

Development process of a prototype for fuel-cell powered electrical vehicles based on modeling and simulation



Goal of the job



- Use an existing Tractor!
- Substitute the big lead acid battery!
- Built in a fuel cell system!
- Make it suitable for daily use!
- Think about low cost development and integration!
- Variants management!
- Speed up development time
- ...
- keep cool...we have an answer J



Technical Challenge of the project

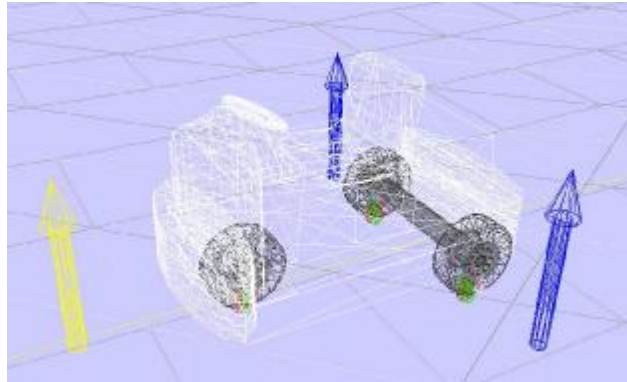


- Definition of the stack size of the fuel cell system
- Build up an electronic system that controls the stack and its power- and cooling- management
- Guarantee the drivability of the tractor
- Reduce all development costs

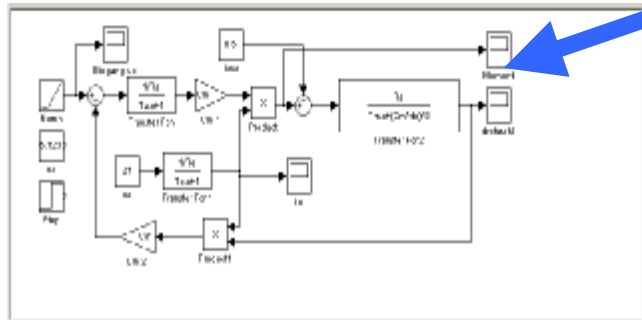
-> the only answer to this is:

Modeling and Simulation

The entire Tractor



mechanical model



electrical model



Electronic
control unit



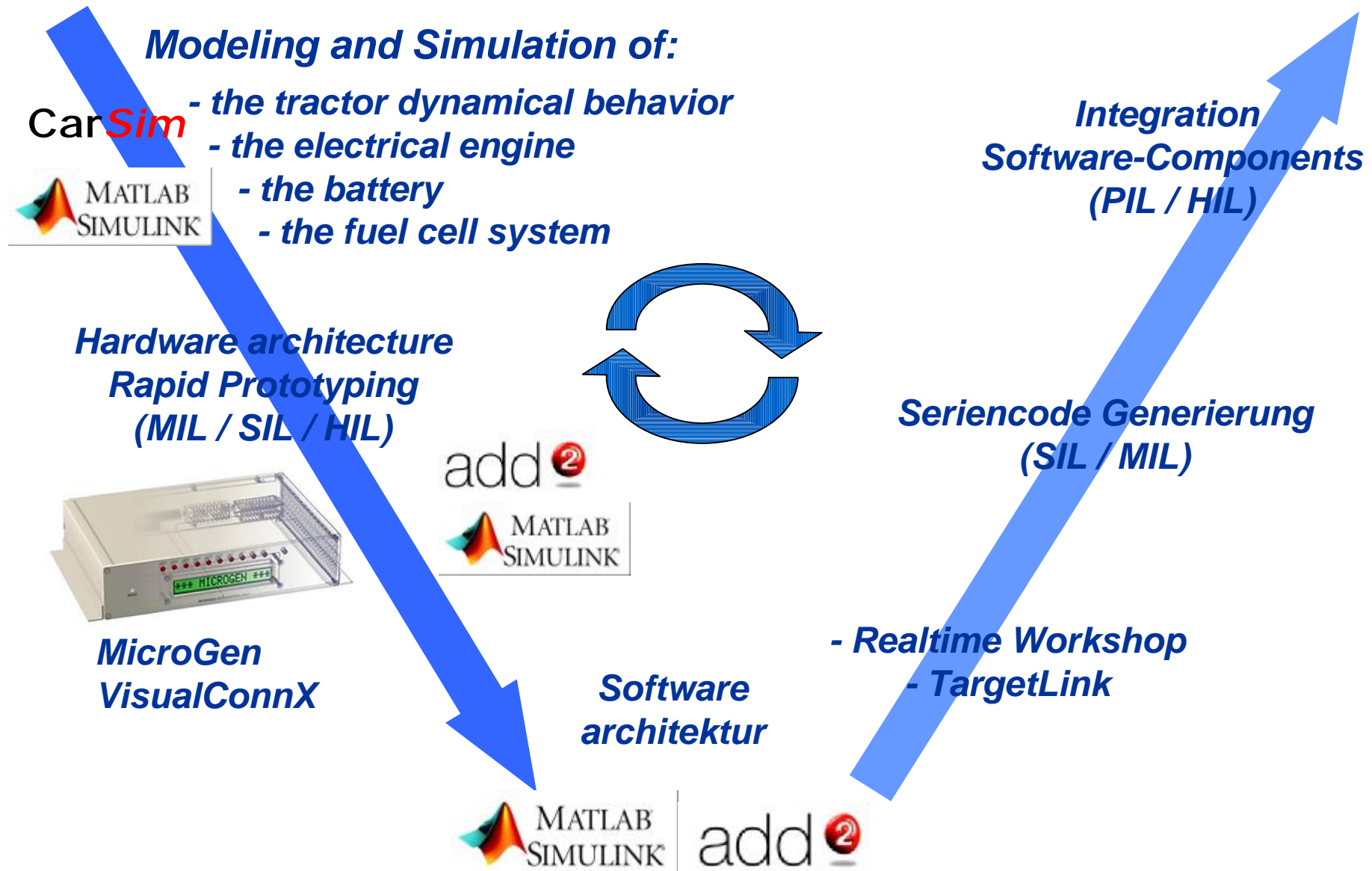
engine



battery

What had to be done along the V-curve

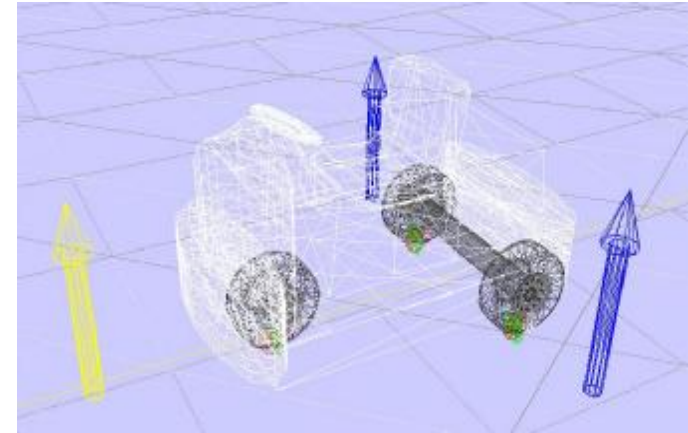
MAGNUM



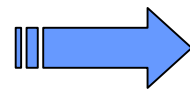
Modeling and Simulation of:



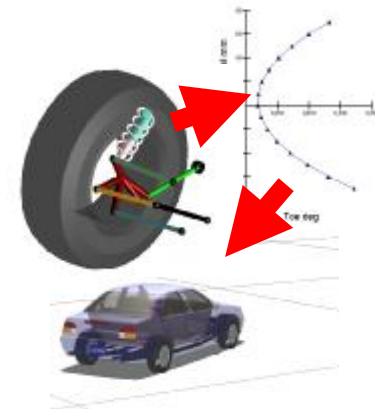
- Tractor electrical and mechanical behavior:
 - energy consumption
 - max power
 - total operating distance and hours
 - typical masses and loads



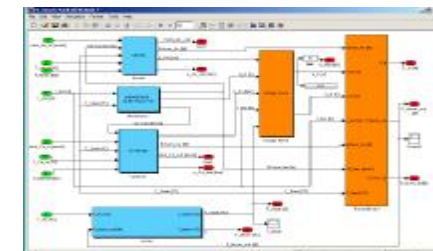
- Challenges of the mechanical simulation model
 - 3-wheel suspension
 - solid rubber tires
 - rubber springs
 - no extra dampers
 - lots of trailers



CarSim



- Challenges of the electrical simulation model
 - DC-engine
 - Battery model

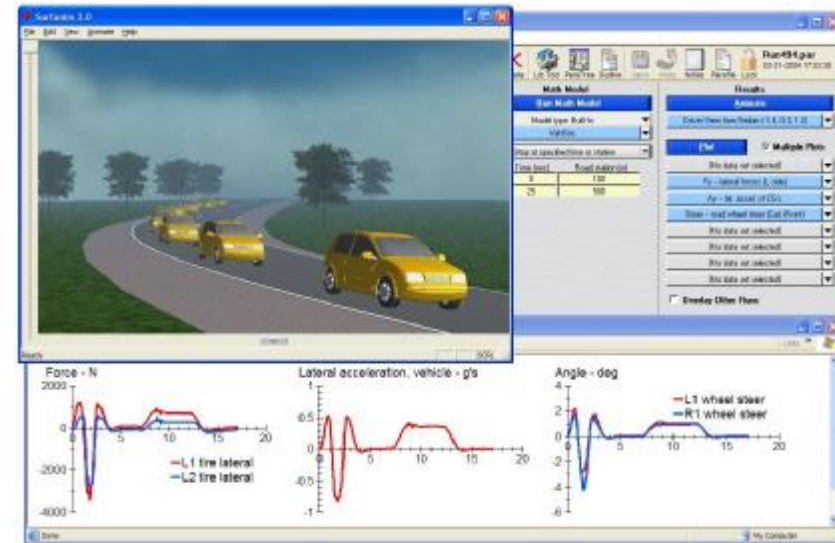


Car*Sim* and MATLAB/Simulink



Car*Sim*

- Advanced Vehicle Dynamics Software
- runs on ordinary Windows desktop and laptop PCs
- vehicle properties are defined by parameters and tables
- Is able to run with MATLAB/Simulink
- provides an S-Function model for importing/exporting all key variables



Car*Sim* and MATLAB/Simulink

- CarSim is not Simulink based but has an Interface
- standalone Solver
- 500 different variables are available for importing and exporting
- MATLAB/Simulink as sub-components of any vehicle model
- Robust models even in very low speed conditions
- Easy to replace parts of the powertrain with external models

Tractor simulation run with Car*Sim*



Video

Modeling and Simulation of:



- Fuel Cell electrochemical behavior

Energy balancing

Resulting form factor

Stack system dynamic



- Challenges of the electromechanical simulation model

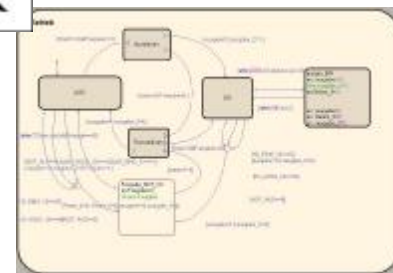
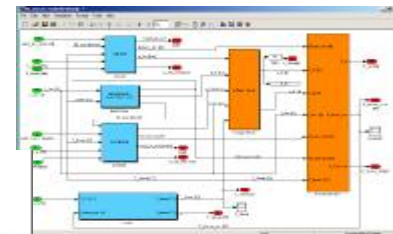
hydrogen- and oxygen- gas flow

electrical and thermal power

heating and cooling model



Stateflow® control

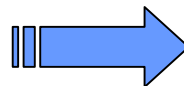


- Challenges of the fuel cell controlling strategy

Model based engineering

Automatic code generation

Graphical source language



Electronic Hardware (ECU)



- Electronic control unit

Energy balancing

Resulting form factor

Stack system dynamic



- Challenges for the electronic hardware

conform to Automotive Specification

Rugged Construction

Small

All-In-One Solution

Wide range of I/O and
communications facilities (CAN, LIN, RS232 ...)



MicroGen

- Complete Software development under Matlab/Simulink®/Stateflow®
- Including blocksets for all IO's and special functionalities

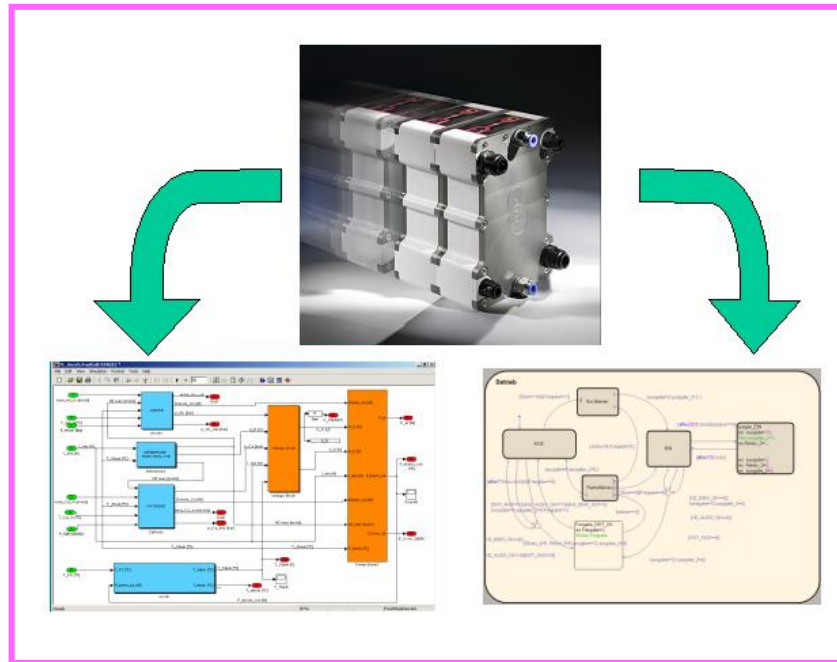


VisualConnX®

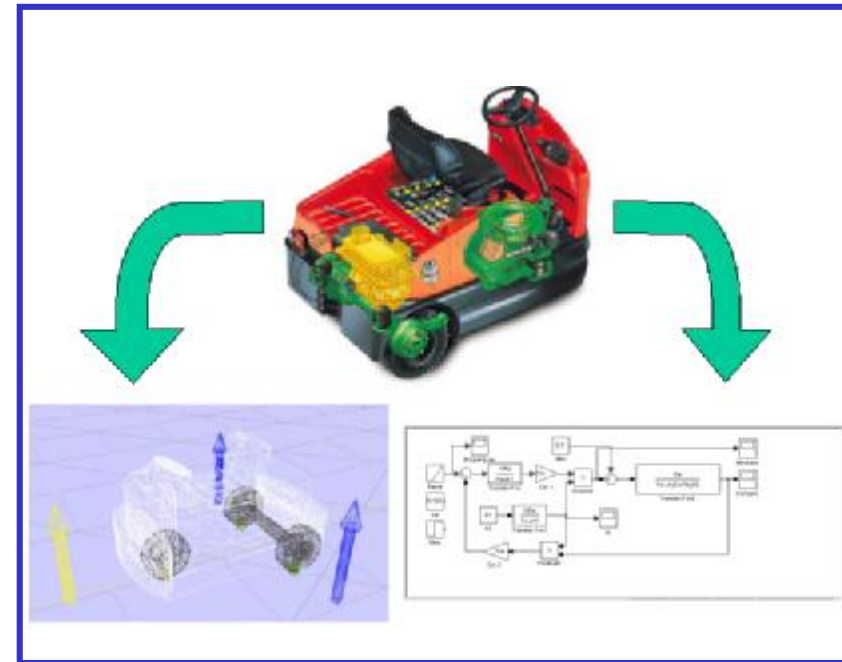
- Realtime graphical user interface with drag and drop functionality
- CCP over CAN connection to the MicroGen
- making signals and parameters accessible
- no requirement to write any software
- data can be viewed or changed remotely in the target system
- graphical objects, or “controls”, can be placed anywhere on a form



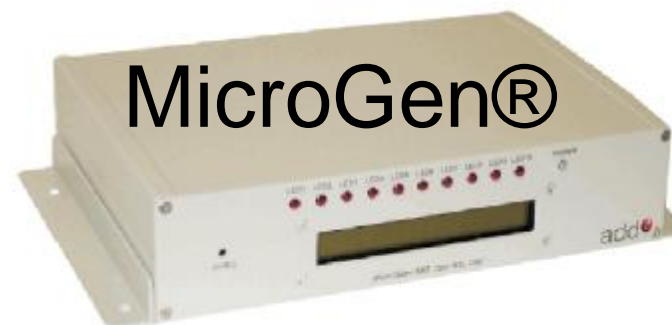
Virtual system Integration



Fuel-Cell
model

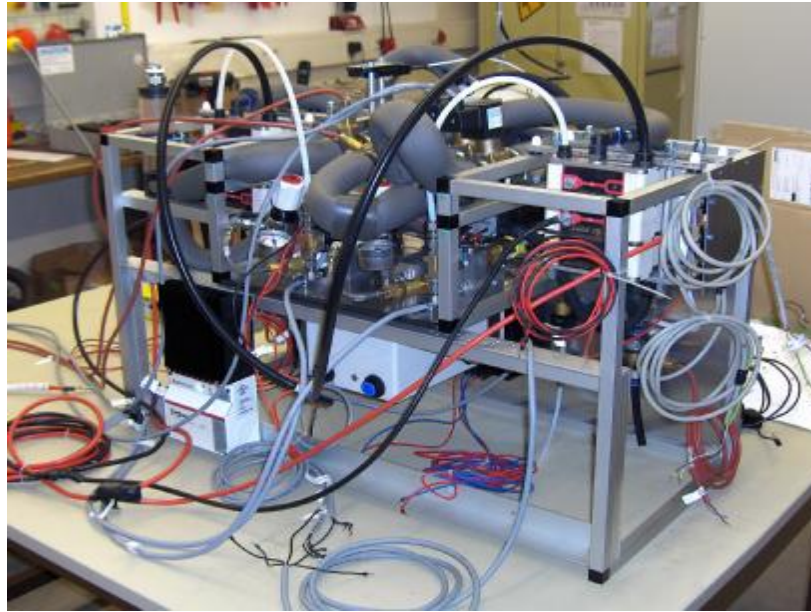


Tractor
model



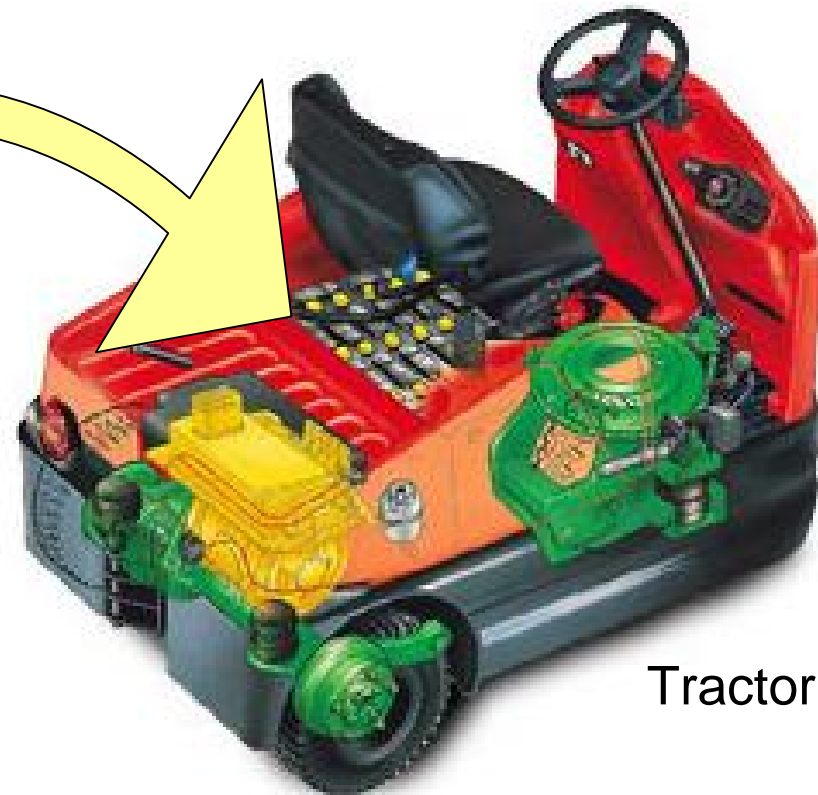
Real system Integration

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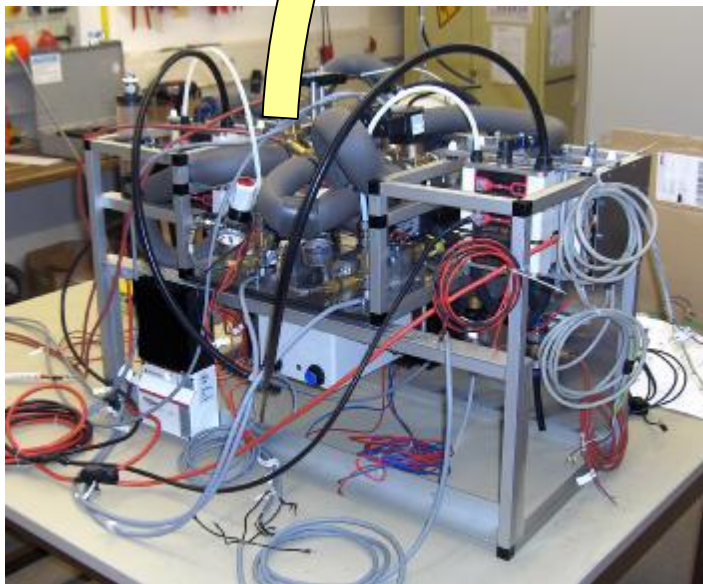


Battery replacement

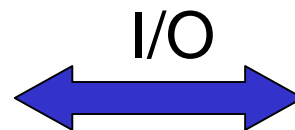
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Tractor



Fuel-Cell Module



MicroGen

Tractor simulation run with Car*Sim*



Video

Thank you!