AUTOMATED DRIVING DATA CHAIN CHALLENGES
Tomorrow’s Situation: Sensors, Maps and Online Data The Vehicle Looks beyond 300m and Around the Corner

1. Highly accurate map model provided and updated via the Backend
2. Extended preview information
3. Extension of limited in-vehicle resources
4. Fleet based data collection

Vehicle Sensor range 0-300m

Close preview: 10 minutes
Automated driving data chain and ecosystem

Reference architecture proposed by OADF

**INFRASTRUCTURE**

- Live Map Updates (Dynamic Data)
- Maps & Updates
- (Dyn.) Data Production
- Analytics/Sensor Fusion
- Data Collection Strategy
- Systematic Data Collection (Mobile Mapping)
- Community Data Store

**VEHICLE**

- Live Map Delivery
- HD Map Delivery
- Infotainment Map Delivery
- Data Store
- Local Live Map (Dynamic Data)
- HD Map
- Infotainment Map

**Backend** (one or multiple) operated by Map supplier / OEM / 3rd Party

**OEM-specific Backends**

- Local Live Map Provider
- ADAS Horizon Provider

- (Local) Sensors
- (V2x) provided Sensors

**ADAS**

- Environmental Model
- Localization
- Data Collection (raw or pre-processed)

Flament | Automated Vehicle Symposium | July 2017
Map database

- Layers
  - e.g. hazard spots
  - e.g. traffic information
  - e.g. speed limits

Digital map (static)

NDS: Incremental Map Update

- Determination of location and most probable path (MPP)
- Enrichment of MPP with road information (e.g. topography, speed limits)
- Conversion into ADASIS format

TPEG: Traffic Information

In-vehicle systems

- HMI
- ADAS, Energy Management

Relevant information for road ahead (ADASIS Format)
ADASIS horizon – evolution to the cloud

<table>
<thead>
<tr>
<th>Local</th>
<th>Hybrid</th>
<th>Cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Local Diagram" /></td>
<td><img src="image2.png" alt="Hybrid Diagram" /></td>
<td><img src="image3.png" alt="Cloud Diagram" /></td>
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</table>

### In-vehicle embedded software

<table>
<thead>
<tr>
<th>i.</th>
<th>ii.</th>
<th>iii.</th>
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<tbody>
<tr>
<td>function ↔ horizon provider ↔ map</td>
<td>function ↔ horizon provider ↔ map ↔ map</td>
<td>function ↔ horizon provider ↔ map ↔ dynamic data</td>
</tr>
</tbody>
</table>

### Cloud-based backend software

<table>
<thead>
<tr>
<th>Link to NDS</th>
<th>Link to NDS &amp; TPEG</th>
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</thead>
</table>

**i.** ADASIS Horizon uses data from local map database and provides information for functions in the vehicle

**ii.** ADASIS Horizon uses recent data from updated map database via cloud backend or live data from additional databases and provides information for functions in the vehicle

**iii.** ADASIS Horizon uses cloud-based data and provides information for in-vehicle functions directly from the cloud
ADASIS V3 specification supports highly automated driving

New ADASIS V3 specifications supports different aspects of autonomous driving

1. Support of HAD maps (NDS)
ADASIS V3 specification supports highly automated driving

Lane model & Geometry

Example: Highway Exit

“switch from a map-centric view to a vehicle-centric view of the world to create a simpler representation”
ADASIS V3 specification supports highly automated driving

Lane model:

Segmentation of road into stretches with same lane characteristics

- **1st level = path description**
- **level detail:** number of lanes for each segment

- 3 Lanes
- 1 Lane
- 3+1 Lanes
- 3 Lanes + shoulder

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ADASIS V3 specification supports highly automated driving

Lane Model & Connectivity

Lane Model & Connectivity: Logical Description similar to v2

2nd level = logical view
level detail:
lane details and their connectivity

Lane #1: normal
Lane #2: normal
Lane #3: normal
Lane #4: normal

Lane #1: ramp
Lane #2: normal
Lane #3: normal
Lane #4: normal

© Wikimedia Commons, licensed by CC-by-SA 2.5
ADASIS V3 specification supports highly automated driving

Lane Model & Connectivity

Geometry for Linear Objects:
• Lane Boundaries
• Guardrails

3rd level = geometry description
level detail:
geometry of road, lane and lines

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Lane #3: normal  Lane #2: normal  Lane #1: normal
ADASIS Forum
Membership & Steering Board

From 46 to 52 ADASIS Forum Members (updated 31 May 2017)

<table>
<thead>
<tr>
<th>Vehicle Manufacturers (16)</th>
<th>ADAS Suppliers (15)</th>
<th>Navigation System Suppliers (13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMW</td>
<td>Autonomos</td>
<td>AISIN AW</td>
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<tr>
<td>China FAW-RDC **</td>
<td>Continental Automotive *</td>
<td>Alpine</td>
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<td>CRF (FCA) **</td>
<td>CTAG</td>
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<td>Daimler *</td>
<td>Denso</td>
<td>Elektrobit Automotive</td>
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<td>dSPACE</td>
<td>Garmin</td>
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<td>Ford-Otosan</td>
<td>**Fujitsu Ten (Europe) **</td>
<td>Harman</td>
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<td>Honda *</td>
<td>Hitachi</td>
<td>Mappers Co. **</td>
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<td>Hyundai Motor Company</td>
<td>Ibeo</td>
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<td>IPG</td>
<td>MXNAVI</td>
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<td>Opel *</td>
<td>LG Electronic</td>
<td>NNG LLC</td>
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<td>Nissan</td>
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<td>Renault</td>
<td>Magneti Marelli</td>
<td>Robert Bosch GmbH*</td>
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<tr>
<td>Toyota Motor Corp.</td>
<td>Novero</td>
<td>Telenav</td>
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<td>Volkswagen</td>
<td>TRW (ZF)</td>
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<td>Volvo Car Corp.</td>
<td>Valeo</td>
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<td>Volvo Tech. Dev. Corp.</td>
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<th>Map &amp; Data Providers (8)</th>
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* Steering Board Members
** New Members since June 2016
Automated driving data chain and ecosystem

Reference architecture proposed by OADF

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Environmental Model

Localization

Data Collection (raw or pre-processed)

Community Data Store

Systematic Data Collection (Mobile Mapping)

ADAS

NDS

Flament | Automated Vehicle Symposium | July 2017
INTRODUCTION TO SENSORIS
SENSORIS: Sensor Ingestion Interface Specification

Standardization of sensor data content

Vehicle-to-Cloud / Cloud-to-Cloud
- Sensor manufacturers
- Car manufacturers
- Location-based services provider
- Mobile network operators

Part of Open AutoDrive Forum
- Focus on Sensor Data up-stream
- Alignment with NDS, ADASIS, TISA
SENSORIS architecture: Multi-role model
Use Case: Real-time services

Traffic flow
Traffic incidents

Hazard warnings

Environmental conditions

Traffic signage
Use Case: Map maintenance

- Road geometry and attributes
- Lane geometry and attributes
- POI entries and exits
- Road condition
Use Case: Statistical analysis

- Historical and real-time data analysis
- Personal preference learning
- POI recommendations
# SENSORIS Members

## ADAS manufacturers
- AISIN AW
- Continental Automotive GmbH
- DENSO
- Fujitsu Ten (Europe) GmbH
- LG Electronics
- Valeo Comfort and Driving Assistance

## Location content & Service providers
- AutoNavi Software Co. Ltd.
- HERE Global B.V.
- INRIX Inc.
- NavInfo Co.Ltd.
- TomTom International B.V.
- Zenrin

## Navigation System Suppliers
- Elektrobit Automotive GmbH
- Harman
- Hyundai Mnsoft
- NNG
- PIONEER Co.
- Robert Bosch Car Multimedia GmbH

## Sensor & Component Manufacturers
- Qualcomm

## Telecom & Cloud Infrastructure Providers
- IBM

## Vehicle manufacturers
- Audi
- Daimler AG
- Jaguar Land Rover Limited
- Volvo Car

## Other
- ICCS

## In process to join
- BMW AG
- CTAG
- Delphi
- Ericsson
- Nissan
- Tass International
- TeleNav
- Toyota
- Trafikverket
- VTT
- Wuhan kotei informatics
Conclusions

• ADASIS and SENSORIS are both industry-wide specification initiatives facilitating the use of map data in automated vehicles
• ADASIS V3 transforms the map information into relevant data for the Automated Driving functions
• SENSORIS gathers vehicle sensor data to make it accessible in the cloud for various real-time, historical and statistical purposes
• ADASIS and SENSORIS are part of the Open Auto Drive Forum
I think you should be more explicit here in step two.
HERE Digital Infrastructure Technologies

Autonomous Vehicle Symposium
July 11, 2017
A history of transforming maps into location technology

1985
Navigation Technologies founded

1994
1st map for in-car nav
1st map for web

2004
1st map for ADAS
1st map for phone
1st map for Adaptive Cruise Control

2007
Community mapping
Offline maps for mobile

2009
1st map for Predictive Cruise Control
High-precision data collection and map-building technology
Use of sensor data for map building

2011
1st pure location cloud

2015
3 new investors

HERE Technologies © 2017 HERE
Beyond roads
Things
People
Spatial/aerial
The intelligent car

- Assistance
- Automation
- Learning
HERE’s View of Digital Infrastructure to Power Automated Vehicles

- Built on the HERE Open Location Platform
- Active pilots (Colorado DOT, Iowa DOT) to develop standards for infrastructure data
Sensor Data → Self-Healing Map

Vehicles, IoT devices

The edge

OEM backend

The cloud

ERTICO/OADF*: SENSORIS data standard

*Open Auto Drive Forum: openautodrive.org
HERE Cooperative V2X Road Hazard Example

Incident detection

- Smartphones, aftermarket devices or embedded solutions become a collective community – detecting changing road or environmental conditions
- Incidents or event information may also be manually input from the community and authorities
HERE Cooperative V2X Road Hazard Example

Reporting & Location Cloud Analytics

• Receiving and ingesting incident data
• Running analytics
• Determining identification of an impact area
HERE Cooperative V2X Road Hazard Example

Distribution of Road Hazard Warnings

• The impact area and incident message type are sent to traffic management centers and back to the drivers across all connected infrastructure in the affected area.
WHY FLEXIBILITY MATTERS IN AUTONOMOUS CAR DESIGN

Intel® Architecture for Autonomous Driving
July 2017
Workloads are more than artificial intelligence (AI).

Some critical algorithms haven’t even been developed yet.

System designs will need to change down the road.

Intel powers hundreds of level 4 and level 5 test vehicles.

Autonomous Vehicles are an End-to-End Solution.
BUILDING THE BEST AUTONOMOUS BRAIN

SENSE
The vehicle collects sensor data to “see” its surroundings

FUSE
Data is correlated and fused to create a model of the environment

DECIDE
The vehicle decides how to proceed
WORK WITH FEWER LIMITS
Design with Flexible, Scalable Intel Architecture

Greater agility
to adapt to evolving system designs

More flexibility
to place compute

Optimized performance
per watt

Future programmability
with FPGAs

Lower TCO
with FPGAs over ASICs

Faster
software development

Reduced
training time in the data center
DRIVING IS EXTREMELY COMPLICATED
DETECTION DNN: LANES
NVIDIA SELF-DRIVING AI

AI THAT MIMICS HUMAN BEHAVIOR
SELF-DRIVING TO STARBUCKS

MULTIPLE AI’S WORKING TOGETHER
ENABLING THE NEXT-GENERATION OF DRIVER ASSISTANCE
ALERT: Cross-Traffic Danger!
Thank you!

timwong@nvidia.com
Recent progress of dynamic map in Japan

12nd July, 2017
Automated Vehicles Symposium 2017
Hilton San Francisco Union Square, USA

Satoru Nakajo, the University of Tokyo
Contents of the presentation

0. Overview of SIP-adus

1. FOT 2017-2018

2. Standardization activities

3. Challenges we are facing (personal view)

Ref. Workshop in Tokyo
SIP: Cross-ministerial Strategic Innovation Promotion Program

- Start from FY2013.
- Cross-ministerial Initiatives.
- Promote focused, end-to-end research and development, from basic research to practical application and commercialization.
- Total budget for FY2016 was ¥50 billion (around 500 million dollars).

0. Overview of SIP-adus

¥2.7 billion (FY2016) (around 27 million dollars)
0. Overview of SIP-adus

(I) Development and verification of automated driving system

(II) Basic technologies to reduce traffic fatalities and congestion

(III) International cooperation

(IV) Development for next generation urban transport

Area of Cooperation

Area of Competition

Driver

Road Transport system

Traffic environment

Vehicle

(1) Dynamic Map

(2) Prediction based on ITS information

(3) Sensors

(5) System Security

(4) Driver Model

(1) Open research facility

(2) Social acceptance

(3) Technology transfer

(1) Enhanced local traffic management

(2) Next generation transport system

(1) Traffic fatality reduction effect estimation method & national shared database

(2) Macro and micro data analysis and simulation technology

(3) Local traffic CO₂ emission visualization technology

(1) Traffic fatality reduction effect estimation method & national shared database

(2) Macro and micro data analysis and simulation technology

(3) Local traffic CO₂ emission visualization technology
0. Overview of SIP-adus

✓ Research results by SIP-adus
   http://en.sip-adus.jp/ (results of FY2014-FY2016 are available)

✓ Specification on map features and attributes for ADS by JAMA
   http://www.jama.or.jp/safe/automated_driving/pdf/recommended_spec.pdf
   (Japanese) JAMA: Japan Automobile Manufacturers Association Inc.

✓ A company “Dynamic Map Platform Inc. (DMP)” had established in June 2017
1. FOT 2017-2018

- SIP-adus is planning FOTs for 5 technological fields.
  - Dynamic map
  - HMI
  - Information Security
  - Pedestrian Accidents Reduction
  - Advanced Urban Transit

- Call for Participants (first call) was completed.
  - Call for participants (First call) by each technological fields including Dynamic Map
  - Sample Distribution of the map before the test would be available
  - Entry (in English) was possible from following HP
    (you can also access from http://en.sip-adus.jp/)
1. FOT 2017-2018

- Overview of Dynamic Map FOT

**Expressway**

**Ordinary roads**

**Test course**

Expressway: — and —

Total 300km length routes where begins at newly developed test course of Japan Automobile Research Institute (JARI) and includes part of Metropolitan expressway, TOMEI expressway, SHIN-TOMEI expressway, and JOBAN expressway.
1. FOT 2017-2018

- Overview of Dynamic Map FOT

**Dynamic Map**
- 3-D high resolution map data validation such as road geometry, environment and civil structures
- Verification of semi dynamic information such as traffic congestion and construction information
- Validation of collecting, generating, and distributing dynamic map information

Outline of FOT

Schedule

- **Mid. of November 2016 – May 2017**
  - FOT detailed planning / Coordination with relevant agencies
- **June 2017 –**
  - Participants recruitment / Site preparation
- **September 2017 –**
  - Commencement of FOT
- **March 2018**
  - Interim report
- **March 2019**
  - Final report
2. Standardization activities

- Promote standardization activities at ISO/TC204
- Discussion for the importance of industrial specifications
3. Challenges we are facing (personal view)

- Connection between static and dynamic (inc. semi.) data
- Map updates (before actual changes)
- Map definition for various roads including local streets
- Relationship between Dynamic Map and Navigation data
- Balance between Map and other key elements such as sensing devices, AI algorithm

- Try to go forward by FOTs (real experiments) and discussions
Workshop 2017 will be held on 14\textsuperscript{th} to 16\textsuperscript{th} Nov. in Tokyo

- Just after the 8\textsuperscript{th} OADF meting (13\textsuperscript{th} Nov.) in Tokyo
- (almost of) all presentations will be done by or translated \textbf{in English}
- Dynamic Map will be one of the main topic
- Last day of the workshop will be only available for invited person
  (around 20 people for each topic, mainly for discussion)
- Further details will be released at the following website
  
  \url{http://en.sip-adus.jp/}
END

snakajo@csis.u-tokyo.ac.jp