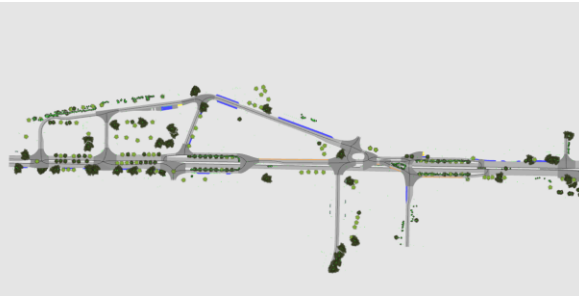


Precise worldwide ultra HD Map Road Data Collection for IPG CarMaker

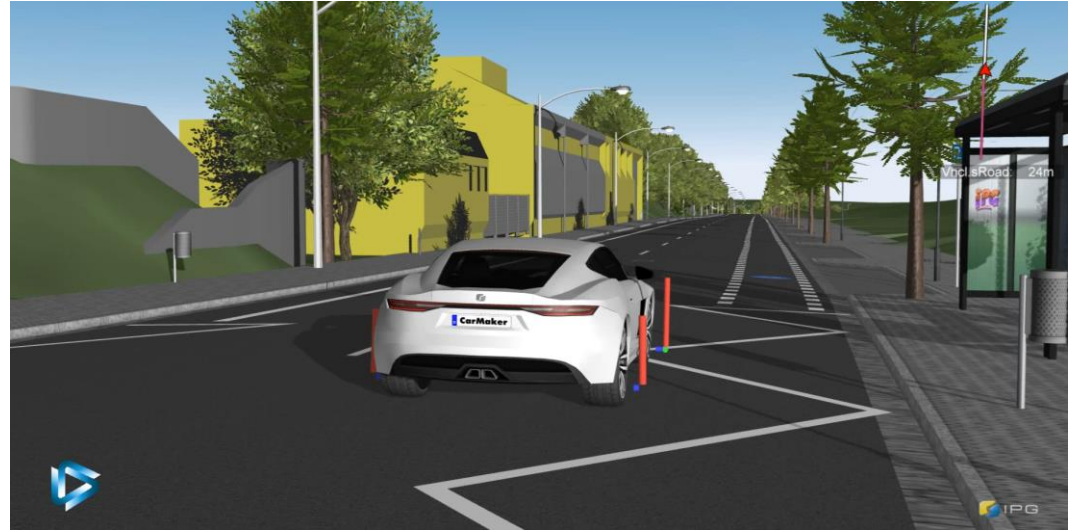
as basis for virtual Testing and Simulation

Dr.-Ing. Gunnar Gräfe



Ultra HD Map Data as basis for Virtual Testing and Simulation

- Identical digital twin of real-world roads as prerequisite for comparable testing in reality and in virtual environments
- Technical solution for digitizing public road networks with sufficient accuracy and resolution is high-end mobile surveying using perfect vehicle motion compensation, high-resolution scanners and multiple calibrated cameras.
- Various results may be derived from high-resolution survey data, e.g. digital road surface models, precise high-definition reference maps, traffic scenario data, 3d environment models etc.



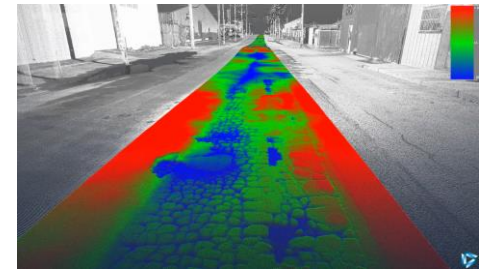
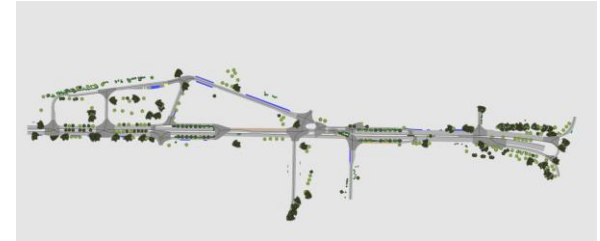
3D Mapping Solutions – The company

- Headquarters: Holzkirchen, Germany
Subsidiary: 3D Mapping Solutions Inc., Pittsburgh, PA, USA
- Founded 2007 by Gunnar Gräfe and Martin Lang, both with more than 20 years experience in kinematic surveying
- 66 highly skilled employees
- Almost all automobile manufacturers/suppliers worldwide as customers
- Active internationally (Europe, USA, China, Japan) with various own survey-systems of type KiSS and MoSES
- In addition, we can use our mobile mapping partner-systems worldwide.



3D Mapping Solutions - Main products for available tracks

- Ultra HD Maps in OpenDRIVE or other formats
 - Compatible with all major simulation software packages or driving simulators
 - Main 3D Mapping Solutions product are high-fidelity maps based on high-resolution mapping data suited for **high-end simulation and validation**
 - Relative accuracy < 1 cm
- High-resolution road surface models for perfect vertical stimulation of the vehicle
 - delivered in OpenCRG or other formats
 - fully compatible to the latest OpenDRIVE versions or other software packages.
 - Relative accuracy < 1 mm
- 3D environment model for perfect visual (and material) representation.



3D Mapping sensor data as basis for ultra HD Maps and simulation



- Precise high resolution scanner data



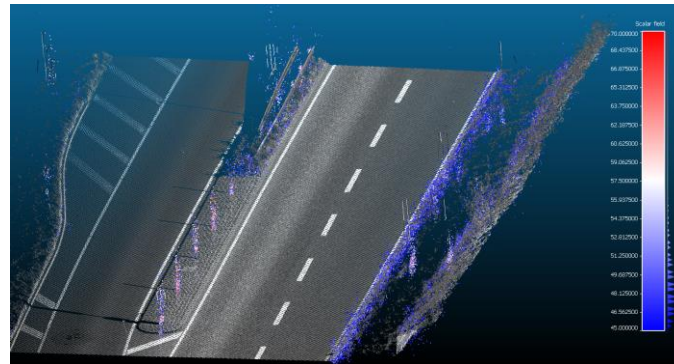
- 360° panoramic camera as basis for texturing



- Calibrated color cameras



- Calibrated infrared cameras



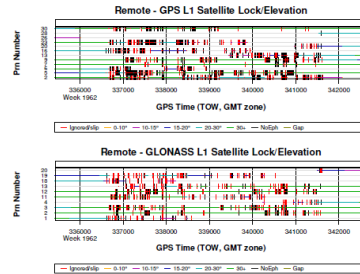
- Precise Radar Reference Measurements as basis for radar simulation
- Scanner data point cloud (grey) and radar data point cloud (color)

Mobile Mapping



- Mission Planning
- Mapping of any kind of roads
- Digitalization of the 360 Degree Road Corridor with max. 12 Cameras and 2 Laser Scanners

Data processing



- Post-Processing
- Quality Management
- Homogenization
- Scanner and Image Data-Processing

Data analysis



- Automatic, semi-automatic and manual Object Data Extraction
- All Elements in One „As-Built-Plan“

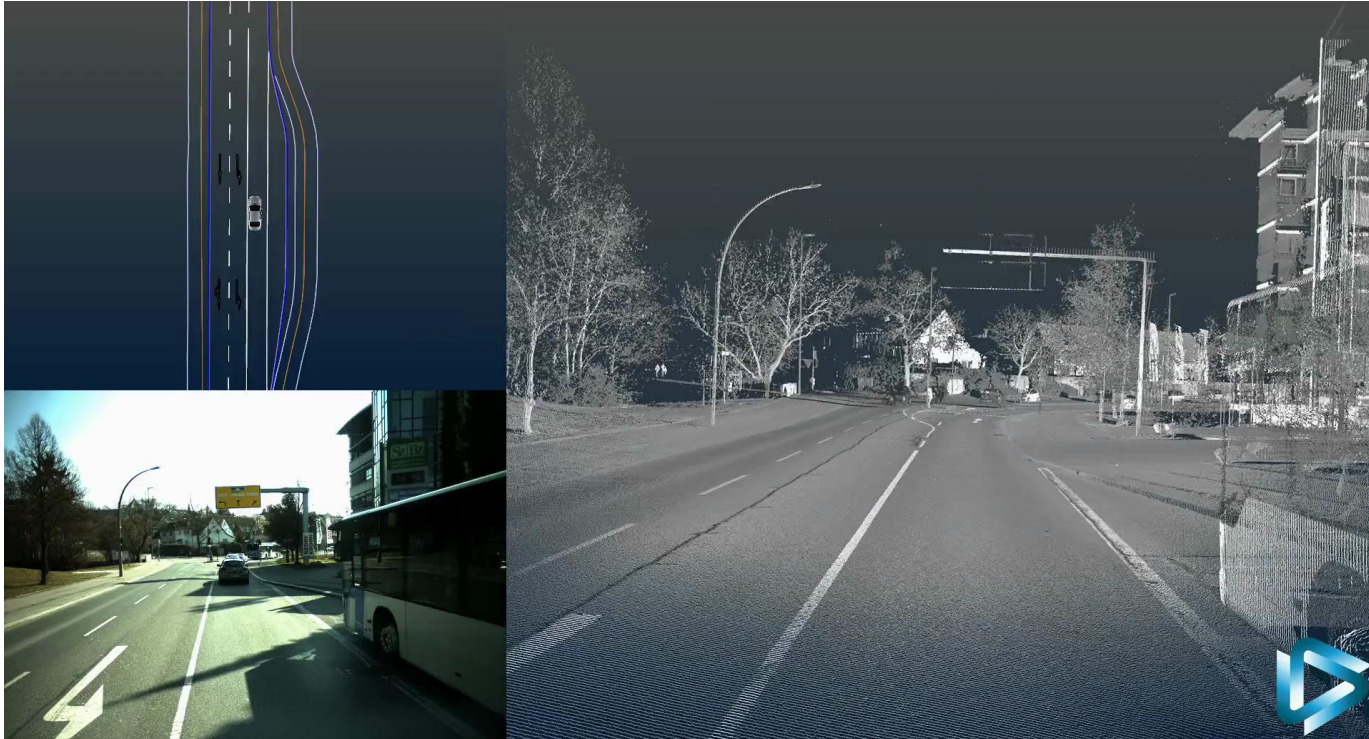
Ultra HD-Map



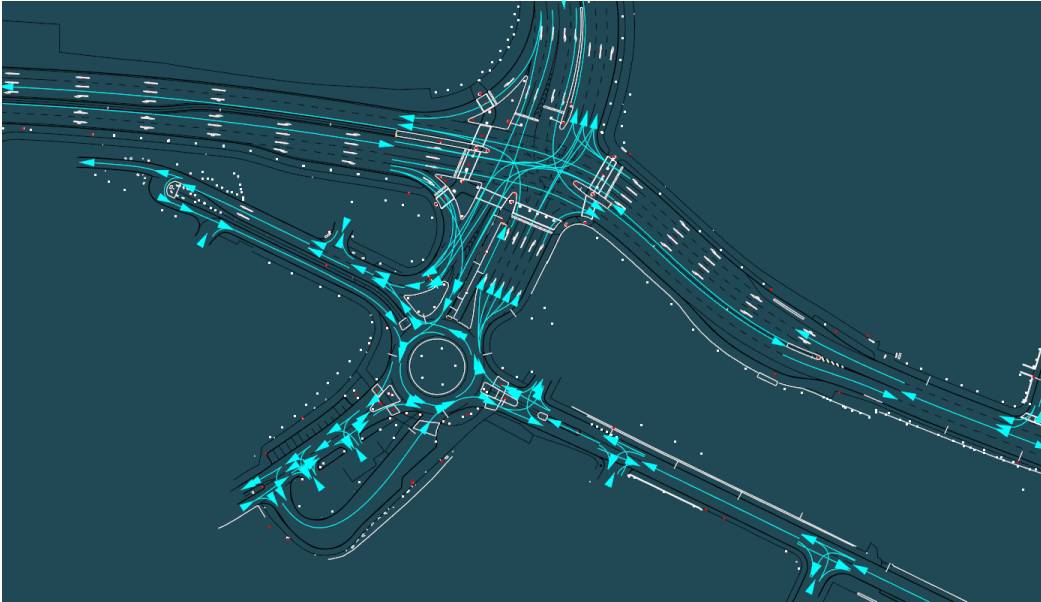
- Traffic and Connection Logic
- Precise, intelligent HD Map in appropriate formats, e.g. OpenDRIVE or Road5 for IPG CarMaker, which is most widely used as ultra HD Map format for testing and simulation

Continuous development of our own software + customer support during the entire project

Example: exact digital twin including traffic and connection logic



Example: exact digital twin including traffic and connection logic



The Ultra HD Maps of 3D Mapping Solutions contain the complete vectorized as-built plan and object data.

This example of a complex intersection shows:

- 150 lines with a total length of 7 km
- 33 km lane borders (driving, shoulder, green, curbs, sidewalk, biking)
- 500 Traffic signs
- 240 trees
- 208 traffic light bulbs
- 200 vegetation
- 110 streetlamp
- 87 traffic lights
- 14 road marks

Content of high-definition (ultra) HD reference maps

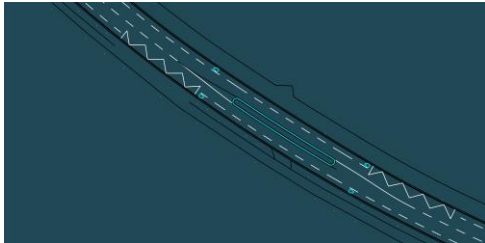


- The high-definition reference map in the car is regarded as sensor of unlimited range.
 - Most important is guaranteed relative accuracy for all 3D objects in the road corridor between 5 mm and 5 cm, depending on the object type.
 - Ultra HD map data is required in intelligent formats such as OpenDRIVE, HereLiveMap or IPG Road 5.
-
- Complete as-built object data, e.g. all markings, guardrails, signs, road posts, tunnels, bridges, sign bridges, fundamentals, curbstones, entrances, exits, intersections including all ramps and connections, resting areas etc.
 - In addition to the classical „as-built“ plan, the data formats contain the complete logical and sematic road structure in strict hierarchical order.

Ultra HD Maps in Road5 Format for IPG CarMaker



Object information extraction on the basis of camera and scanner data, e.g. traffic signs, markings, guide posts etc..



Vectorized HD Map production, using the 3D Mapping Solutions CAD system including the complete complexity of the topological road network structure



Export of the precise as-built-plan into Road5 Format for IPG CarMaker, which can directly be used for customer applications.



Ultra HD Maps in Road5 format for IPG CarMaker



Road Network in Santa Clara including 3D environment model



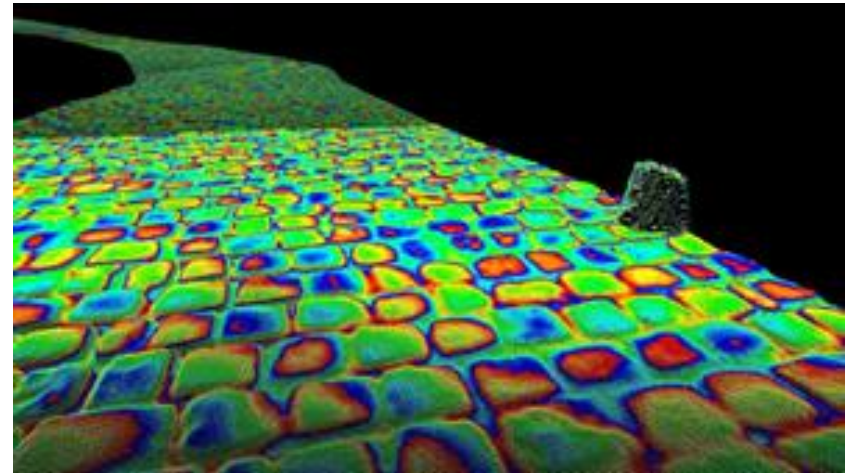
Example for a 3D ENVIRONMENT MODEL for highway A8



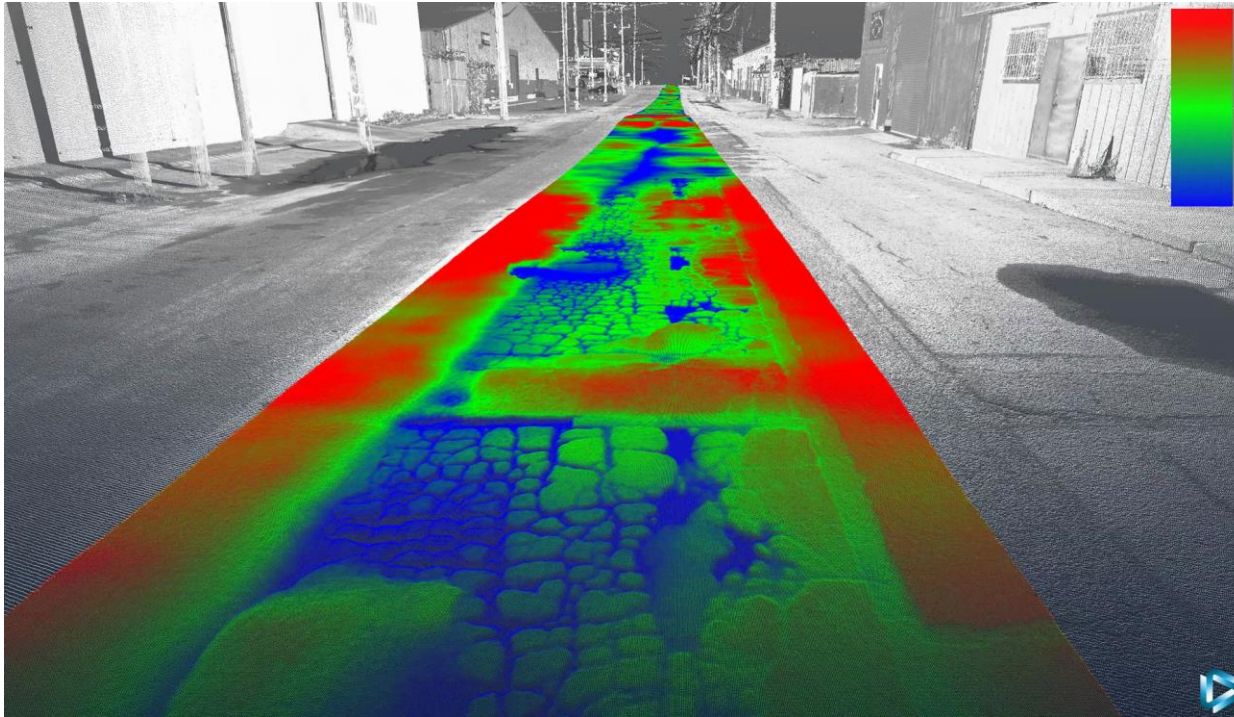
Regular grid road surface models in OpenCRG



- Public road with cobblestones
- Road surface model with regular grid 5 x 5 mm
- height resolution 0.1 mm
- Height accuracy < 1 mm



Regular grid road surface models in OpenCRG



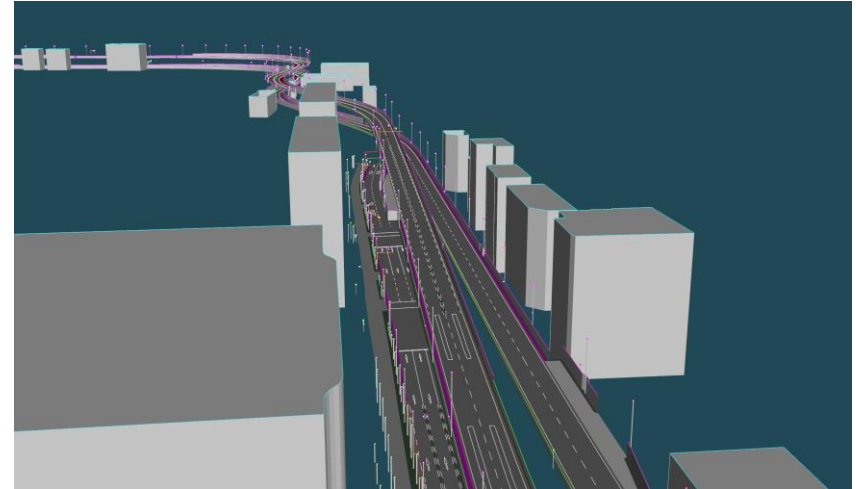
- Inner-city public road
- Road surface model with regular grid 5 x 5 mm
- height resolution 0.1 mm
- Height accuracy < 1 mm

Worldwide Road Data Collection - Introduction

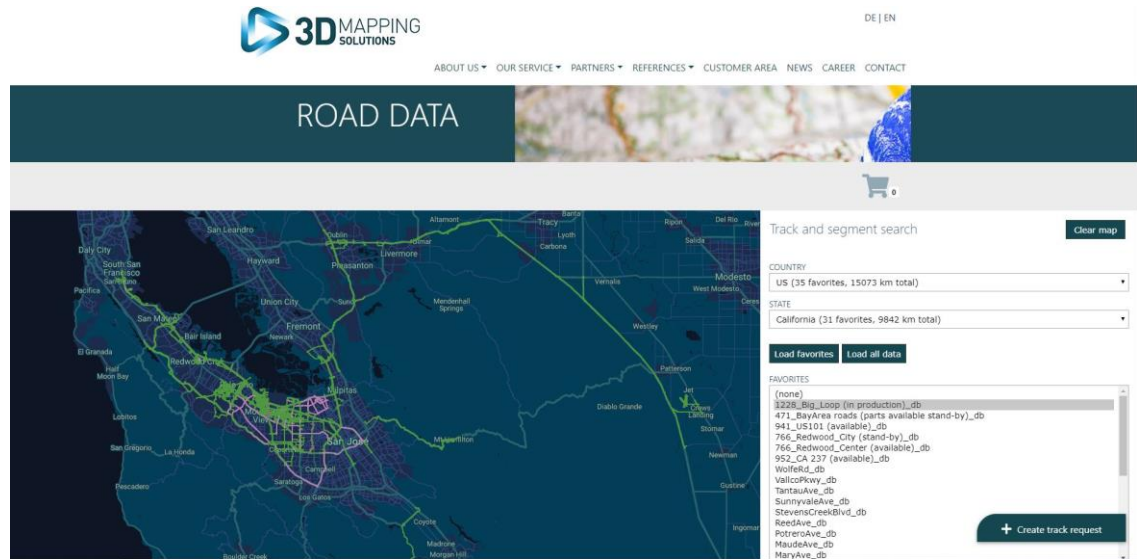


Motivation to provide HD Maps as Collection

- The need for HD Reference Map data is increasing rapidly.
- HD Reference Map data is needed worldwide in **representative samples** of the road network.
- As soon as a request for a dataset comes up, the HD Map data is often **instantly needed**. HD Map data production of new datasets takes time, so production is always under time pressure and the road data collection **avoids waiting time**.
- The available HD Map datasets of the Road data collection enable each customer to choose an existing Map to be instantly operable, while his specific route of interest is produced.
- The pricing gets significantly cheaper for everybody, because the Map production effort is shared.



- In 2016 3D Mapping Solutions started building its road database, which now consists of more than **150.000 km of roads**, owned by 3D Mapping Solutions and free of 3rd party rights.
- Already recorded routes can be selected and viewed by country and federal state.
- Further configurations can be made via road classifications and geometry.
- Several routes have been defined as Favorites and are **available as high-resolution HD map reference datasets**.
- Our homepage also offers the possibility to make non-binding suggestions for new roads to be included in our data collection.



3D MAPPING SOLUTIONS

ABOUT US ▾ OUR SERVICE ▾ PARTNERS ▾ REFERENCES ▾ CUSTOMER AREA ▾ NEWS ▾ CAREER ▾ CONTACT

ROAD DATA

DE | EN

Track and segment search [Clear map](#)

COUNTRY
US (35 favorites, 15073 km total)

STATE
California (31 favorites, 9842 km total)

[Load favorites](#) [Load all data](#)

FAVORITES

(none)

3228_Bay_Loop (in production)_db

471_BayArea roads (parts available stand-by)_db

941_US101 (available)_db

766_Redwood_City (stand-by)_db

766_Redwood_Center (available)_db

952_CA 237 (available)_db

Worfield_db

VallcoPovy_db

TantauAve_db

SunnyvaleAve_db

StevensCreekBlvd_db

ReedAve_db

PotreroAve_db

Maudslove_db

MaryAve_db

[+ Create track request](#)

Race Tracks, Proving Grounds and automotive Test Facilities

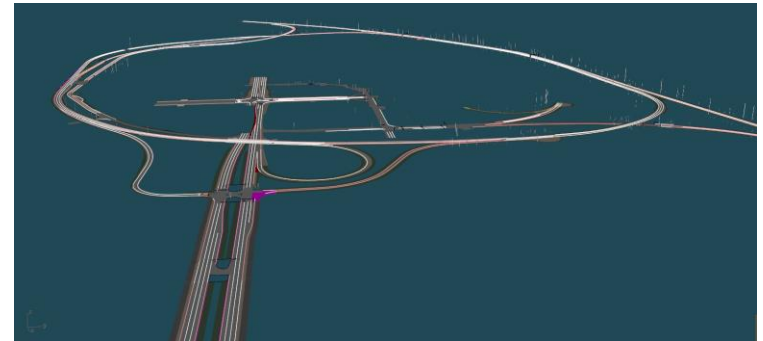
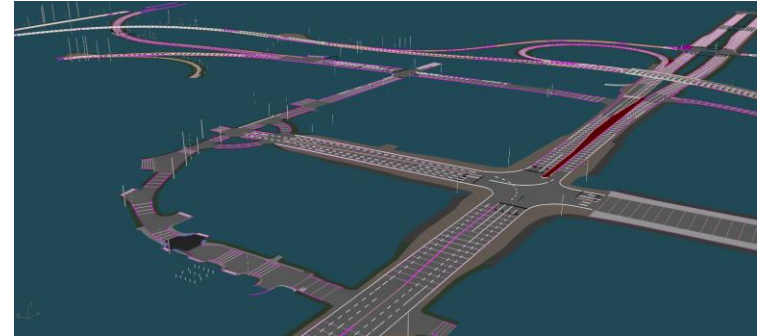
- 3D Mapping Solutions has digitized and processed lots of Race Tracks and Proving Grounds as a service.
- For some Proving Grounds and Race Tracks 3D Mapping Solutions has cooperation contracts to resell and license the data.
- Various Race Tracks on Public Roads are “ready-to-use”

Race Tracks / Proving Grounds, which can be licensed for 3D Mapping	Length [km] (incl. pit lane and track variations)
Nürburgring - Nordschleife	21,4
Nürburgring - GP Course	6,6
Le Mans - 24H	14,6
Le Mans - Bugatti	4,7
Spielberg Red Bull Ring	5,7
Sachsenring	4,4
Hockenheimring	6,4
Lausitzring	14,4
American Centre for Mobility (ACM)	16,0
Pikes Peak	20,0
Etc.	



Example: ACM Willow Run

- American Center for Mobility near Detroit
- 16 km of proving ground with 41 intersections
- Precise HD reference map data for autonomous driving applications available

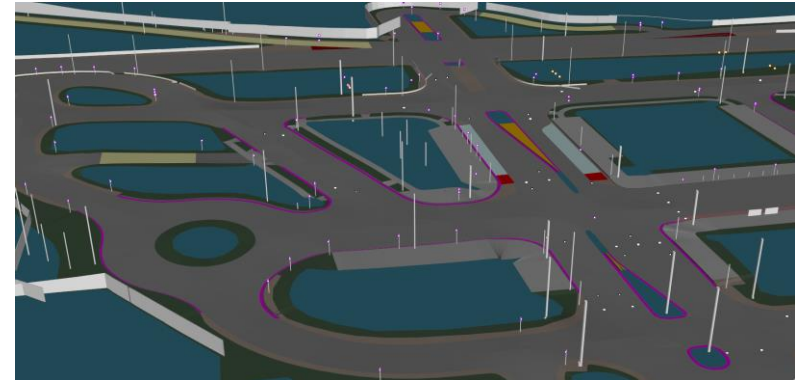
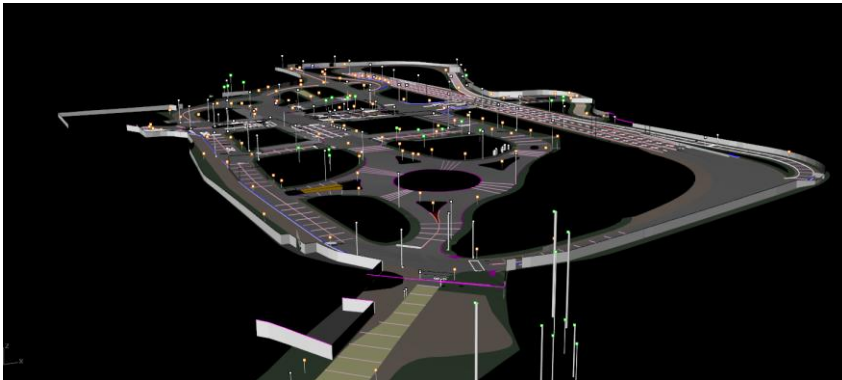


Animated Pointcloud of ACM Willow Run



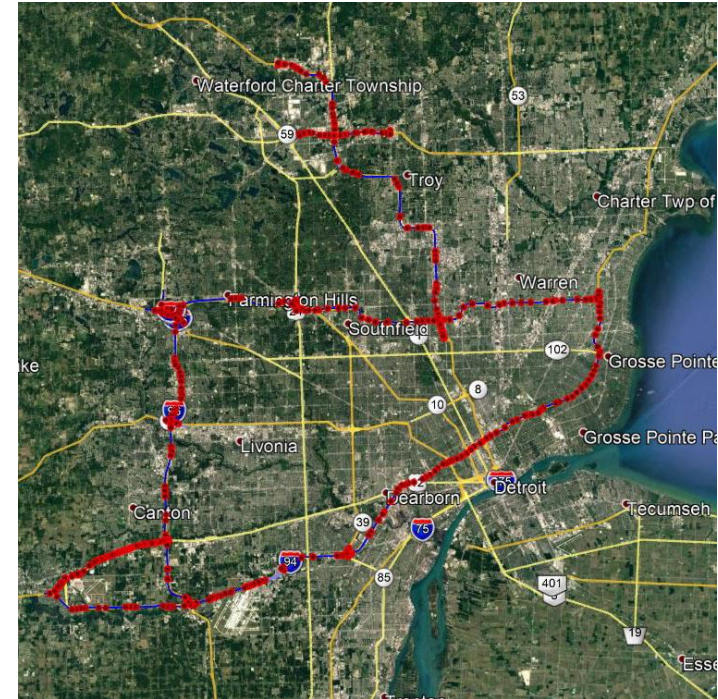
Example: MCity

- Proving ground for autonomous driving of the University of Michigan on the North Campus in Ann Arbor
- Intersections, roundabouts, multi lanes and multiple turns



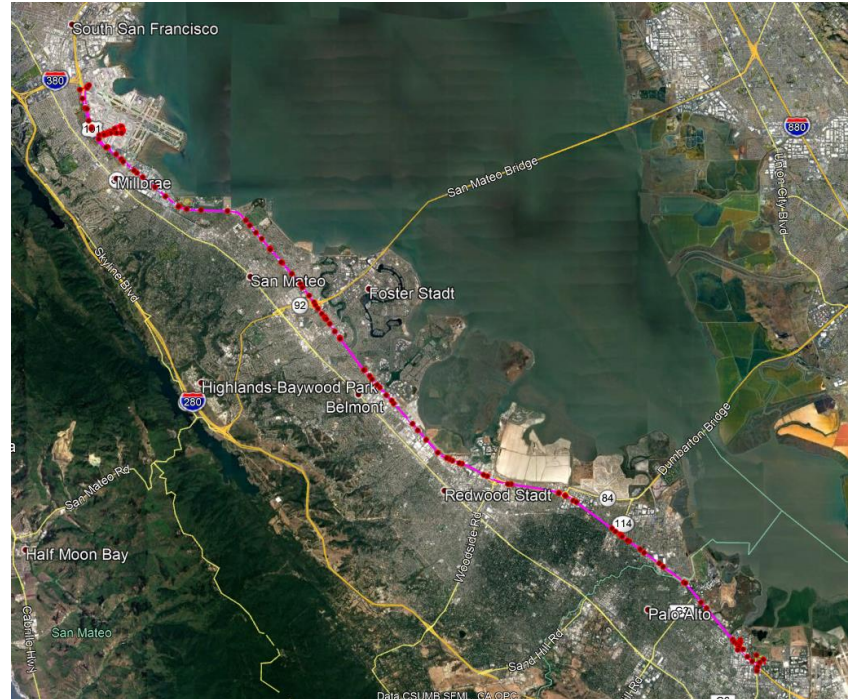
Example: Detroit, MI

- Sections of the Interstate Ring, Auburn Hills and Willow Run
- Total length of 558 km and 636 intersections surveyed
- Precise HD reference map data available for large parts already



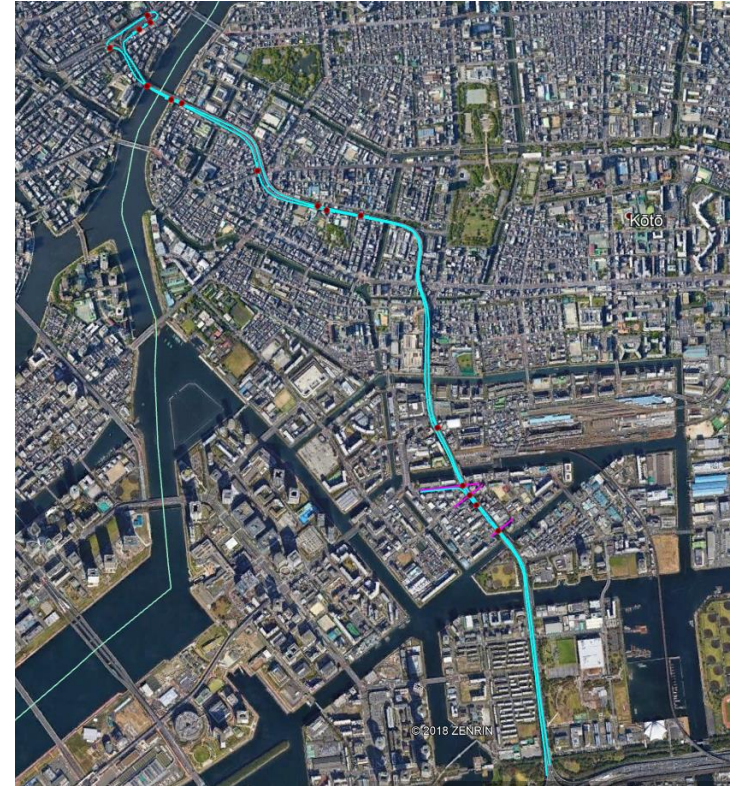
Example: US 101, CA

- Part of the highly complex US 101 from SF Airport to Mountain View in both directions
- Total length 111 km (of which 84 km Highway, 19.5 km side roads and 7 km inner-city), 135 intersections
- Precise HD reference map data for autonomous driving applications is available



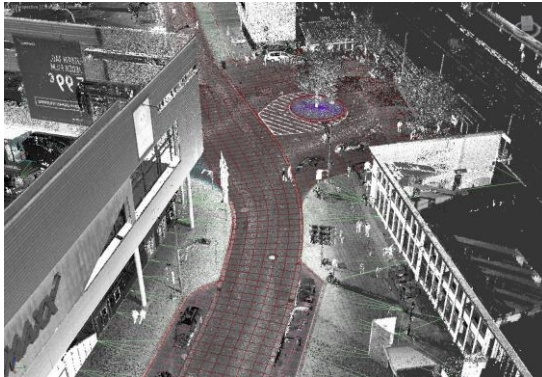
Example: Tokyo, Japan

- 14 km section (both directions) of the Metropolitan Expressway No. 9 (Fukagawa Route) in Tokyo with 18 intersections
- Precise HD reference map data for autonomous driving applications is available



Complete Simulation dataset for WOLFSBURG

HD Map in ROAD5 for IPG CarMaker, CRG road surface model and photo-realistic 3D environment

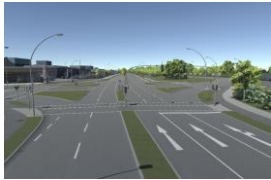


Ready-to-use Track Packages out of the Road Data Collection





- Among the big variety of available tracks, some sections have been selected and assembled to track packages ready to be used and purchased.
- Customers may select their own user-defined track packages.
- Currently we have defined:


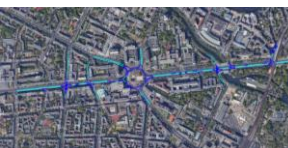



- **Demo data tracks** – available in Road5 for IPG CarMaker
 - **Sample package – fast driving** – available in Road5
 - **Sample package – inner-city driving** – available in Road5
 - Ultra HD Maps and 3D Environment as basis for realistic Simulation
 - **Mixed Simulation Package Germany / Austria** – available in Road5
 - Examples for Simulation Datasets
 - **Wolfsburg** – available in Road5 for IPG
 - **Munich Schwabing** – available in Road5
 - **Berlin** – available in Road5
 - ... and many more ...












Sample Packages (examples)

Track Name	Illustration
Pikes Peak	
Testfield A9	
California State Route 237	
I-75 Detroit	

Track Name	Illustration
Santa Clara (CA)	
Testbed Berlin	
Wolfsburg Inner City	
Redwood (CA)	

Track Packages: Vehicle Dynamics

Track Name	Illustration	
France E9		
Germany A99		
Germany A7		
MI I75		

Track Name	Illustration
Sunnyvale (CA)	
Cupertino (CA)	
Santa Clara (CA)	
Cupertino (CA)	



- Surface model with relative height accuracy < 1 mm
- Available options
 - **5 x 5 cm** regular grid as CRG or RGR
 - **5 x 5 mm** regular grid as CRG or RGR
 - Various other resolutions
- 3D environment models as basis for perfect realistic driving simulation

Thank you for your attention!



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