:

Application training courses are offered for all AVL AST software products.

Content: * see chapter 2.1

- Application method, special theory, application examples
- Special modeling, post-processing technology
- Result evaluation and integration

Goals:

- Special application oriented knowledge

Customer Benefit:

- A fast and efficient way to learn a new software application field

Duration:

- Depending on training (see subsequent product listing)

Price (excl. Tax): * see chapter 2.1

- For scheduled training courses held in Graz, the price is:
  c) 450 euro per day and participant
  d) 225 euro per day and participant for universities

  AVL offers fixed dates for **scheduled training courses**, typically one training course per quarter of the year. At these training courses, engineers from different companies can participate (max. 12 people).

- Alternatively, training can be held on request. For **training on request**, the total price for one AST engineer for 1 full day training is:
  - In Graz: 1350 euro for max. 4 participants
  - In Europe: 2000 euro for max. 6 participants at the customer location, including travel and accommodation
  - The rest of the world: 5700 euro for 2 days training, including travel and accommodation. For each additional day, 1350 euro.

Contact	
Information & Organization	Training Organization – Petra Pintaric (ast_training@avl.com)
Registration	link to registration (inquiry) on the AVL Homepage
Training Schedule	AVL Training Calendars

Further information:

- Application training courses are on request after completing the basic training.
- Pre-requisites: Completing the related Basic Training Course.

3.2.3 Premium Software Training Package

Premium software training packages are extensions of the basic or application software training. They offer additional contact with the trainer beyond the training days.

ID	Service
CC_323	Premium Software Training Package

Purpose:

The premium software training package will help the users learn how to use the software faster by offering extended contact with the trainer with regular meetings after the basic or application software training. Meetings and additional training days are always held individually for each customer.

Validity:

Premium software training packages are offered for all AVL AST software products.

Content:

- Discussion about user experience
- Review of user generated models

Goals:

- Increase experience and application of the software at the customer location

Customer Benefit:

- A faster way to get information and a speed-up of profitable work with software

Duration:

- Weekly online meetings, approx. 2 hours each for 4 weeks following the basic or application training
- Additional training day after 4 weeks
- Biweekly online meetings, approx. 2 hours each for 8 weeks following the additional training day

Price (excl. Tax): * see chapter 2.1

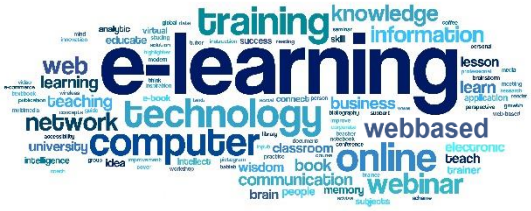
- With an additional training day done at an AVL affiliate or via web-service: 3500 euro for max. 4 participants
- With an additional training day done at the customer location with a local trainer from an affiliate: 5000 euro for max. 4 participants at the customer location, including travel and accommodation
- With an additional training day done at the customer location requiring experts from other affiliates: 6000 euro for max. 4 participants, including travel and accommodation

Contact	
Information & Organization	Training Organization – Petra Pintaric (ast_training@avl.com)
Registration	link to registration (inquiry) on the AVL Homepage
Training Schedule	AVL Training Calendars

Further information:

- Premium training packages can only be purchased in combination with basic or application training.
- Premium training packages can also be purchased following a standard scheduled training course, but meetings and additional training days are always held individually for each customer.
- Pre-requisites: Completing the Basic or Application Training Course.

3.2.4 E-Learning



In addition to the face2face training courses, AST also offers various online training courses. E-Learning (or electric learning) includes all forms of learning in which electronic or digital media are used as the learning material.

3.2.4.1 Remote/ Online Training

Remote training courses are "real-time" training courses with the trainer and the trainees doing the training online, regardless of the country. For better communication, the trainer uses a headset with a microphone and a webcam with different view options.

ID	Service
CC_324	Remote/ Online Training

Purpose:

- Training courses are done online.

Validity:

Remote/ online training courses are offered for all AVL AST software products.

Requirement:

- Local software and license installation at the customer location

Content: * see chapter 2.1

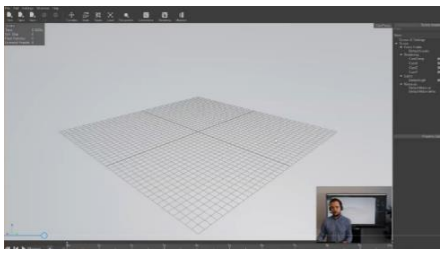
- Introduction, theory, primer examples, modeling, simulation, and post-processing or
- Application method, special theory, application examples,
- Special modeling, post-processing technology

Goals:

- Basic knowledge,
- Capability of software handling or
- Special application-oriented knowledge

Customer Benefit:

- A fast and efficient way to learn a new software application field
- No travel costs



Duration:

- Depending on training (see subsequent product listing)

Price (excl. Tax): * see chapter 2.1

- For scheduled training courses, the price is:
  - 450 euro per day and participant
  - 225 euro per day and participant for universities

  AVL offers fixed dates for scheduled training courses, typically one training course per quarter of the year. At these training courses, engineers from different companies can participate (max. 9 people).
- Alternatively, training can be held on request. For training on request, the total price for one AST engineer for 1 full day training is:
  - 1350 euro for max. 4 participants

Contact	
Information & Organization	Training Organization – Petra Pintaric (ast_training@avl.com)
Registration	link to registration (inquiry) on the AVL Homepage
Training Schedule	AVL Training Calendars

3.2.4.1 Hybrid Training

Hybrid training, also known as blended learning or mixed-mode instruction, is an education approach that combines online education materials and opportunities for online interaction with traditional location-based classroom methods. Hybrid training is a combination of "live" F2F training courses with participants at the Training Center in Graz and trainees participating online.

ID	Service
CC_324	Hybdrid Training

Purpose:

- Depending on the possibilities and preferences, the participants join the training either F2F or online.

Requirement:

- The participants who join the training online need to install software and licenses on their computers.

Content: * see chapter 2.1

- Introduction, theory, primer examples, modeling, simulation, and post-processing or
- Application method, special theory, application examples,
- Special modeling, post-processing technology

Goals:

- Basic knowledge,
- Capability of software handling or
- Special application-oriented knowledge

Customer Benefit:

- A fast and efficient way to learn a new software application field
- A flexible arrangement for different customer needs

Duration:

- Depending on training (see subsequent product listing)

Price (excl. Tax): * see chapter 2.1

- For scheduled training courses, the price is:
  - 450 euro per day and participant
  - 225 euro per day and participant for universities

  AVL offers fixed dates for scheduled training courses, typically one training course per quarter of the year. At these training courses, engineers from different companies can participate (max. 9 people).
- Alternatively, training can be held on request. For training on request, the total price for one AST engineer for 1 full day training is:
  - 1350 euro for max. 4 participants

Contact	
Information & Organization	Training Organization – Petra Pintaric (ast_training@avl.com)
Registration	link to registration (inquiry) on the AVL Homepage
Training Schedule	AVL Training Calendars

3.2.4.2 Remote or Hybrid Training in the Cloud

Trainees can use our software on MS Accure cloud – the trainer can log on to the cloud and support the trainee. Depending on the location, different virtual machines (e.g. US/Europe) are used.

Additionally, the specification is done according to the software (SW) package and CPU power used. Cloud Training is offered for all SDT- and AWS-based tools and for VSM.

ID	Service
CC_324	Remote or Hybrid Training in the Cloud

Purpose:

- The participants do not need to install the license on their computer for the training.

Requirement:

- Strong internet connection

Content: * see chapter 2.1

- Introduction, theory, primer examples, modeling, simulation, and post-processing or
- Application method, special theory, application examples,
- Special modeling, post-processing technology

Goals:

- Basic knowledge,
- Capability of software handling or
- Special application-oriented knowledge

Customer Benefit:

- A fast and efficient way to learn a new software application field
- Deeper interaction between the trainer and the trainee due to screen sharing in both directions
- No local installations necessary on the customer side
- No travel costs

Duration:

- Depending on training (see subsequent product listing)

Price (excl. Tax): * see chapter 2.1

- For scheduled training courses, the price is:
  - 450 euro per day and participant
  - 225 euro per day and participant for Universities
- Alternatively, training can be held on request. For training on request, the total price for one AST engineer for 1 full day training is:
  - 1350 euro for max. 4 participants
- Additional cost for cloud training (max. 8 users):
  - 550 euro for setting up the cloud and the introduction
  - + 60 euro per day for running the cloud
  - Software-Support costs extra

Contact	
Information & Organization	Training Organization – Petra Pintaric (ast_training@avl.com)
Registration	link to registration (inquiry) on the AVL Homepage
Training Schedule	AVL Training Calendars

3.2.5 Online Video Training

All customers with a valid license can get access to our video training. To get access, please contact ast_training@avl.com.
You will get a pdf file with valid links for about 1 month of the ordered training.

Please note that these video training courses are not a full substitute for a complete standard training!

The following video training courses are available:

Basic Training	
• TCSS-01	AVL CRUISE™ Basic
• TCMV-01	AVL CRUISE™ M Engineering Enhanced - Software Training for VTB / Gasoline
• TCMV-02	AVL CRUISE™ M Engineering Enhanced - Software Training for VTB / Diesel
• TEPR-01	AVL EXCITE™ Piston &Rings Basic – Piston Dynamics
• TEPR-02	AVL EXCITE™ Ring Dynamics
• TEPR-03	AVL EXCITE™ Piston & Rings Lube Oil Consumption
• TPREO-01	PreonLab™ Basic
• TEPU-01	AVL EXCITE™ PowerUnit Basic
• TEPU-04	AVL EXCITE™ PUMain Bearing and Conrod Bearing Analysis
• TEPU-15	AVL EXCITE™ Power Unit Acoustic Training
• TMCO-01	Model.CONNECT™ Office Basic
• TSPA-01	AVL SPA™ Basic
• TCOM-01	AVL COMPOSE™ Basic
• TCMF-01	AVL CRUISE™ M Flow Basic
• TCM-01	AVL CRUISE™ M Basic GUI
• TCM-02	AVL CRUISE™ M Basic Intro
• TCME-02	AVL CRUISE™ M Physical Engine / DIESEL
• TFME-01	AVL FIRE™ M Engine
• TFIM-01	AVL FIRE™ M Basic
Electrification Training	
• TELA-01	AVL EXCITE™ E-Axle NVH and Durability Analysis (AWS based)
• TELA-02	AVL EXCITE™ E-Axle NVH and Durability Analysis (SDT based)
• TELB-01	AVL FIRE™ M Battery Thermal and Hazard Investigation
• TELF-01	AVL FIRE™ M PEM Fuel Cell Module Performance Analysis
• TELM-01	AVL FIRE™ M PMSM E-Machine Electromagnetics and Thermal Investigation
• TELM-03	AVL EXCITE™ Electric Machine Rotor-Dynamics
• TELV-01	AVL CRUISE™ M Battery and Range Extended Electric Vehicle
• TELV-02	AVL CRUISE™ M Fuel Cell Electric Vehicle
• TELV-03	AVL CRUISE™ M Hybrid Electric Vehicle

We are continuously working on recordings for new training courses. Please contact us for more information.

3.2.6 Electrification Training

3.2.6.1 Electrification Training Vehicle

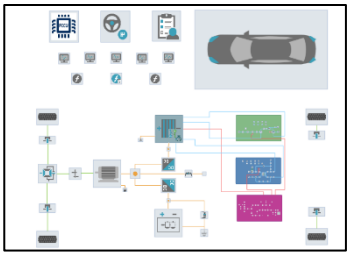
TELV-01 / Battery and Range Extended Electric Vehicle Concept Finding & Layout

Models:
C04036_Basic_Circuits.proj
C04042_DCDC_Converter.proj
C04044_Power_Consumer.proj
C04050_Lowpass_Filter.proj
C11013_Mechanical_Consumer.proj
C04048_EM_Speed_Control.proj
C04004_BEV_DoE.proj
C04002_BEV.proj
C04032_Range_Extended_EV.proj

Module 1* Basic	Module 2 Application	Module 3 Application
1 Day	1 Day	1 Day
Introduction ▪ CRUISE M GUI, Pre- and Post-processing ▪ Control domain in CRUISE M ▪ Electric domain in CRUISE M ▪ Mechanical domain in CRUISE M ▪ Basic model setup with calculation tasks ▪ Simple powertrain	**BEV powertrain model** ▪ Simple powertrain ▪ Advanced powertrain ▪ Introduction to BMS ▪ E-motor current control ▪ Model analysis	**Applications & REEV powertrain model** ▪ Cycle run & FLA ▪ Parameters, scenarios and DoE ▪ REEV & controller ▪ Simple thermal model ▪ Model analysis

TELV-02 / Fuel Cell Electric Vehicle Concept Finding & Layout

Models:
C04063_FC_Testbed
C04069_Water_Separator
C04078_PEMFC_Cold_start
C04060_Anode
C04062_Therm_Mgmnt_FCEV_BoP
C04014_Powertrain_FCEV
C04016_Powertrain_Mech_FCEV
C04093_FCEV_BoP_RedDim_PEMFC
C04064_Humidifier
C04072_PEMFC_Reduced_Dim
C04075_BoP_Component_Sizing_Cathode
C04061_Cathode
C04013_FCEV_BoP_Analytical_PEMFC
C04015_Powertrain_El_FCEV
C04017_FCEV_ElChem_FC

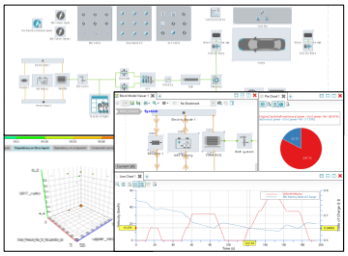


Module 1* Basic	Module 2 Application	Module 3 Application
1 Day	1 Day	1 Day
Introduction ▪ CRUISE M GUI, Pre- and Post-processing ▪ Control domain in CRUISE M ▪ Electric domain in CRUISE M ▪ Mechanical domain in CRUISE M ▪ Basic model setup with calculation tasks ▪ Simple powertrain	**FCEV powertrain model** ▪ BOP intro ▪ Gas path domain in CRUISE M ▪ Anode ▪ Cathode ▪ Liquid domain in CRUISE M ▪ Thermal domain in CRUISE M	**Applications & FCEV power-train model** ▪ Reduced dimensionality Fuel Cell ▪ Advanced powertrain ▪ Degradation ▪ Q&A

* Module 1 (Basic Training for TELV-01, TELV-02 & TELV-03) only has to be done once

TELV-03 / Hybrid Electric Vehicle Concept Finding & Layout

Models:
HC04024_HEV_P2_AMT_FWD.proj
C04032_Range_Extended_EV.proj
C11027_Man_FWD.proj
C04030_MHEV_P3_AMT_FWD.projEV_P2_AMT_FWD.proj
Series_Hybrid_RE_Basic_Model.proj
Man_FWD.proj
PX_PMG_AMT_FWD.proj



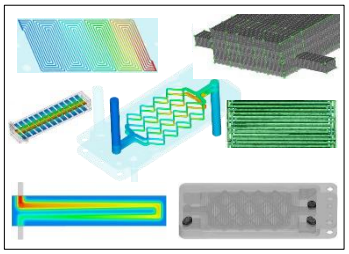
Module 1* Basic	**Module 2** Application	**Module 3** Application
1 Day	**1 Day**	**1 Day**
Introduction ▪ CRUISE M GUI, Pre- and Post-processing ▪ Mechanical domain in CRUISE M ▪ Electric domain in CRUISE M ▪ Basic model setup with calculation tasks ▪ Simple powertrain	**HEV powertrain model** ▪ Run basic vehicle model with post-processing ▪ Overview on hybrid concepts Px ▪ Modify basic vehicle to a hybrid configuration P0+P2 ▪ Simple control function implementation	**HEV powertrain model** ▪ Simple control function implementation ▪ Introduction to BMS ▪ E-motor current control ▪ Simple thermal model

* Module 1 (Basic Training for TELV-01, TELV-02 & TELV-03)) only has to be done once

3.2.6.2. Electrification Training Fuel Cell (PEM)

TELF-01 / PEM Fuel Cell Module Performance Analysis

Models:
9106_LTPEM_FC_Straight_Channel
9335_LTPEM_FC_Cooling
9336_LTPEM_FC_Discretized_ZBT_50
9337_LTPEM_FC_Discretized_Homogenized_ZBT_50
9507_LTPEM_FC_CAD_Workflow

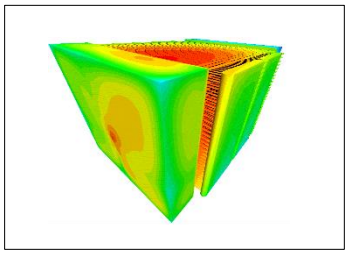


Module 1* Basic	**Module 2** Application	**Module 3** Application
1 Day	**1 Day**	**1 Day**
Introduction ▪ FIRE M introduction ▪ SDT GUI, Pre- and Post-processing ▪ Case definition, parameters and job submission ▪ Basic model set-up	**PEM FC Basic Training** ▪ PEM FC surface preparation ▪ Interactive meshing (Single Serpentine Flow Channel PEM FC) ▪ Automatic meshing (FC Diamond) ▪ Basic simulation setup for fuel cell module	**PEM FC Application Training** ▪ Advanced surface repair (ZBT PEM FC) ▪ Specific oriented simulation setup for fuel cell module ▪ Analysis of FC specific results (Post-processing and discussion)

* Module 1 (Basic Training for TELF-01,TELF-02, TELB-01 & TELM-01, TELP-01) only has to be done once

TELF-02 / SOFC Module Performance Analysis

Models:
9344_SOFC_Straight_Channel
9345_SOFC_Single_Cell
9346_SOFC_Stack

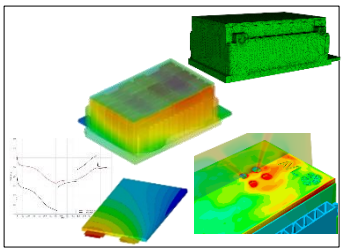


Module 1* Basic	**Module 2** Application	**Module 3** Application
1 Day	**1 Day**	**1 Day**
Introduction ▪ FIRE M introduction ▪ SDT GUI, Pre- and Post-processing ▪ Case definition, parameters and job submission ▪ Basic model setup FIRE M introduction ▪ SDT GUI, Pre- and Post-processing ▪ Case definition, parameters and job submission ▪ Basic model setup (straight channel geometry	**SOFC Basic Training** ▪ SOFC surface preparation ▪ Discretized modeling approach ▪ Homogenized modeling approach ▪ Basic simulation setup for fuel cell module	**SOFC Application Training** ▪ Introduction stack modeling ▪ Detailed simulation setup ▪ Analysis of stack-specific results (Post-processing and discussion)

3.2.6.3 Electrification Training Battery

TELB-01 / Battery Thermal and Hazard Investigation

Models:
9107_Battery_Cooling
9320_ET_Battery
9322_Battery_Thermal_Runaway



Module 1* Basic	**Module 2** Application	**Module 3** Application	**Module 4** Application
1 Day	**1 Day**	**1 Day**	**1/2 Day**
Introduction ▪ FIRE M introduction ▪ SDT GUI, Pre- and Post-processing ▪ Case definition, parameters and job submission ▪ Basic model set-up	**Thermal analysis** ▪ Introduction to battery technology and simulation ▪ Preparation of CAD data and meshing ▪ Basic model setup for Battery Cooling	**Hazard investigation** ▪ Introduction to battery thermal runaway ▪ Setup for thermal runaway simulations ▪ Analysis of results (Propagation times, flammability)	**Electrothermal battery models** ▪ Introduction to ET battery models ▪ Data requirements and processing for ET models ▪ Setup of ET simulations

* Module 1 (Basic Training for TELF-01,TELF-02, TELB-01 & TELM-01, TELP-01) only has to be done once

3.2.6.4 Electrification Training Power Electronics

TELP-01 / FIRE M Power Electronics

Models:
9107_Battery_Cooling
9505_Power_Inverter_Cooling_Workflow

Module 1* Basic

1/2

Introduction

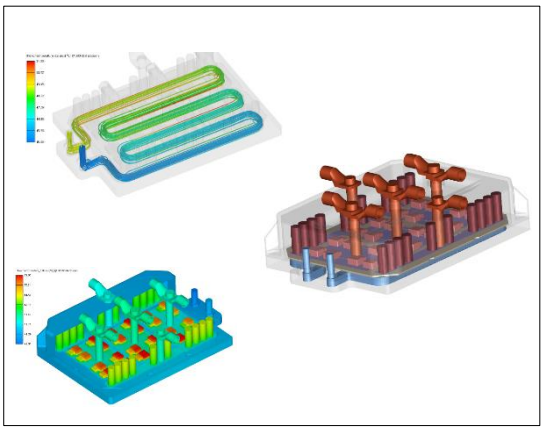
- FIRE M introduction
- SDT GUI, Pre- and Post-processing
- Case definition, parameters and job submission
- Basic model set-up

Module 2 Application

1/2 Day

Power electronics

- Introduction to power electronics simulation
- Preparation of CAD data and meshin
- Basic model setup for Power inverter

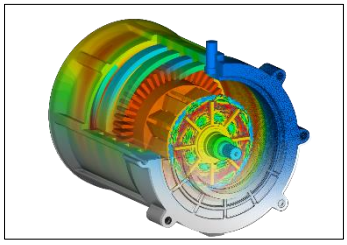


* Module 1 (Basic Training for TELF-01, TELB-01 & TELM-01, TELP-01) only has to be done once

3.2.6.4 Electrification Training Electric Motor

TELM-01 / PMSM E-Machine Electromagnetics and Thermal Investigation

Models:
9504_E-Motor Cooling Workflow



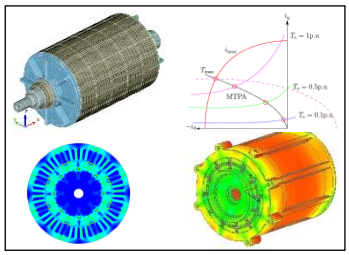
Module 1* Basic	Module 2 Application	Module 3 Application
1 Day	1 Day	1 Day
Introduction ▪ FIRE M introduction ▪ SDT GUI, Pre- and Post-processing ▪ Case definition, parameters and job submission ▪ Basic model set-up	**E-machine electro-magnetic analysis** ▪ Intro of 2.5D electro-magnetic capabilities and modeling appr. ▪ E-machine modeling using EMT*** and from CAD import ▪ Setup of EM simulation ▪ Results evaluation ▪ Export results for further analyses ▪ Modify the model	**E-machine thermal analysis** ▪ Intro of thermal capabilities and 3D modeling approaches ▪ Calculation of losses ▪ CAD preparation and meshing ▪ Model setup with combined liquid and air cooling ▪ Analysis of temperatures

* Module 1 (Basic Training for TELF-01, TELB-01 & TELM-01, TELP-01) only has to be done once

TELM-02 / E-Machine NVH Analysis with Electrical Network

Models:
502_E_Axle AWS E-machine ElectroMagnetic Installation model for NVH

Module 1 Basic	Module 2 Application
1/2 Day	1 Day
Introduction ▪ FIRE M introduction ▪ SDT GUI, Pre- and Post-processing ▪ Case definition, parameters and job submission ▪ Basic model set-up	**Model Set-up** ▪ Data generation with EMT (Electric Machine Tool) ▪ Setup of Models for NVH task (frequency domain/time domain) – EMC0 & stator forces + post processing ▪ Setup of models for higher electrical order effects and (low speed) rotor dynamics– EMC1 ▪ Data check with property assistant



TELM-03 / Electric Machine Rotor-Dynamics

Models:
501_E_machine_standalone\RotorDyn
V301_RotDynBearingStiffness.ex
V301_RotorDyn.ex

Module 1
Basic

1/4 Day

Rotor-dynamics Theory Introduction

- Introduction to Rotor-dynamics theory
- Basics about critical speeds, upward and backward whirling modes

Module 2
Application

1/4 Day

Complex Modal Analysis

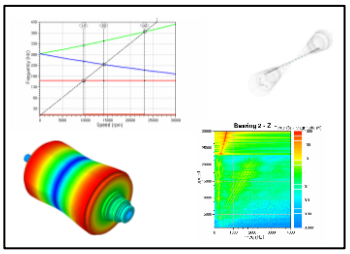
- Introduction to Shaft Modeler tool
- Setup of the Shaft Modeler Rotor
- Bearing Stiffness calculation
- Complex Modal Analysis of the rotor

Module 3
Application

1/2 Day

Transient Dynamic Analysis

- Setup of the E machine Excite model for Rotor-dynamics
- Introduction to the EMC joint in Excite
- Results Evaluation



3.2.6.5 Electrification Training E-Axle

TELA-01 / E-Axle NVH and Durability Analysis (AWS based)

Models:
502_E_Axle

Module 1*
Basic

1 Day

Advanced simulation

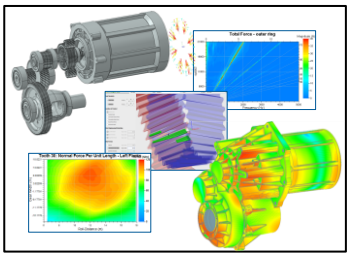
- Introduction of EXCITE Power Unit capabilities and modeling approaches to simulate eAxles with cylindrical and planetary gear stages
- Creating an advanced eAxle model
- Results evaluation using Impress Chart and Impress 3D (Data Recovery), gear mesh evaluation

Module 2
Application

1 Day

Extended simulation

- Modeling extensions:
- Microgeometry – contact plots
- FlexGear – retained nodes
- Stator – teeth forces
- RCA (Root Cause Analysis)
- MA (Modal Analysis)
- NTPA (Numerical Transfer Path Analysis)
- TF (Transfer Functions)



* Module 1 (Basic Training for TELA-01 & TELA-02) only has to be done once

TELA-02 / E-Axle NVH and Durability (SDT based)

Models:
502_E_Axle

Module 1*
Basic

1 Day

Advanced simulation

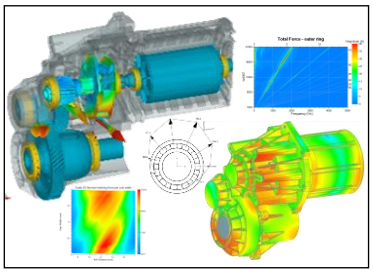
- Introduction of EXCITE for eAxle (SDT) capabilities and modeling approaches to simulate e-axles with cylindrical and planetary gear stages
- Creating e-Axle model in BASIC modeling level
- Results evaluation in IMPRESSTM M, gear mesh evaluation, report generation

Module 2
Application

1 Day

Extended simulation

- Model extensions in EXPERT modeling level
- Stator – teeth forces
- Component Modeler
- FlexGear – retained nodes
- RCA (Root Cause Analysis)
- MA (Modal Analysis)
- NTPA (Numerical Transfer Path Analysis)
- TF (Transfer Functions)



* Module 1 (Basic Training for TELA-01 & TELA-02) only has to be done once

3.2.7 AVL BOOST™ Training Courses

TBCS-01 / BOOST Basic Training Course

Models:
4t1.bwf
ottocalc_short.bwf
TCI_short.bwf
4t1_gasoline_transient_ECU_driv.bwf

Module 1
Basic

1 Day

Introduction

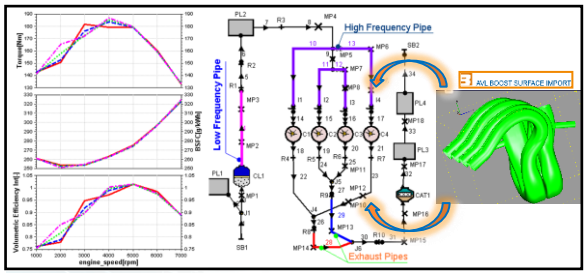
- Introduction and Theory
- Create a Model of a 4-stroke Gasoline or Diesel Engine
- (1 cylinder gasoline model optional - aimed for customers dealing with the motorcycle engines)
- Series Calculation
- Post-processing
- Control Elements
- MATLAB Interfaces
- BURN module: combustion – rate of heat release evaluation based on measurement data

Module 1
Basic

1/2 Day

Calculation

- Transient Calculation (on request as additional ½ day)



TBCS-02 / BOOST Aftertreatment

Required pre-requisites: TBCS-01

Models:
DOC_LightOff.bwf
SCRT_AdDesorbtion.bwf
SCRT_Parameter_Sets.bwf
DPF_Loading.bwf
DPF_BackDiffusion.bwf
EHC_DOC_ECE_Cycle.bwf
OxiCat_LightOff.bwf
SCR_WCL_AdDesorbtion.bwf
DPF_BareTrapRegen.bwf
DPF_Filtration_Soot_Classes.bwf
WHTC_400s_EAS.bwf
WHTC_600s_EAS_Controlled.bwf

Module 2
Application

1 Day

Introduction

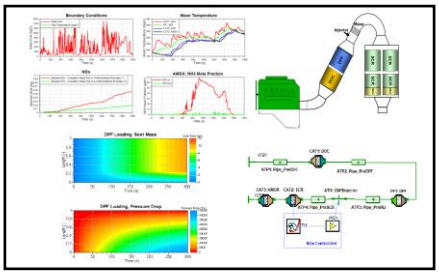
- Introduction and Theory
- Examples: DOC Light Off and DPF Regeneration
- Kinetic Parameters Calibration Using Optimization Tool
- Introduction to AST User Coding Interface

Module 2
Application

1/2 Day

Simulation

- Complete EAS System modeling using test bed data
- Control functions



TBCS-03 / BOOST Linear and Non-Linear Acoustics

Required pre-requisites: TBCS-01

Models:

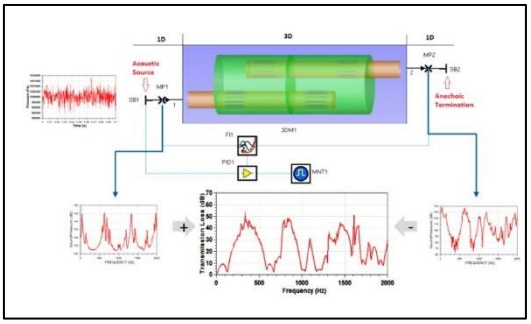
3D_Mesh_Transmission_Loss.bwf

Module 2
Application

1 Day

Introduction and Theory

- Example: Exhaust Muffler Model (Rock-drill)
- Advantages/Disad-vantages of Linear vs. Non-linear Solu-tion
- Transmission Loss Adjustment Using Optimization Tool



TBCS-04 / BOOST Turbocharger

Required pre-requisites: TBCS-01

Models:

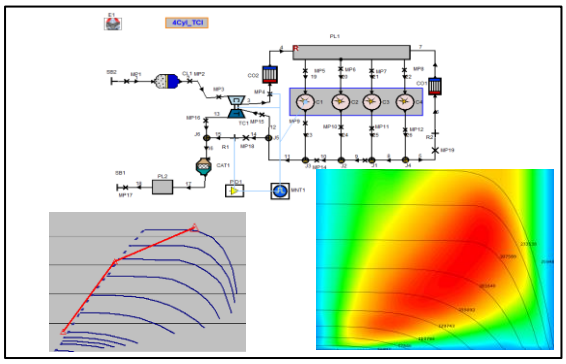
TCI_calc.bwf
TCI_calc_short.bwf
TCI_calc_TC_match.bwf
first.bwf

Module 2
Application

1/2 Day

Introduction and Theory

- BOOST Simplified Turbocharger Model
- Turbocharger Match-ing and Full Turbo-charger Model



3.2.8 AVL CRUISE™ Training Courses

TCSS-01 / CRUISE Basic Training Course

Models:
Man_FWD ver_0001
Aut_FWD ver_0001

Module 1
Basic

1 Day

Introduction

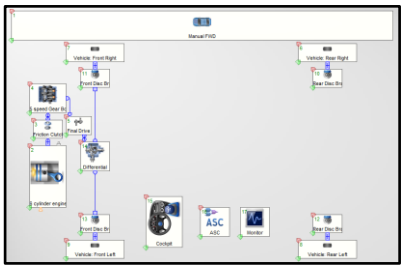
- Introduction
- Creating a basic vehicle model
- Setting up the Cycle Run Calculation Task
- Running a simulation
- Post-processing

Module 1
Basic

1 Day

Calculation

- Overview of other calculation tasks (e.g. Full load acceleration, max. velocity, etc.)
- Modifying a manual transmission vehicle to an automatic transmission vehicle
- Explanation of different calculation types (variations) with post-processing



TCSS-02 / CRUISE HEV and EV Modeling

Required pre-requisites: TCSS-01

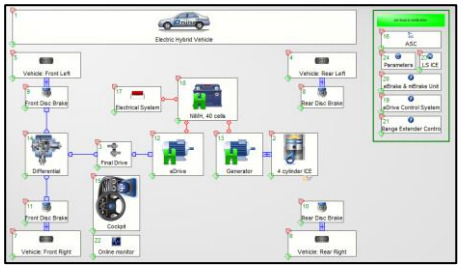
Models:
Electric_Vehicle ver_0001
Range_Extender ver_0001
Hybrid_2 ver_0002
Mild_Hybrid ver_0001

Module 2
Application

1 Day

Introduction

- Introduction of Electrical Components
- Model Setup
- Basic Controller Usage (No Controller Development)
- Example of using a Matlab based controller (No Matlab usage)



TCSS-03 / CRUISE Interfaces

Required pre-requisites: TCSS-01

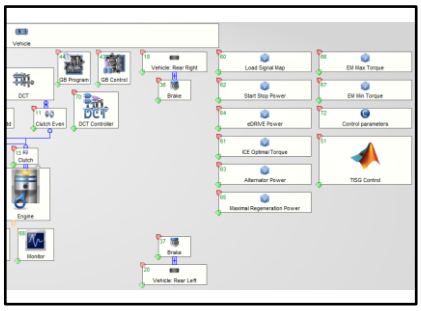
Models:
Matlab API ver_0001
Matlab DLL ver_0001
Function C ver_0001
Function RPN ver_0001
Map ver_0001

Module 2
Application

1 Day

Import Interfaces

- Introduction and overview
- Matlab API
- Matlab DLL
- Function
- Map



TCSS-04 / CRUISE GSP

Required pre-requisites: TCSS-01

Models:
GSP Wizard AMT ver_0001
GSP AMT ver_0001

Module 2
Application

1 Day

Introduction

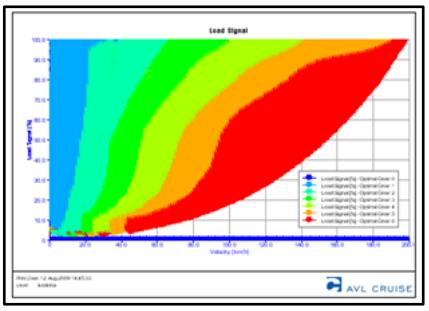
- Introduction and overview
- GSP Wizard
- GSP Generation

Module 2
Application

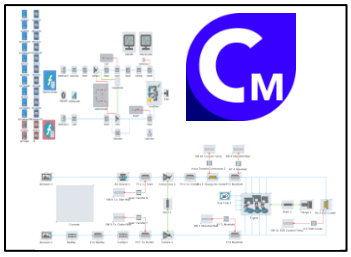
1/2 Day

GSP OPtimisation

- GSP Optimisation



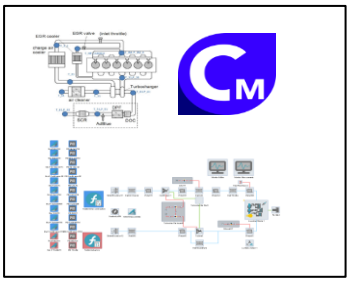
3.2.9 AVL CRUISE™ M Training Courses



CRUISE M Physical Engine Basic Training Courses
TCME-01 / CRUISE M Physical Engine / GASOLINE
TCME-02 / CRUISE M Physical Engine / DIESEL

Models:
C06111_EPW_CAR_Gasoline
C06107_EPW_CAR_Diesel

Module 1 Basic	Module 1 Basic	Module 1 Basic
1 Day	1 Day	1 Day
Introduction ▪ CRUISE M GUI, Pre- and Post-processing ▪ Gaseous domain in CRUISE M ▪ Basic model setup with calculation tasks	**Engine model** ▪ Steady State Engine model ▪ Transient Engine model	**Engine model** ▪ Turbocharger ▪ Transient control



CRUISE M Engineering Enhanced Engine Basic Training
TCME-03 / CRUISE M Engineering Enhanced - Engine Basic / GASOLINE
TCME-04 / CRUISE M Engineering Enhanced - Engine Basic / DIESEL

Models:
C06056_Gasoline_EE_Calibration

Module 1 Basic	Module 1 Basic	Module 1 Basic
1 Day	1 Day	1 Day
Introduction ▪ CRUISE M GUI, Pre- and Post-processing ▪ Engineering Enhanced Cylinder ▪ Gaseous domain in CRUISE M ▪ Basic model setup with calculation tasks	**Engineering Enhanced Engine model** ▪ Steady State model ▪ Transient model	**Engineering Enhanced Engine model** ▪ Turbocharger ▪ Transient control ▪ Peripheral models

CRUISE M Engineering Enhanced EAS Basic Training
TCME-05 / CRUISE M Engineering Enhanced EAS / GASOLINE
TCME-06 / CRUISE M Engineering Enhanced EAS / DIESEL

Models:
TCME-05: C06049_Gasoline_EAS_Demo.proj
TCME-06: C06039_Diesel_EAS_ASC_Wizard_Demo.proj
C06040_Diesel_EAS_Demo.proj
C06041_Diesel_EAS_SCR_Wizard_Demo.proj
C06042_Diesel_EAS_sDPF_Wizard_Demo.proj

Module 1
Basic

1 Day

Introduction and Basic Modeling

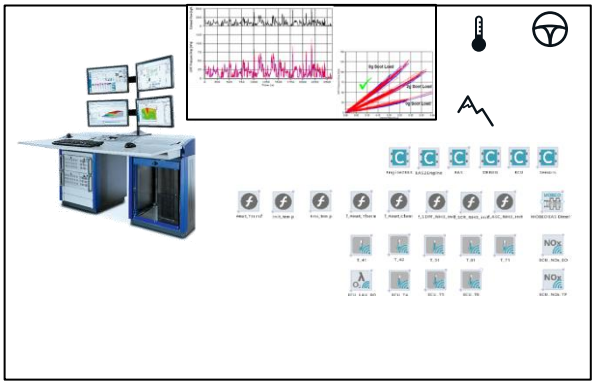
- Engineering Enhanced EAS Gasoline/Diesel block
- EAS model setup (simple and advanced model

Module 1
Basic

1 Day

Basic Modeling EAS

- EAS model parameterization (kinetics, heat transfer and pressure loss refinement)
- EAS model export (preparation for HiL usage



TCMF-01 / CRUISE M Flow Basic

Models:
Several simple models, not part of the installation

Module 1
Basic

1 Day

Introduction and Basic Modeling

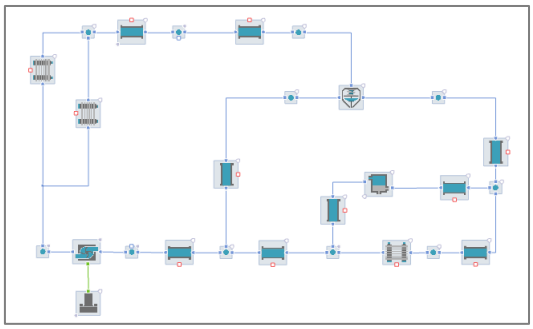
- Thermal management Introduction
- Liquid Flow Domain in CRUISE™ M
- Hydraulic Calibration
- Underhood Modeling

Module 1
Basic

1 Day

Basic Modeling and Circuits

- Heat Exchangers and Heat Transfer
- Pumps
- Valves
- Building and Calibrating Circuits



TCMA-01 / CRUISE M Physical Engine VTMS Training / GASOLINE
TCMA-02 / CRUISE M Physical Engine VTMS Training / DIESEL

Required pre-requisites: TCMF-01 and TCME-01,02

Models:
Same as in TCMF-01
C09002_1_4L_PFI_FTC_Gasoline_VTMS
C09009_1_5L_4Cyl_FTC_VTMS

Module 2
Application

1 Day

Introduction and Basic Modeling

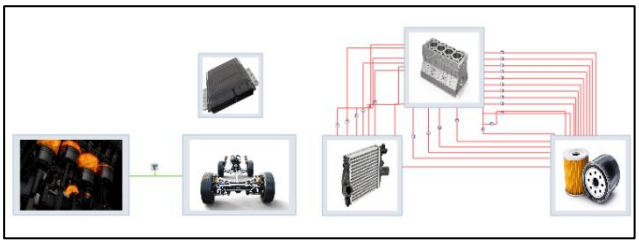
- Thermal management Introduction
- Liquid Flow Domain in CRUISE™ M
- Hydraulic Calibration
- Underhood Modeling

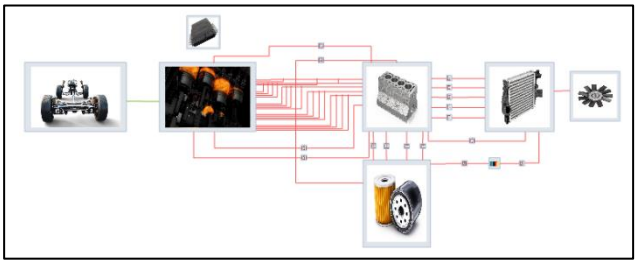
Module 2
Application

1 Day

Basic Modeling and Circuits

- Heat Exchangers and Heat Transfer
- Pumps
- Valves
- Building and Calibrating Circuits





Module 2
Application

1 Day

VTMS Modeling

- Thermal network modeling
- Coupling of engine and driveline models

Module 2
Application

1 Day

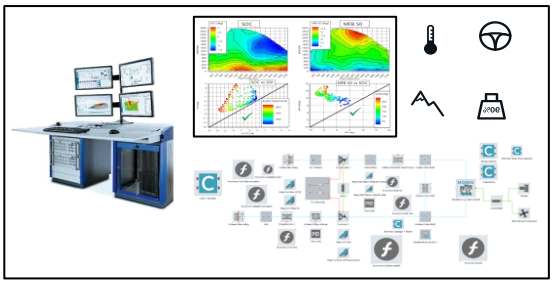
VTMS Modeling

- Coupling of the flow circuits
- Drive cycle simulation set-up

TCMV-01 / CRUISE M Engineering Enhanced Software Training for VTB / Gasoline
TCMV-02 / CRUISE M Engineering Enhanced Software Training for VTB / DIESEL

Required Prerequisites: Customer order of VTB (Virtual TestBed) from AVL ITS

Models:
C06056_Gasoline_EE_Calibration



Module 1
Basic

1 Day

Introduction

- CRUISE M GUI, Pre- and Post-processing
- Engineering Enhanced Cylinder
- Gaseous domain in CRUISE M
- Basic model setup with calculation tasks

Module 2
Application

1 Day

Engineering Enhanced Engine model

- Steady State model
- Transient model
- Turbocharger
- Transient control
- Peripheral models

Module 2
Application

1 Day

Engineering Enhanced Engine model

- Steady State model
- Transient model
- Turbocharger
- Transient control
- Peripheral models

Module 3
Application

1 Day

VTB application extensions

- Measurement data evaluation
- Data visualization
- Engine Calibration
- Engine extensions (sensors, robustness, non-standard conditions)
- HiL usage

Module 3
Application

1 Day

VTB application extensions

- Measurement data evaluation
- Data visualization
- Engine Calibration
- Engine extensions (sensors, robustness, non-standard conditions)
- HiL usage

Module 3
Application

1 Day

VTB application extensions

- Measurement data evaluation
- Data visualization
- Engine Calibration
- Engine extensions (sensors, robustness, non-standard conditions)
- HiL usage

Module 4
Application

1 Day

Engineering Enhanced EAS model

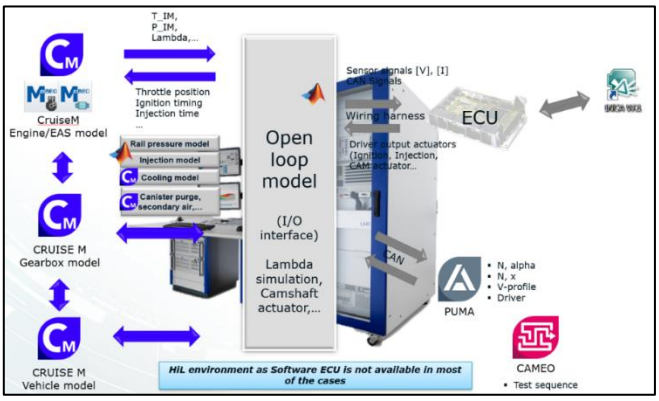
- Engineering Enhanced EAS Gasoline/Diesel block
- EAS model setup (simple and advanced model)
- EAS model parameterization (kinetics, heat transfer and pressure loss refinement)
- EAS model export (preparation for HiL usage)

Module 4
Application

1 Day

Engineering Enhanced EAS model

- Engineering Enhanced EAS Gasoline/Diesel block
- EAS model setup (simple and advanced model)
- EAS model parameterization (kinetics, heat transfer and pressure loss refinement)
- EAS model export (preparation for HiL usage)



TCMH-01 / CRUISE M Mobile A/C Basic

Required pre-requisites: TCMF-01

Models:
C01001_AC_Circuit_EV
C01002_Heat_Pump_Cycle_Internal_HE
C01008_Single_Stage_Controlled

Module 2
Application

1 Day

Introduction

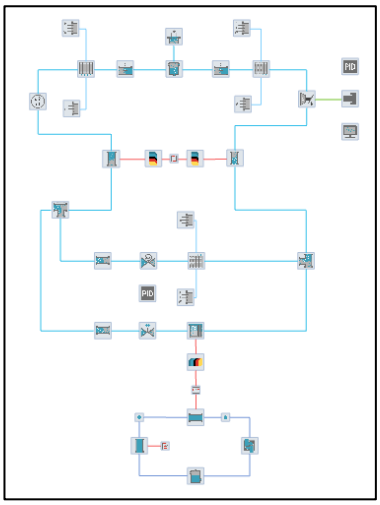
- Introduction to CRUISE M
- AC/WHR domain introduction
- Refrigeration system modeling basics

Module 2
Application

1 Day

Basic Modeling and Circuits

- Air-conditioning modeling
- Heat pump modeling



TCMH-02 / CRUISE M BEV with HVAC

Required pre-requisites: TELV-01 and TCMH-01

Models:
C01001_AC_Circuit_EV
C05058_Cabin_Air_ReCirc_Sys_GF

Module 2
Application

1 Day

HVAC in BEVs

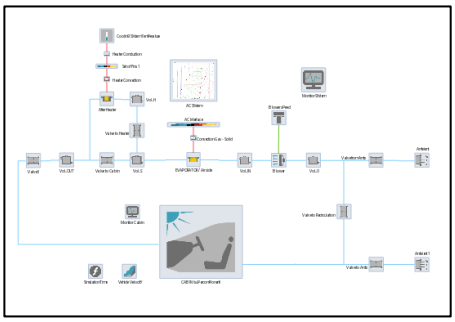
- Refrigeration modeling basics
- AC modeling
- Cabin modeling
- Integration with BEV model

Module 2
Application

1 Day

HVAC in BEVs

- Refrigeration modeling basics
- AC modeling
- Cabin modeling
- Integration with BEV model



TCMH-03 / CRUISE M BEV VTMS and HVAC

Models:
C01001_AC_Circuit_EV
C05058_Cabin_Air_ReCirc_Sys_GF

Module 1
Basic

1 Day

Vehicle and Flow Introduction

- Summary of TELV-01, vehicle modeling overview
- CRUISE M basic workflow
- Usage of vehicle model for drive cycle simulation
- Cooling circuit modeling
- Pressure drop and heat transfer calibration

Module 2
Application

1 Day

Flow and A/C Modeling

- Pump and valve modeling
- Circuit formation and calibration
- Air conditioning system modeling
- Extension of A/C model with a chiller

Module 3
Application

1 Day

Vehicle and Flow Introduction

- Battery modeling – discretization of battery module
- Electric machine thermal modeling
- Vehicle cabin modeling

Module 4
Application

1 Day

Integration of Vehicle and Thermal Models

- Integration of vehicle model and battery thermal model
- Integration of electric motor thermal model
- Integration of A/C and cabin model
- Drive cycle simulation and model variation

3.2.10 AVL EXCITE™ Designer Training Course

TEDE-01 / EXCITE Designer Basic

Models:
121_Designer_I4\excite\IL4

Module 1
Basic

1 Day

Introduction and Basic Modeling

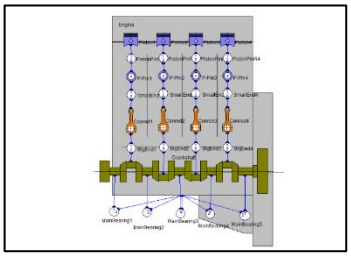
- Introduction and Theory
- Bearing, Torsion and Strength Application Create a Model of an 4 Cylinder Engine

Module 1
Basic

1 Day

Basic Modeling

- Post-Processing
- Crankshaft Pre-Processing using AutoSHAFT approach



3.2.11 AVL EXCITE™ Piston&Rings Training Courses

TEPR-01 / EXCITE Piston Basic

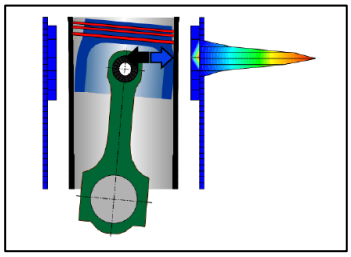
Models:
203_I4_Demo_Diesel\excite_pr\I4_demo_diesel
202_GasolineEngine\excite_pr\1_4L-Gasoline

Module 1
Basic

1 Day

Introduction and Basic Modeling

- Piston Dynamics – Theory
- General information
- Calculation assumptions
- Modeling Guidelines
- Build up and run a model



TEPR-02 / EXCITE Ring Basic

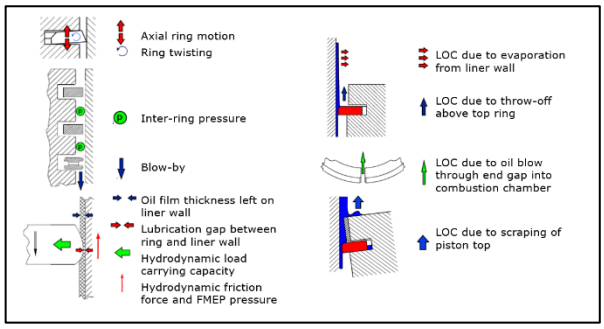
Models:
202_GasolineEngine\excite_pr\1_4L-Gasoline
203_I4_Demo_Diesel\excite_pr\I4_demo_diesel

Module 1
Basic

1 Day

Introduction and Basic Modeling

- Ring Dynamics - Theory
- General Information
- Ring Dynamics Modeling Approaches
- Lube Oil Consumption - Theory
- Build up and run a model



3.2.12 AVL EXCITE™ Power Unit Training Courses

TEPU-01 / EXCITE Power Unit Basic

Models:
100_General\excite\General_Example3_extended
101_Primer\excite\Primer_FEM_NONL_abq

Module 1
Basic

1 Day

Introduction and Basic Modeling

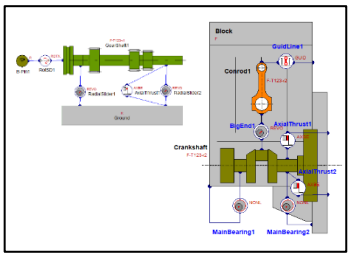
- Introduction and Theory
- Bodies and Joints
- Loads and Initial Conditions
- Crank Train Globals
- Matrix Reduction of Simple Structured Bodies
- Set-up of Analysis Cases and Simulation Control
- Create a Simple Multi-Body Dynamics Model

Module 1
Basic

1 Day

Basic Modeling

- Matrix Reduction of Volumetric Models
- Create a Model of a Single Cylinder
- 2D and 3D Post-processing
- Internal Data Recovery



TEPU-02 / EXCITE Power Unit Crankshaft Dynamics
Required pre-requisites: TEPU-01

Models:
102_I4_Demo\excite\I4_demo_CS_SHM_abq_enhd_sweep.ex
102_I4_Demo\excite\I4_demo_CS_FEM_abq_enhd_sweep.ex

Module 2
Application

1 Day

Introduction and Modeling

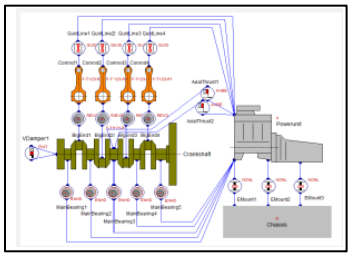
- Introduction and Theory
- Modeling Guidelines
- AutoSHAFT Approach
- Setup of I4 Demo Model (Structured Model)

Module 2
Application

1 Day

Modeling

- Setup of I4 Demo Model (Volumetric Model)
- Postprocessing



TEPU-03 / EXCITE Power Unit Crankshaft Stress Analysis
Required pre-requisites: TEPU-01 and 02

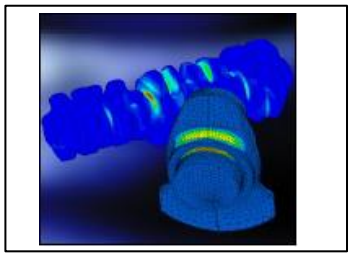
Models:
102_I4_Demo\excite\I4_demo_CS_SHM_abq_enhd_sweep.ex
102_I4_Demo\excite\I4_demo_CS_FEM_abq_enhd_sweep.ex

Module 2
Application

1 Day

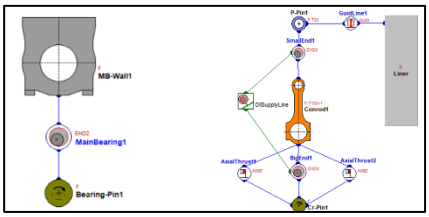
Introduction and Theory

- Overview of the Strength Analysis based on the MBD Stress Analysis using FEA and Fillet Modeler approaches based on the In-line 4-cylinder Example



TEPU-04 / EXCITE Power Unit Main Bearing and Conrod Bearing Analysis
Required pre-requisites: TEPU-01

Models: installation examples
103_Bearing\excite\MainBearing_EHD_abq.ex
104_Conrod\excite\Conrod_abaqus_OSL.ex



Module 2
Application

1/4 Day

Introduction and Theory

- Agenda
- Introduction
- Features and Applications
- Theory (EHD joint)
- Friction
- Surface Roughness and Micro-contact Analysis

Module 2
Application

1/4 Day

Modeling Guidelines (FE and EXCITE)

- FE Model Requirements, retained nodes and condensation
- EXCITE PU modeling
- Thermal Analysis
- Wear Analysis
- Oil Supply Lines

Module 2
Application

1/4 Day

MB and Conrod Bearing Models – Practice

- Overview of EHD Definitions in GUI
- Body definitions
- Joint definitions
- Loads
- Create Model, Simulation, Create Results

Module 2
Application

1/4 Day

Post-processing

- 2D post-processing, IMPRESS Chart
- 3D post-processing, IMPRESS 3D

TEPU-05 / EXCITE Power Unit Main Bearing Wall and Conrod Stress Analysis
Required pre-requisites: TEPU-01

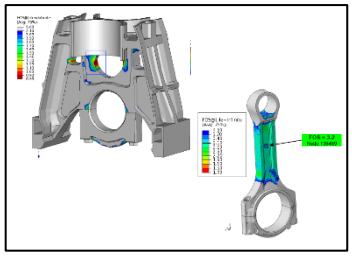
Models:
103_Bearing\excite\MainBearing_EHD_abq.ex
104_Conrod\excite\Conrod_abaqus.ex

Module 2
Application

1 Day

Introduction and Theory

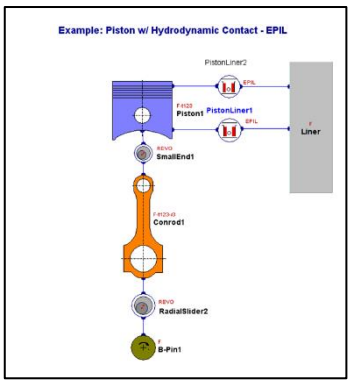
- Introduction and theory
- FEModeling Guidelines for MB Wall and Conrod
- High Cycle Fatigue (only presentation)
- Thermal Analysis
- Fretting



TEPU-06 / EXCITE Power Unit 3D Piston Dynamics

Required pre-requisites: TEPU-01

Models:
105_Piston\excite\Piston_hydro_ABQ.ex



Module 2
Application

1 Day

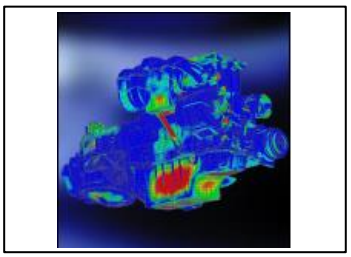
Introduction and Modeling

- Introduction and Theory
- Modeling Guidelines
- Create Piston-Liner Analysis Model
- Post-processing

TEPU-07 / EXCITE Power Unit Noise, Vibration & Harshness Structural

Required pre-requisites: TEPU-01 and 02

Models:
102_I4_Demo\excite\I4_demo_PU_FEM_abq_nonl_sweep.ex



Module 2
Application

1 Day

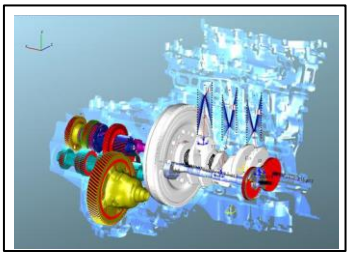
Introduction and Modeling

- Introduction and Theory
- Modeling Guidelines
- Data Recovery
- NVH Example based on the Inline 4-Cylinder Example
- Post-processing

TEPU-08 / EXCITE Power Unit Transmission MT or AT

Required pre-requisites: TEPU-01

Models:
107_I4_Demo_TransmissionManual\excite\I4_demo_transmission_rigid.ex
107_I4_Demo_TransmissionManual\excite\I4_demo_transmission_NVH.ex or
107a_I4_Demo_TransmissionAutomatic\excite\I4_demo_automatic_transmission.ex



Module 2
Application

1 Day

Introduction and Modeling

- Introduction
- Gear rattle, gear whine, heartbeat noise
- Gear joints
- Single gear pair model
- Create simple transmission model

Module 2
Application

1 Day

Modeling

- Create Standalone
- Automotive gearbox model
- Assembly of engine, gearbox and driveline
- Dual Mass Flywheel and Clutch modeling

TEPU-09 / EXCITE Power Unit Driveline Vehicle Integration

Required pre-requisites: TEPU-01

Models:
107_I4_Demo_TransmissionManual\excite\I4_demo_transmission_rigid.ex
107_I4_Demo_TransmissionManual\excite\I4_demo_transmission_rigid_clutch_DMF.ex
107_I4_Demo_TransmissionManual\excite\I4_demo_transmission_clonk_loadIni.ex

Module 2
Application

1 Day

Introduction and Modeling

- Driveline NVH Phenomena
- Modeling approach and Driveline Components
- From 1D Pure Torsional to 3D Approach

Module 2
Application

1 Day

Modeling

- Create a Model of a Front Wheel Drive
- Shuffle and Clonk Investigation
- Post-processing

TEPU-12 / EXCITE Power Unit Micro-contact Analysis

Required pre-requisites: TEPU-01 and 04 or 06

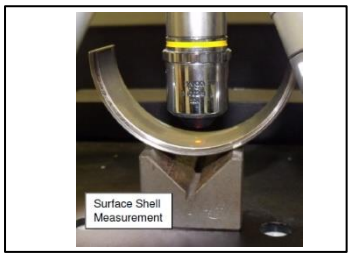
Models:
103_Bearing\excite\MainBearing_EHD_abq.ex

Module 2
Application

1/2 Day

Introduction and Theory

- Roughness Data Import
- Contact Data Evaluation
- Contact Data Selection in EXCITE



TEPU-15 / EXCITE Power Unit Acoustics (Air Born Noise)

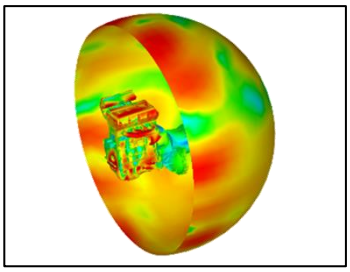
Models:
4001_I4_Demo\I4_demo_full_workflow.proj

Module 1
Basic

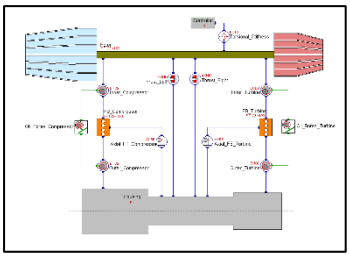
1 Day

Introduction and Basic Modeling

- Introduction and Theory of EXCITE Acoustics
- Generation of acoustic and filed point mesh
- Boundary condition set-tings and simulation run
- Excite Acoustics 2D Post-processing
- Excite Acoustics 3D Post-processing



TEPU-16 / EXCITE Power Unit Turbo Charger



Models:
111_Turbo_Charger\excite\111_Turbocharger.ex

Module 1
Basic

1 Day

Introduction and Modeling

- Theory introduction and FE model require-ments for EXCITE
- Turbocharger rotor modeling and rotor modal analysis in Shaftmodeler
- Create a turbocharger model

Module 1
Basic

1 Day

Bearing modeling and running the simulation

- Oil film modeling
- Roller bearing model-ing
- Simulation and results parameter definition
- Running simulation for different speed cases

Module 1
Basic

1 Day

Results Evaluation

- Introduction in AVL Impress Chart post-processing tool.
- Turbocharger results evaluations.
- Q & A

3.2.13 AVL EXCITE™ Timing Drive Training Courses

TETD-01 / EXCITE Timing Drive Basic Dynamics Calculation

Models:

01_SVT-Intake_OHC-Flat-Tappet.etd
02_SVT-Exhaust_OHC-Finger-Follower.etd
03_Intake-Camshaft.etd
04_Exhaust-Camshaft.etd
05_Timing-Gear-Train.etd
06_Intake-Valve-Train-System.etd
07_Exhaust-Valve-Train-System.etd
08_Timing-Drive_w-Gear-Train.etd
09_Chain-Drive.etd
10_Timing-Drive_w-Chain-Drive.etd

Module 1
Basic

1 Day

Introduction

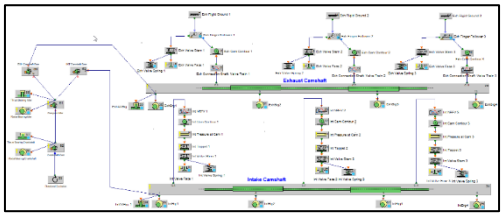
- Introduction and Theory
- Single Valve Train Dynamics
  Shaft Systems

Module 1
Basic

1 Day

Theory

- Gear Train Dynamics
- Timing Drive Dynamics
- Chain & Belt Drives
- Result Analysis



TETD-05 / EXCITE Timing Drive Chain & Belt Drives

Required pre-requisites: TETD-01

Models:

09_Chain-Drive.etd
10_Timing-Drive_w-Chain-Drive.etd

Module 2
Application

1 Day

Introduction and Modeling

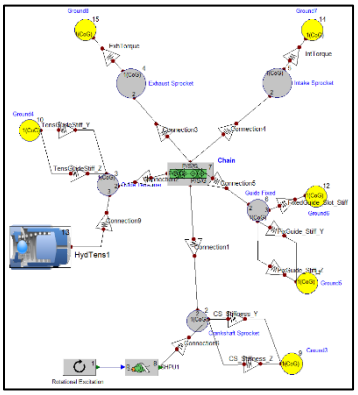
- Modeling General Mechanical Systems
- Overview of Macro Elements for Chains and Belts

Module 2
Application

1 Day

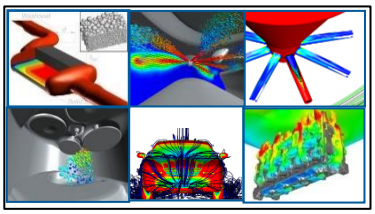
Modeling

- Setting up of Application Example
- Result Analysis
- Modeling General Hydraulic Systems



3.2.14 AVL FIRE™ Training Courses

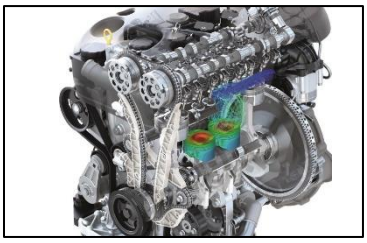
TFGP-01 / FIRE Basic (General Purpose)



Models:
900_Intake Manifold
952_Sliding Grid Interface: Rotating Object
901_FAME™ Hexa: Cooling Jacket

Module 1 Basic	Module 1 Basic	Module 1 Basic
1 Day	1 Day	1 Day
Introduction ▪ Introduction to AVL FIRE ▪ Basic Model Generation ▪ Mesh generation (for non-moving, steady geometries) ▪ Simulation setup – basics Postprocessing – basics	**Main features** ▪ Computational volume domain in FAME HEXA ▪ Advanced features, such as Sliding, MRF ▪ Basic model setup FIRE WM ▪ Post-processing in FIRE WM ▪ Self-working on example	**Other tools/features** ▪ Moving mesh concept ▪ Sliding, MRF ▪ Advanced simulation setup ▪ Optimizatio, formulas ▪ Impress chart post-processing

TFEN-01 / Fire Basic Training (Engine Related)



Models:
900_Intake_Manifold
923_ICE_FAME_Engine_Plus
922_ESE Diesel

Module 1 Basic	Module 1 Basic	Module 1 Basic
1 Day	1 Day	1 Day
Introduction ▪ Introduction to AVL FIRE ▪ Basic Model Generation ▪ Mesh generation (for non-moving, steady geometries) ▪ Simulation setup – basics ▪ Postprocessing – basics	**Advanced Feature** ▪ Extended Simulation Setup ▪ Typical boundary conditions, turbulence modeling, numerics ▪ Basic modeling generation for moving boundaries ▪ Mesh generation concepts for moving boundaries (especially engine-related)	**Advanced Feature** ▪ Continuation of topics from Day 2 ▪ Simulation setup and result analysis ▪ Open issues, answering questions, etc.

TFEN-03 / FIRE IC Engine – GDI Nozzle

Required pre-requisites: TFEN-01

Models:
979_GDI_Flash_Boiling

Module 2
Application

1 Day

Introduction

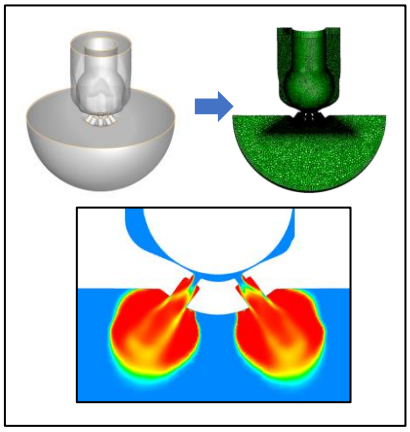
- FIRE™ M Nozzle flow Pre-processing capabilities
- Interactive meshing basics and modeling
- Block structured and automated meshing solution
- Mesh movement; moving mesh or movement by formula

Module 2
Application

1 Day

Multi-phase module

- GDI Nozzle flow simulation setup
- Performance Parameter: discharge rate, flow uniformity at the outlet, erosion probability, adhesion force model, flash boiling cavitation model
- Eulerian Multiphase Models, cavitation model, erosion model, nozzle interface
- Running and monitoring of the simulation
- Post-processing and Application specific 2D result analysis
- Optional demo: LaGrange spray coupling using the nozzle file as input on a simple spray-box geometry



TFEN-04 / FIRE IC Engine – Piston cooling Analysis

Required pre-requisites: TFEN-01

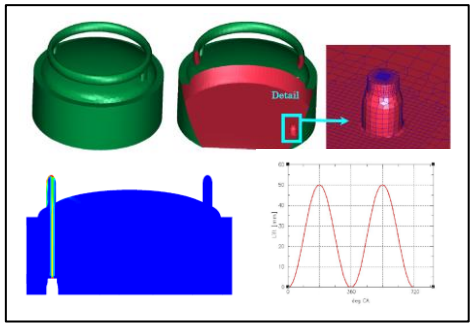
Models:
9400 Automatic Optimization Example

Module 2
Application

1 Day

Introduction and Simulation

- FIRE GUI basics, Pre- and Post-processing
- Calculation domain definition and generation
- Calculation preconditions, setup and initial calculation
- Simulation result analysis



TFEN-17 / FIRE IC Engine Aftertreatment - TWC & GPF

Required pre-requisites: TFEN-01

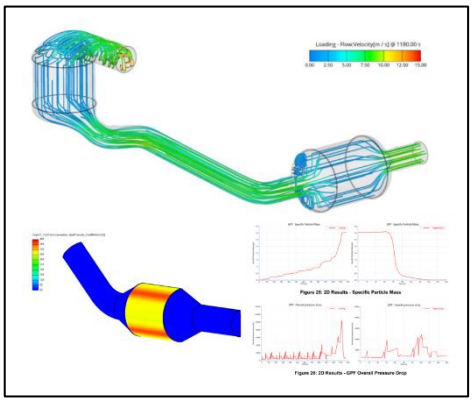
Models:
907_Catalyst
908_Gasoline_Particulate_Filter

Module 2
Application

1 Day

Introduction and Simulation

- Introduction to Aftertreatment Simulation (BOOST / CM / FIRE)
- Performance Parameter: Uniformity, Species Conversion, Soot Loading/Regeneration
- Introduction to Automatic Kinetic parametrization
- Model Generation (general approach)
- Exhaust Gas Aftertreatment Module
- Setup of Simulation Control File
- Result Analysis



TFEN-18 / FIRE IC Engine - Aftertreatment - SCR & DPF

Required pre-requisites: TFEN-01

Models:
909_Particulate_Filter
911_Diesel_Exhaust_System
924_Damaged_Particulate_Filter
932_Selective_Catalytic_Reactor

Module 2
Application

1 Day

Introduction and Simulation

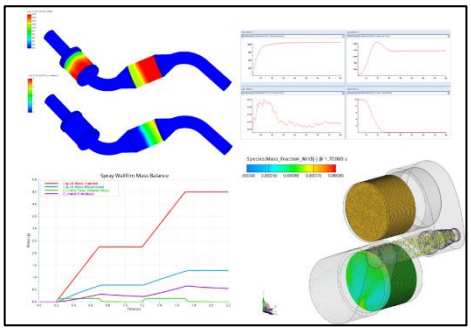
- Introduction to Aftertreatment Simulation (BOOST / CM / FIRE)
- SCR Simulation workflow: steady – transient, speed up
- Performance Parameter: AdBlue Injection, Uniformity of Ammonia, Wall film, Species Conversion, Deposits
- Model Generation (HD example approach)
- Exhaust Gas Aftertreatment Module, Lagrangian Multphase Module
- Setup of Simulation Control File
- Result Analysis

Module 2
Application

1 Day

Afertreatment module

- DPF Simulation workflow
- Performance Parameter: Pressure Drop, Loading / Regeneration of Soot, Temperature Gradients, Crack Risk
- Model Generation (DPF example approach)
- Exhaust Gas Aftertreatment Module
- Setup of Simulation Control File
- Result Analysis



TFEE-01 / FIRE (Module Specific) ESE Diesel GUI

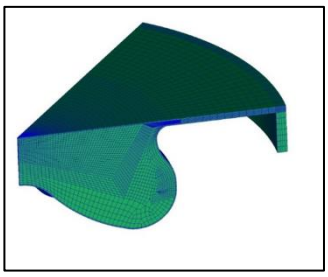
Models:
922_Ese_Diesel

Module 1
Basic

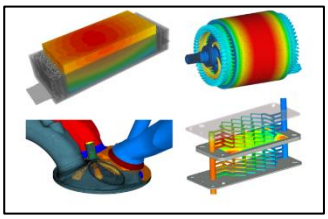
1 Day

Introduction and Basic Modeling

- Introduction to IC engine simulations
- Segment specification
- Model generation using ESE Diesel
- Geometry description
- Mesh generation options
- Compression volume, compensation volume
- Modeling centric / eccentric combustion chamber / injection nozzle
- Simulation setup
- Post-processing



3.2.15 AVL FIRE™ M Training Courses



TFIM-01 / FIRE M Basic

Models:
9102_Cooling Jacket.proj
9104_Parameters and Scenarios
9301_Cylinder Head
9303_Porosity
9103_Interactive Meshing

Module 1
Basic

1 Day

Introduction

- FIRE M GUI - Pre-processing
- Computational volume domain in FIRE M
- Basic model setup FIRE M
- Post-processing in IMPRESS M

Module 2
Basic

1 Day

Advanced features – Embedded body

- Simple setup of each user
- Advanced features as embedded body
- Introduction to Interactive meshing
- Embedding control with multiple meshes
- Model analysis

Module 3
Basic

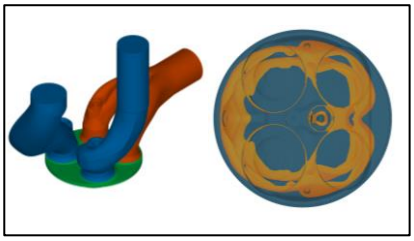
1 Day

Advanced features - Multi-domain

- Multi-material approach
- Multi-material setup, sliding moving mesh
- Checking simulation parameters and scenarios
- Advanced reporting in IMPRESS M
- Activating modules in FIREM GUI

TFME-01 / FIRE M Engine (GDI/ PFI/ Diesel Engine Related)

Required pre-requisites: TFIM-01, Module 1



Models:
9600_In-cylinder flow
9601_Fame Engine Pre-processing
9602_Fame Engine Post-processing
9603_Engine Automated workflow
9604_PFI Engine Automated workflow

Module 1
Application

1 Day

Pre-processing

- Model preparation
- Surface preparation
- Selection definition
- Movement prescription
- Mesh generation

Simulation Setup

- Template definition
- Boundary conditions
- Initial conditions
- Convergence criteria
- Underrelaxation
- Differencing schemes
- Turbulence modeling

Module 2
Application

1 Day

Physical Models

- Species transport
- Spray model
- Combustion / reaction model
- Emission model
- Knocking model
- Post-processing
- Result analysis

Post-processing

- Running simulations
- Simulation monitoring
- Post-processing
- Result analysis

TFME-02 / FIRE M IC Engine - Diesel Injection Nozzle
Required pre-requisites: TFME-01

Models:
9103_Interactive_Meshing.proj
9310_Diesel_Injector.proj
9312_Automated_Injector.proj

Module 2
Application

1 Day

Introduction

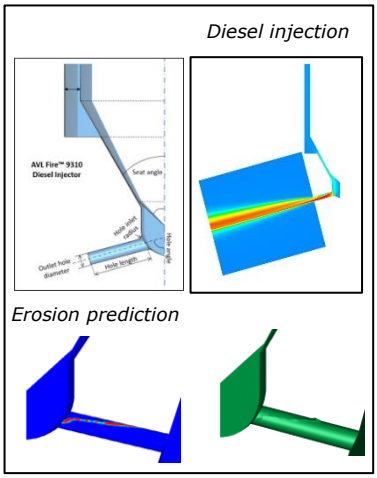
- FIRE™ M Nozzle flow Pre-processing capabilities
- Interactive meshing basic and modeling
- Block structured and automated meshing solution
- Mesh movement; moving mesh or movement by formula

Module 2
Application

1 Day

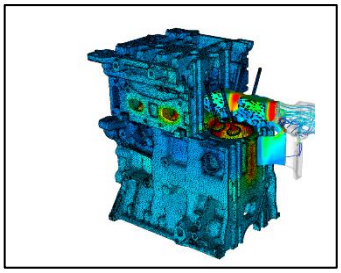
Multi-phase module

- Nozzle flow simulation setup
- Performance Parameter: discharge rate, flow uniformity at the outlet, cavitation intensity, erosion probability
- Eulerian Multiphase Models, cavitation model, erosion model, nozzle interface
- Running and monitoring of the simulation
- Post-processing and Application-specific 2D result analysis
- Optional demo: Lagrangian spray coupling using the nozzle file as input on a simple spray-box geometry



TFME-04 / FIRE M Head Block Compound
Required pre-requisites: TFME-01

Models:
9301_Cylinder_Head.proj
Internal training material: Foton GDI Engine
9520_HBC_Thermal_Load_Management.proj (will be released in R2022.1)
Internal training material: Foton GDI Engine



Module 2
Application

1 Day

Introduction

- Introduction of the HBC application and simulation specifics
- Heat transfer model parameters and influence on the results
- FIRE M GUI, Pre- and Post-processing
- Basic model setup with calculation tasks

Module 2
Application

1 Day

Modeling

- Preparation of HBC input model (CAD data)
- Multi-domain model generation
- Setup of the simulation
- Starting and monitoring Result analysis

Module 2
Application

1 Day

HBC module

- Introduction of the HBC transient operation and simulation specifics
- Preparation of input data (System level VTMS – 1D simulation)
- Preparation of input data (Cylinder Inner flow – 3D simulation)
- Setup of the HBC simulation
- Transient simulation-specific parameters
- Starting and monitoring of the simulation
- Result analysis
- Mapping of 3D AVL FIRE results to the FEM mesh

TFME-05 / FIRE M Liner Cavitation

Required pre-requisites: TFME-01

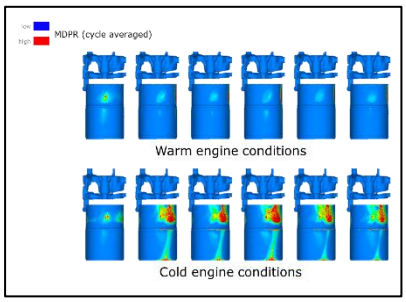
Models:
9506_Liner_Cavitation.proj

Module 2
Application

1 Day

Introduction and Simulation

- Introduction of the Liner Cavitation application and simulation specifics
- Preparation of excitation data (obtained with EX-CITE simulation)
- Setup of the simulation
- Simulation-specific parameters and their influence on the results
- Starting and monitoring of the simulation
- Result analysis



TFME-06 / FIRE M IC Engine - Intake Port Flow

Required pre-requisites: TFIM-01

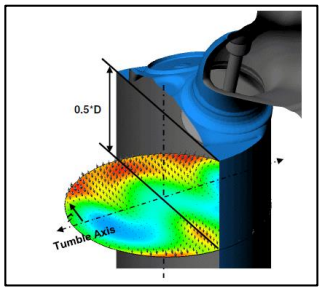
Models:
9502_Port Workflow

Module 2
Application

1 Day

Introduction and Modeling

- Introduction to port flow simulation
- Flow evaluation - parameters (discharge rate, swirl/tumble)
- Formulas
- Single model generation (Reference TFIM-01)
- Series of model generation
- Single and series simulation setup and running
- Result analysis



TFME-07 / FIRE M (Module-Specific) Eulerian Multiphase Module
Required pre-requisites: TFIM-01

Models:
9356_Tank_Filling.proj
9384_Embedded_Body_Gearbox.proj
9310_Diesel_Injector.proj

Module 2
Application

1 Day

Introduction

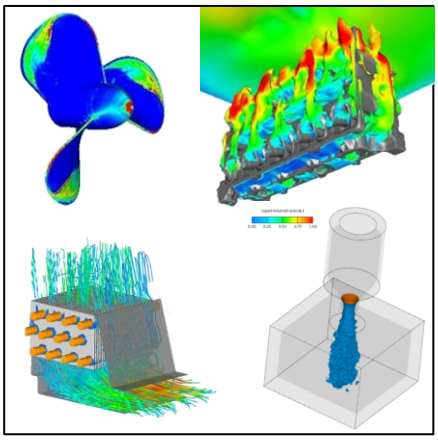
- Theory on Eulerian multi-phase module
- Available multi-phase specific modeling approaches in FIRE M
- Cavitation/Erosion model
- Quenching model
- Eulerian spray
- Melting/Solidification
- Basic example preparation

Module 2
Application

1 Day

Simulation

- Used example Pre-processing
- Calculation domain definition and generation
- Calculation preconditions, setup and initial calculation
- Simulation result analysis



TFME-08 / FIRE M (Module-Specific) Quenching
Required pre-requisites: TFIM-01

Models:
9307_Steel_Quenching.proj
9308_Quenching.proj
9309_RPI_Wall_Boiling.proj

Module 2
Application

1 Day

Introduction

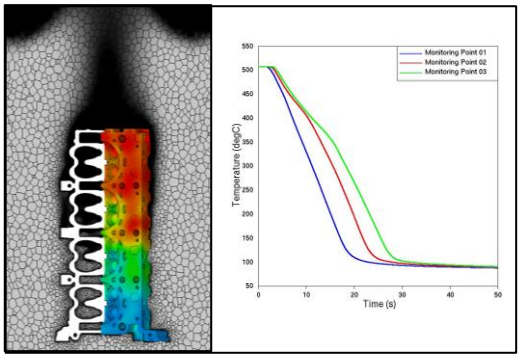
- Theory on Eulerian multi-phase module
- Available multi-phase specific modeling approaches in FIRE™ M
- Introduction into Quenching module
- Model preparation and Mesh generation
- Basic example preparation

Module 2
Application

1 Day

Simulation

- Used example Pre-processing
- Calculation domain definition and generation
- Calculation preconditions, setup and initial calculation
- Simulation result analysis



TFME-09 / FIRE M IC Engine - Aftertreatment - SCR

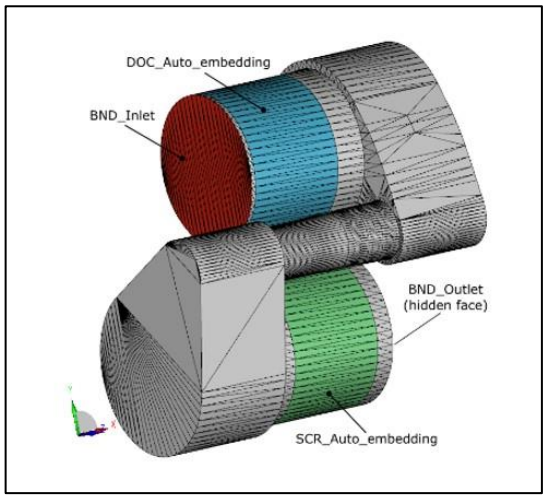
Models:
9305_Aftertreatment_AdBlue_SCR

Module 2
Application

1 Day

Introduction and Modeling

- Workflow Overview
- Preprocessing – Selection Creation
- Simulation Setup (Steady Case)
- Sim Postprocessing and Discussion ulation Setup (Transient Case)



TFMA-01 / FIRE M Automatic Optimization
Required pre-requisites: TFIM-01

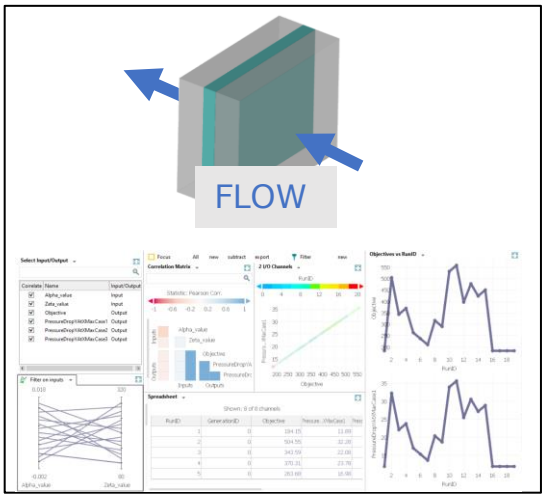
Models:
9400_Automatic Optimization Example

Module 2
Application

1 Day

Introduction and Modeling

- FIRE M GUI basics, Pre- and Post-processing
- Calculation domain definition and generation
- Calculation preconditions, setup and initial calculation
- Optimization setup and objective definition
- Optimization result analysis



3.2.16 AVL SAMOS™ Training Course

TSAM-01 / SAMOS Basic

Models:
Included in SAMOS-AT SW-Package: madlein.e00

Module 1
Basic

1 Day

Introduction and Theory

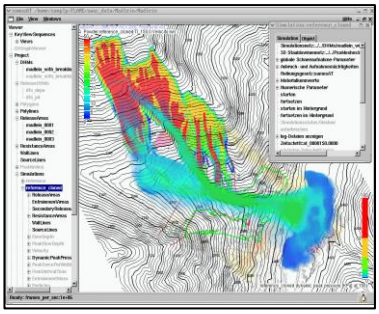
- Laws of Conservation and Fluid Mechanics
- Theory of Dense Flow Avalanches
- Theory of Powder Snow Avalanches
- Numerical Models

Module 1
Basic

1 Day

Theory

- General Software Handling
- Digital Terrain Models
- Release and Entrainment Area Definitions
- Dense Flow Simulation and Postprocessing
- Powder Snow Simulation and Postprocessing



3.2.17 Model.CONNECT™ Training Course

TCMO-01 / Model.CONNECT Basic

Models:
Primer.proj
CRUISE_M.proj
MATLAB.proj

Module 1
Basic

1 Day

Introduction

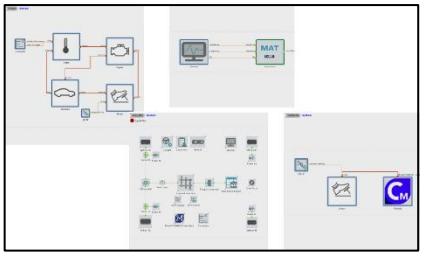
- Model.Connect presentation
- Model.Connect Basic and overview
- Inserting components
- Component properties
- Connecting components
- Simulation properties
- Online monitoring
- Run the simulation
- Results tab
- Debugging
- Case generation

Module 1
Basic

1 Day

Interfacing

- CruiseM interface
- MATLAB interfaces fmi.LAB



3.2.18 PreonLab™ Training Course

TPREO-01 / PreonLab Basic

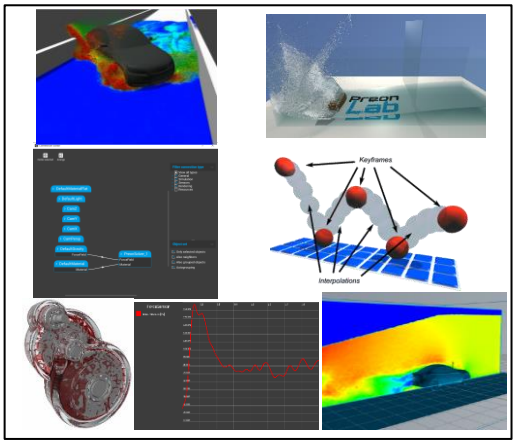
Models:
RainWaterManagement
Airflow.prscene
Drain.prscene
GearBox_RBS Geometries

Module 1
Basic

1 Day

Basic Introduction

- Introduction
- Solver
- Boundary handling
- PreonLab basic usage
- Sources
- Connections
- Keyframes
- Visualizations
- Force fields
- Sensors
- Rigid body GearBox



TPYT-01 / Python Basic

Module 1
Basic

1 Day

Introduction

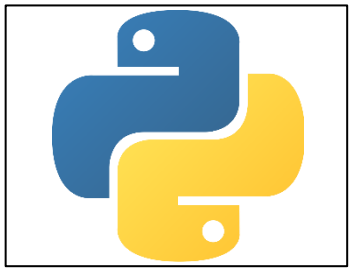
- Introduction
- Overview of the Language
- Python Data Types
- Control Statements

Module 1
Basic

1 Day

Theory

- Input/Output Facilities
- Functions and Modules
- Object Oriented Programming
- Working Session

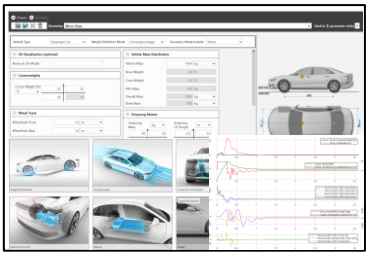


3.2.19 AVL VSM™ Training Courses

TVSM-01 / VSM Basic

Models:
Template VSM models (various)
Manage_Simulink_Parameters.zip
Battery.zip
KnC_Neutral_Example.zip
Simulink_inplementation.zip
HV_Battery_Example_Extended.zip

RDE
Vehicle_Model_Factory_Example.zip
Hydro_Engine_Mounts.7z
Sequence_and_Simbook.7z
HV_Battery_Example_Base.zip



Module 1
Basic

1 Day

Introduction & Setups

- Introduction to Applications
- VSM Basics/Workflow
- Setups: Vehicle Geometry & Aerodynamics
- Setups: Suspension & Compliance
- Setups: Tyre & Tyre Plotter

Module 1
Basic

1 Day

Setups (cont.) & Track Generation

- Setups: Spring & Damper & Anti-Roll Bar
- Setups: Bumpstop & Rebound Limiter
- Setups: Drivetrain & Engine
- Setups: Hybrid & Electric Motor, Electric Controller, Battery
- Track Generation
- 3D Viever

Module 1
Basic

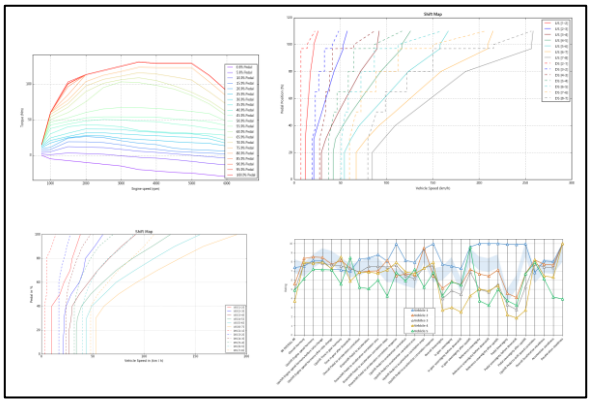
1 Day

Applications

- Driver Setup
- Variation
- Results & Postprocessing
- VSM Matlab Simulink
- VSM Vehicle Model Factory

3.2.20 AVL SPA™ Training Courses

TSPA-01 / SPA Basic



Module 1
Basic

1 Day

Introduction an application

- What is AVL SPA
- SPA GUI
- Basic model setup
- Criteria Introduction
- Rating Improvement
- Report Generation

3.3 Non-Standard Software Training

Beside the standard training courses, AVL AST offers non-standard training courses for specific customer interests that are based on customer models as on-the-job training.

Such training courses are treated as separate projects. Content, duration, and price will be defined individually according to the specific needs and requests. A separate project proposal will be given by AVL AST (refer also to **chapter 5**).

Non-standard training is offered for advanced simulation solutions for virtual development and for the following solution areas:

For further information or a specific project proposal, contact your responsible AST Sales Manager.

Contact	
Additional Information	Responsible Sales Manager
Proposal	Responsible Sales Manager

3.4 Software Support

Software support at AST is organized according to the AST Global Customer Support Process (GCSP).

The GCSP defines the process steps for answering all regular customer questions and requests related to AVL AST software products. The defined process does not cover customer contact which takes place within project work or joint research developments.

The GCSP includes a level concept:

- 1st level support is done by local AST affiliates (if no local affiliate is available, 1st level support is done by AST in Graz)
- 2nd level support by AST headquarters in Graz

AST offers support by email. Telephone support is offered for 1st level support at some AST affiliates. Telephone support is not given by AST in Graz or for 2nd level support generally.

For each product or product group, a Support Master is defined. He/she is responsible for all related support requests and distributes the support requests to the different support engineers.

To receive software support, it is mandatory to have a valid maintenance contract and to have participated in a related training course held by AVL. Within the partnership programs UPP ("university partnership program") and RPP ("research partnership program"), a dedicated person is defined. He/she acts as a contact person to our support organization.

ID	Service
CC_33	Software Support

Purpose:

Software support via email is the single point of contact for customers regarding software-related issues (beside sales information).

AST support engineers are highly experienced calculation engineers, who also perform software training and project work in simulation projects within AVL's engine development process or separate pilot, validation, or method development projects for customers.

Validity:

The CSP is defined worldwide and is valid for all AVL AST software tools.

Content:

- Answer software-related questions
- Take over change requests or enhancement requests from customers and transfer them to development and product management

Goals:

- Help the customer with daily problems
- Improve product quality and customer satisfaction
- Support development with information about customer needs and recommendations
- Improve the relationship with the customer

Customer Benefit:

- One contact for all software-related questions
- Application know-how of all AST support engineers

Duration:

- 30 hours per year of software support is included with each license.
- If this limit is exceeded, it will be charged separately and treated as consulting or project work.

Price (excl. Tax):

Software support via email is free of charge for every customer of AST products.

Contact	
About the Process	Customer Support Manager – Christian Vock (christian.vock@avl.com)
Who is my Local Support?	Please contact your local sales manager or local support via email.

Further information:

- Customer Support Process --> An overview of the GCSP is given in Appendix 7.1.

4. Know-How Transfer & Engineering Support

This service group sets its focus on engineering know-how and its transfer to the customer.

Contact	
Additional Information	Responsible Sales Manager
Proposal	Responsible Sales Manager

4.1 Technology Seminars

Technology seminars are organized as TechDays by AST Graz or a local affiliate. They can be performed for a specific customer and at the customer location, or as a corporate event where different customers can participate.

ID	Service
CC_41	Technology Seminars / TechDays

Purpose:

Within the frame of a technology seminar, a specific engineering topic and application field is discussed, including theoretical background, application field, problems, and solutions. The focus is set on simulation-related problems and solutions.

Validity:

All engineering topics, which are connected to AST software products, can be addressed. Although the seminar content is kept more general and not focused on AST products, AST-specific solutions and benefits are presented as AST know-how is based on those methods and tools.

Content:

- Definition of the entire topic
- Theoretical background
- Components and functionality
- Problems and engineering tasks, which have to be solved
- Technical solutions and applied methods

Goals:

- Generate understanding of the engineering topic
- Transfer of application know-how for the specific topic
- Understanding of cross effects

Customer Benefit:

- Compressed know-how transfer of cutting-edge technology for a specific application field

Duration:

- The duration depends on the specific topic, but it is typically between 1 and 3 days.

Price (excl. Tax): * see chapter 2.1

♦ Seminar fee for a TechDay starts from **350 euro** per participant and it may vary..

4.2 Engineering Support

This module focuses mainly on the usage of AVL AST software products in daily life and real development projects, including the interpretation of results and dealing with variants (*application-oriented*).

Specific services are:

- Start-up support
- Enhancement support
- Consulting
- Software customization and specific software development

4.2.1 Start-up Support

ID	Service
CC_421	Start-up Support

Purpose:

Start-up support is on-the-job training for a standard application using a specific customer model. It is organized as a separate project for a defined period of time. The target is to get started with a real application example. Start-up support can be performed at AST in Graz, entirely or partly at the customer location. Typically, AST performs the main steps of the investigation and afterwards re-performs each step on site together with the customer. AST makes use of these models and results for a detailed explanation of each work step.

Validity:

Start-up support is offered for all standard applications and all AST products. Standard applications refer to the standard training courses offered by AST.

An input sheet defining all required data and models is sent to the customer in advance.

Content:

- Explanation of the workflow and all work steps
- Setup of necessary models, performing analysis, evaluation and interpretation of results
- Explanation of the introduction of modifications
- Hints and significant information about the application
- The workflow and the entire work performed will be documented in a report.

Goals:

- The entire workflow performed
- The customer can perform the specific application by him/herself.

Customer Benefit:

- Knowledge transfer from AVL for standard application
- Usage of customer models
- The customer becoming skilled with the new tool and application in a short time
- Maximum training effect

Duration:

- The duration of start-up support is **8 to 10 weeks**.
- 3 weeks of this period are defined as the customer and the AVL engineers working together. This can be either held at AVL in Graz or at the customer location.
- The specific customer model should be sent to AST about 2 weeks in advance to ensure that the AST engineer gets familiar with the model and performs all the necessary modifications to the model or defines these modifications.
- The main work steps are done by AVL separately to keep the on-site period at maximum efficiency. All work performed is documented and explained.

Price (excl. Tax):

The total cost is in the range of **22,000 to 55,000 euro** (depending on the application and the complexity of work). Travel and accommodation for the AVL engineer are charged separately.

4.2.2 Enhancement Support

Enhancement support is offered to experienced users of AVL AST software tools. Within this module, know-how about very specific new features or methods is investigated, transferred to the customer, and implemented into the specific development process.

Enhancement support is guided by a specific model and application using customer-specific data. A comparison to the previous methods and validation by measurements could be part of this work.

ID	Service
CC_422	Enhancement Support

Enhancement support is on-the-job training for the usage of a new feature or method, offered by AST software, using a specific customer model. It is organized as a separate project for a defined period of time. The target is to integrate this feature or method into the customer-specific application work.

Enhancement support can be performed at AST in Graz or at the customer location.

The specific customer model should be sent to AST about 2 weeks in advance to ensure that the AST engineer gets familiar with the model and performs all the necessary modifications to the model or defines these modifications. Model requirements are sent to the customer in advance.

Validity:

Enhancement support is offered for all AST products.

Content:

- Explanation about functionality of the feature and the method
- Update of the customer-specific methodology and workflow
- Application on a customer model
- Comparison of the old and new workflow, model changes and results
- Hints and significant information

Goals:

- Detailed know-how transfer of new features and methods
- The customer can perform the specific application by himself/herself.

Customer Benefit:

- Knowledge transfer from AVL for new features and methods
- Usage of customer models
- The customer becoming skilled with the new features and methods in a short time
- Maximum training effect

Duration:

- The duration of enhancement support is **1 to 5 weeks**.
- The entire period is defined as the customer and the AVL engineer working together. This can be either held at AVL in Graz or at the customer location.

Price (excl. Tax): * see chapter 2.1

The price for one AST engineer for 1 week (5 full working days) at the customer location and the preparation phase is:

- Preparation phase: **3500 euro*** see chapter 2.1
- **7000 euro per week**; excl. travel and accommodation* see chapter 2.1

Travel and accommodation for the AVL engineer are charged separately.

4.2.3 Consulting

This module describes the possibility to book highly skilled and experienced engineers from AST for a defined period of time for work at the customer location.

ID	Service
CC_423	Consulting

Purpose:

AST offers on-site work of highly skilled and experienced engineers for various advanced applications using AST tools.

Any specific material, such as the models or results for the on-site work, should be sent to AST at least 2 weeks in advance so that the AST engineer can be well prepared to increase the efficiency of the on-site work.

Validity:

Consulting work is valid for all applications where AST tools are the main simulation tools and which are covered by training and support activities from AST.

Content:

- AST engineers can be booked for a period of days, weeks or longer.
- The customer also has the possibility to book a contingent of hours or days, which is valid for a period of 1 year. Within this year, the agreed amount of time can be used whenever it is required. On-site work has to be purchased at least 2 weeks before the trip.

Goals:

- AST engineers work at the customer location in close cooperation with local engineers.

Customer Benefit:

- Problem investigation by experienced AST engineers
- Usage of the latest methodology and features of AST software
- Know-how transfer to customer engineers; integration of methods into a specific development process
- A fast solution of pending problems; direct contact to software developers
- Extends capacity on the customer side

Duration:

Depending on the definition.

Price (excl. Tax): * see chapter 2.1

The total price for one AST engineer for 1 full day at the customer location is:

- **1350 euro**; excl. travel and accommodation * see chapter 2.1
- **2000 euro** (in Europe), including travel and accommodation * see chapter 2.1

Preparation work is included in the given price.

4.2.4 Software Customization and Specific Software Development

AST offers the possibility to customize its software according to the specific needs and requirements of the customer. AVL AST software offers various options for **customization** (depending on the features and interfaces of the specific software tool), such as:

- Creation of template models
- User functions
- Macros
- APPs and Workflows using COMPOSE
- Python scripts (i.e. for post-processing)
- MATLAB models, using existing interfaces
- FMU models, using existing interfaces
- EXCEL templates (e.g. for pre-processing)

Update of the general GUI and kernel is not part of this service, although this service can be offered as **customer-specific software development**. In such cases, a separate agreement has to be made. The new features and enhancements will be implemented in subsequent releases of the standard AST release. AVL grants the customer an exclusive use of the developed features for a period of 6 months after receiving a written approval of the extension from the customer. AST will also guarantee the compatibility of the developed feature for subsequent releases if it is part of the standard AST release.

ID	Service
CC_424	Software Customization

Purpose:

AST offers the possibility to customize its software according to the specific needs and requirements of the customer. Work is typically done at AST. A training on the usage and implementation of the customized part is included.

Validity:

Software customization is valid for all features developed for customization, offered for a specific AST tool (see above). Customer-specific software development is treated separately.

Content:

- A setup of customer-specific functionality
- Testing of the new functionality using a standard model or a customer model
- Training about the usage and implementation of the new functionality

Goals:

- Customized functionality ready to use
- Know-how transfer of the usage, modification, and implementation of the functionality

Customer Benefit:

- Implement customer-specific solutions
- Independent from the regular release cycle

Duration:

- This depends on the complexity of the requirement. Minimum effort is in the range of 1 week.

Price (excl. Tax): * see chapter 2.1

The total price for one AST engineer for 1 full day is:

- **1350 euro (at AVL AST in Graz)** * see chapter 2.1

The total price of the final training and know-how transfer (1 day) is:

- **2000 euro** (in Europe), including travel and accommodation* see chapter 2.1

5. Project Work

In addition to the services described in the previous chapters, we provide services for the improvement of the applied methods and for the development of new simulation methods in close cooperation with the customer, up to complex project work, including simulation-measurement comparison for validation of methods or taking over design responsibility.

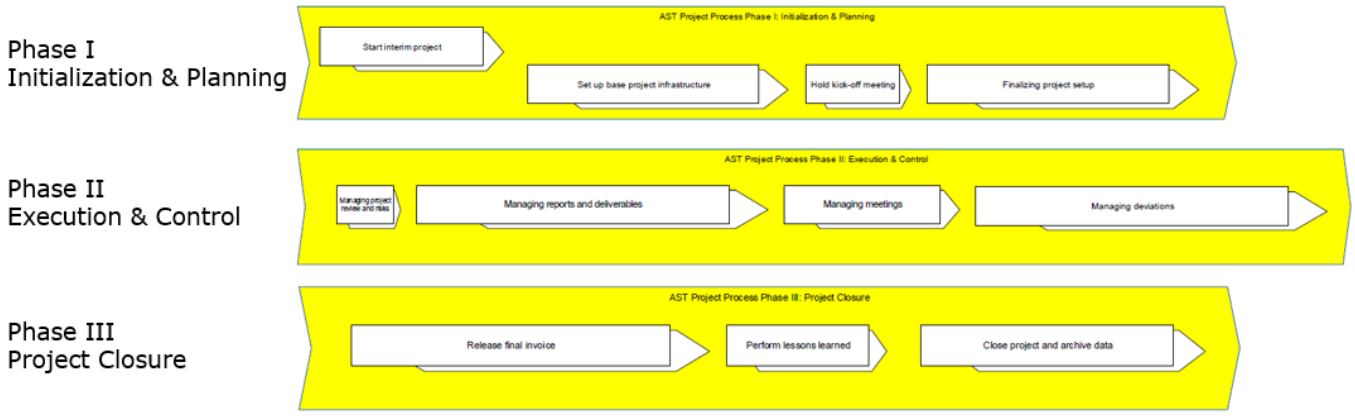
AST offers a wide range of simulation project work using analytical and numerical methods in the field of mobility and non-mobility industry. Applications use software products, serviced by AST, as well as different third-party tools.

Simulation work is offered for:

- Structural mechanics and dynamics applications
- Thermo-fluid dynamics in 0D/1D and 3D
- 3D CFD applications using FV and SPH approaches
- 2D and 3D electro-magnetic and electro-chemical applications
- Multi-body dynamics for durability and NVH
- 0D/1D mechanical, electrical, and hydraulic system simulation
- MiL / SiL applications in office and on RT-platforms
- HiL integration with xCUs
- Multiphysics applications and co-simulations between differet domains and approaches

The project can cover the entire simulation, including model setup, definition of boundary conditions, analysis and result evaluation and interpretation. AST will give clear conclusions and recommendations on the analysis performed and the investigated design.

Each project is performed according to the **AST project process** (PP), guided by continuous documentation and finalized by a report describing all steps, the models used, and the results obtained. Optionally, know-how transfer is done at the end of the project.



Typical project definitions are:

- Development of new methodologies
- Increase of efficiency and advanced solutions
- Validation projects, including comparison to measurements
- Implementation of new methods into the development process (process integration)
- Research and development (R&D) projects
- Dedicated projects or joint and research (J&R) projects

Measurements for validation can be performed at AVL, at the customer location, or by a third-party supplier.

Projects can be performed by AST alone or together with the customer (sharing the work) as joint and research projects (J&R).

For further information or a specific project proposal, contact your responsible AST Sales Manager.

6. Model Identification

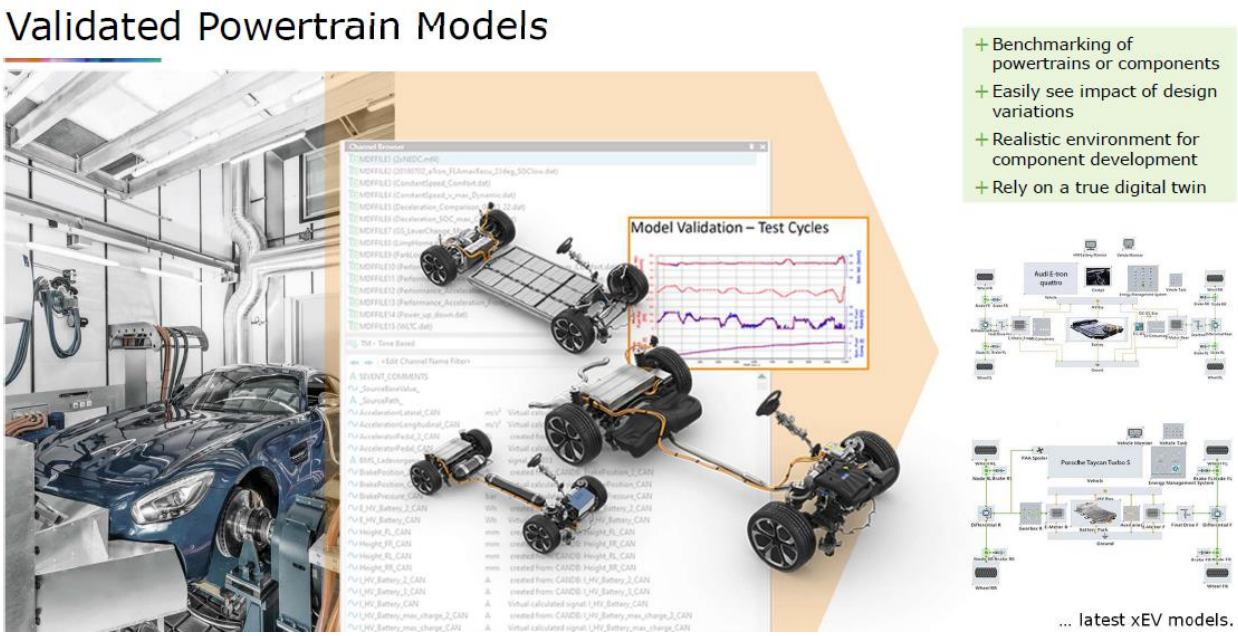
Within this service, AST takes care of specific measurements and the generation of fully parameterized and validated simulation models. Measurements are either done at and by AVL, or by selected partners.

Examples for possible measurements:

- **Surface Measurement** and Contact Data Extraction - EXCITE Micro-slide Analysis (EXCITE Power Unit EHD or EPIL joints; EXCITE Piston & Rings contact models)
- **Belt Characteristics Measurement** of a Poly-V Belt (EXCITE Timing Drive)
- **Engine or Transmission Mount Characteristics** – static (0-50Hz) and dynamic mount characteristic (50-~1-2kHz) (EXCITE Power Unit)
- **Dual Mass Flywheel Characteristics** - DMF's parameters like basic hysteresis, quasi-static characteristics, and dynamic stiffness characteristics (EXCITE Power Unit or Timing Drive)

7. Validated Powertrain Models

AVL offers different **validated CRUISE M powertrain models**, based on benchmarking data, or creates such models, based on the data provided by the customer.



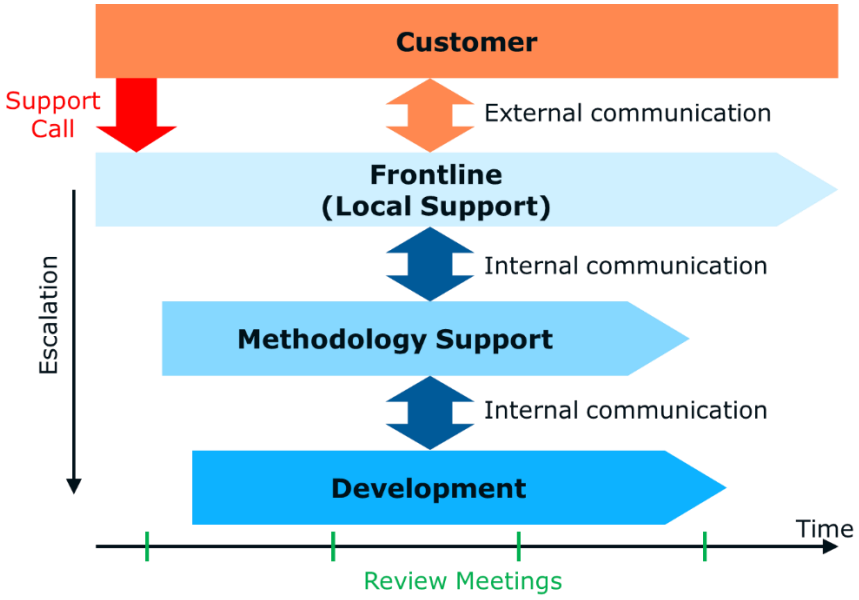
For further information or a specific project proposal, contact your responsible AST Sales Manager.

8. Appendix

8.1 AST Global Customer Support Process (GCSP)

- The GCSP defines the process steps for handling all customer questions and requests related to the usage of the software products maintained by AVL AST.
- It describes all interactions between the customer, the frontline team (local affiliate support team), the methodology support team at the service base, and the development team during the handling of support cases.
- The GCSP defines when and how a development request is generated out of a support case.

These main functions are summarized in the following figure:



GCSP: Basic Process

8.1.1 Local Point of Contact

The local support teams at the affiliates collect all customer requests. They are also responsible for the entire communication between the customer and the AVL support. Information about the contacts within our service organization can be found in chapter **3.4** or on the AVL homepage http://www.avl.com/hotlines.

8.1.2 Level Concept

The AST GCSP has different levels.

- Frontline support (1st level) is done by local AST affiliates (if no local affiliate is available, 1st level support is done by AST Service Base)
- Methodology support (2nd level) is done by AST Service Base

For each Support Team (individual for different products/ product groups and locations), a Support Master is defined. He/she is responsible for all related support requests and distributes the support requests to the different support engineers.

8.1.3 Escalation Model

The escalation depends on the time scale and the category of the support case.

The escalation model defines the treatment of critical support cases, which require special effort and extended capacity. The escalation is done based on regular review meetings by the review team, which includes the support masters, local and global support managers, and the people responsible for a specific application area.

Main Target:

- Identify possible high importance problems in an early phase of the support chain in order to define the necessary measures before the problem escalates between the customer and AVL.
- Possible measures are providing the necessary capacity and shifting priority between other tasks.

Training courses 2023 - Graz

January	February	March	April	May	June
1 S National Holiday	1 W EXCITE Designer; CRUISE	1 W Battery and Range Extended Electric Vehicle	1 S	1 M National Holiday 18	1 T
2 M 1	2 T EXCITE Designer	2 T Battery and Range Extended Electric Vehicle	2 S	2 T	2 F
3 T	3 F	3 F	3 M 14	3 W	3 S
4 W	4 S	4 S	4 T EXCITE Power Unit	4 T	4 S
5 T	5 S	5 S	5 W EXCITE Power Unit	5 F	5 M 23
6 F National Holiday	6 M Model.CONNECT 6	6 M 10	6 T	6 S	6 T
7 S	7 T Model.CONNECT	7 T PMSM E-Machine Electromagnetics and Thermal Investigation	7 F	7 S	7 W
8 S	8 W	8 W PMSM E-Machine Electromagnetics and Thermal Investigation	8 S	8 M 19	8 T National Holiday
9 M 2	9 T	9 T PMSM E-Machine Electromagnetics and Thermal Inves-	9 S	9 T FIRE M	9 F
10 T	10 F	10 F	10 M National Holiday 15	10 W FIRE M	10 S
11 W	11 S	11 S	11 T Fuel Cell Electric Vehicle	11 T FIRE M	11 S
12 T	12 S	12 S	12 W Fuel Cell Electric Vehicle	12 F	12 M 24
13 F	13 M CRUISE M Engineering Enhanced 7	13 M 11	13 T Fuel Cell Electric Vehicle	13 S	13 T
14 S	14 T VSM; CRUISE M Engineering Enhanced	14 T E-Machine NVH Analysis with Electrical Network	14 F	14 S	14 W
15 S	15 W VSM; CRUISE M Engineering Enhanced	15 W E-Machine NVH Analysis with Electrical Network	15 S	15 M 20	15 T
16 M 3	16 T VSM	16 T PreonLab	16 S	16 T BEV with HVAC	16 F
17 T CRUISE M Engine	17 F	17 F	17 M 16	17 W BEV with HVAC	17 S
18 W CRUISE M Engine	18 S	18 S	18 T	18 T National Holiday	18 S
19 T CRUISE M Engine	19 S	19 S	19 W PEM Fuel Cell Module	19 F	19 M 25
20 F	20 M 8	20 M 12	20 T PEM Fuel Cell Module	20 S	20 T
21 S	21 T EXCITE Piston & Rings; BOOST	21 T FIRE SAMOS	21 F PEM Fuel Cell Module	21 S	21 W
22 S	22 W EXCITE Piston & Rings; BOOST	22 W FIRE SAMOS; E-Axle NVH and Durability	22 S	22 M 21	22 T
23 M 4	23 T BOOST	23 T E-Axle NVH and Durability (AWS based)	23 S	23 T Hybrid Electric Vehicle Concept Finding & Layout	23 F
24 T EXCITE Timing Drive; FIRE	24 F	24 F	24 M 17	24 W Hybrid Electric Vehicle Concept Finding & Layout	24 S
25 W EXCITE Timing Drive; FIRE	25 S	25 S	25 T Electric Machine Rotor-Dynamics	25 T Hybrid Electric Vehicle Concept Finding & Layout	25 S
26 T FIRE	26 S	26 S	26 W Electric Machine Rotor-Dynamics	26 F	26 M 26
27 F	27 M 9	27 M Battery Thermal and Hazard Investigation 13	27 T	27 S	27 T EXCITE Timing Drive
28 S	28 T Battery and Range Extended Electric Vehicle	28 T Battery Thermal and Hazard Investigation	28 F	28 S	28 W EXCITE Timing Drive
29 S		29 W Battery Thermal and Hazard Investigation	29 S	29 M National Holiday 22	29 T
30 M 5		30 T Battery Thermal and Hazard Investigation	30 S	30 T	30 F
31 T CRUISE		31 F		31 W	

Training courses 2023 –Graz

July	August	September	October	November	December
1 S	1 T	1 F	1 S	1 W National Holiday	1 F
2 S	2 W	2 S	2 M 40	2 T	2 S
3 M 27	3 T	3 S	3 T CRUISE M Engine	3 F	3 S
4 T	4 F	4 M 36	4 W CRUISE M Engine	4 S	4 M E-Machine NVH Analysis with Electrical Network 50
5 W	5 S	5 T PMSM E-Machine Electromagnetics and Thermal Investigation	5 T CRUISE M Engine	5 S	5 T E-Machine NVH Analysis with Electrical Network
6 T	6 S	6 W PMSM E-Machine Electromagnetics and Thermal Investigation	6 F	6 M 45	6 W
7 F	7 M 32	7 T PMSM E-Machine Electromagnetics and Thermal Investigation	7 S	7 T Model.CONNECT	7 T
8 S	8 T	8 F	8 S	8 W Model.CONNECT	8 F National Holiday
9 S	9 W	9 S	9 M Battery Thermal and Hazard Investigation 41	9 T	9 S
10 M 28	10 T	10 S	10 T Battery Thermal and Hazard Investigation	10 F	10 S
11 T	11 F	11 M 37	11 W Battery Thermal and Hazard Investigation	11 S	11 M 50
12 W	12 S	12 T CRUISE / PEM Fuel Cell Module	12 T Battery Thermal and Hazard Investigation	12 S	12 T Fuel Cell Electric Vehicle
13 T	11 S	13 W CRUISE / PEM Fuel Cell Module	13 F	13 M 46	13 W Fuel Cell Electric Vehicle
14 F	14 M 33	14 T PEM Fuel Cell Module	14 S	14 T E-Axle NVH and Durability (AWS based)	14 T Fuel Cell Electric Vehicle
15 S	15 T National Holiday	15 F	15 S	15 W E-Axle NVH and Durability (AWS based)	15 F
16 S	16 W	16 S	16 M FIRE M 42	16 T	16 S
17 M 29	17 T	17 S	17 T FIRE M / Electric Machine Rotor-Dynamics	17 F	17 S
18 T	18 F	18 M EXCITE Designer 38	18 W FIRE M / Electric Machine Rotor-Dynamics	18 S	18 M Hybrid Electric Vehicle Concept Finding & Layout 51
19 W	19 S	19 T VSM / EXCITE Designer	19 T PreonLab	19 S	19 T Hybrid Electric Vehicle Concept Finding & Layout
20 T	20 S	20 W VSM	20 F	20 M 47	20 W Hybrid Electric Vehicle Concept Finding & Layout
21 F	21 M 34	21 T VSM	21 S	21 T Battery and Range Extended Electric Vehicle	21 T
22 S	22 T	22 F	22 S	22 W Battery and Range Extended Electric Vehicle	22 F
23 S	23 W	23 S	23 M EXCITE Power Unit 43	23 T Battery and Range Extended Electric Vehicle	23 S
24 M 30	24 T	24 S	24 T EXCITE Power Unit	24 F	24 S
25 T	25 F	25 M 39	25 W	25 S	25 M National Holiday 52
26 W	26 S	26 T EXCITE Piston & Rings	26 T National Holiday	26 S	26 T National Holiday
27 T	27 S	27 W EXCITE Piston & Rings	27 F	27 M 48	27 W
28 F	28 M 35	28 T	28 S	28 T FIRE	28 T
29 S	29 T	29 F	29 S	29 W FIRE / CRUISE M Mobile A/C Basic	29 F
30 S	30 W	30 S	30 M 44	30 T FIRE / CRUISE M Mobile A/C Basic	30 S
31 M 31	31 T		31 T		31 S National Holiday

Training courses 2023 - France

January	February	March	April	May	June	July	August	September	October	November	December
1 S National Holiday	1 W CRUISE M	1 W	1 S	1 M National Holiday 18	1 T	1 S	1 T	1 F	1 S	1 W National Holiday	1 F
2 M 1	2 T CRUISE M	2 T	2 S	2 T	2 F	2 S	2 W	2 S	2 M 40	2 T	2 S
3 T	3 F	3 F	3 M 14	3 W	3 S	3 M 27	3 T	3 S	3 T	3 F	3 S
4 W	4 S	4 S	4 T	4 T	4 S	4 T	4 F	4 M 36	4 W PREONLAB	4 S	4 M 49
5 T	5 S	5 S	5 W	5 F	5 M 23	5 W	5 S	5 T	5 T PREONLAB	5 S	5 T
6 F National Holiday	6 M 6	6 M 10	6 T	6 S	6 T	6 T	6 S	6 W	6 F	6 M 45	6 W
7 S	7 T	7 T	7 F	7 S	7 W	7 F	7 M 32	7 T	7 S	7 T	7 T
8 S	8 W PREONLAB	8 W Model.CONNECT	8 S	8 M 19	8 T National Holiday	8 S	8 T	8 F	8 S	8 W	8 F National Holiday
9 M 2	9 T PREONLAB	9 T Model.CONNECT	9 S	9 T	9 F	9 S	9 W	9 S	9 M 41	9 T	9 S
10 T	10 F	10 F	10 M National Holiday 15	10 W	10 S	10 M 28	10 T	10 S	10 T	10 F	10 S
11 W	11 S	11 S	11 T	11 T	11 S	11 T	11 F	11 M 37	11 W	11 S	11 M 50
12 T	12 S	12 S	12 W	12 F	12 M 24	12 W	12 S	12 T	12 T	12 S	12 T
13 F	13 M 7	13 M 11	13 T	13 S	13 T	13 T	11 S	13 W EXCITE eAxle	13 F	13 M 46	13 W
14 S	14 T	14 T	14 F	14 S	14 W	14 F	14 M 33	14 T EXCITE eAxle	14 S	14 T	14 T
15 S	15 W	15 W	15 S	15 M 20	15 T	15 S	15 T National Holiday	15 F	15 S	15 W	15 F
16 M 3	16 T	16 T	16 S	16 T	16 F	16 S	16 W	16 S	16 M 42	16 T	16 S
17 T	17 F	17 F	17 M 16	17 W	17 S	17 M 29	17 T	17 S	17 T	17 F	17 S
18 W EXCITE eAxle	18 S	18 S	18 T	18 T National Holiday	18 S	18 T	18 F	18 M 38	18 W Model.CONNECT	18 S	18 M 51
19 T EXCITE eAxle	19 S	19 S	19 W	19 F	19 M 25	19 W	19 S	19 T	19 T Model.CONNECT	19 S	19 T
20 F	20 M 8	20 M 12	20 T	20 S	20 T	20 T	20 S	20 W FIRE M	20 F	20 M 47	20 W
21 S	21 T	21 T	21 F	21 S	21 W	21 F	21 M 34	21 T FIRE M	21 S	21 T	21 T
22 S	22 W	22 W	22 S	22 M 21	22 T	22 S	22 T	22 F	22 S	22 W	22 F
23 M 4	23 T	23 T	23 S	23 T	23 F	23 S	23 W	23 S	23 M 43	23 T	23 S
24 T	24 F	24 F	24 M 17	24 W	24 S	24 M 30	24 T	24 S	24 T	24 F	24 S
25 W FIRE M	25 S	25 S	25 T	25 T	25 S	25 T	25 F	25 M 39	25 W	25 S	25 M National Holiday 52
26 T FIRE M	26 S	26 S	26 W	26 F	26 M 26	26 W	26 S	26 T	26 T National Holiday	26 S	26 T National Holiday
27 F	27 M 9	27 M 13	27 T	27 S	27 T	27 T	27 S	27 W CRUISE M	27 F	27 M 48	27 W
28 S	28 T	28 T	28 F	28 S	28 W	28 F	28 M 35	28 T CRUISE M	28 S	28 T	28 T
29 S		29 W	29 S	29 M National Holiday 22	29 T	29 S	29 T	29 F	29 S	29 W	29 F
30 M 5		30 T	30 S	30 T	30 F	30 S	30 W	30 S	30 M 44	30 T	30 S
31 T		31 F		31 W		31 M 31	31 T		31 T		31 S National Holiday