

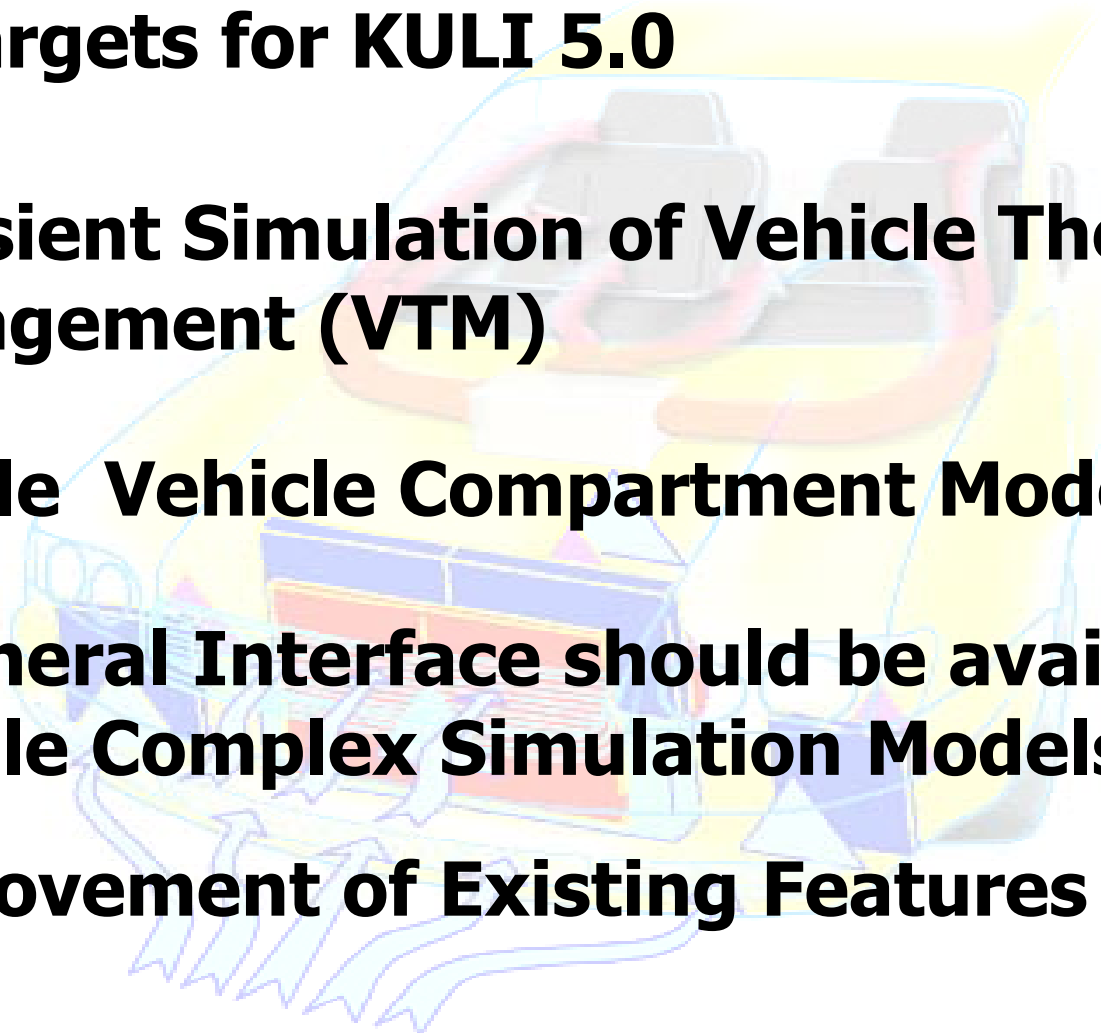
# New Version KULI 5.0

**Josef Hager**



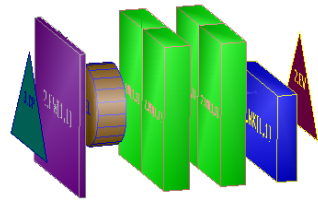
## **KULI Goes Transient**

### **Main targets for KULI 5.0**

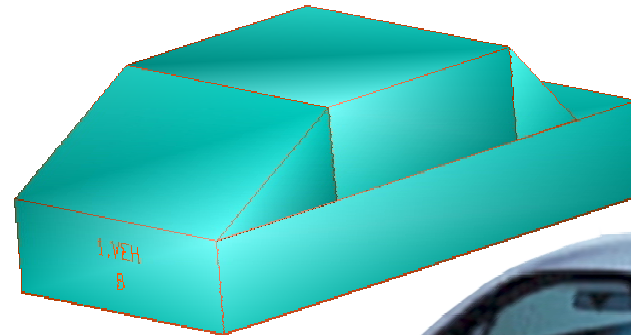
- **Transient Simulation of Vehicle Thermal Management (VTM)**
  - **Simple Vehicle Compartment Model in KULI**
  - **A General Interface should be available to Handle Complex Simulation Models**
  - **Improvement of Existing Features in KULI**
- 

# Subsystems

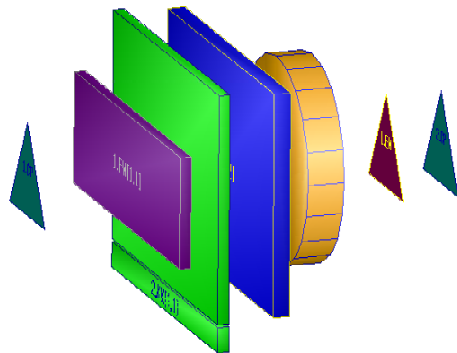
**HVAC System**



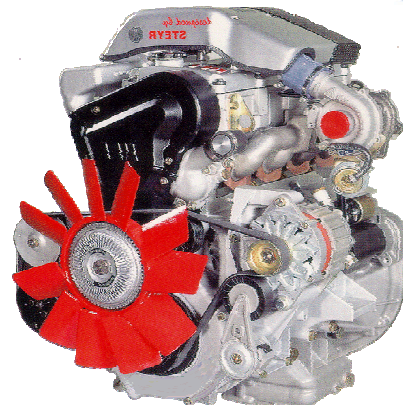
**Car Body**



**Engine Cooling**



**Engine**

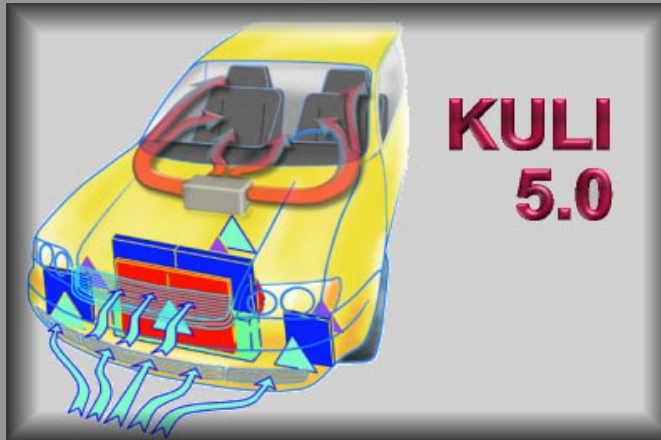


## Basic Software and Modules

**KULI  
ADVANCED**

**KULI AC**

**KULI  
5.0**



**KULI DRIVE**

**KULI  
HEATSIM**

# New GUI - General

**KULI - System generation [Ex\_Fluid.scs]\***

File · Library · Insert · Component · Output · Graphics mode · Extras · Windows / Toolbars

Help

General data | Inner circuit | Air side | Simul. param.

User: TZS

Date (0=current): 01.01.2000 00:00:00

Department:

Purpose: ExampleCAR

Results: Tutorial

Report No.: 0000

**Inner circuit**

1. Water circuit Medium: glys\_b.dat  
Comments: ExampleCAR

1. Charge air circuit Medium: air\_b.dat  
Comments: Charge air cooling circuit

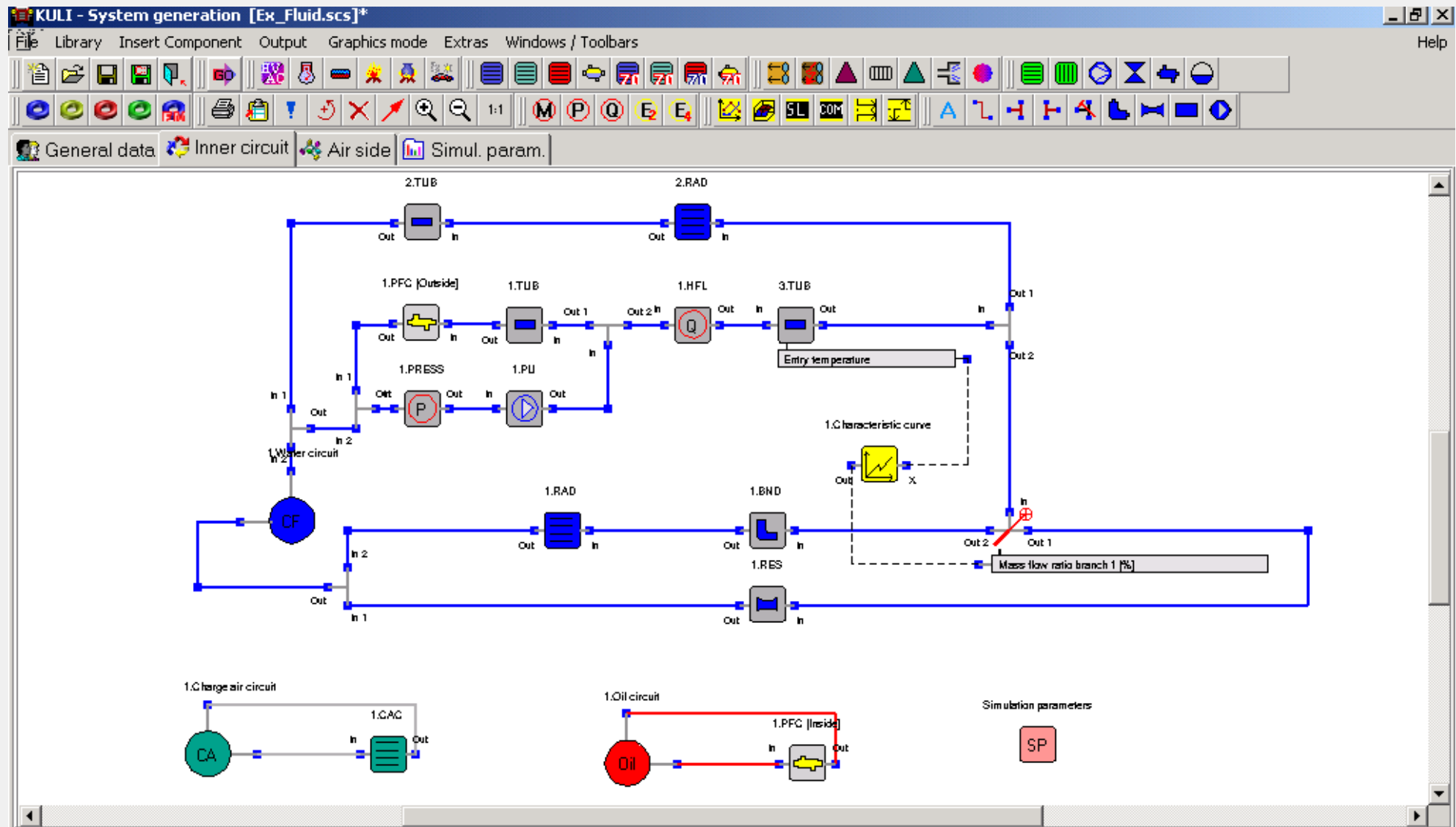
1. Oil circuit Medium: 10w40.dat  
Comments: Oil circuit

**ExampleCAR**

General

- 1. CP "Example 0,8"
- 2. CP "Example -0,3"
- 1. EFan "Electrically Driven Fan with 3 Stages"
- 1. BIR "EW 250"
- 1. ARes "Resistance for air conditioning condens"
- 1. CAC
- 1. MFan "Fan with visco-clutch"
- 1. RAD "1 pass cross flow heat exchanger"
- 1. HFL "Heat flow target"
- 1. PU "Pump"
- 1. PRESS "Pressure target"
- 1. PFC
- 1. VALVE
- 2. RAD "Heater matrix"
- 2. EFan "Electrically driven"
- 2. BIR "Identical to EW005"
- 1. BRA
- 1. CONF
- 2. BRA
- 2. CONF

# New GUI – Fluid Circuits



# New GUI – Air Side

File Library Insert Component Output Graphics mode Extras Windows / Toolbars Help

General data Inner circuit Air side Simul. param.

Components Blocks / Nodes

Blocks

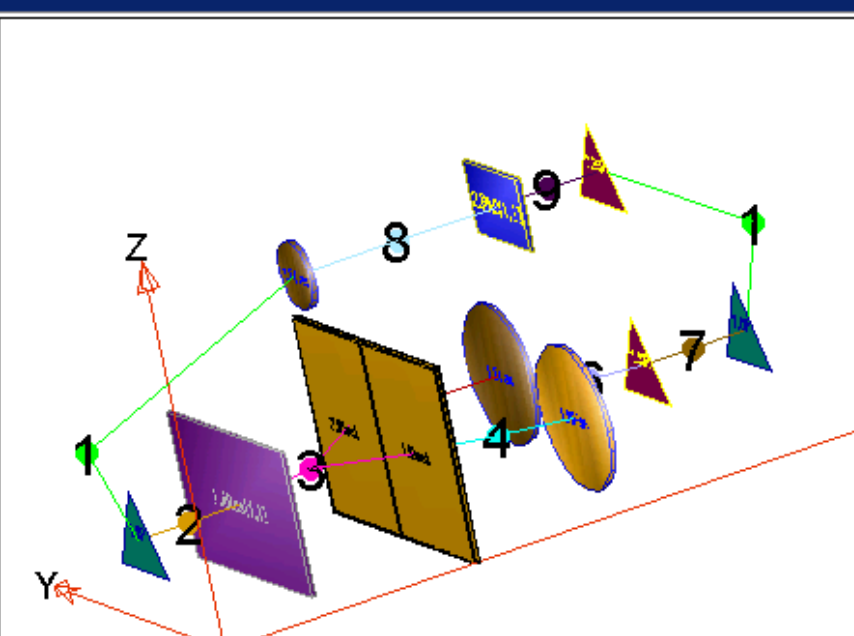
Block	Components	Resistance matrix
1	1.RAD[1,1]; 1.CAC[1,1]	
2	1.RAD[2,1]; 1.CAC[2,1]	

Surroundings medium  
air\_b.dat  
Components for block 1 / node 1

Nodes

Nodes	Previous	Next
1	2.CP; 2.BiR	1.CP; 2.EFan
2	1.CP	1.ARes[1,1]
3	1.ARes[1,1]	1.Block; 2.Block
4	1.Block	1.MFan
5	2.Block	1.EFan

☐ Use only 1. element





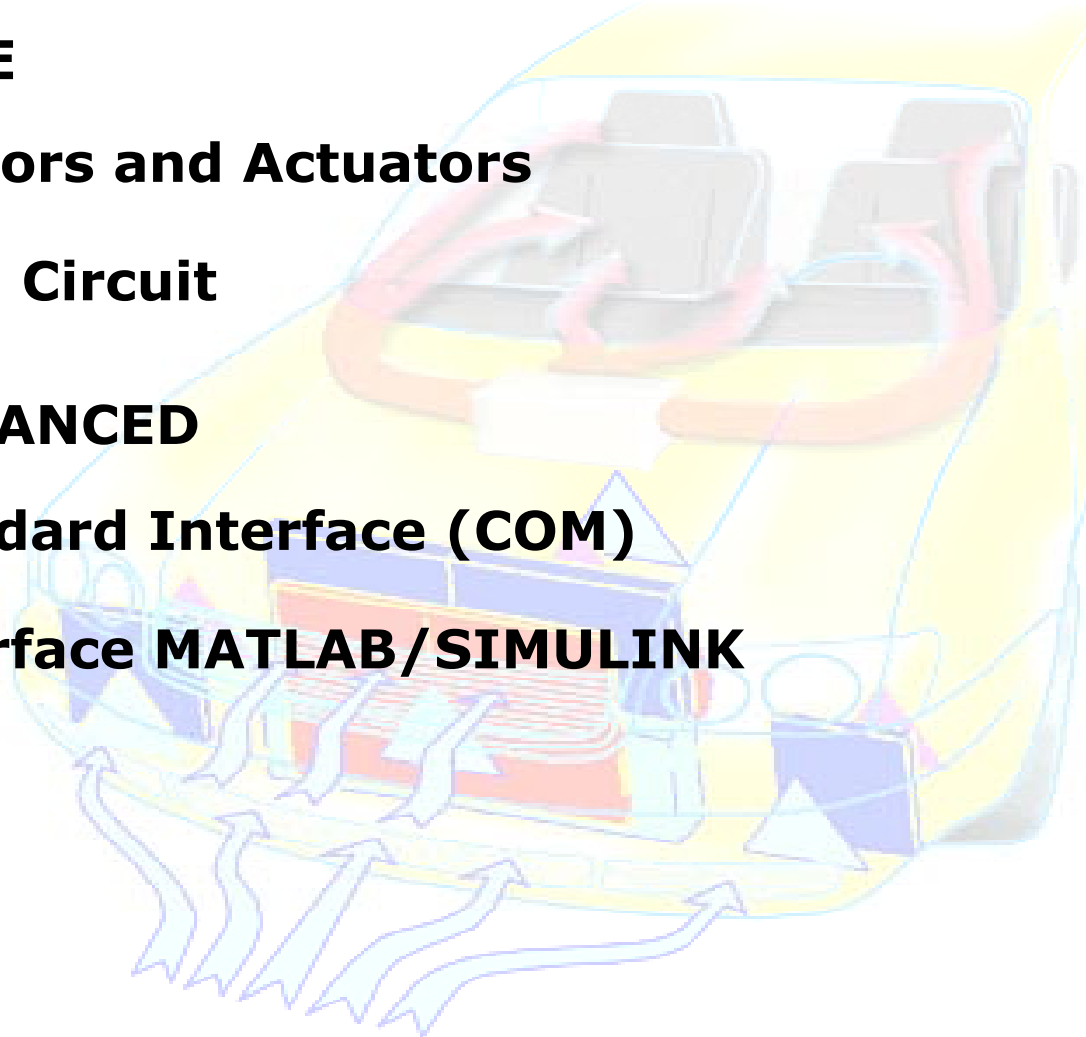
## KULI 5.0 – New Features

### KULI BASE

- **Sensors and Actuators**
- **Fluid Circuit**

### KULI ADVANCED

- **Standard Interface (COM)**
- **Interface MATLAB/SIMULINK**





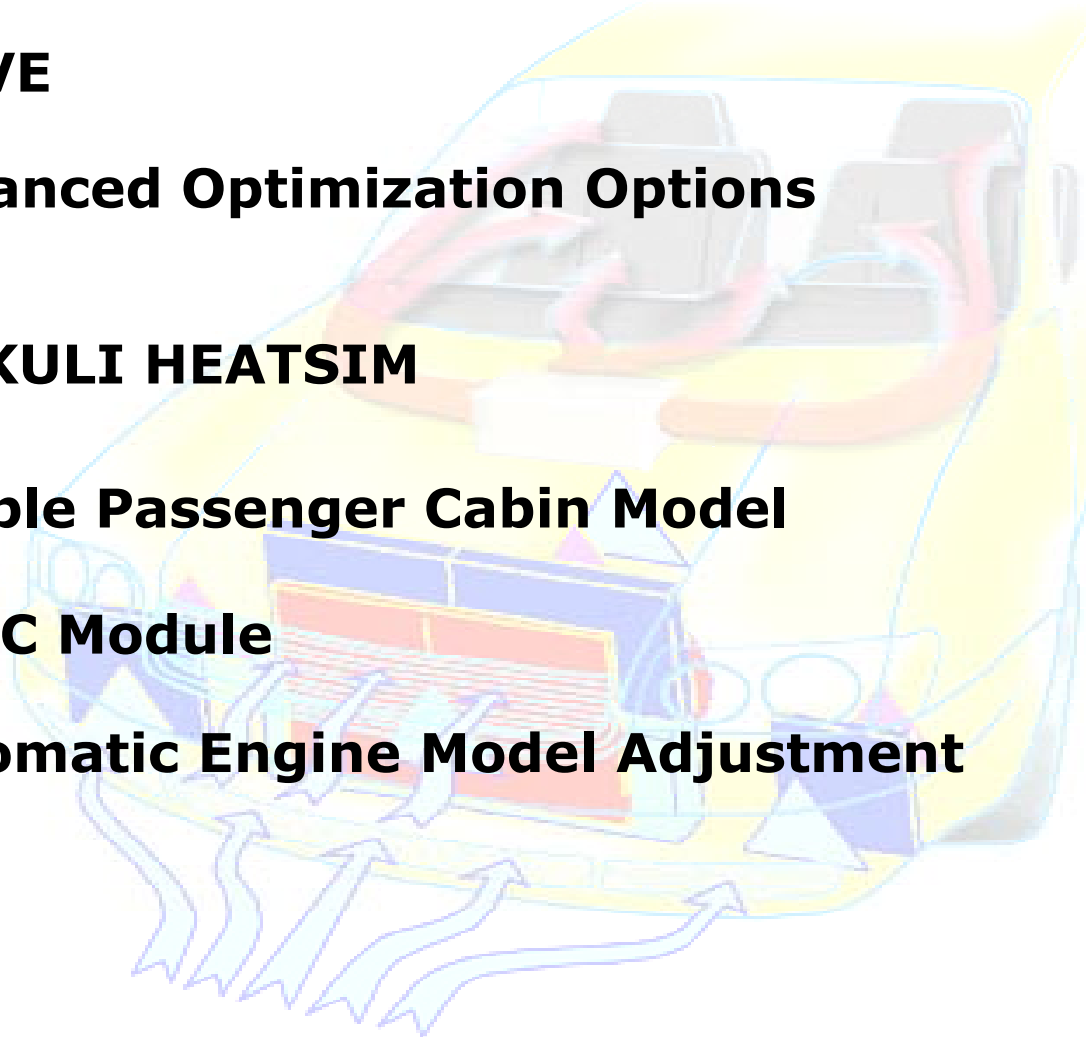
## **KULI 5.0 - New Features continued**

### **KULI DRIVE**

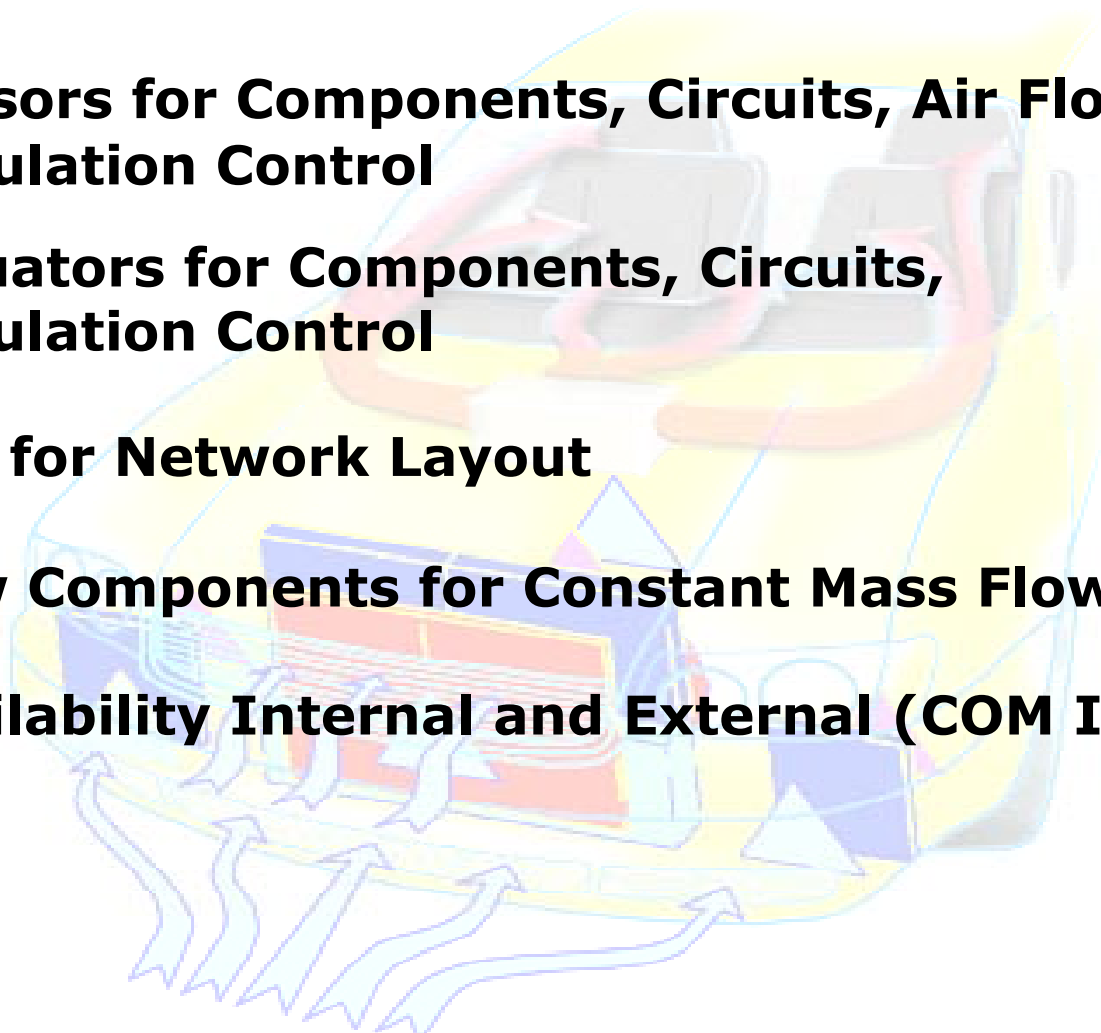
- **Enhanced Optimization Options**

### **KULI AC, KULI HEATSIM**

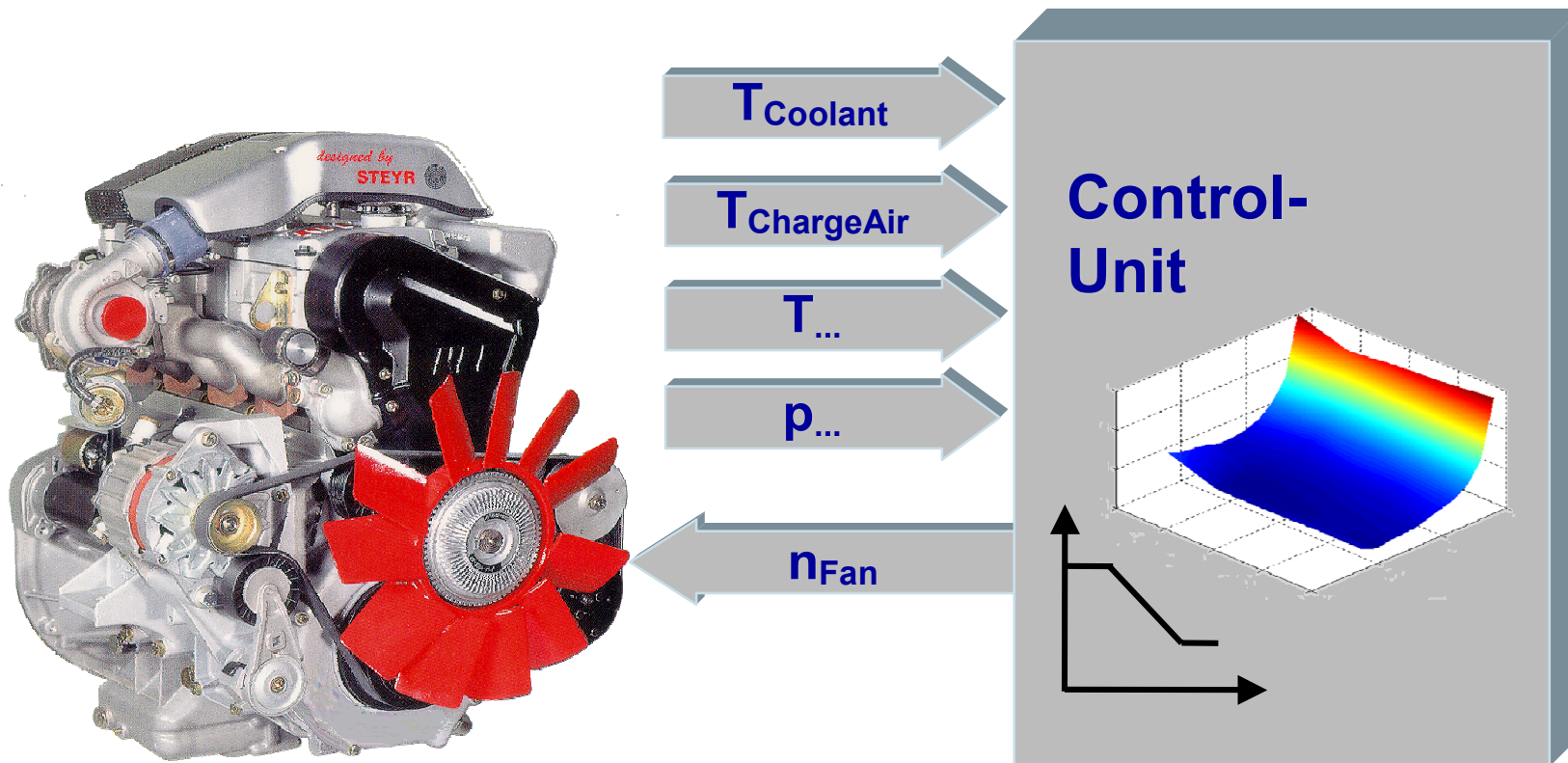
- **Simple Passenger Cabin Model**
- **HVAC Module**
- **Automatic Engine Model Adjustment**



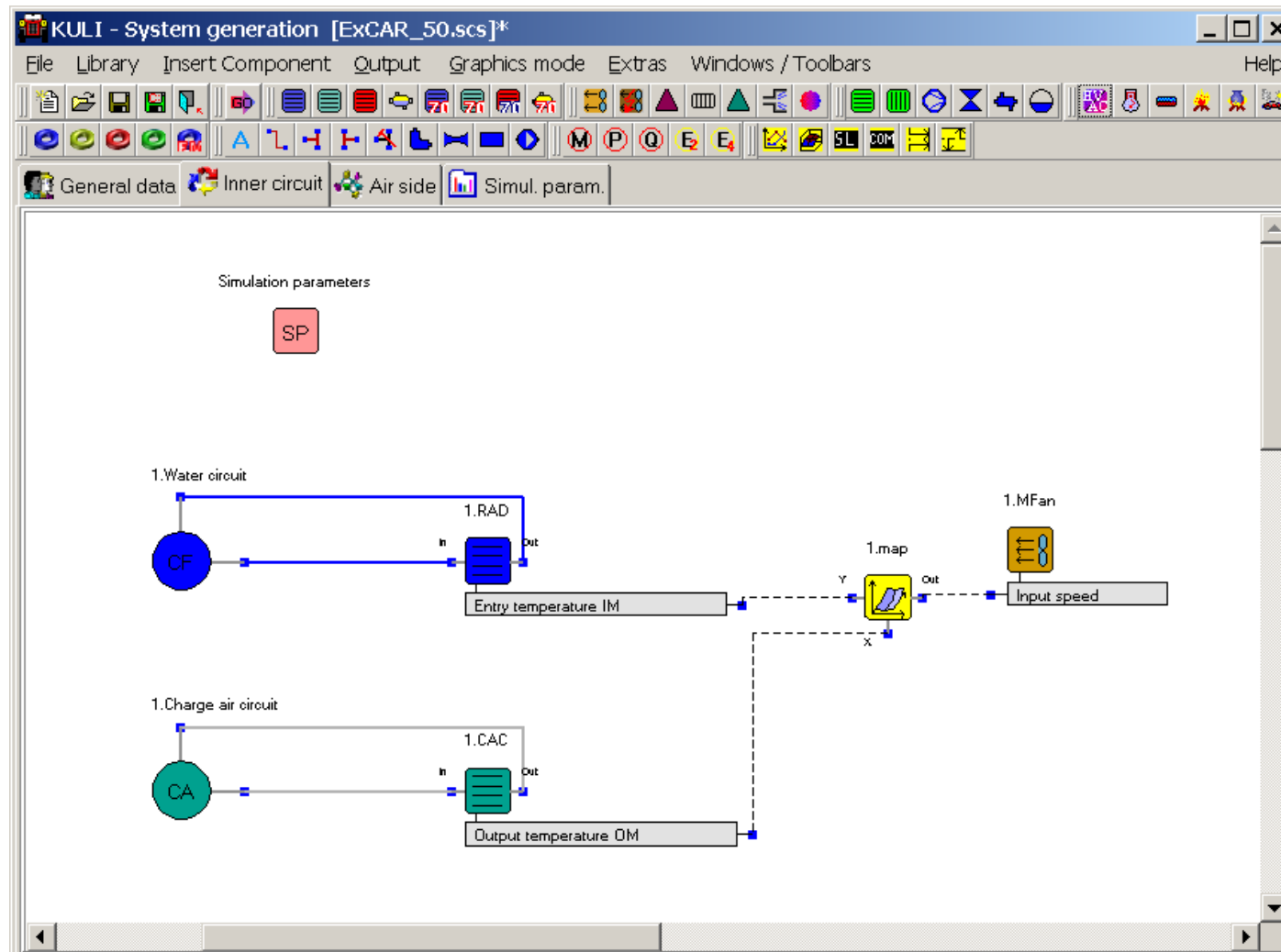
# Sensors and Actuators

- 
- **Sensors for Components, Circuits, Air Flow, Simulation Control**
  - **Actuators for Components, Circuits, Simulation Control**
  - **GUI for Network Layout**
  - **New Components for Constant Mass Flows**
  - **Availability Internal and External (COM Interface)**

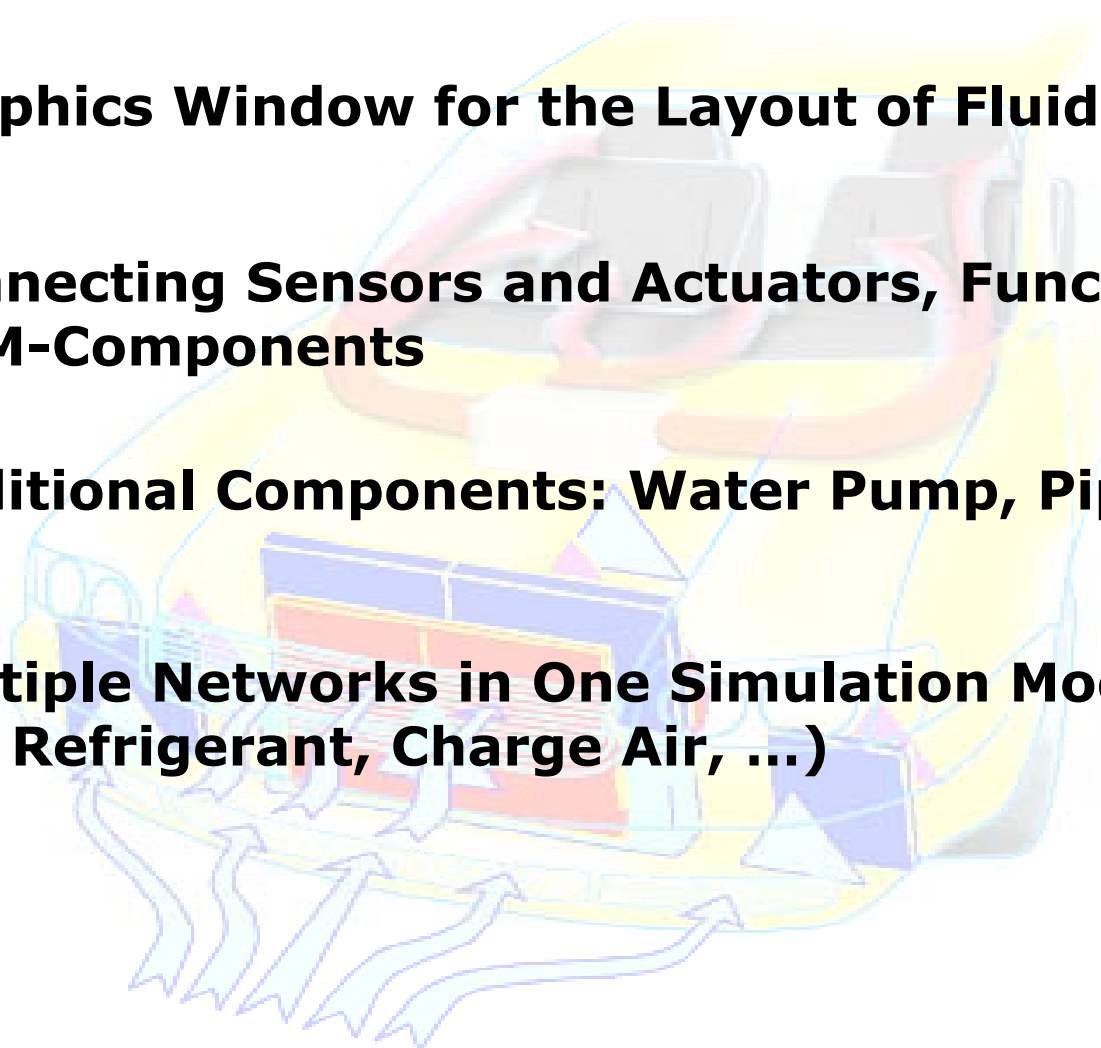
# Sensors and Actuators



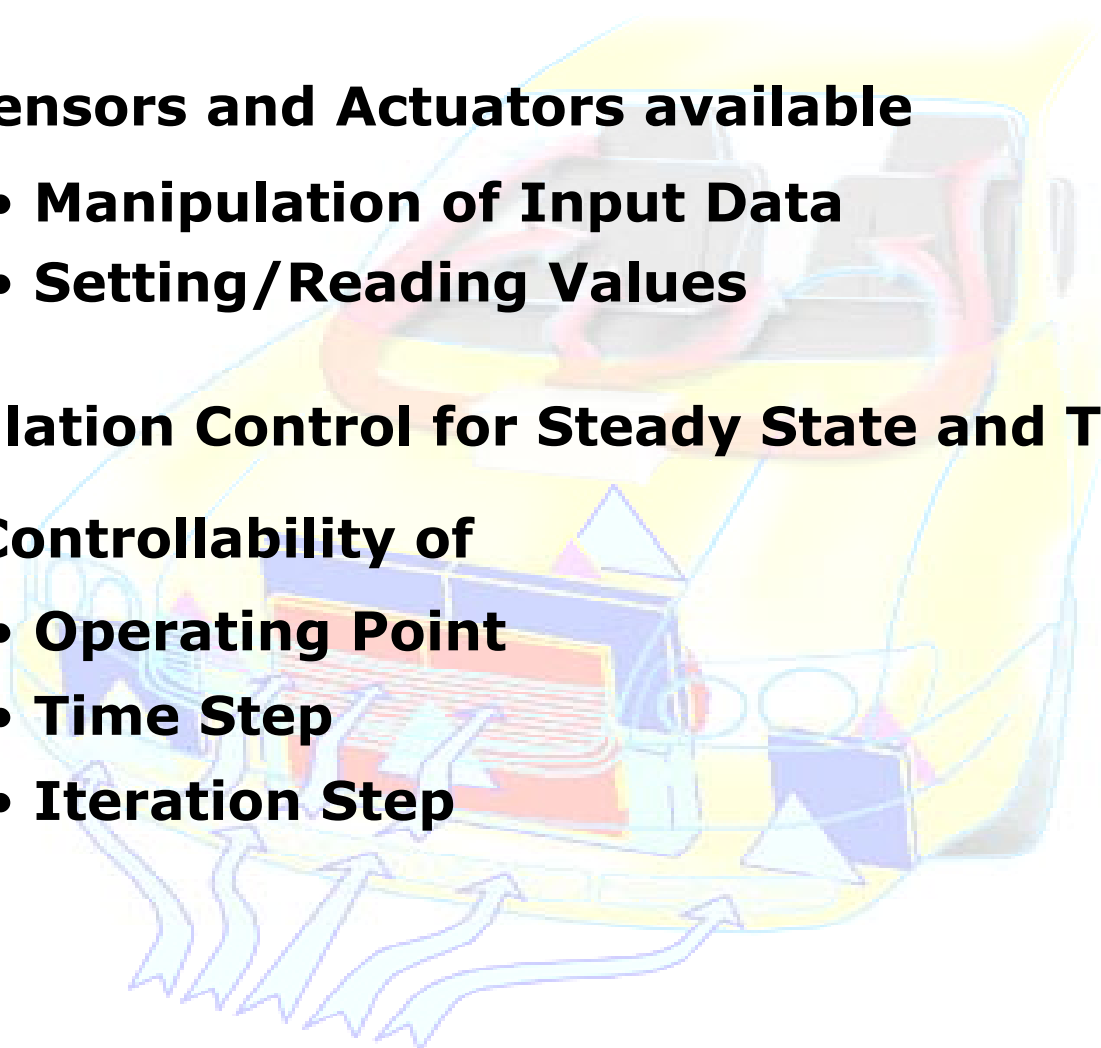
# Sensors and Actuators – Internal Use



# KULI Fluid Circuit

- **Graphics Window for the Layout of Fluid Networks**
  - **Connecting Sensors and Actuators, Function Maps, COM-Components**
  - **Additional Components: Water Pump, Pipes, Bends, ...**
  - **Multiple Networks in One Simulation Model (Coolant, Oil, Refrigerant, Charge Air, ...)**
- 

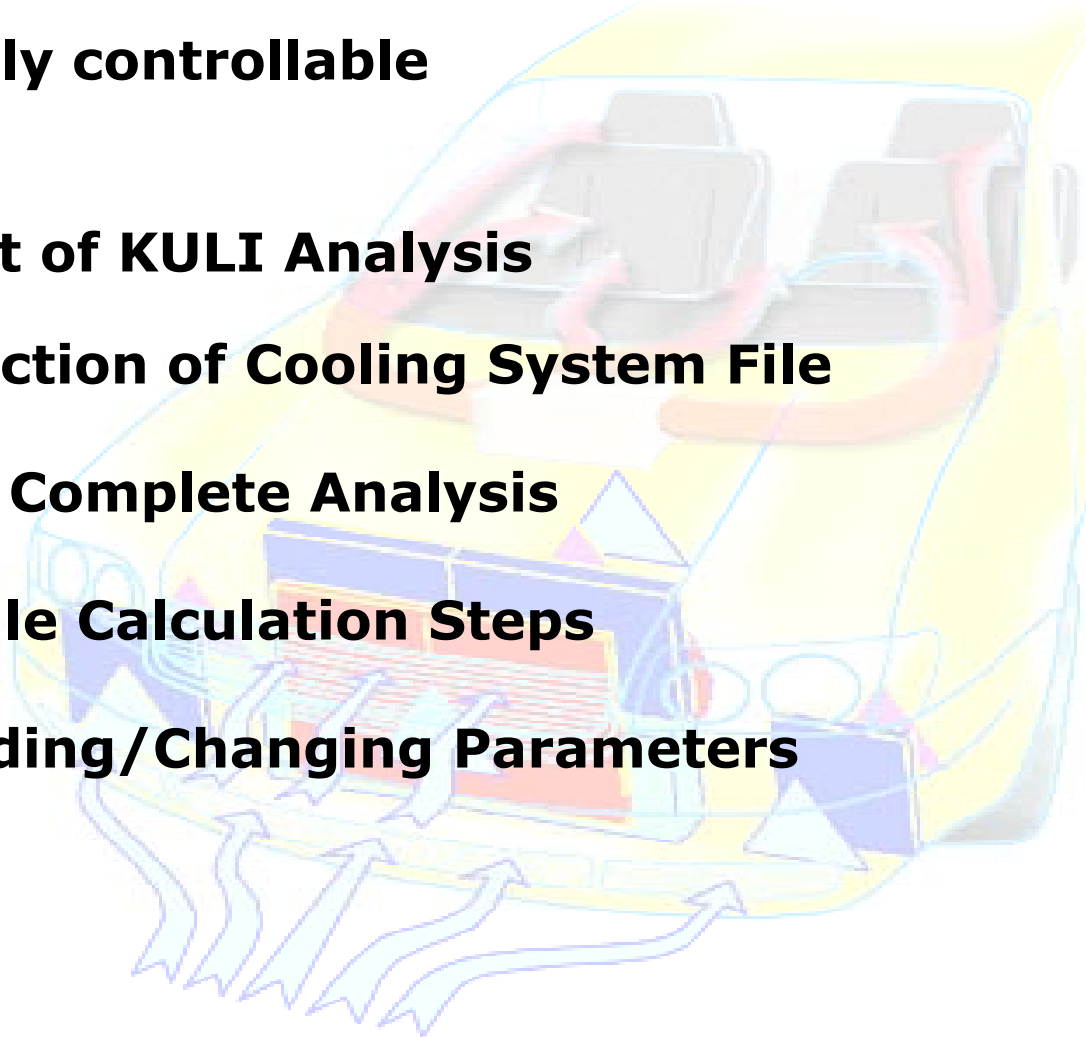
## **General KULI Interface (COM)**

- 
- **All Sensors and Actuators available**
    - **Manipulation of Input Data**
    - **Setting/Reading Values**
  - **Simulation Control for Steady State and Transient**
    - Controllability of**
      - **Operating Point**
      - **Time Step**
      - **Iteration Step**

# KULI COM Control

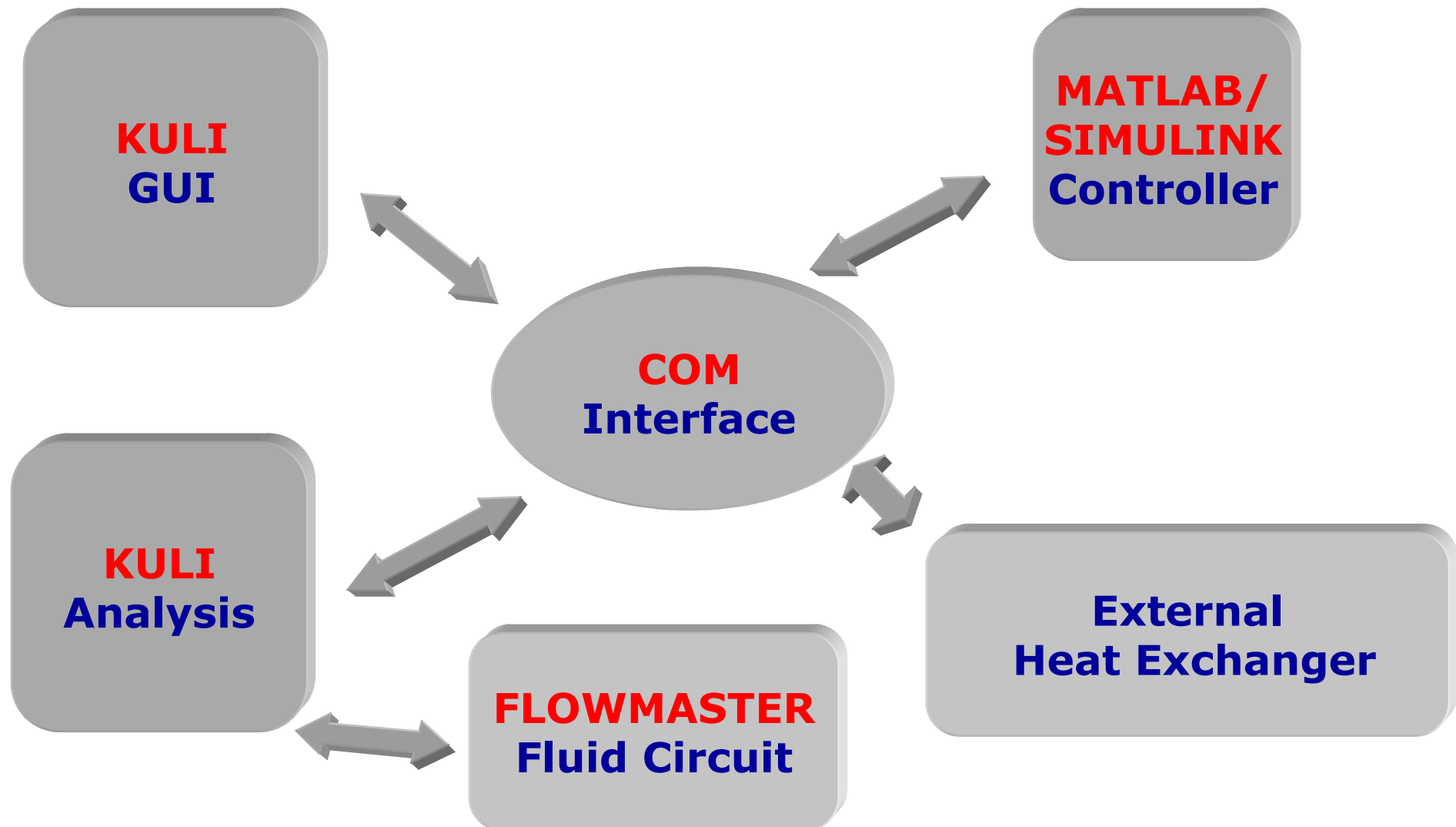
## Externally controllable

- **Start of KULI Analysis**
- **Selection of Cooling System File**
- **Run Complete Analysis**
- **Single Calculation Steps**
- **Reading/Changing Parameters**

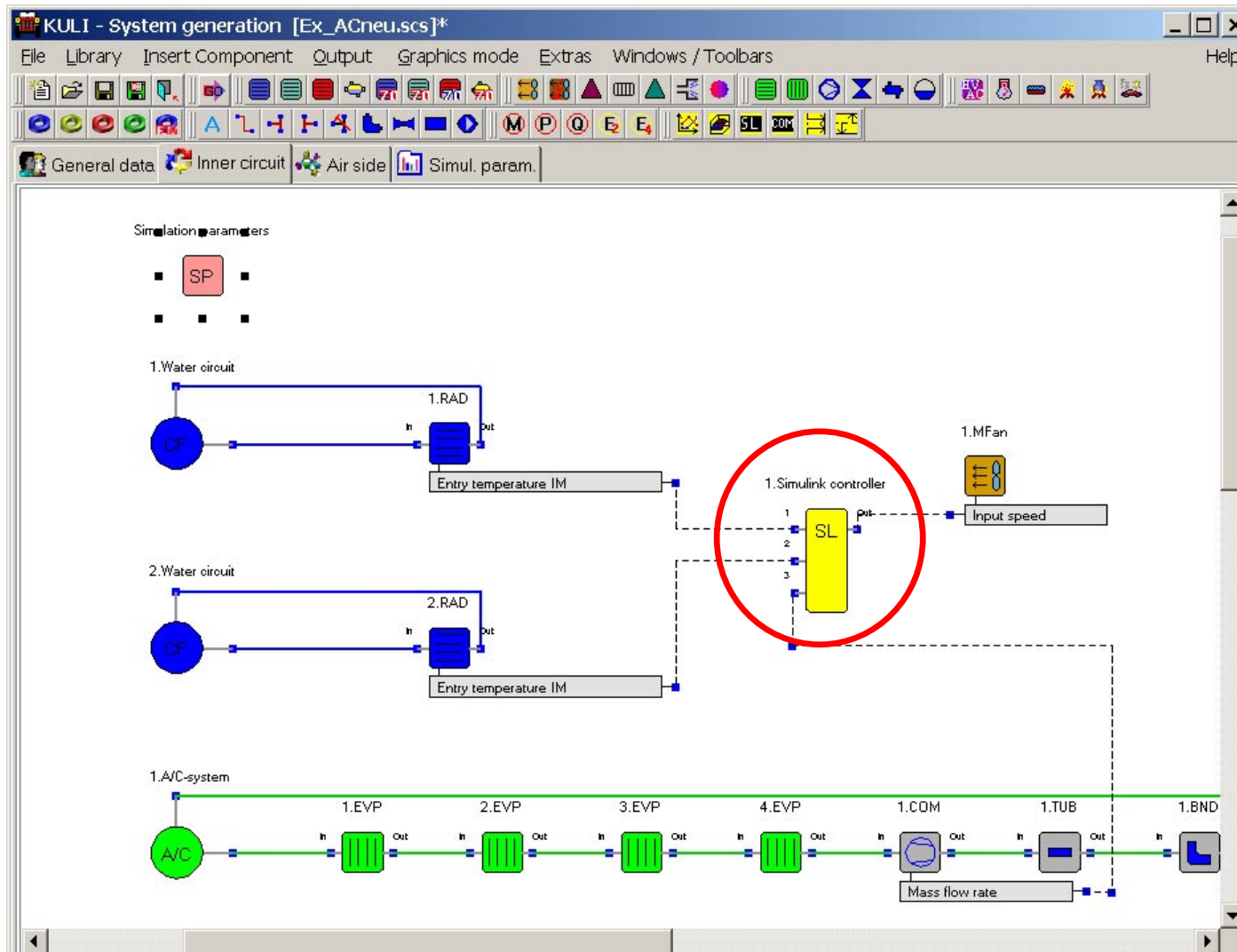




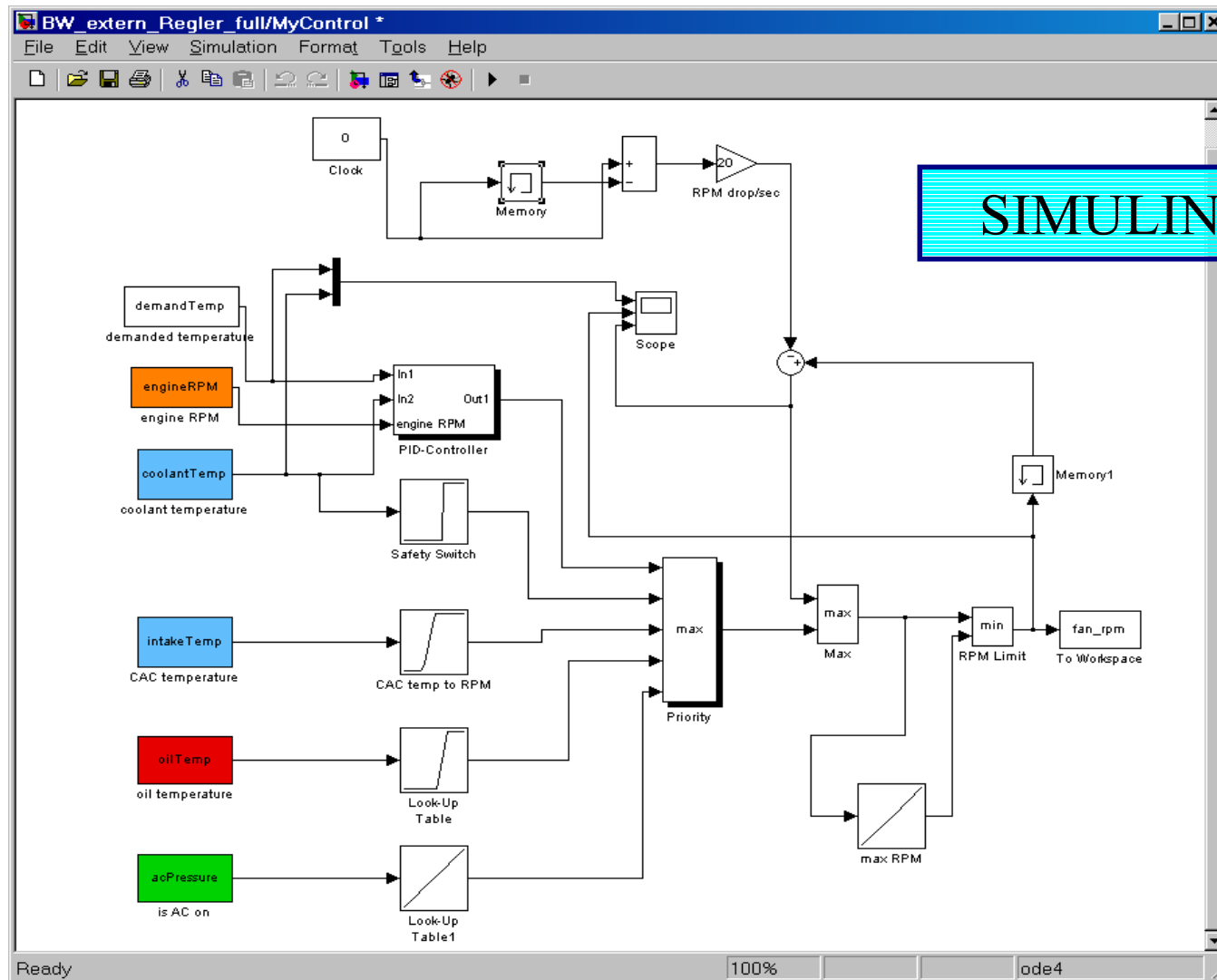
## KULI-COM Interface Structure



# SIMULINK-Controller



# SIMULINK-Controller



**SIMULINK-Controller**

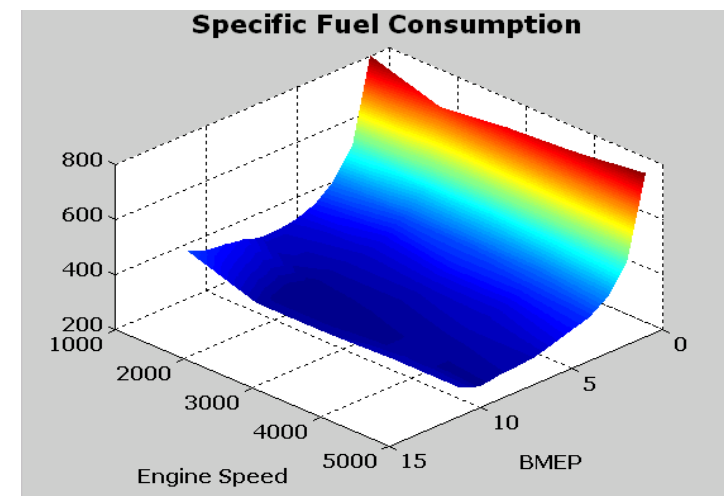
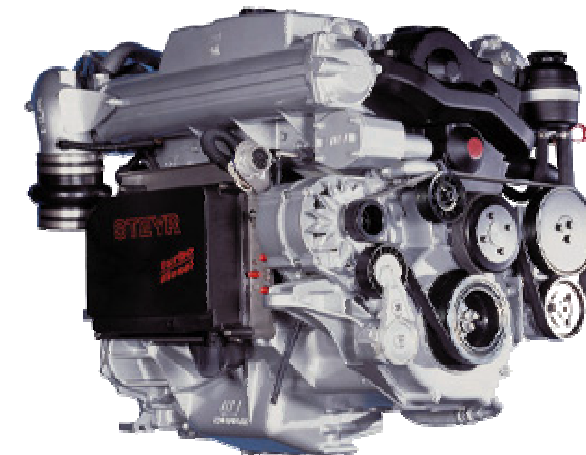
# Engine Model

## Approach

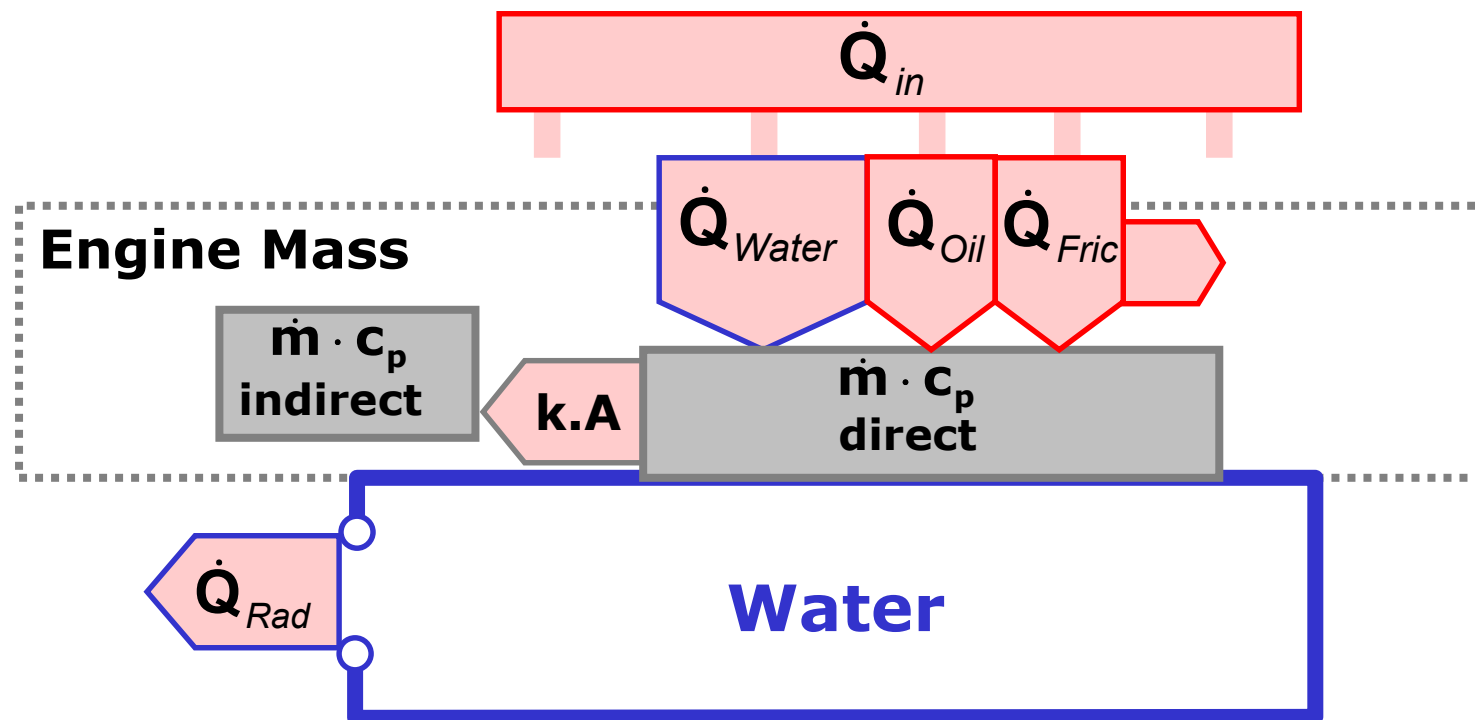
- Physical Properties
- Measured Engine Maps
- Reference Measurements
- Divided in Subsystems

## Application Support

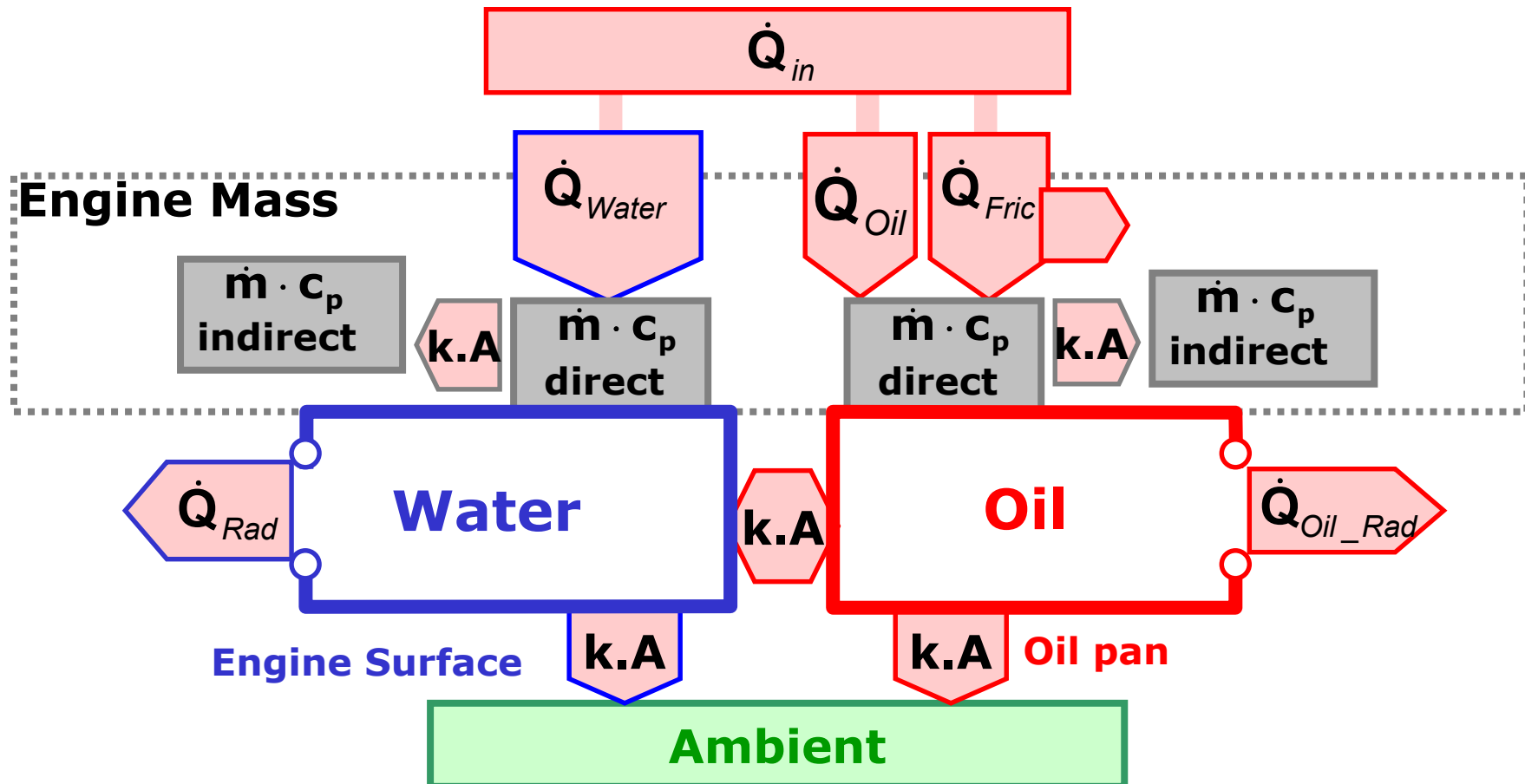
- Regulation for Model Set Up
- Routines for Automatic Tuning of Simulation Model



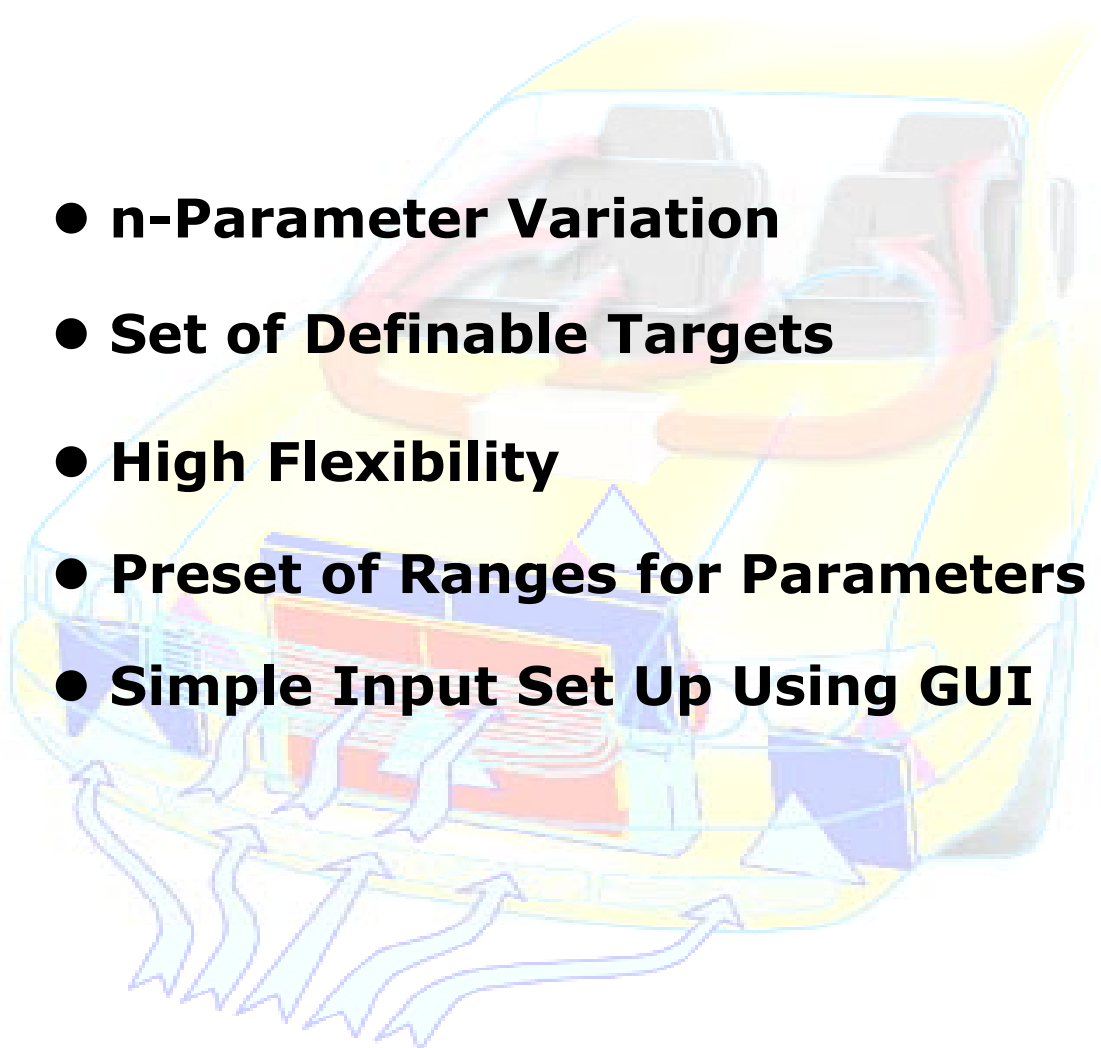
## 2-Mass Engine Model for Transient Simulation



# Engine Model

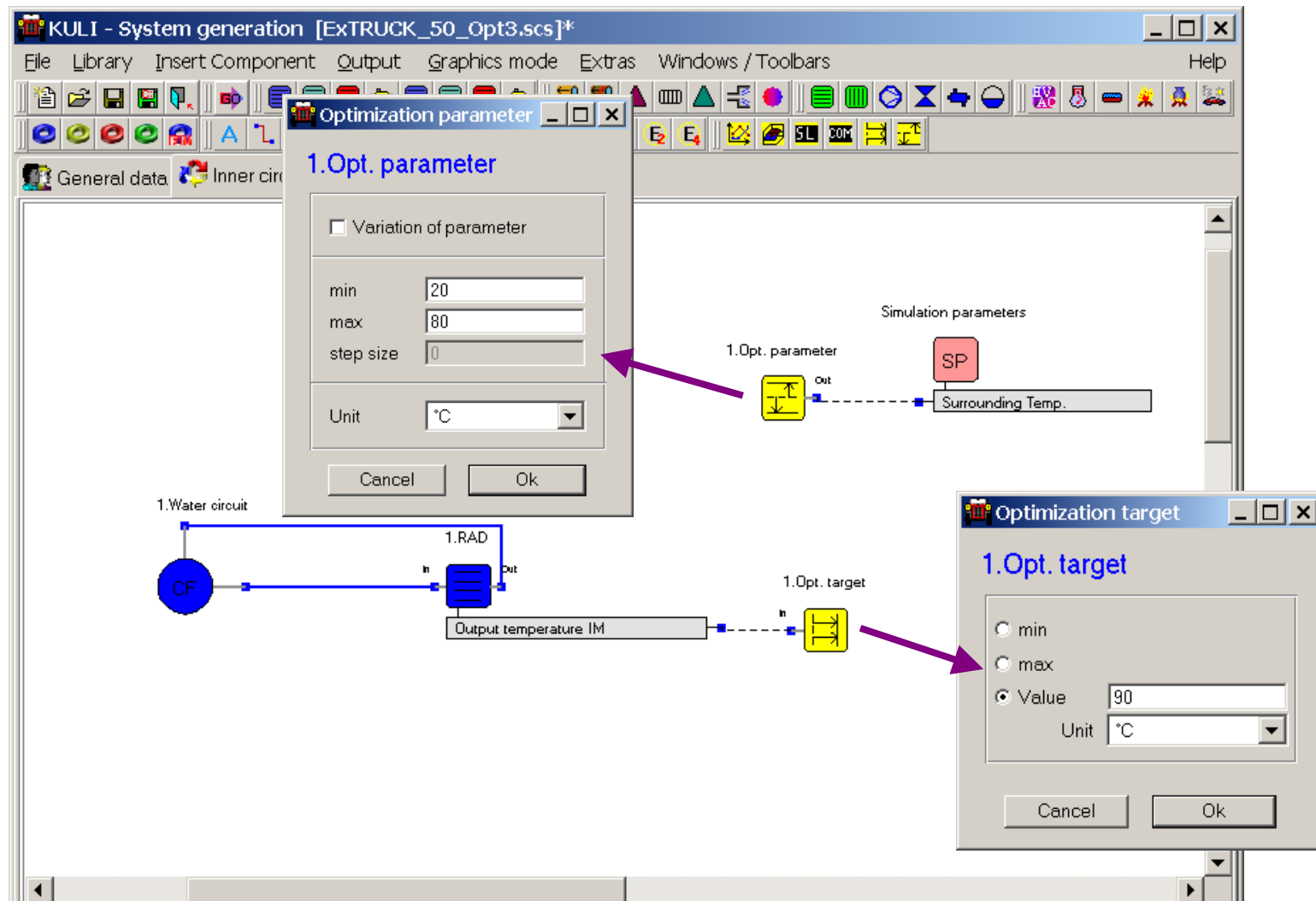


# Enhanced Optimization

- 
- **n-Parameter Variation**
  - **Set of Definable Targets**
  - **High Flexibility**
  - **Preset of Ranges for Parameters**
  - **Simple Input Set Up Using GUI**



# Optimization



# Future Development

## KULI ADVANCED

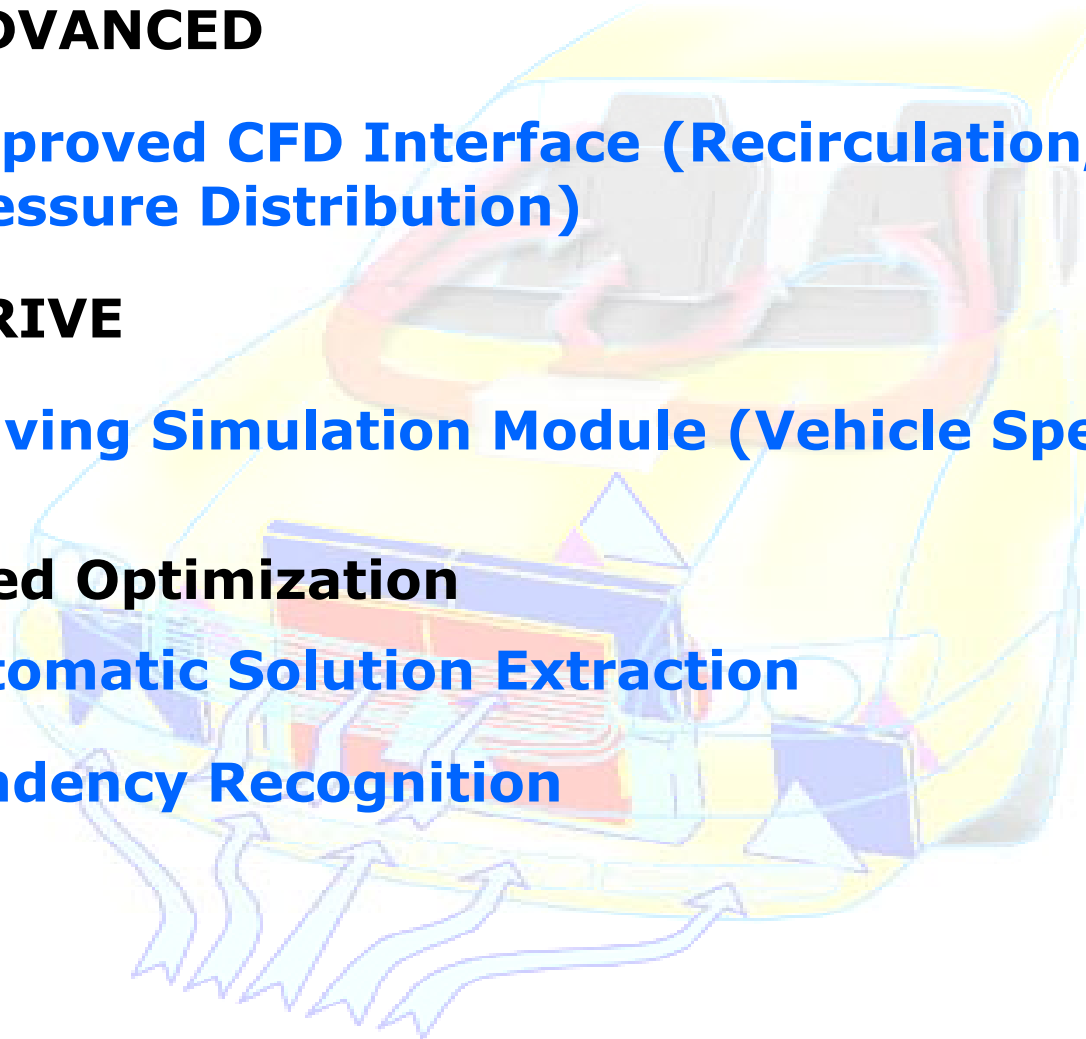
- **Improved CFD Interface (Recirculation, Pressure Distribution)**

## KULI DRIVE

- **Driving Simulation Module (Vehicle Speed vs. Time)**

## Enhanced Optimization

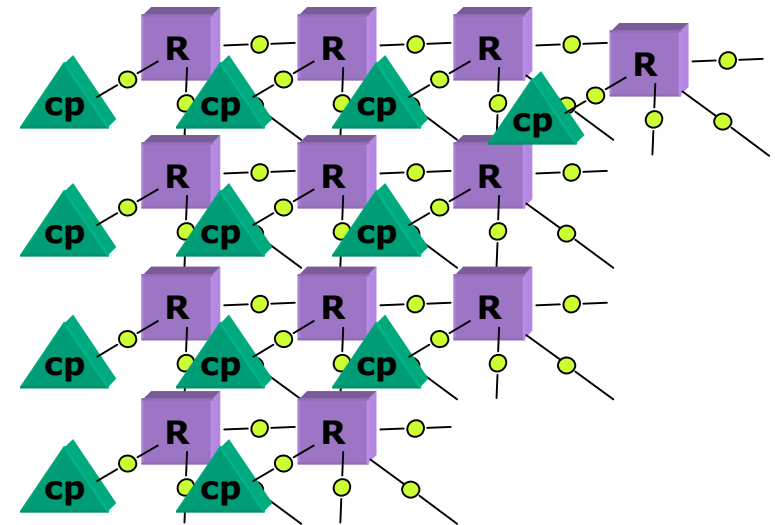
- **Automatic Solution Extraction**
- **Tendency Recognition**



# Future Development

## Improved CFD Interface

- **Local Flow Distribution**
- **Local Pressure Distribution**
- **Local Recirculation**
  - **CFD Data Import**
  - **Included in CFD-Interface**



# Future Development

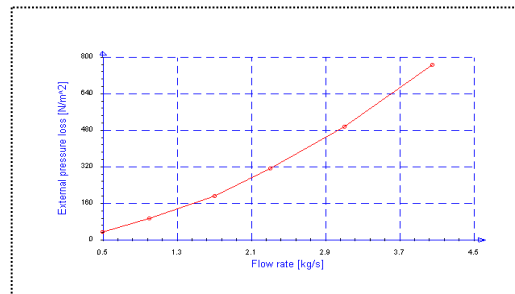
## Pressure Distribution (cp Matrix)

**Cp Matrix**

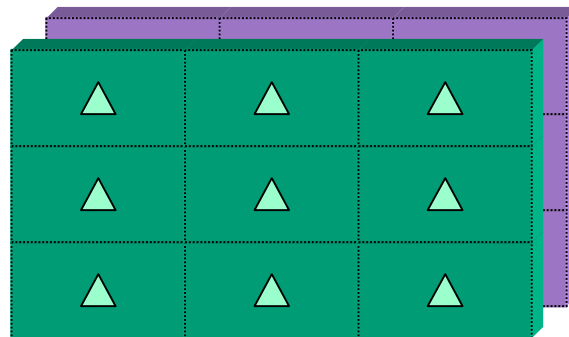
0,62	0,70	0,62
0,71	0,80	0,71
0,73	0,84	0,73



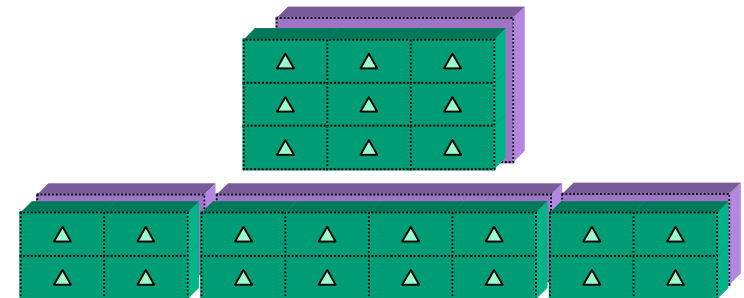
**Area Resistance**



**Automatic  
Generation**



**Application  
Vehicle  
Front**



# Future Development

## Driving Simulation Module

