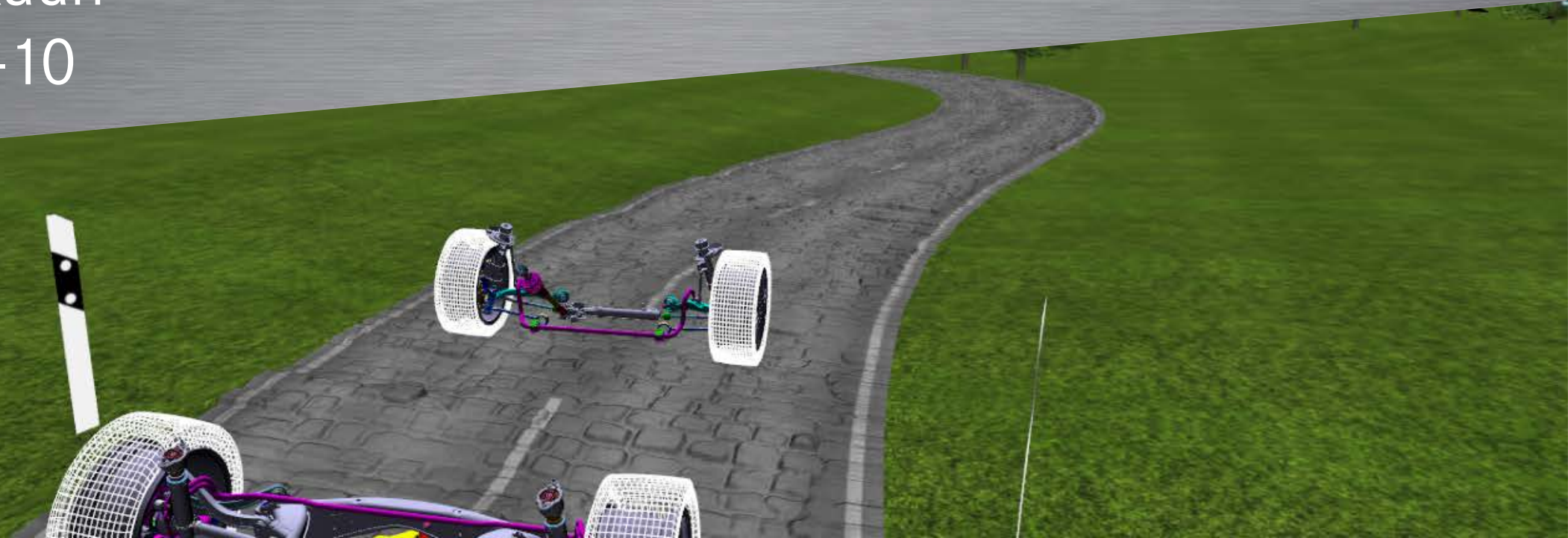


DAIMLER

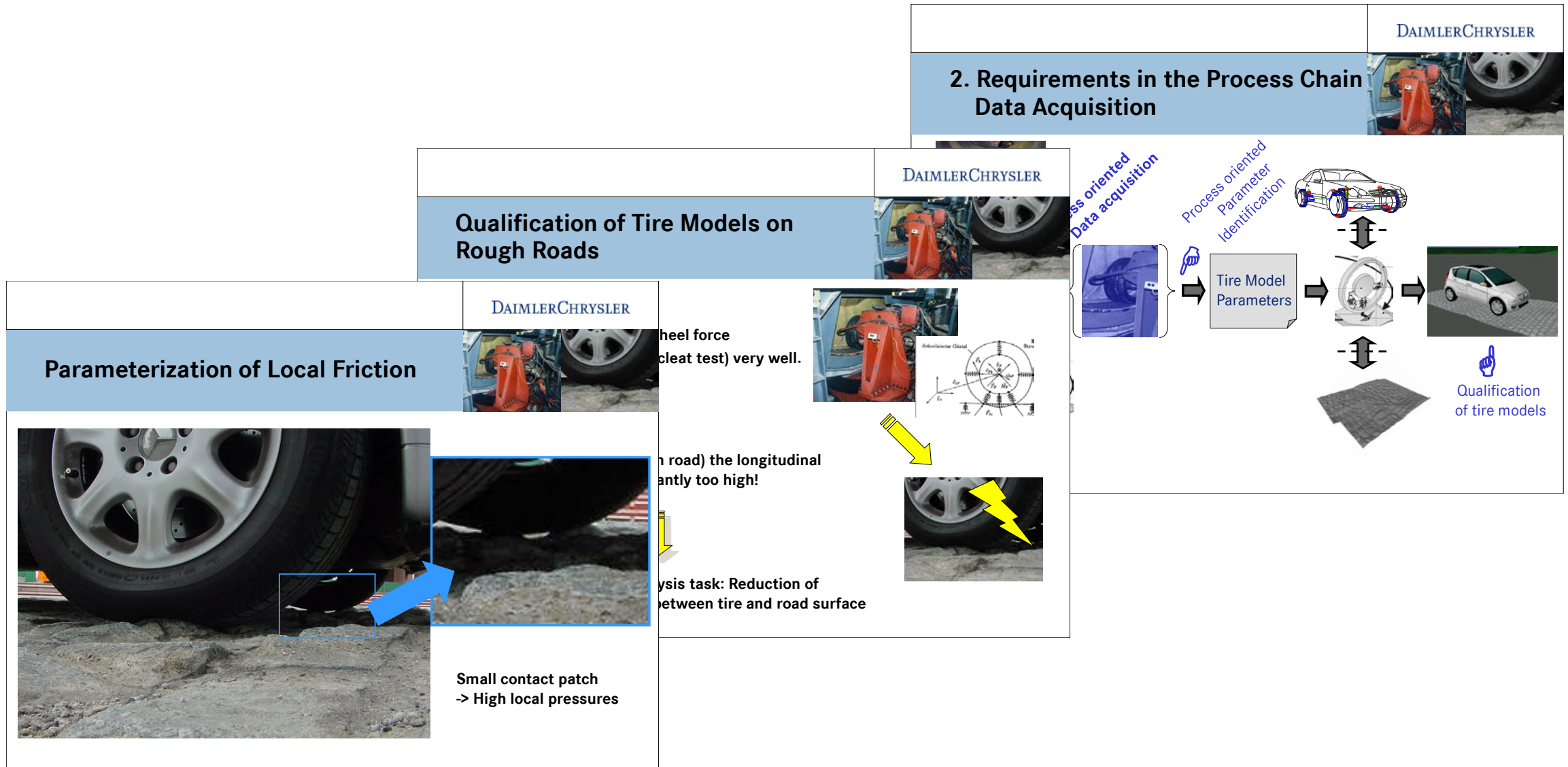
Representing Road Surfaces with OpenCRG:
some insight into its background and applications

Jochen Rauh

2018-10-10



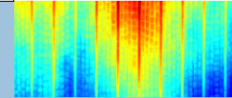
TireWheelTech 2006: Process Stability for Tire Simulation



Evolution of road surface measurement technology

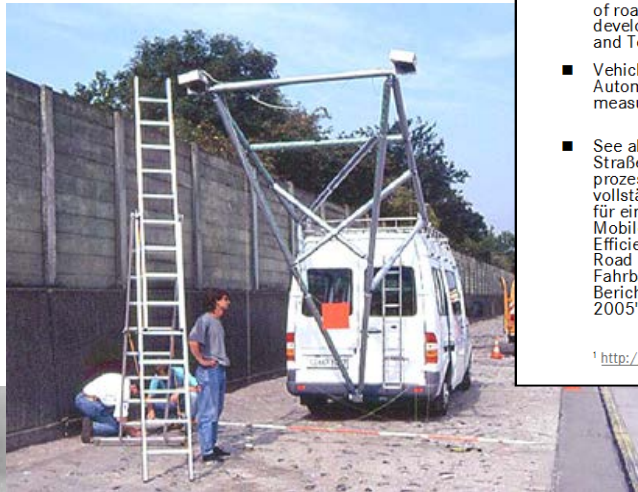
DAIMLERCHRYSLER

Road Measurements- Today

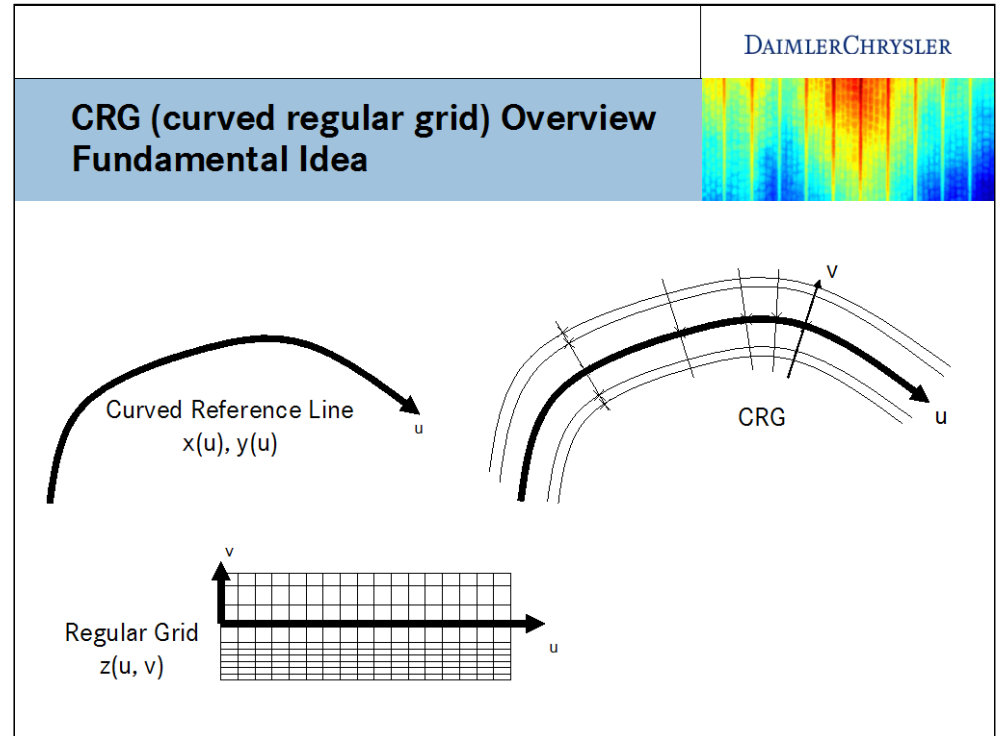
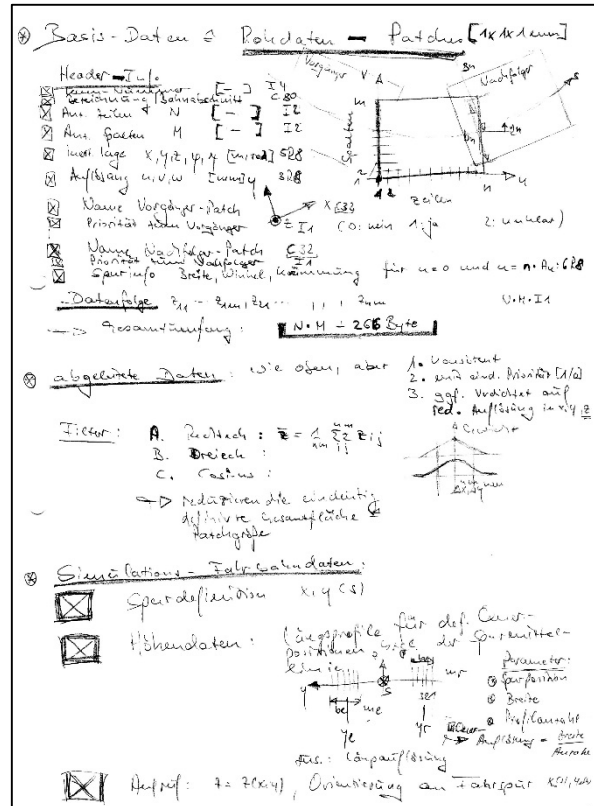
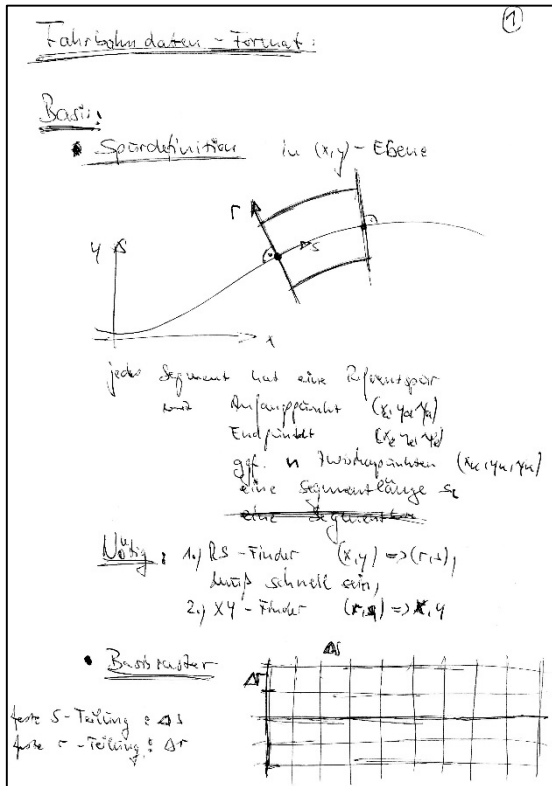


- Vehicle for high-resolution measurements of road surfaces in moving traffic was developed by DaimlerChrysler Research and Technology
- Vehicle is now operated by TÜV SÜD Automotive GmbH to provide measurements to everyone¹.
- See also: Gimmler, Rauh, Ammon: Straßenprofile: Mobile Messung, prozessgerechte Datenaufbereitung und vollständige Bewertung bereiten die Basis für eine effektive Simulation (Road Profiles: Mobile Measurement, Data Processing for Efficient Simulation and Assessment of Road Properties). In "Reifen-Fahrwerk-Fahrbahn Hannover 25./26.10.2005, VDI-Bericht 1912, VDI-Verlag, Düsseldorf, 2005"

¹ <http://www.tuev-sued.de/3D-Track>



Looking for a road surface representation optimized for minimal memory and compute time consumption



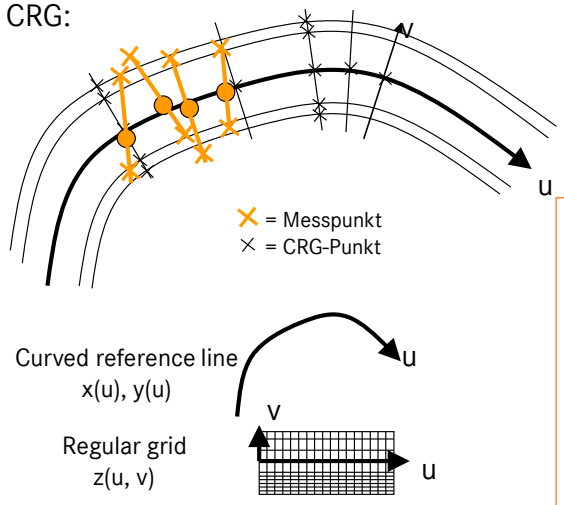
OEM working group 6.1.3 on Tire Simulation

2007-03-06: Proposal of CRG as common road data format

DAIMLERCHRYSLER

Straßenprofile: Messung, Aufbereitung, Bewertung als Basis zur Simulation

**Neues Straßendatenformat: CRG
(Curved Regular Grid)**



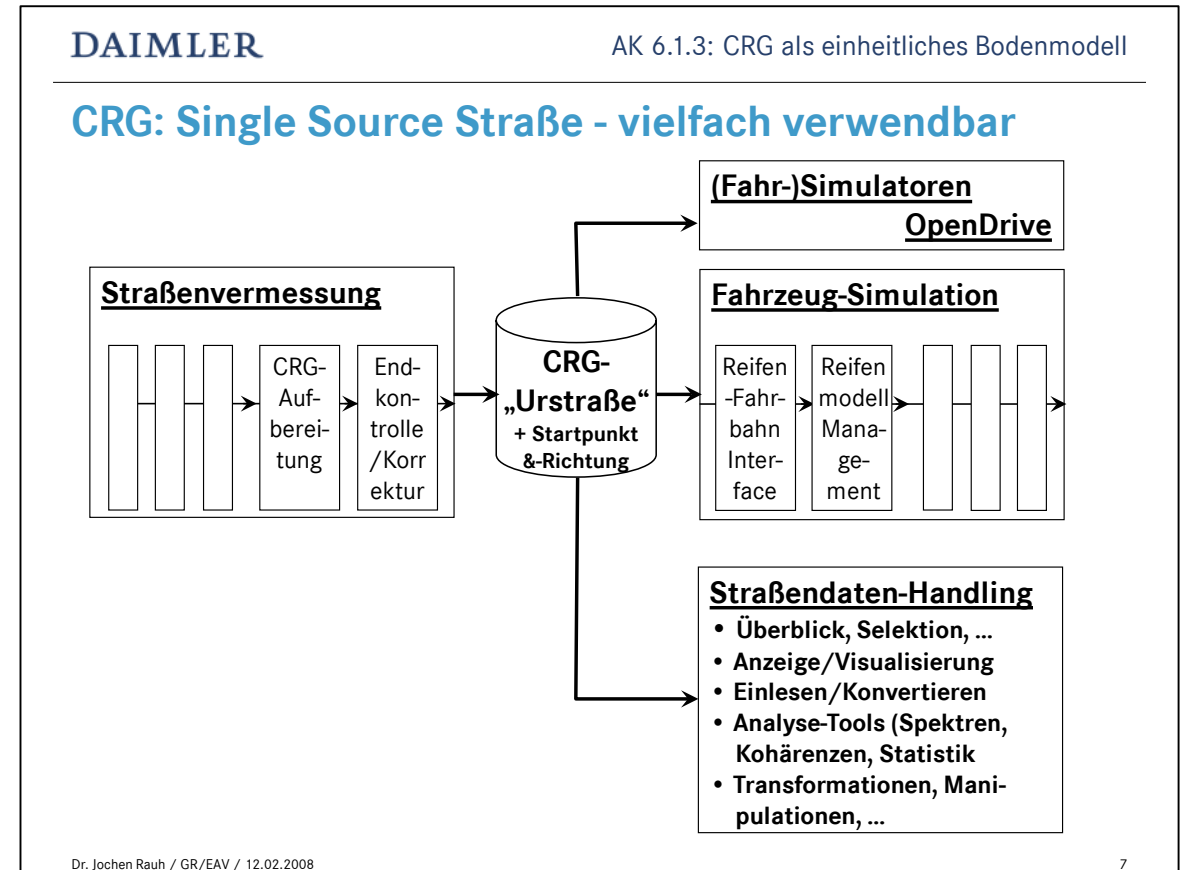
CRG:
 × = Messpunkt
 × = CRG-Punkt

Curved reference line
 $x(u), y(u)$

Regular grid
 $z(u, v)$

- bietet ein effizientes Speicherformat:
1km x 2m; 1cm xy-Auflösung: < 80MB
- liefert konsistente Daten:
z.B. Abweichungen leicht erkennbar
- verringert die Simulationszeit:
Straße alleine: Faktor 10...100
- Daten sind schon vernetzt:
keine zusätzliche Triangulation nötig

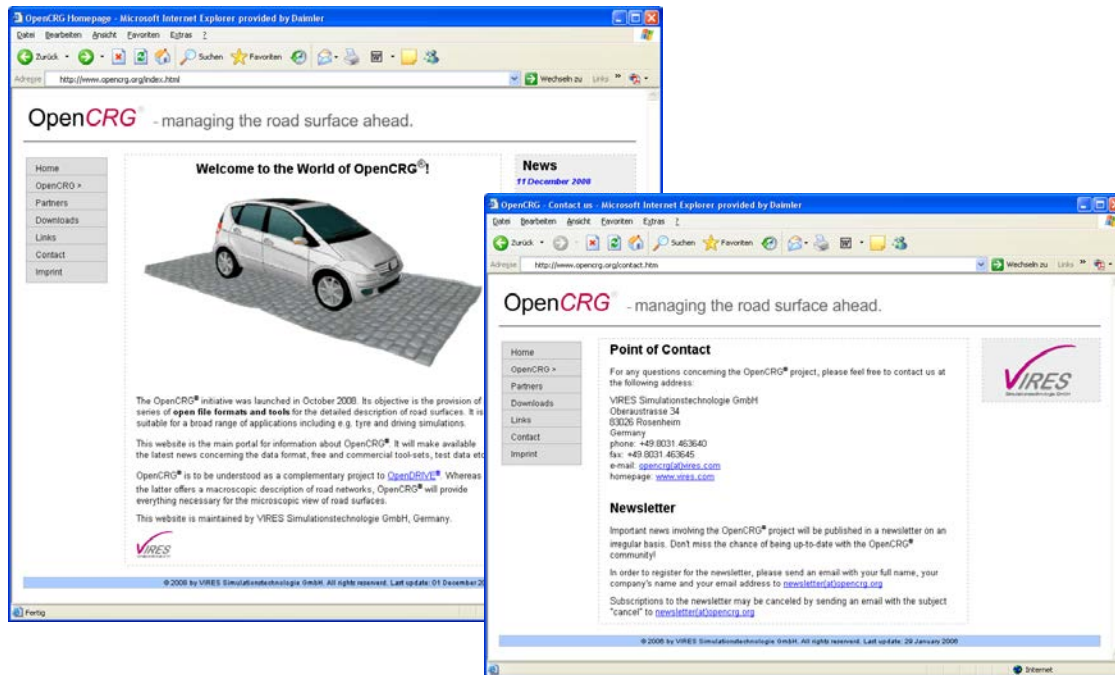
3D-VDI-2005.ppt 9



OpenCRG gets public tire.wheel.tech 2008-12-11

OpenCRG

OpenCRG is on <http://www.opencrg.org>



AK 6.1.3 11.12.2008

OpenCRG

References

1. Gimmler H., Ammon D. & Rauh J. (2005). Road Profiles: Mobile Measurement, Data Processing for Efficient Simulation and Assessment of Road Properties. VDI-Report No. 1912, 335-352 (in German).
2. N.N. (2007). Announcement of OpenDRIVE extension with CRG (Curved Regular Grid) Road Profile Data Format. <http://www.opendrive.org>
3. N.N. (2008). Announcement of OpenCRG <http://www.opencrg.org>
4. Rauh J. (2003). Virtual Development of Ride and Handling Characteristics for Advanced Passenger Cars. Vehicle System Dynamics 40(1):135-155.
5. Rauh J. (2005). CRG (Curved Regular Grid) Road Profile Data Format. <http://www.tuev-sued.de/3D-Track>.
6. Rauh J. & Mössner-Beigel M. (2008). Tyre simulation challenges. Vehicle System Dynamics, 46 (Supp 1), 49-62.
7. Schick B., Gimmler H., Rauh J. & Witschass S. (2006). 3D-TRACK – Give the simulation the chance for a better work! Mobile, high-resolution topology and roughness measuring of road surfaces to create 3D track models. F2006V095 FISITA automotive world congress, 22.-27.10.2006, Yokohama.

AK 6.1.3 11.12.2008

Hosting of OpenCRG as OpenSource Project supported by Vires – thank you!



The screenshot shows a web browser window displaying the OpenCRG website. The address bar shows 'http://www.opencrg.org/'. The page features the OpenCRG logo with the tagline 'managing the road surface ahead'. A navigation menu includes 'Home' and 'Downloads'. A prominent announcement banner reads 'April 17th, 2018: OpenCRG 1.1.2 available!' with a 'Get it...' button. Below the banner, a section titled 'Welcome to the World of OpenCRG®!' provides introductory text about the project's goals and its relationship to OpenDRIVE®.

OpenCRG®
managing the road surface ahead

Home Downloads

April 17th, 2018: OpenCRG 1.1.2 available!

Get it...

Welcome to the World of OpenCRG®!

The OpenCRG® initiative was launched in October 2008. Its objective is the provision of a series of **open file formats and open source tools** for the detailed description, creation and evaluation of road surfaces. It is suitable for a broad range of applications including e.g. tyre and driving simulations.

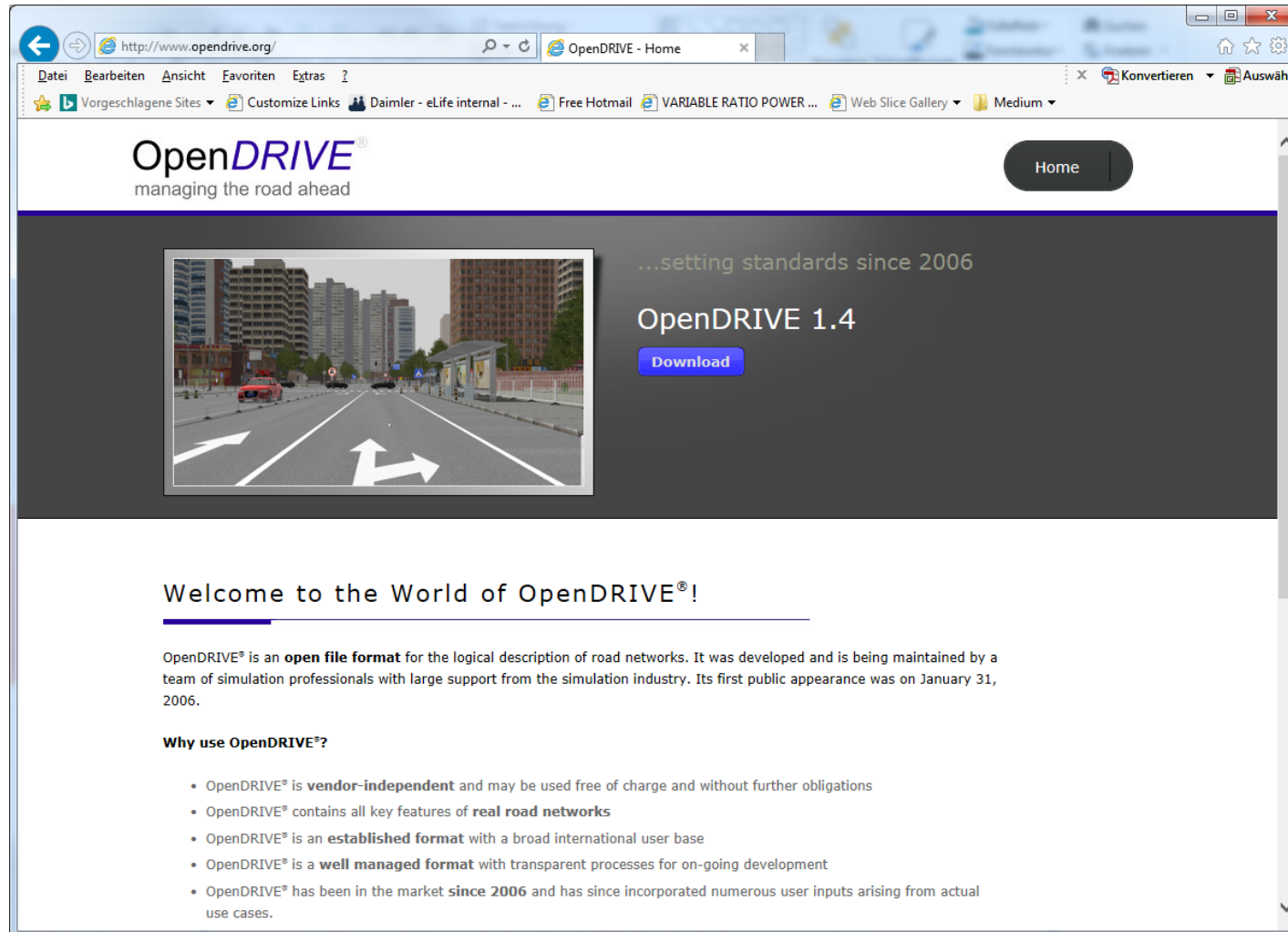
This website is the main portal for information about OpenCRG®. It will make available the latest news concerning the data format, free and commercial tool-sets, test data etc.

OpenCRG® is to be understood as a complementary project to [OpenDRIVE®](#). Whereas the latter offers a macroscopic description of road networks, OpenCRG® will provide everything necessary for the microscopic view of road surfaces.



<http://www.opencrg.org>
<mailto:opencrg@opencrg.org>

OpenDRIVE represents details of road surfaces using OpenCRG



The screenshot shows a web browser window displaying the OpenDRIVE website. The browser's address bar shows the URL <http://www.opendrive.org/>. The website header features the OpenDRIVE logo with the tagline "managing the road ahead" and a "Home" button. Below the header, there is a main content area with a dark background. On the left, there is a small image of a city street with a car and a bus. To the right of the image, the text reads "...setting standards since 2006" and "OpenDRIVE 1.4" with a blue "Download" button. Below this, there is a section titled "Welcome to the World of OpenDRIVE®!" followed by a paragraph of text and a section titled "Why use OpenDRIVE®?" with a bulleted list of features.

OpenDRIVE® managing the road ahead

Home

...setting standards since 2006

OpenDRIVE 1.4

Download

Welcome to the World of OpenDRIVE®!

OpenDRIVE® is an **open file format** for the logical description of road networks. It was developed and is being maintained by a team of simulation professionals with large support from the simulation industry. Its first public appearance was on January 31, 2006.

Why use OpenDRIVE®?

- OpenDRIVE® is **vendor-independent** and may be used free of charge and without further obligations
- OpenDRIVE® contains all key features of **real road networks**
- OpenDRIVE® is an **established format** with a broad international user base
- OpenDRIVE® is a **well managed format** with transparent processes for on-going development
- OpenDRIVE® has been in the market **since 2006** and has since incorporated numerous user inputs arising from actual use cases.



<http://www.opendrive.org>

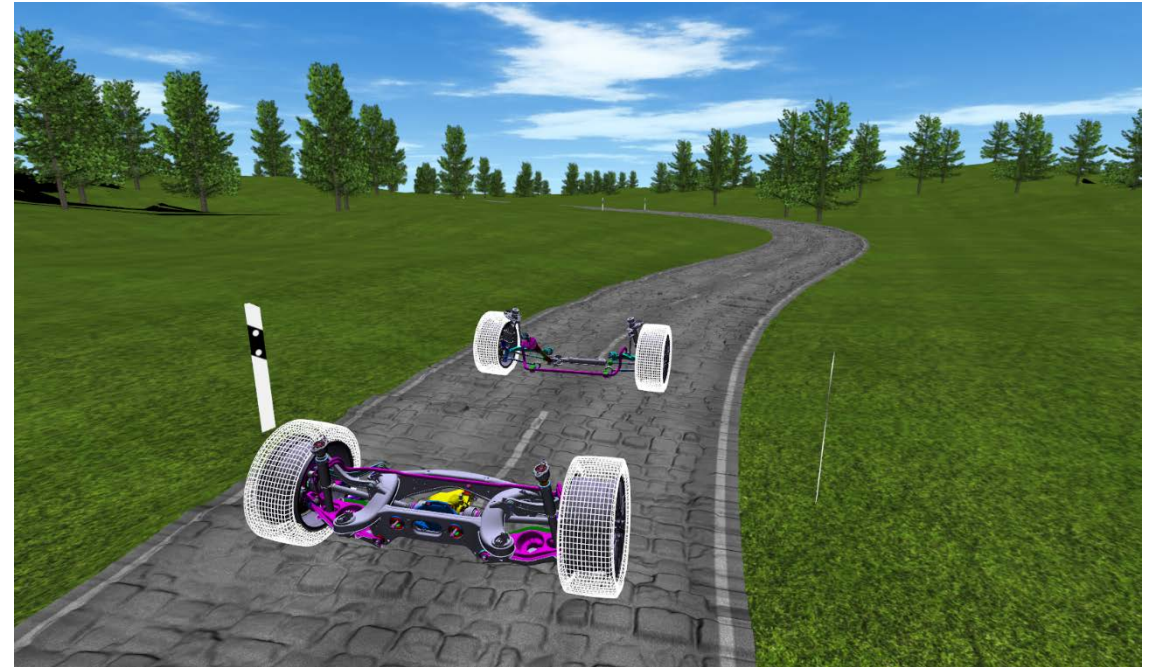
<mailto:opendrive@opendrive.org>

2018: Today's OpenCRG applications

Most intense application area is still road surface representation for comfort and durability simulation, but we also use CRG to represent distributed scalar properties of the road, e.g.

- Friction attributes (friction coefficient)
- Visual attributes (grey value)
- ...

We use data from real road measurements as well as data generated synthetically to represent deliberate operating conditions and disturbances.



2018ff: What's next?

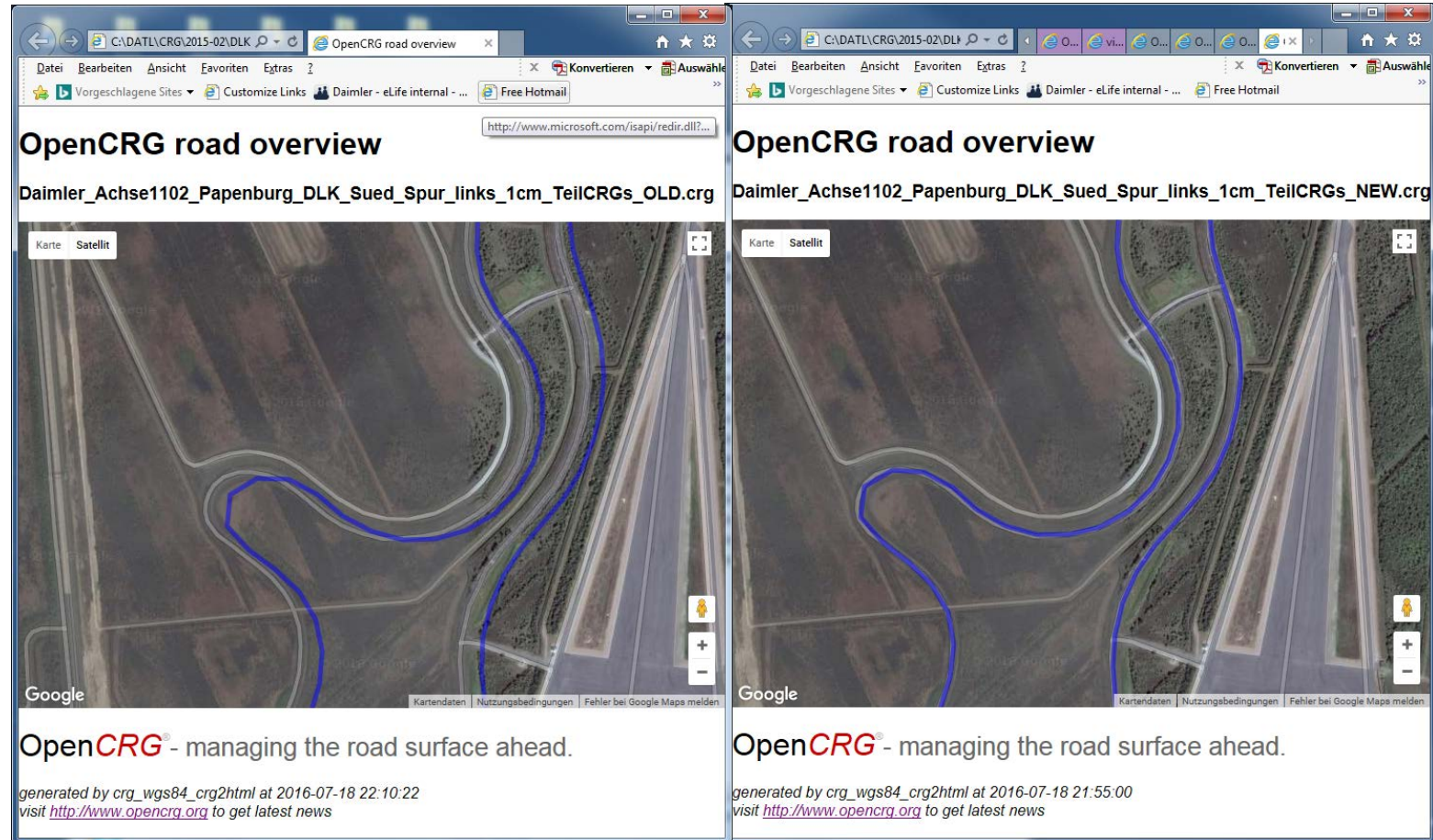
- OpenSource projects like OpenCRG need supporters and contributors!
- During 10 years of OpenCRG, VIRE Simulationstechnik GmbH did an excellent job to code and document the C reference implementation, to continue hosting, bug fixing, answering user questions and user support – thank you for all effort!
- 3D Mapping Solutions GmbH also supported OpenCRG by hosting a workshop and supporting many users with their questions related to OpenCRG – thank you, too!
- Jochen Rauh provides some internal support at Daimler, and sometimes gets involved in more complex support topics – mostly answering at night or weekend 😊😊
- OpenDRIVE is on its way to ASAM – OpenCRG will do the same!

2018ff: upcoming contribution by Jochen Rauh

Forward/backward transformation
GEO-coordinates (lon/lat) <->
CRG-coordinates (x/y)
from meter accuracy to centimeter
accuracy by simply adding some
projection information, e.g.

```
pro.proj.nm = 'TM_6';  
pro.proj.f0 = 0.9996;  
pro.proj.e0 = 500000;
```

(will soon be available in Matlab
reference implementation of
OpenCRG)



Open **CRG**[®] - managing the road surface ahead.