Title:

«ADAMS2CM converter» & «TestManager Automatic Compiler»: from full ADAMS multi-body model to IPG CarMaker Real Time based model.
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The need of ADAMS2CM converter

• Structure of ADAMS2CM converter

• Results of ADAMS vs CM/TM models comparison

• Conclusions, developments and potentials
MSC ADAMS is the most diffused Multi Body (MB) tool in the world. It is commonly used for:

- MULTI-BODY suspensions design.
- Generic bushing effects simulation.
- Reaction forces on any structure point.
- Design of geometry and dimensions of components.
- Simulation of subsystems dynamic response.
- Virtual test bench for suspensions.
- FEM analysis of chassis.
- Virtual test bench for suspensions.
The need of ADAMS2CM converter

IPG Automotive CarMaker is a real-time based vehicle model suitable for:

- Vehicle Dynamics modeling.
- Real time HIL applications.
- ADAS systems.
- Closed loop maneuvers (IPG Driver).
- Complex scenarios definition.
- Traffic interactions.
A car manufacturer needs to deal with both the two complementary worlds...

For early process stages:
- Whole vehicle dynamics analysis.
- Single subsystems (no ECUs, no controllers, …)

For further stages:
- Whole vehicle and subsystems analysis.
- Hardware verification (HIL).
The need of ADAMS2CM converter

A way to pass from one world to the other is needed...

«ADAMS2CM converter»:
- **Fast** conversion.
- **Reliable** model conversion.
- **Semi-automated** procedure.

...that means **time** and **money** saving!
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The following subsystems of the vehicle can be converted:

- Suspension kinematics and compliance.
- Sprung mass.
- Steering.
- Powertrain.
- Brakes.
- Aerodynamics.
- Tires.
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Most of the ADAMS subsystem can be directly converted...
What does it mean «direct» conversion? Here an example about ICE Engine Maps

ADAMS data: Engine maps

CM data: Engine maps

Direct import of data

CM engine GUI
The following subsystems of the vehicle can be converted:

- Suspension kinematics and compliance.
- Sprung mass.
- Steering.
- Powertrain.
- Aerodynamics.
- Brakes.
- Tires.

Suspensions have to be translated into look-up-tables: need of a non-direct conversion...
What does it mean «non-direct» conversion? Here an example about Suspension Kinematics.

- Suspensions and steer analysis in ADAMS.
- Data extraction and conversion,
- creation of CM readable model.

Suspensions steer assembly in ADAMS.

CM suspension model
The converted model is finally compared with the original one according to customized criteria:

Each CarManufacturer defines its own set of standard maneuvers:
- Transient and steady state tests.
- Longitudinal and lateral tests.

Each CarManufacturer defines also its own matching evaluation criteria.
In order to increase automation level a new tool has been created: «Test Manager Automatic Compiler»

- Automatic generation of complex .ts files.
- Increase test manager flexibility.
- Create hundreds of variations in few seconds.
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Sample compiling procedure:
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Results of ADAMS vs CM models comparison

The conversion result is finally verified comparing original ADAMS model and CM model.

Each Car Manufacturer defines:

- A list of maneuvers to be simulated (steady state, transient...);
- An appropriated set of parameters for each maneuver (speed, steer angle, ...);
- The indices to be calculated to evaluate the matching of the results;
- A final synthetic index to evaluate the accuracy of conversion process.
Results of ADAMS vs CM models comparison

The conversion result is finally verified comparing original ADAMS model and CM model.

Each Car Manufacturer defines:

- A list of maneuvers to be simulated (steady state, transient...);
- An appropriated set of parameters for each maneuver (speed, steer angle, ...).

«Test Manager Automatic Compiler» is be used to automatically generate the test manager for models comparison:

- Tests selection from customized list
- Parameters adaptation
- Automatic Test Manager creation
The conversion procedure has been verified together with a big Car Manufacturer.

Below the list of chosen maneuvers:

<table>
<thead>
<tr>
<th>Applications</th>
<th>Lateral</th>
<th>Longitudinal</th>
<th>Combined</th>
</tr>
</thead>
</table>
| **Steady state** | • Steer ramp (fast, slow) | • Concentrated obstacle (symmetric and asymmetric)  
• Comfort test (CRG)  
• Throttle release  
• Coast down | • Brake while turn  
• Acceleration while turn |
| **Transient** | • Steer steps  
• Steer sweep  
• Sine with dwell | • Braking  
• Acceleration |   |
Results of ADAMS vs CM models comparison

APPLICATION: CarMaker

VEHICLE MODEL: Sample car (2 axles)

TEST: Open Loop Slow Steering Ramp

INPUTS:
- Constant reference speed: 60 km/h
- Fixed gear: 4°
- Steer angle reference signal: 0°-180° ramp

Reference Speed

![Reference Speed Graph]

Reference Steer

![Reference Steer Graph]
Results from CM have been compared with those from ADAMS:

NOTE: for confidentiality no details about calculated indices are shown.

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Roll Angle
- Side slip Angle

Results of ADAMS vs CM models comparison

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Front vertical forces.
- Side slip Angle.
- Roll Angle.

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Roll Angle
- Side slip Angle

Results of ADAMS vs CM models comparison

Front ground lateral forces

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Front Tyre Side Slip Angle.
- Front Ground Lateral Forces

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

Front suspensions travel.

Front tyre side slip Angle.

Front ground lateral forces

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Front suspensions travel.
- Front tyre side slip Angle.
- Front ground lateral forces.
- Side slip Angle.
- Roll Angle.
- Front vertical forces.

(*) numerical values hidden for confidentiality
RESULTS OF ADAMS VS CM MODELS COMPARISON

APPLICATION: CarMaker
VEHICLE MODEL: Sample car (2 axles)

TEST: Sine with dwell

INPUTS:
- Constant reference speed: 60 km/h
- Throttle release
- Sine with dwell steer reference
Results from CM have been compared with those from ADAMS:

Side slip Angle.

NOTE: for confidentiality no details about calculated indices are shown.

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

Results of ADAMS vs CM models comparison

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Roll Angle.
- Side slip Angle.
- Front vertical forces.

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- **Front vertical forces**
- **Side slip Angle.**
- **Front ground lateral forces**

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Front tyre side slip Angle.
- Front ground lateral forces

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

- Front suspensions travel.
- Front tyre side slip Angle.
- Front ground lateral forces
- Front vertical forces.

Results of ADAMS vs CM models comparison

(*) numerical values hidden for confidentiality
Results from CM have been compared with those from ADAMS:

Front suspensions travel.

Front tyre side slip Angle.

Front ground lateral forces

Front vertical forces.

Side slip Angle.

Roll Angle.

Results of ADAMS vs CM models comparison

(*) numerical values hidden for confidentiality
Finally the *Car Manufacturer* defined its own accuracy index:

Results of ADAMS vs CM models comparison

«ADAMS2CM converter»
(final overall index for all the tests)

<table>
<thead>
<tr>
<th>Avg. Accuracy</th>
<th>Dev.Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.5%</td>
<td>1.5%</td>
</tr>
</tbody>
</table>
Results of ADAMS vs CM models comparison

APPLICATION: TruckMaker

VEHICLE MODEL: Sample truck (4 axles)

TEST: Sine with dwell

INPUTS:
- Constant reference speed: 60 km/h
- Throttle release
- Sine with dwell steer reference

![Reference Throttle Graph]

![Reference Steer Graph]
Results of ADAMS vs CM models comparison

Results from TM have been compared with those from ADAMS:

NOTE: for confidentiality no details about calculated indices are shown.

(*) numerical values hidden for confidentiality
Results from TM have been compared with those from ADAMS:

Results of ADAMS vs CM models comparison

- Lateral acceleration
- Roll Angle

(*) numerical values hidden for confidentiality
Results from TM have been compared with those from ADAMS:

- Lateral acceleration.
- Roll Angle.
- 1° axle vertical forces.

Results of ADAMS vs CM models comparison

(*) numerical values hidden for confidentiality
Results from TM have been compared with those from ADAMS:

1° axle ground lateral forces

(*) numerical values hidden for confidentiality
Results from TM have been compared with those from ADAMS:

1° axle tyre side slip Angle.

1° axle ground lateral forces

(*) numerical values hidden for confidentiality
Results from TM have been compared with those from ADAMS:

Front suspensions travel.

1° axle tyre side slip Angle.

1° axle ground lateral forces

(*) numerical values hidden for confidentiality
Results from TM have been compared with those from ADAMS:

- Front suspensions travel.
- Lateral acceleration.
- Roll Angle.
- 1° axle tyre side slip Angle.
- 1° axle ground lateral forces.
- 1° axle vertical forces.

(*) numerical values hidden for confidentiality
Finally the *Car Manufacturer* defined its own accuracy index:

```
«ADAMS2CM converter»
(final overall index for all the tests)

<table>
<thead>
<tr>
<th>Avg. Accuracy</th>
<th>Dev.Std.</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.0%</td>
<td>2.0%</td>
</tr>
</tbody>
</table>
```
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Conclusions, developments and potentials
CONCLUSIONS

• mostly all “nowadays” OEM use ADAMS for vehicle early-stage design;
• OEM will continue to exploit ADAMS functionality;
• common vision for incoming future is the growing need of RT simulation as well;
• a synergy between MB and RT simulation is a “must”;

→ objective need of a (semi)automatic, reliable ADAMS2CM tool, updated year-by-year as front end of both the simulation to save time and money.

• The Beta-version of the converter tool has been presented. In detail:
  o each single ADAMS model’s Subsystem arrangement;
  o extraction of required quantities;
  o data translation from ADAMS to CM language;
  o procedure of conversion results comparison over significant maneuvers.

• The toll reliability has been quantified; conversion precision rises up to more than 98% of matching quality;
• Toll has been already applied both to passenger vehicle (2 axles) and to truck (4 axles).
Conclusions, developments and potentials

WIP

• «ADAMS2CM converter» on a pre-developments stage;
• «Test Manager Automatic Self Compiler»: available in Beta-version, both as stand-alone and integrated in ADAMS2CM tool;
• troubleshooting new application samples, CM integration is now running to converge to release 1.0;
## Conclusions, developments and potentials

### Vehicle models database:
**Both ADAMS and CM models will live together and used when necessary!**

<table>
<thead>
<tr>
<th>![Adams Model]</th>
<th>![IPG Logo]</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Car Model]</td>
<td>![CM Logo]</td>
</tr>
<tr>
<td>![Truck Model]</td>
<td>![Vehicle Models]</td>
</tr>
</tbody>
</table>

### POTENTIALS

- Improvements of IPG software potential: ADAMS is now communicating with CM!
- IPG products’ potential market; relevant time saving for the conversion procedure.
- Quality of conversion will be delegated.
- Hand conversion no longer required.
- No risk to hand-conversion errors.
- Rapid conversion from ADAMS to CarMaker through a new concept of model database: both ADAMS and CM models will live together and used when necessary!
Thanks fro your kindly attention!
We wait for you at our demo-stand for further information!

Research partnership in technology innovation (SINCE 2004)

“...our mission is to observe market needs, to design research innovation and transfer achieved methodologies to partner companies to face to every-day challenges...”