SENSORIS

SENSOR INTERFACE SPECIFICATION

INTRODUCTION

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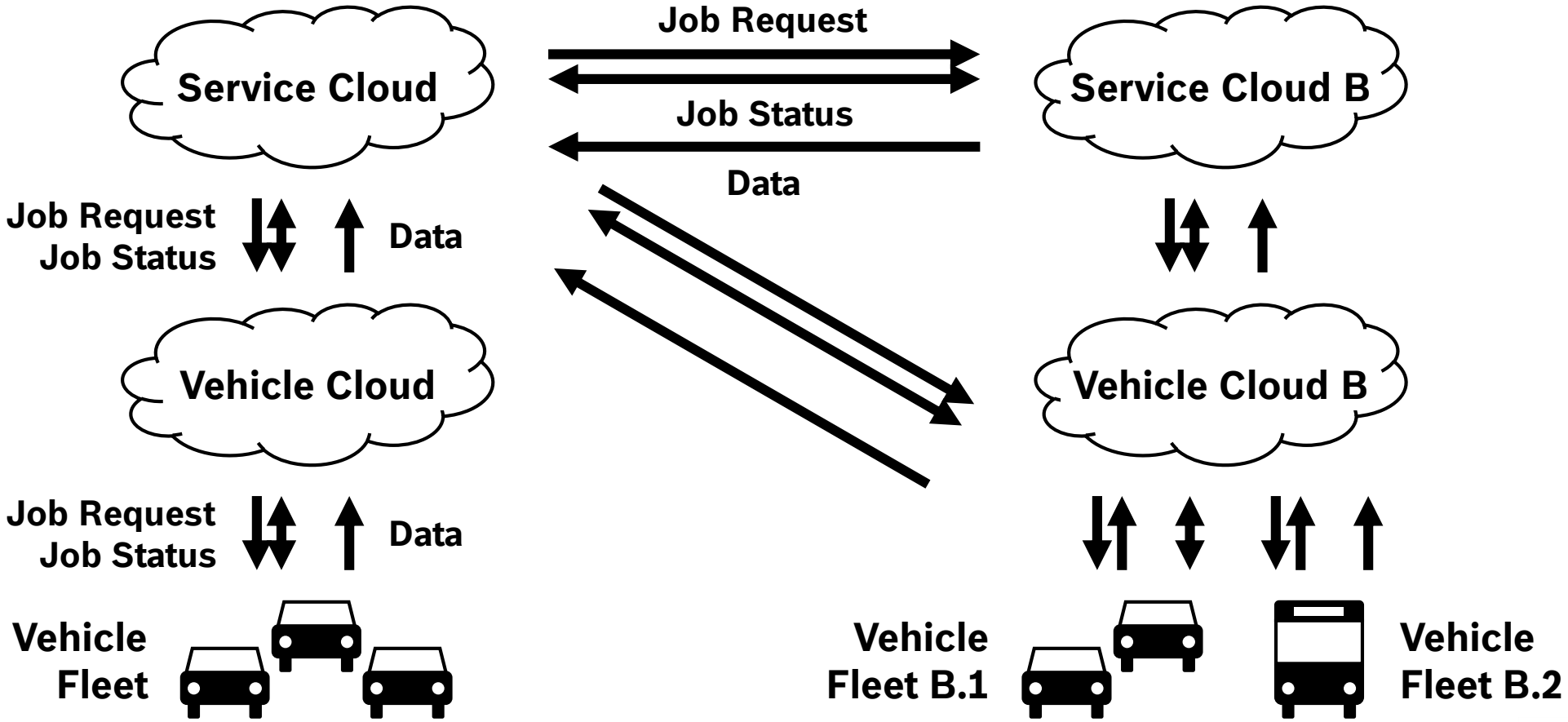
Vehicle Sensor Data and Jobs



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Members

ADAS manufacturer	AISIN AW, Robert Bosch, Continental Automotive, Denso, Huawei, LG Electronics, Valeo, ZF
Location content and service provider	AutoNavi Software, Baidu, HERE Technologies, INRIX, Kuandeng, Mappers, NavInfo, TomTom, Zenrin
Navigation system supplier	Elektrobit Automotive, EnGIS, Harman, Hyundai Mnsoft, MXNavi, Neusoft, NNG, Pioneer, Telenav
Vehicle manufacturer	Audi, BMW, Daimler, Jaguar Land Rover, Nissan, Volvo
Other	CTAG, Fujitsu Ten Europe, IBM, ICCS, Tencent

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Timeline

Jun 2015 **Internal vehicle sensor data interface published by HERE**

HERE asks for **cross OEM standardization** to achieve critical mass of vehicles

Jun 2016 **SENSORIS Innovation Platform** created, coordinated by **Ertico,** under umbrella of **Open AutoDrive Forum (OADF)**

Dec 2016 **Internal job request interface published by HERE**

Jun 2018 **SENSORIS version 1.0.0 as industrial standard**

Jul 2019 **SENSORIS version 1.0.0 as public release, version 1.1.0 including jobs**

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Open AutoDrive Forum

- **Open AutoDrive Forum (OADF)**
  "The cross-domain platform driving standardizations in the area of autonomous driving"

- **Align SENSORIS, NDS, TISA, ADASIS, other consortia, and individual contributors**
  - SENSORIS: vehicle sensor data
  - Navigation Data Standard (NDS): leading world-wide map standard for automotive grade use
  - Traveller Information Services Association (TISA): traffic and travel information services (TPEG, RDS-TMC)
  - Advanced Driver Assistance Systems (ADASIS): electronic horizon, i.e. map data ahead of the vehicle

- **Global meetings** every 4 months (Europe, North America, Asia)
- **Work organized in task forces**

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Scope

Data format
Data types, reference systems

Encoding
De- / serialization

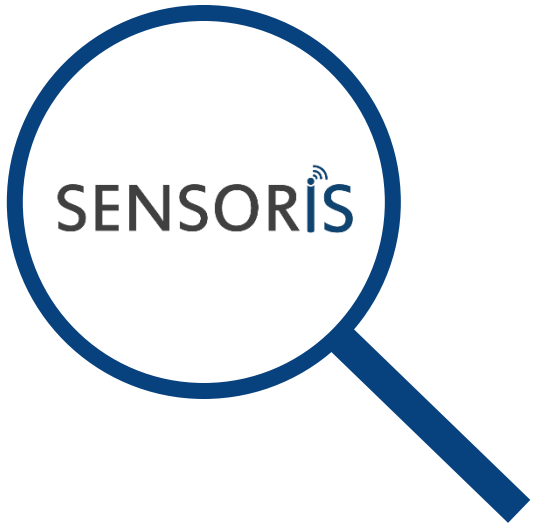
Privacy
Anonymization / pseudonymization

User Interface
Editor, visualization

Validation / Error handling
Integrity, rules

In scope

Out of scope



Security / User Management
Authentication, authorization, encryption, traceability

Transport
Protocol, compression, connection handling, async / synchronous

Resource Management
Priorities, cache / buffer, persistence, parallelization

Operation
Deployment, maintenance, monitoring

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DATA MESSAGES

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Event Categories

- **Covered event categories based on questionnaire to SENSORIS members**

Category / Classes
Positioning, Localization
Object detection
Weather
Parking
Lane
Traffic
Traffic signs
Traffic signals
Brake
Powertrain
Map models

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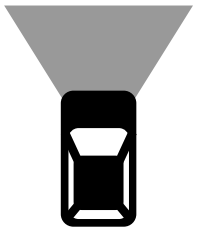
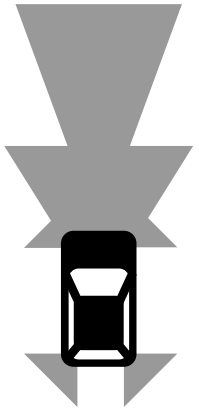
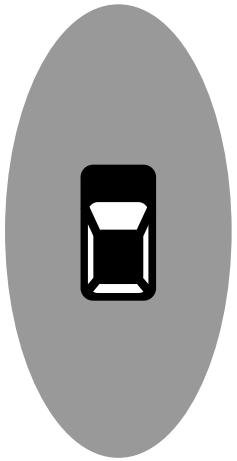
Range of Vehicle Sensor Types



SD
Standard Definition
E.g. video, GPS, gyro, odometry



HD
High Definition
E.g. video, RADAR, ultrasonic, GPS, gyro, odometry, SD map



AD
Automated Driving
360°, e.g. video, RADAR, LIDAR, ultra-sonic, DGPS, gyros, odometry, HD map

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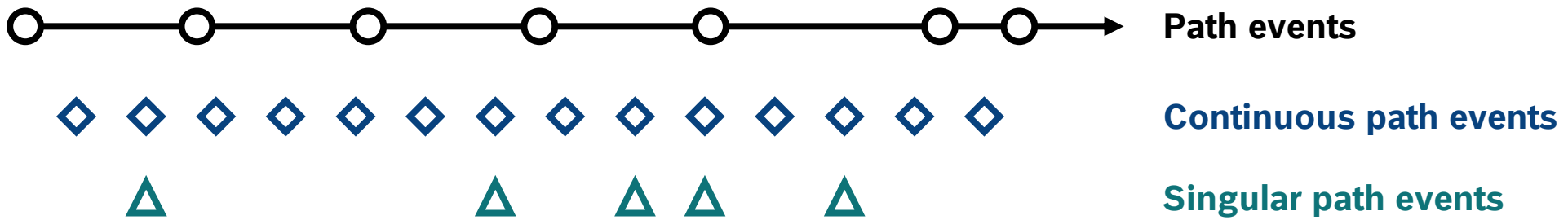
Data Message

- **Structure of data messages**
  - **Envelope:** fundamental information about the originating vehicle, metadata for a session
  - **Events:** vehicle sensor observations of arbitrary type, e.g. position, vehicle status, media…



  - **Events within one message may be in arbitrary order**, i.e. order cannot be depicted based on id, ordering by timestamp in cloud is possible
  - **Mechanism for proprietary extension**

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Reference Systems

- **SENSORIS uses standardized reference systems as a basis**
  - International System of Units (SI)
  - Coordinated Universal Time (UTC)
  - World Geodetic System 1984 (WGS84) and International Terrestrial Reference Frame (ITRF) solutions
  - Principal terms used for road vehicle dynamics defined by International Organization for Standardization (ISO)

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Privacy

- **Regulations**
  - **General Data Protection Regulation (GDPR)** by EU
  - **Resolution on data protection in automated and connected vehicles** agreed worldwide as outcome of 39th International Conference of Data Protection and Privacy Commissioners
- **Task force for analyzing impact** (HERE, Audi, Continental, Harman, IBM, TomTom)
  - **It depends**, i.e. general advice not possible
  - **Disclaimer** as part of interface architecture document, e.g. if privacy relevant data is part of SENSORIS message, then respect GDPR and comparable legislations

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Quality Representation

- **Metadata about quality** can be added at several levels of the data model

- Example: **traffic sign quality**
  - Sign **exists**: Boolean, confidence [0, 100] percent
  - Sign is a **speed sign**: enumeration, confidence [0, 100] percent
  - Sign is a **70 speed sign**: enumeration, confidence [0, 100] percent
  - Sign is at **position**: 2D / 3D position (latitude/ longitude/elevation), position accuracy
  - Sign **additional signs**: see traffic sign quality …

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JOB MESSAGES

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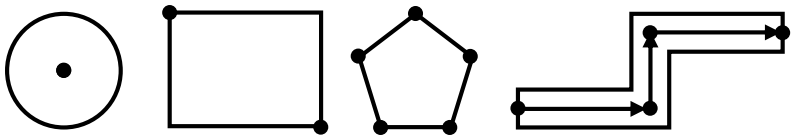
Job Request Message

- **Request vehicle data from vehicle cloud or vehicle fleet**
  - **Identifier to link data message** to corresponding job requests
  - Numeric **priority** in range [1 = highest, 256 = lowest]
- **Restrictions**
  - **Overall:** e.g. total number of messages (also for fail-safe)
  - **Spatial**: circle, rectangle, polygon, directed corridor
  - **Temporal**: date range, weekday, time of day range
  - **Map attribute**: e.g. functional road class
  - **Sensor based**: comparison to thresholds (=, !=, >, <, >=, <=)
  - **Complex expressions** with logical operators AND, OR, and NOT
- **Definition of requested event types and frequency**



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Job Status Message

- **Job state for each job** for vehicle fleet to vehicle cloud and vehicle cloud to service cloud
- **Currently limited to termination information and termination request**

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MESSAGE ENCODING

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Message Encoding Requirements

- Data, job request, and job status messages communicated **over-the-air and over-the-wire**

- **Requirements**
  - **Size** of serialized data shall be **minimized**
  - Serialization shall be able to cope with a **variety of resource sets, operating systems, and programming languages**
  - Encoding shall support **evolution of the data format**
  - **Internationalization** shall be supported
  - **Proprietary extension** shall be possible

- **Large variety of data serialization formats**
  - Apache **Avro,** Apache **Thrift**, and Google **Protocol Buffers fulfil requirements**
  - **Google Protocol Buffers** selected due to its popularity

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Message Encoding in Google Protocol Buffers

- Google Protocol Buffers, short **protobuf**, are a **language-neutral**, **platform-neutral**, and **extensible** mechanism for serializing structured data

1. Define protobuf message types

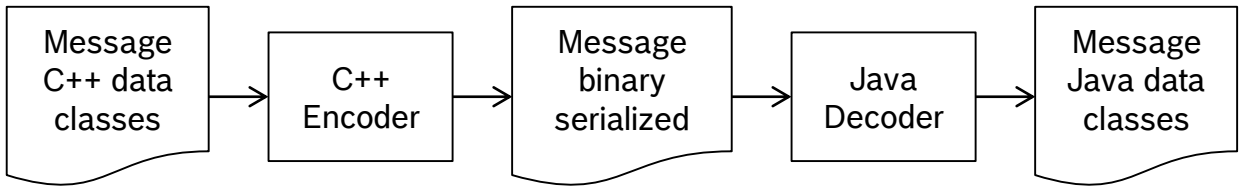
```
message AbsolutePosition {
  double latitude = 1;
  double longitude = 2;
  EllipsoidalPositionError position_error = 3;
}

message EllipsoidalPositionError {
  double length_semi_major_axis = 1;
  double length_semi_minor_axis = 2;
  double heading_major_axis = 3;
}
```

2. Run protobuf compiler

Generates data access classes for C++, Java, Python

Go, Ruby, C#, Objective C, JavaScript, PHP

3. Encode and decode data



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Statistics

- **Possibility to provide statistical information** is baked into data types, e.g. for
  - maximum acceleration in case of crash detection
  - hourly speed histogram

```
message Int64StatisticValues {
  message TypeAndValue {
    enum Type { UNKNOWN = 0; MINIMUM = 1; MAXIMUM = 2; AVERAGE = 3; MEDIAN = 4; }
    Type type = 1; int64 value = 2;
  }
  TimestampInterval timestamp_interval = 1;
  repeated TypeAndValue type_and_value = 2;
}

message Int64Value {
  oneof value_oneof {
    int64 value = 1;
    Int64StatisticValues statistic_values = 2;
    Int64Histogram histogram = 3;
    Int64GaussianDistribution gaussian_distribution = 4;
  }
}
```


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USE CASES & LIAISONS

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Use Cases and Reference Implementation

- **Use case categories**
  - Update of HD maps
  - Near realtime collection of sensor information
  - Vehicle and driver information and statistics

- **Reference implementation**
  - **Under discussion**, implementation together by some SENSORIS members or by external company
  - **Possible technology stack:** transport layer HTTPS + REST / job push from vehicle to vehicle cloud, and from service cloud to vehicle cloud / data push from vehicle to vehicle cloud, and from vehicle cloud to service cloud
  - **Probably cover left out aspects:** validation and error handling / privacy anonymization and pseudonymization / security and user management / resource management

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Liaisons

- **ISO**: transfer of vehicle sensor data from vehicle cloud, possibility to handle SENSORIS messages within Extended Vehicle Web Service, container is currently JSON or CSV
- **GENIVI**: Vehicle Signal Specification for infotainment system, specification not further developed
- **W3C**: browser based API to pull data of vehicle for vehicle infotainment system, based on GENIVI, W3C sees coexistence of W3C web services as API with SENSORIS
- **SIP adus**: complete AD solution including vehicle sensor data and maps in Japan, vehicle data specified within JasPar (Japan Automotive Software Platform and Architecture)
- **Ko-HAF**: Kooperatives hochautomatisiertes Fahren, German public founded project, Bosch CR involved
- **Other**: Australian Road Research Board (send data from truck on-board units to government), CLASS, AUTOPILOT (EU IoT project in context of automated driving), CCC (Car Connectivity Consortium, communication smartphone to vehicle MirrorLink)

CONCLUSION

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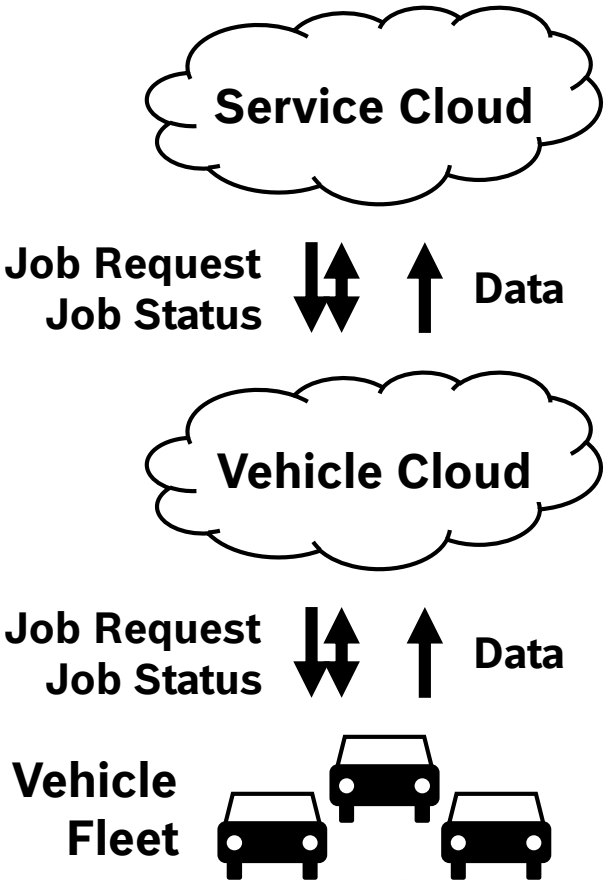
Conclusion

- The **Sensor Interface Specification (SENSORIS)** defines an interface for requesting and sending vehicle sensor data from vehicles to clouds and across clouds
- **Initial proposal by HERE to boost collaboration**
- **SENSORIS platform is growing rapidly** and includes global players from OEMs, map makers, suppliers, infrastructure providers
- **First version of industry standard released in June 2018**
- **Bosch is actively involved in the standardization of SENSORIS**



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THANK YOU

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