INTEGRATION OF POWERTRAIN SIMULATION SOFTWARE INTO DESIGN ASSISTANCE SYSTEM

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Outline

- Introduction
- Concept of Design Assistance System DASY
- Current state of DASY development
- Involvement of simulation software into DASY and examples of simple codes
- Examples of Parametric Models
- Benefits of DASY
- Conclusion

Introduction

Position of Automotive Industry in the Czech Republic

- 3 car OEMs, 2 bus OEMs, 1 for off-road trucks, 1 for tractors. Skoda Auto (VW) and HD OEMs with their own in-house research.
- 30 big component suppliers, 10 of them with R&D. Research branches of foreign companies (Ricardo Prague, PES Prague, mbTech Bohemia, IDIADA, etc.
- 10 inhabitants/vehicle produced in CZ (incl. buses) in comparison to Australia 80 inhabitants/vehicle. Altogether 20% of industrial production volume and 22% of CZ export volume

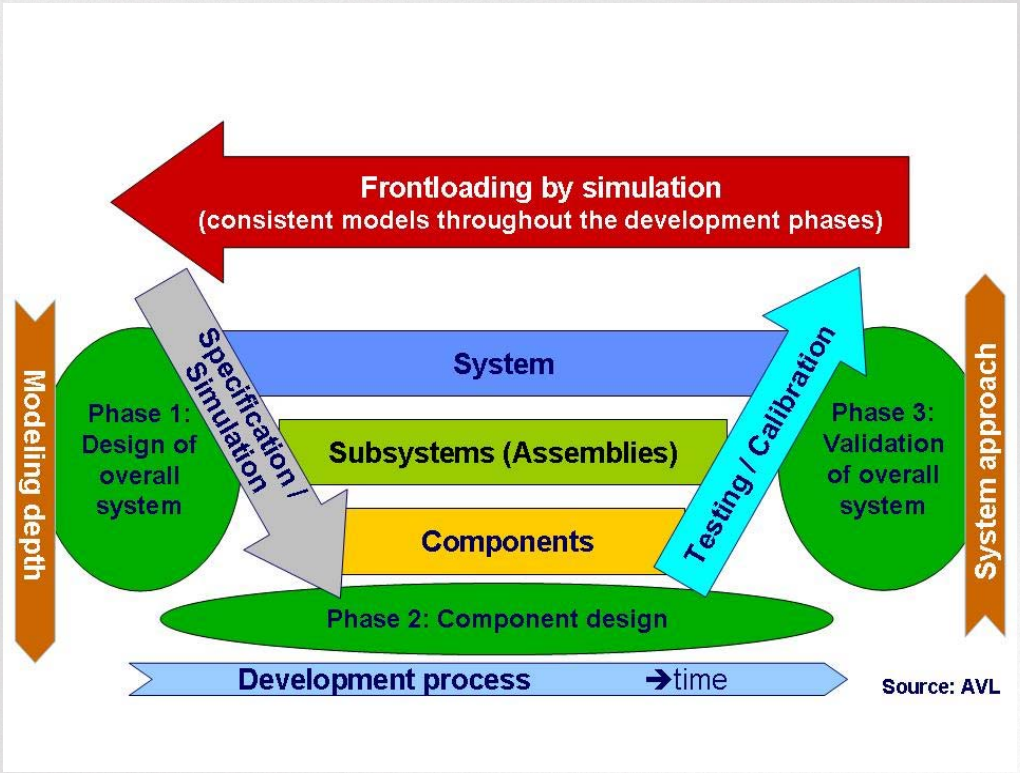
Introduction

- Motivation - demands
  - new concepts of powertrains with improved features;
  - short time-to-market;
  - low research costs.
- Needs for higher-level design tools:
  - the **parametric design** optimizes a fixed structure;
  - the **configuration design** changes the structure - in the simplest case using “old” basic elements;
  - investigation of a new design before experiments are carried on.

Introduction

Concept design

Configuration design



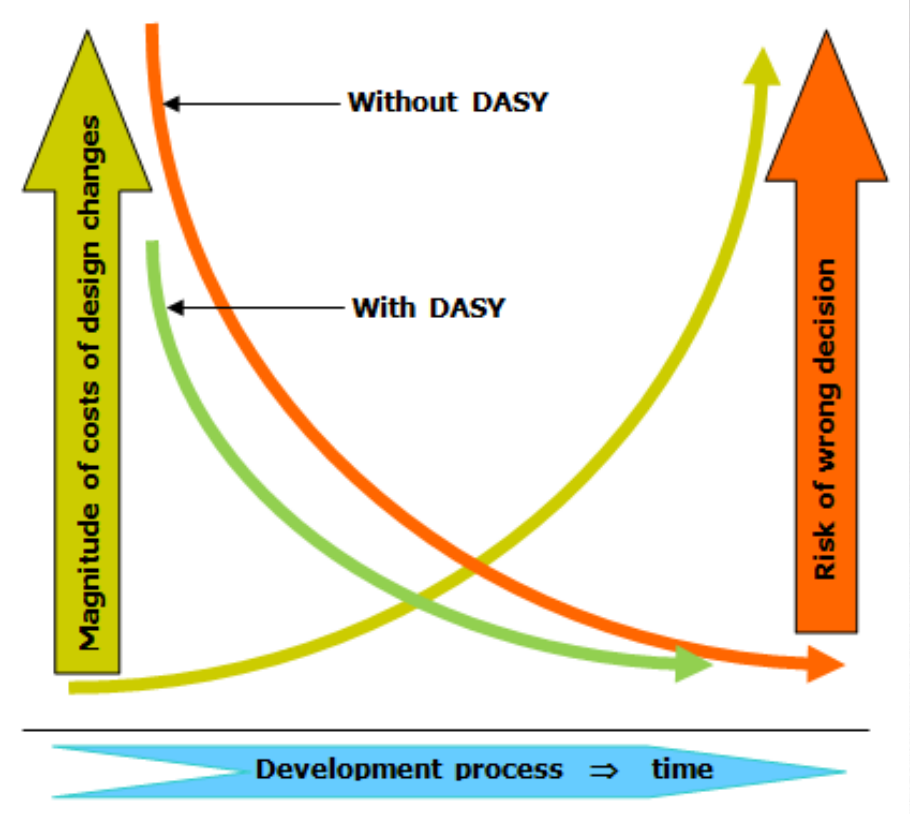
Parametric design

Parametric design calibration

Optimization and Control System Design

Introduction

- The need for design assistance system:
  - keeping and re-using previous experience;
  - using adequate methods during any stage of R&D (different data volumes, different CPU time demands).
- The usage of smart database **decreases the risk of early-stage wrong decisions**, which reduces the future development costs and time.
- The concept of Design Assistance System DASY is being under development at CTU Prague being supported by VECOM EU Marie Curie project.

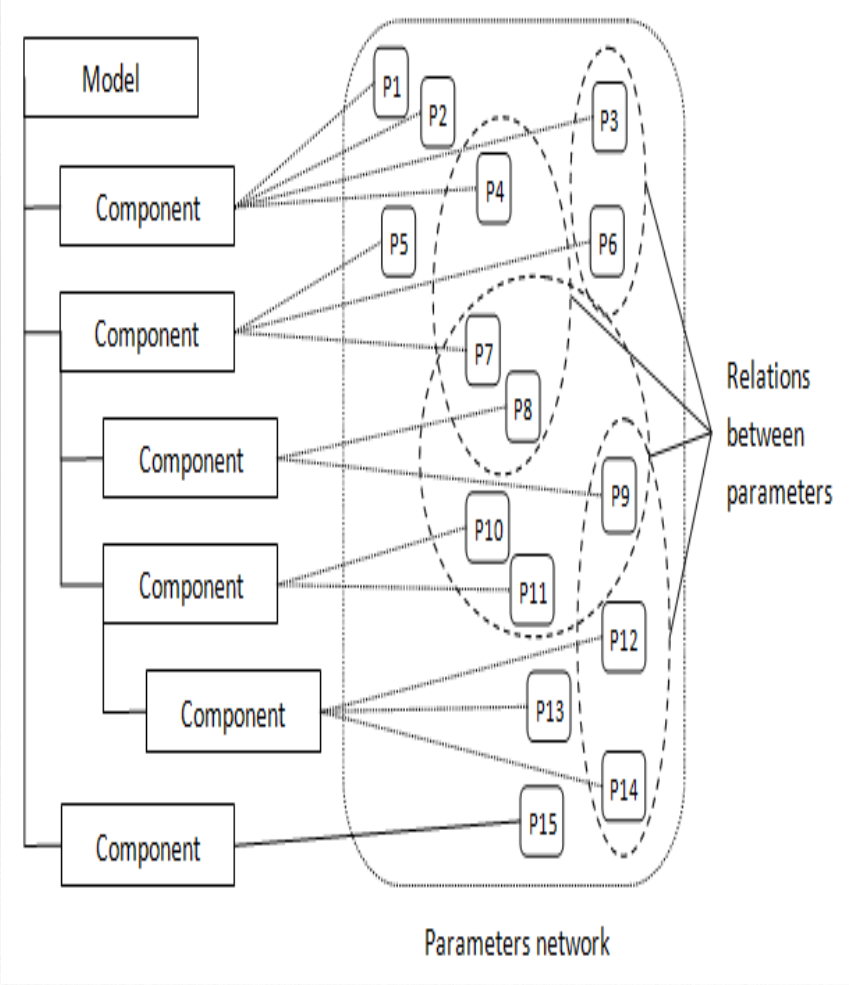


Concept of DASY

- Representation of different powertrain structures ***using self-describing form (flexibility is important)*** in the form of components of different levels.
- Association of development procedures ***of different levels (profoundness, complexity) and different types (experiment/ simulation)*** to structure entities.
- Association of parameters (single numbers or number/text arrays or files) to structure entities.
- Association of parameters to ***computation/experiment*** procedures ***as output/input***.
- ***Evaluation of design network using parameter/procedure associations.***
- Storage of all models (structure entities&parameters&procedures linked to them) in one database with ability to reuse any of them in new projects

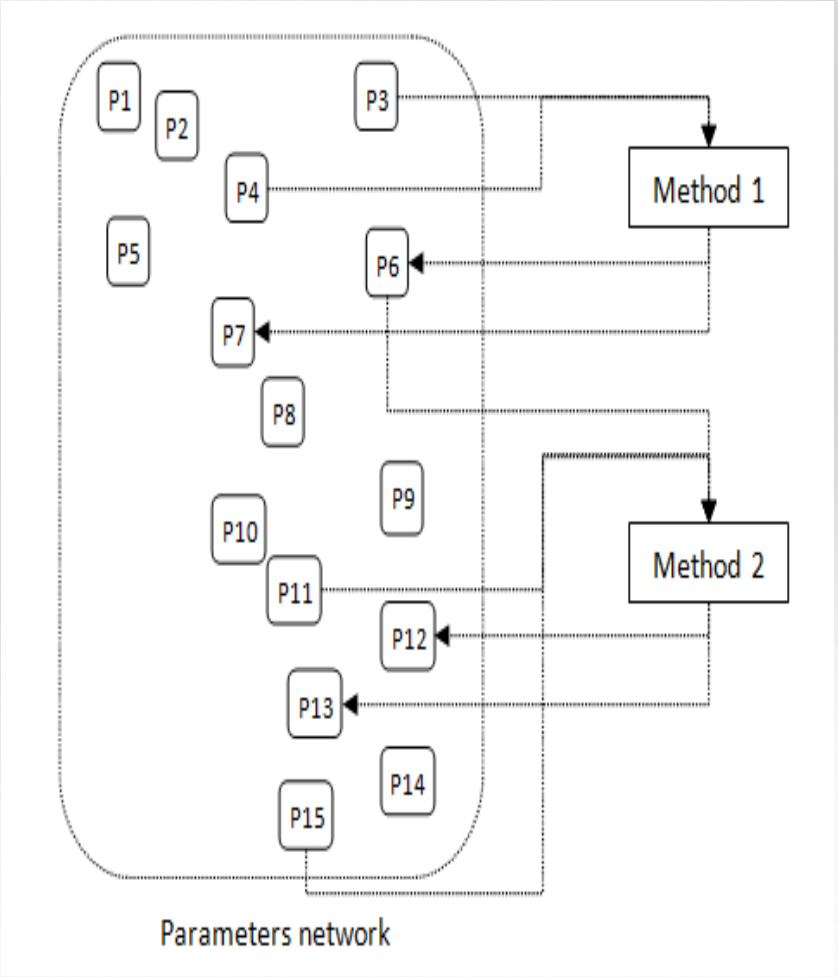
Concept of DASY

- Model in DASY - set of components.
- Each component has a set of parameters, requirements and files (arrays) related to it.
- Each component can have subcomponents and subassemblies.
- All components are stored in the library and can be divided into classes.



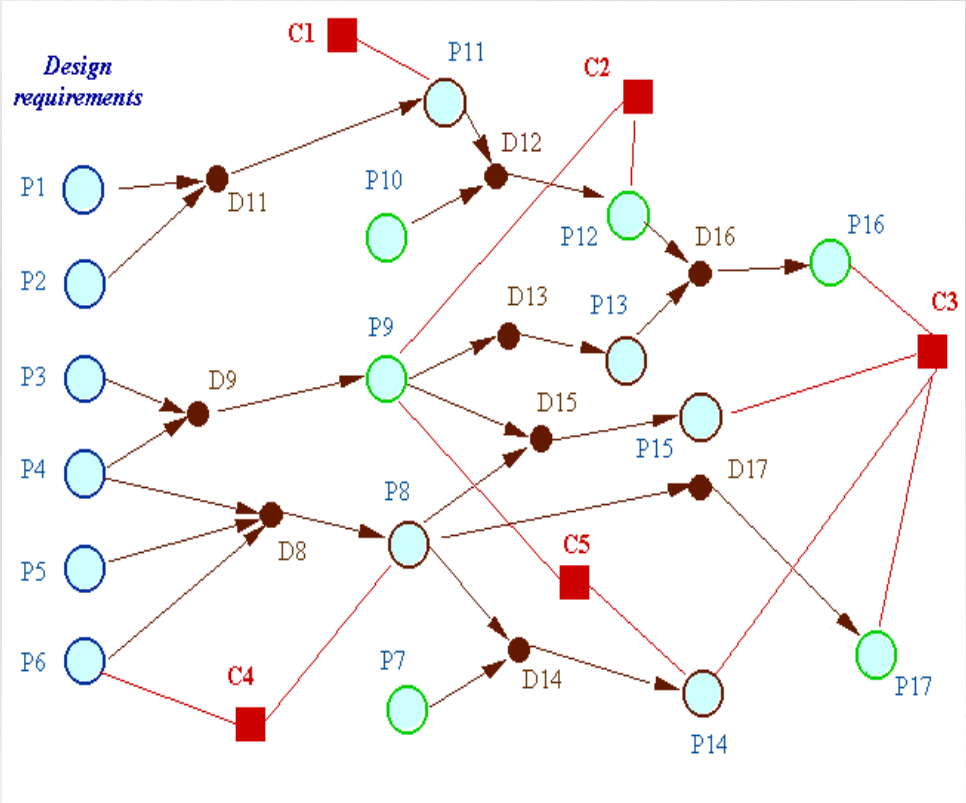
Concept of DASY

- To any level of component or model, the computational, design or experimental methods are linked.
- The methods feature different levels of physical profoundness.
- The deeper to the substance of phenomena description the method is extended to, the more data are called for as input parameters.
- Input and output parameters for one method are distinguished.
- Output of certain method is linked as an input for another one.



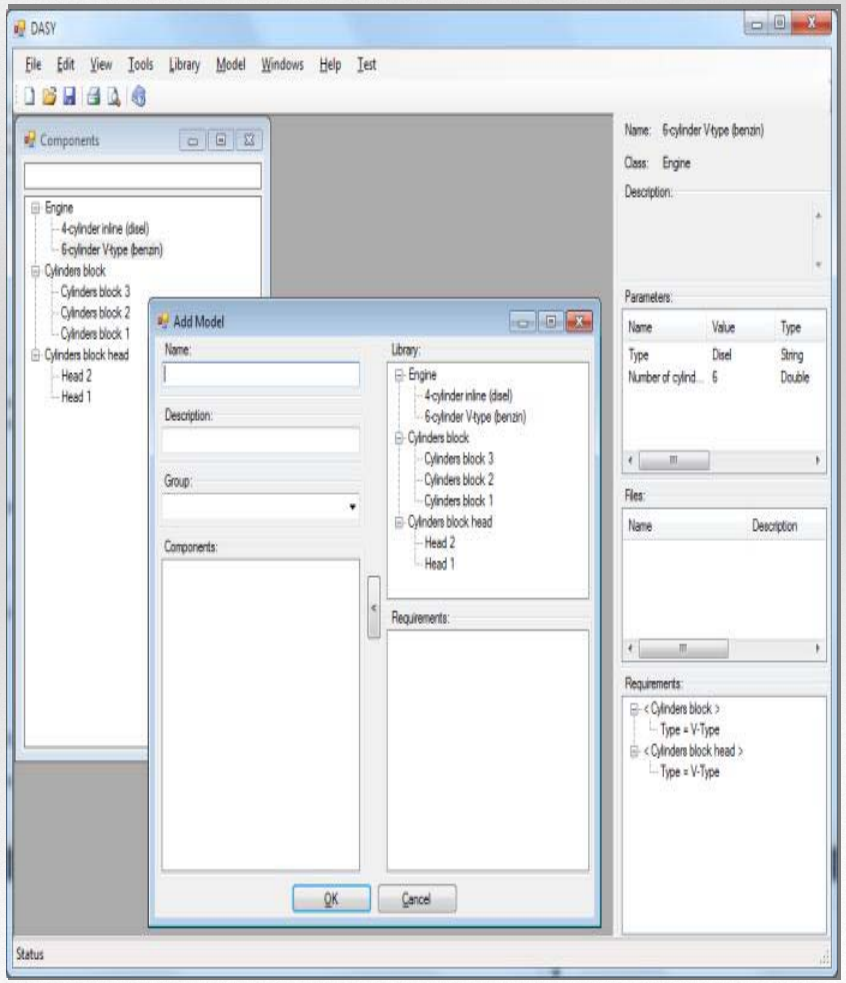
Concept of DASY

- All parameters **P** from all components and procedures **D** form a **design network, starting with utmost output parameters (design requirements)**.
- The design process uses additionally constraints **C** optimized using, e.g., cost functions or just limiting values.
- The inevitable loops in the process are detected and solved by iterations, frequently using lower-level methods to accelerate the process.



Development of DASY

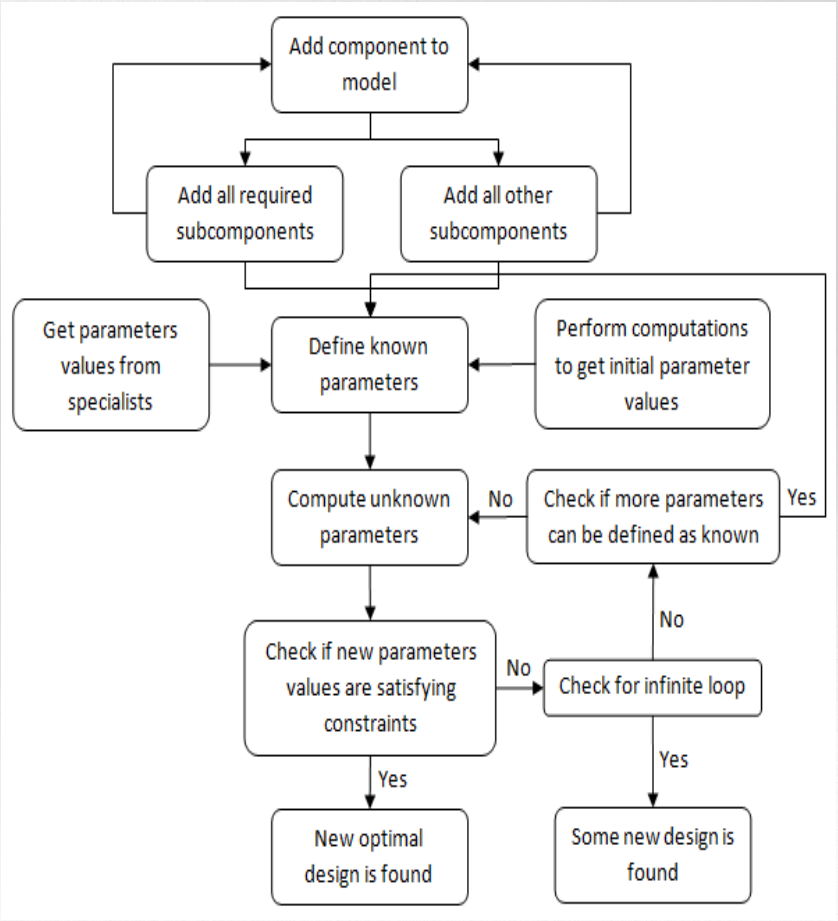
- DASY at the current state of development is a computer program for creation and maintaining a knowledge database.
- It is being developed using C# programming language and Microsoft .NET framework.
- The main goal is the high level of flexibility along with a simple user interface.



Development of DASY

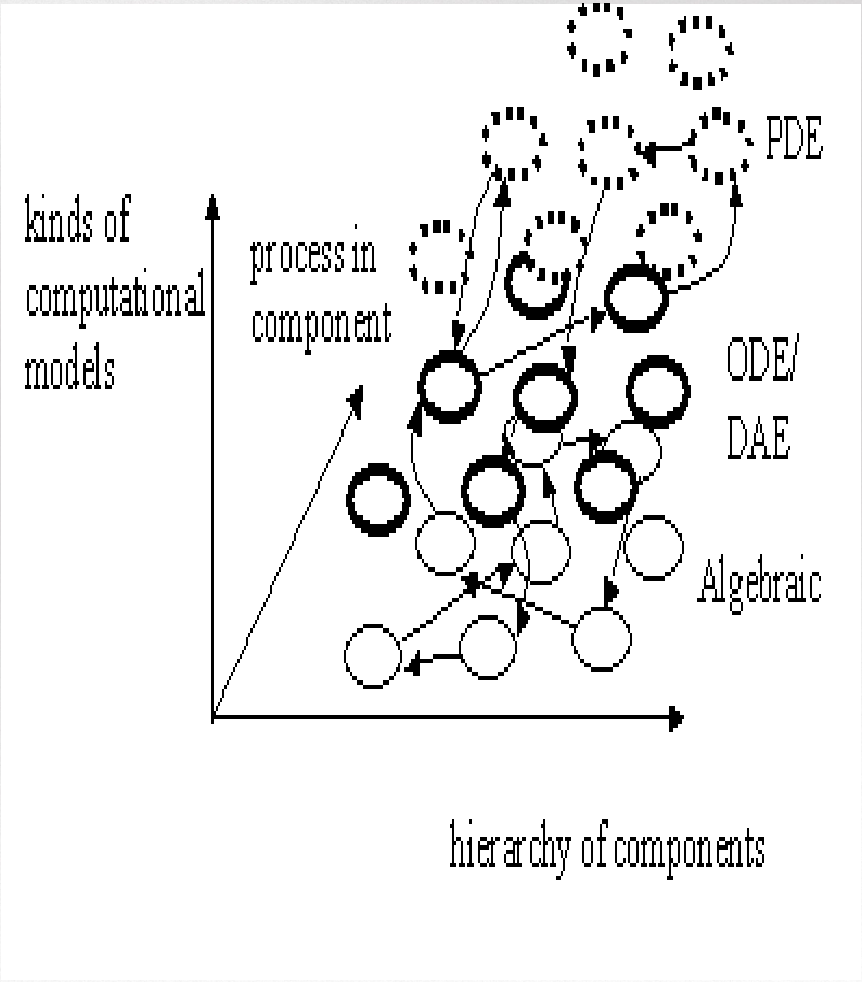
Functions of DASY currently available

- **Creating** components and assemblies.
- **Storing**, grouping and **reusing** created components.
- **Storing**, grouping and **reusing** created models.
- **Exporting** geometrical data to CAD systems in general or specific formats.
- Simple **parameter dependence** studies.

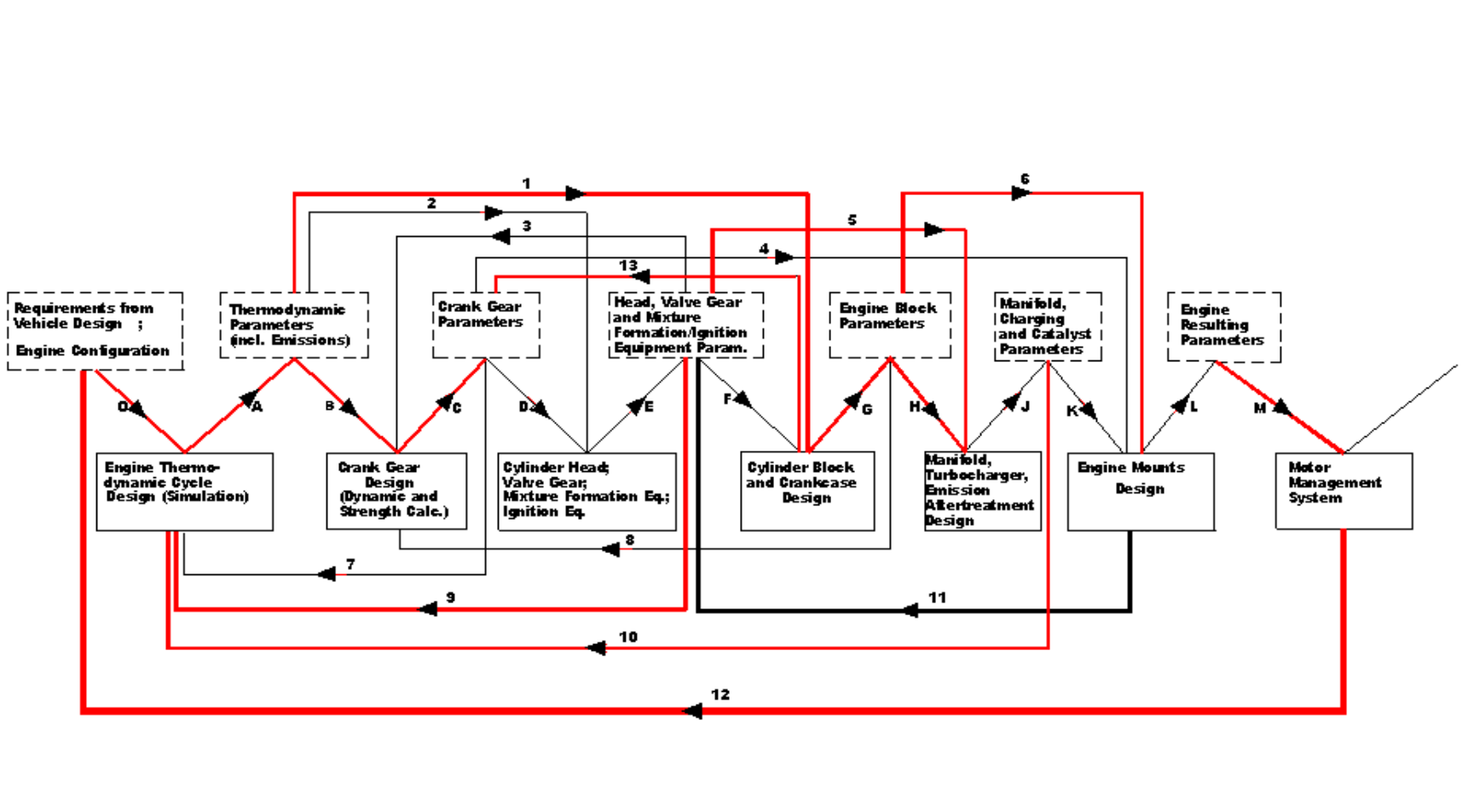


Involvement of Simulation Software

- Commercial software suitable for detailed simulations of almost-ready design – levels of partial differential equations, PDE, or differential-algebraic systems, DAE.
- Algebraic or ODE simple tools are being (re-) developed to cover the early stage design with sufficient speed.
- Calibration by preceding experiments from DASY database.



Involvement of Simulation Software



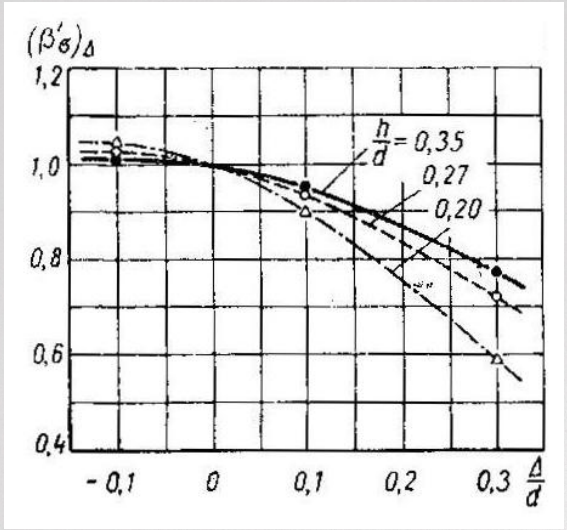
Involvement of Simulation Software

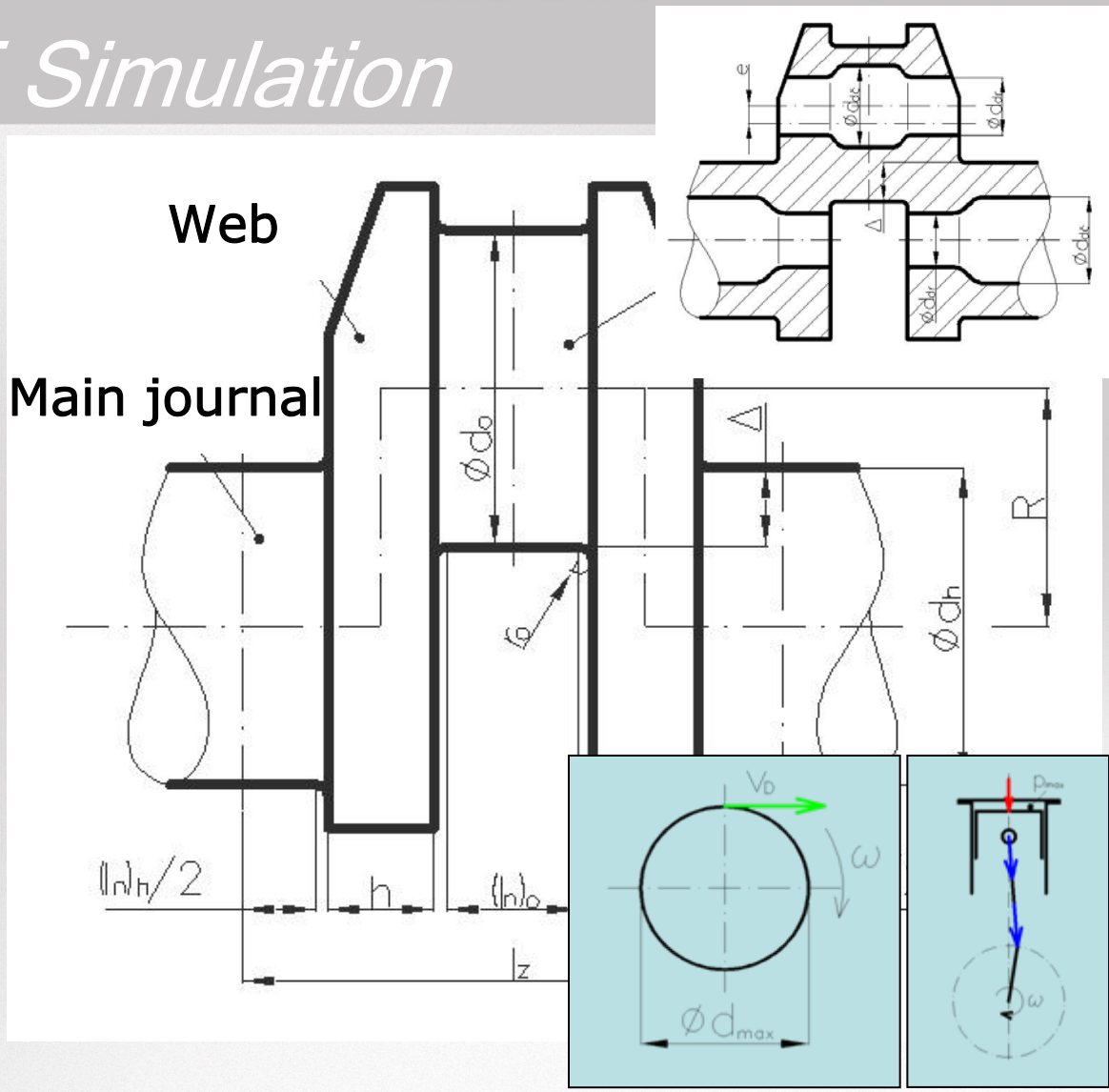
Recently developed modules at AE/ODE levels

- Crank train forces and friction losses.
- Crankshaft pre-design using empirical stress concentration factors (Lejkin or FVV).
- Valve train drive forces and friction losses.
- Mixture requirements (especially for alternative fuels) and pre-matching of mixture formation equipment.
- Fuel injection equipment matching and drive train forces with friction losses.
- Fast turbocharging/supercharging matching module for 4- and 2-stroke engines including VGT, WG, 2-stage turbo and different systems.
- Turbine and compressor map interpolation/extrapolation.
- RT models for (hybrid) vehicle powertrain control, etc.

Example of AE Simulation

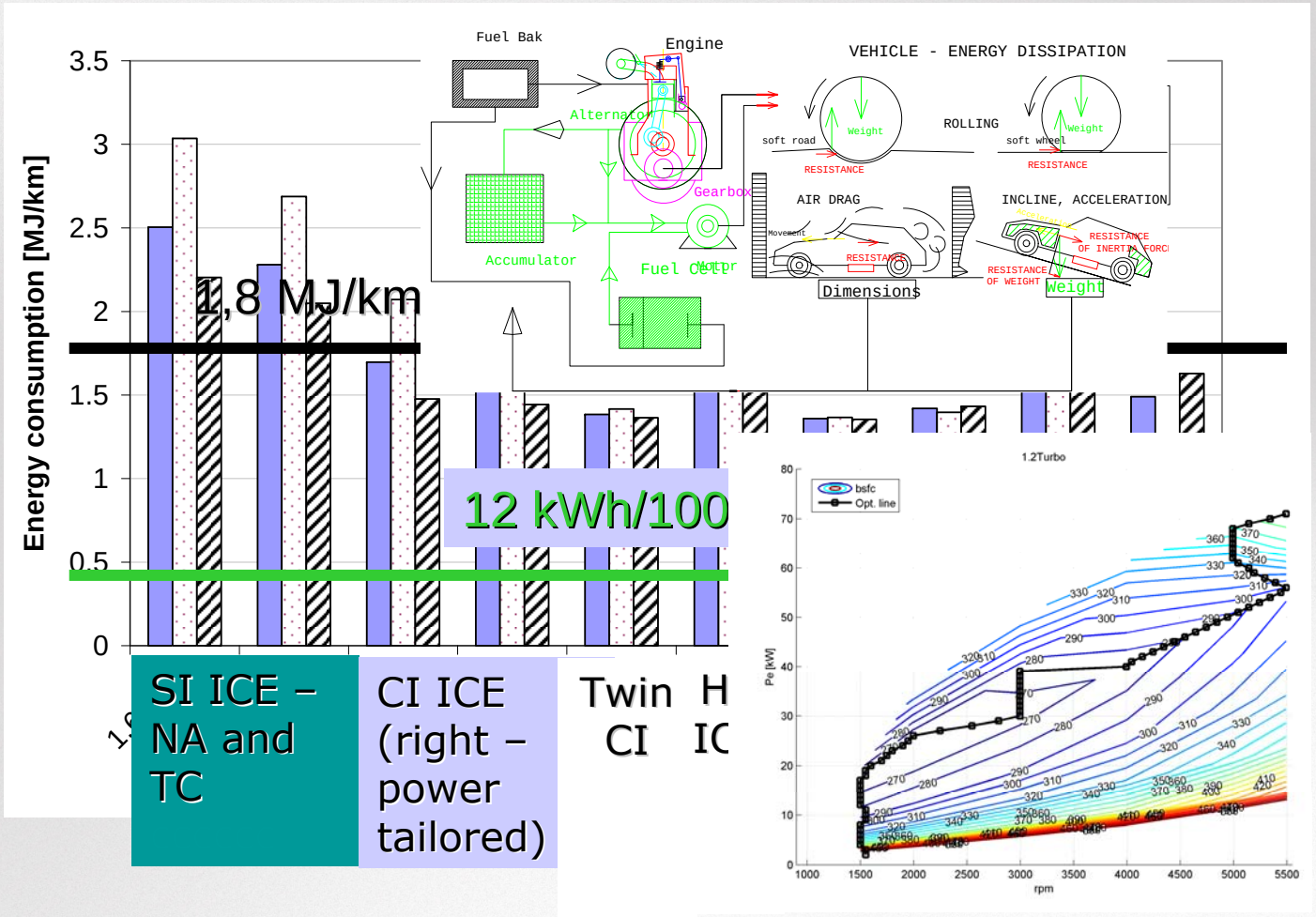
Crank model for fast optimization of cylinder axes distance – e.g., Lejkin's algebraic equations & crank train forces



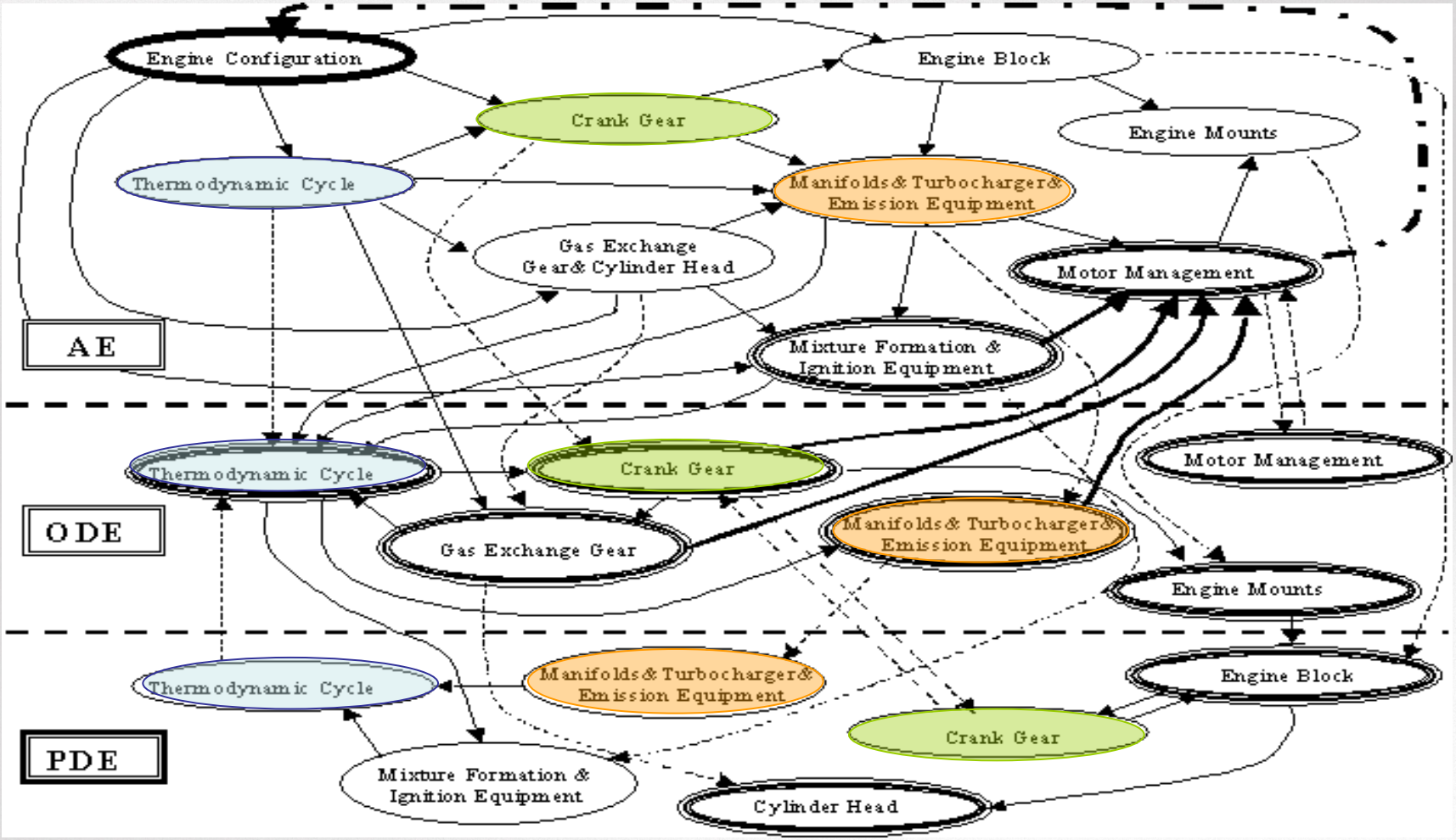


Example of ODE Simulation

Fast RT simulation of vehicle TTW fuel consumption suitable for hybrid control in arbitrary test or operation mode (example of NEDC test)

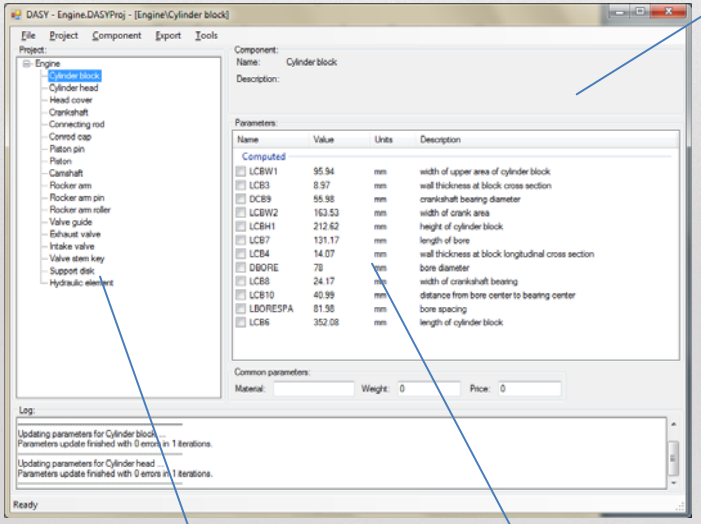


Involvement of Simulation Software



Example of Parametric Model

Model of engine in DASY



Components Parameters

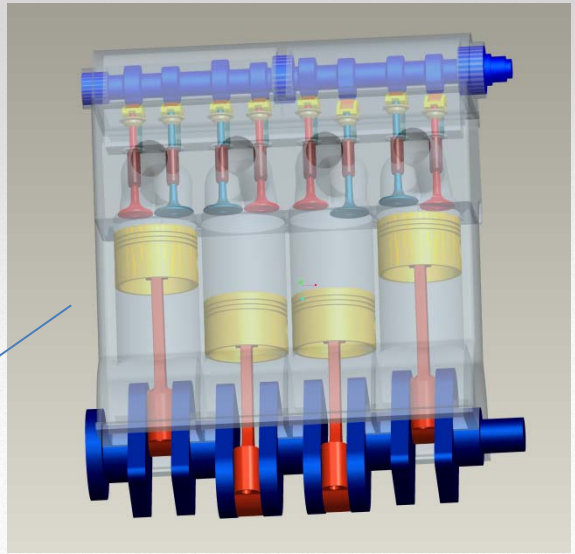
DASY

File with exported parameters

ENGINE.DAT

Pro/Engineer

Solid model



Introduction

Benefits of DASY

- Faster start of modeling stage with initially limited amount of relevant data.
- Avoiding typical and repeated mistakes.
- Lowering cost of modeling stage.
- Simplification of assembly parameterization.
- Keeping the gained knowledge in accessible form for subsequent applications.

Conclusions

- The concept of Design Assistance System DASY has been developed in the form knowledge database.
- Certain applications currently ready for use, including links to CAD systems (CATIA v. 5, Pro/Engineer).
- Good starting point for concept design storing all related data like CAD models, FEA results, drawings, pictures etc.
- High flexibility, any structure can be changed, removed or added if new concept requires it.
- Development of AE/ODE codes is being carried out simultaneously.

- Internal combustion engine concept modeling elaborated to the greatest extent currently, but the goal is describing any other structures used in vehicle design.

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Thank you for your kind attention!

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