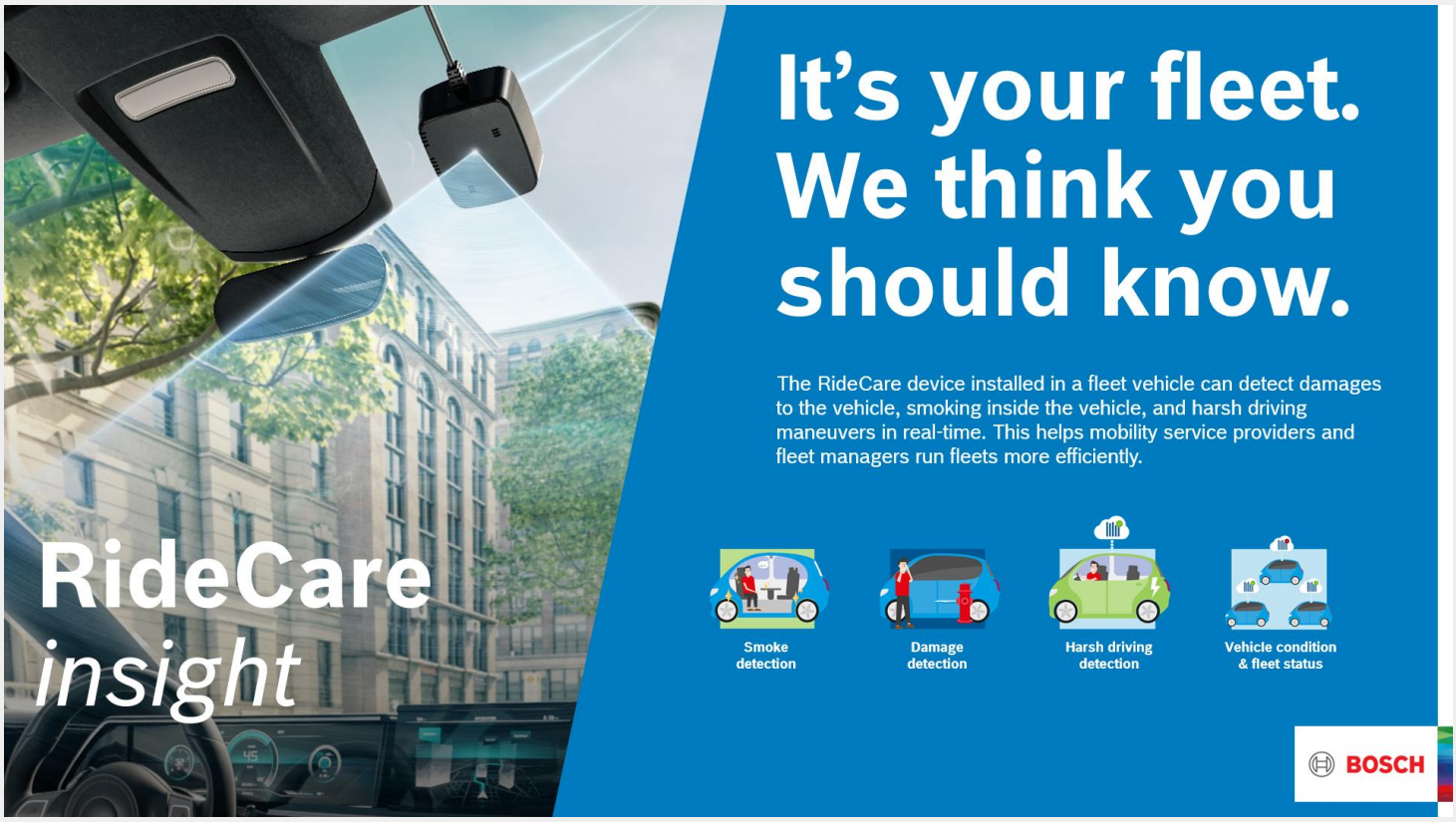
Technical Customer Documentation (TCD)
RideCare *insight*

Product Name: IVS-SLIM
Product Designation: Damage, Smoke & Harsh Driving Detection, Vehicle Condition & Fleet Status
Application: Fleet vehicles, vehicles in shared applications
Version: 3.0
Date: 19.08.2022



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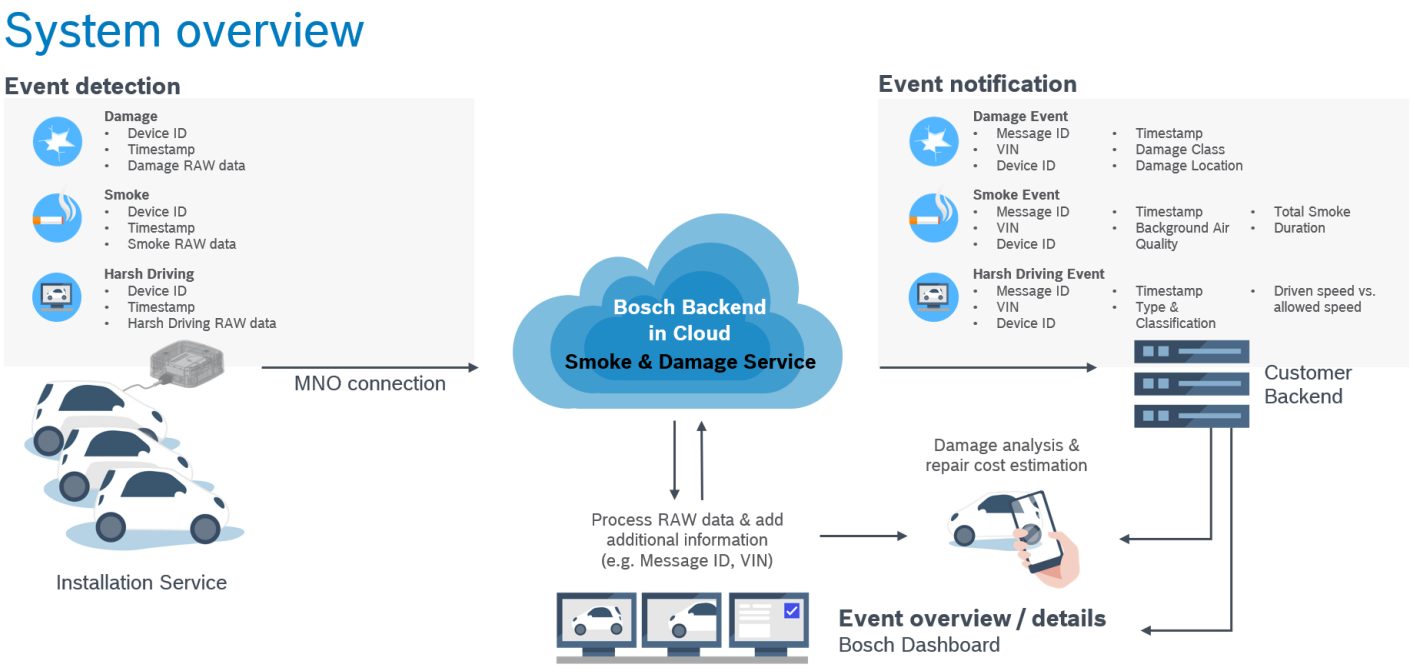
1 Background information

1.1 Solution scope & intended use

Shared or rented vehicles are used by many different customers. During the rental period, the fleet managers (Mobility Service Provider (MSP)) do only have a limited transparency about the handling of the vehicles: Damages happen without being reported, customers smoke inside the vehicles, although this is against the terms & conditions, vehicles are driven more harshly than necessary.

RideCare insight enables the detection of damages on the exterior, smoke inside the vehicles and harsh driving maneuvers in real-time. Therefore, Bosch provides the IVS device which is installed by the MSP into the fleet vehicles. In case of a smoke, damage or harsh driving event, the RAW data is collected in the device and send to the Bosch backend (Amazon cloud EU-server). Within the backend, the events are processed in an automated way (e.g. filtering of false events, severity rating). After processing, the MSP receives an event notification either via email or as a push notification into the MSP backend. Based on the information provided by Bosch, the MSP can use the event data to put forward a claim to their customers. In addition, Bosch is using the damage and harsh driving events to give an indication on the body and wear part condition.

The event details as well as the body and wear condition indexes can be extracted out of the Bosch Customer Dashboard (please see also chapter 2). If the damage analysis and repair cost estimation feature is used by the MSP, the respective reports can also be found in the customer dashboard (vehicle detail view).



1.2 Usage restrictions

RideCare insight shall only be used in the predefined countries and vehicle types (please see pilot agreement/ quotation). If a usage in other vehicle types is intended, the technical feasibility will be evaluated by Bosch. Continued operation at conditions outside of the characteristics specified in this TCD is not permitted. Consequences have to be checked and approved by Bosch.

2 Solution description

RideCare insight consists of three components:

- IVS device
- IVS SW (on the device)
- IVS backend (data processing & storage)

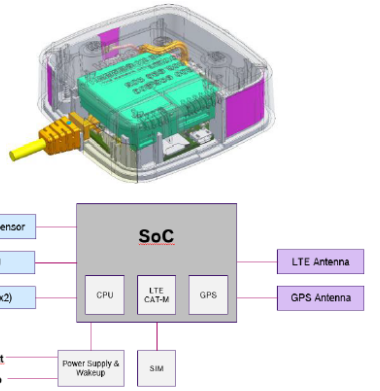
2.1 Device details

To enable the event detection, the IVS device will be provided to the customer and needs to be installed at the windshield of the fleet vehicles. The installation can vary depending the vehicle type. Bosch will support the customer to define the appropriate installation method. More details about the installation can be found in the installation manual.

The IVS device operates in three power modes: Active, low power and ultra-low power. The active mode is triggered when a movement of the vehicle is recognized (e.g. start of engine). If no movement is recognized for more than 15 min, the device switches into the low power mode. If the device is in the low-power mode for more than two weeks, the device switches into the ultra-low power mode.

Further technical details incl. cellular bands & power rating can be found in the user manual.

Set up of Hardware



Operating temperature	-25°C to +60°C (-13°F to 140°F)
Storage temperature	-25°C to +70°C (-13°F to 158°F)
Relative operating humidity	20% to 80%, noncondensing
Input voltage	+8V to +16V DC
Power consumption	500mA @ 12V
Dimensions (W x L x H)	80mm x 80mm x 27mm
Weight	90g

Outside the operating temperature, the correct function of IVS-Slim is not guaranteed.

Cellular bands

European Union, Malaysia:

Cellular bands and power for 7 500 650 504

Mode	Freq in MHz	EIRP in dBm	EIRP in W
GSM900	880.2	36.00	3.98
UMTS I	1920	27.40	0.55
UMTS VIII	880	26.00	0.40
LTE B1	1920	27.40	0.55
LTE B3	1710	28.50	0.71
LTE B7	2500	27.90	0.62
LTE B8	880	26.00	0.40
LTE B20	832	26.00	0.40
LTE B28	703	26.00	0.40

EIRP = maximum conducted output power + antenna gain (IVS Slim uses internal antenna TAOGLAS FXUB89)

United States of America, Canada:

Cellular bands and power for 7 500 650 505

Mode	Freq in MHz	EIRP in dBm	EIRP in W
UMTS B2	1850	27.69	0.59
UMTS B4	1710	28.66	0.73
UMTS B5	824	27.15	0.52
LTE B2	1850	26.31	0.43
LTE B4	1710	28.24	0.67
LTE B5	824	27.19	0.52
LTE B12	699	25.03	0.32

EIRP = maximum conducted output power + antenna gain (IVS Slim uses internal antenna TAOGLAS FXUB87)

As IVS Slim includes antennas, the user and/or bystander has to ensure a minimum distance of more than 20cm to the device.

Description

- Device will be glued onto the windshield via glue pad
- Device will be connected to vehicle power and ground
- The average power consumption of the device is:
  - Active mode: ca. 200 mA
  - Low-power mode: ca. 15 mA
  - Ultra-low power mode: ca. 150 µA
- The network provider is Vodafone
- The data from the device is sent to the Amazon cloud EU-server
- No ASIL required as no direct interface with vehicle

2.2 Feature overview

RideCare insight has the following features:

- Installation service
- Exterior (small) damage detection
- Interior smoke detection
- Harsh driving detection
- Analysis of vehicle condition & fleet status
- Damage analysis & repair cost estimation (executed by Bosch partner)
- Software updates over the air (SOTA)
- Bosch Customer Dashboard

2.2.1 Installation service

During the installation, the IVS device must be (digitally) coupled with a vehicle. Therefore, Bosch provides an Installation Service (web application). Therefore, a smartphone with internet connection is needed (via LTE or WIFI). More details can be found in the installation manual.

2.2.2 Exterior (small) damage detection

The IVS device detects damages on the exterior of the vehicles. The detection is based on the sensor measurements of the vehicle dynamics and can be classified into three damages classes: cosmetic, significant, severe.

Besides the damage detection by the IVS device, damages are also detected in the Bosch backend (machine learning detection, especially for small damages like scratches & dents).

The detection of exterior damages is always possible: during rides and in parked situations (active & low power mode).

Severe Damages: Damages that likely require a repair. The vehicle should not be driven without an inspection of the damage. Most often those damages are reported by the driver.

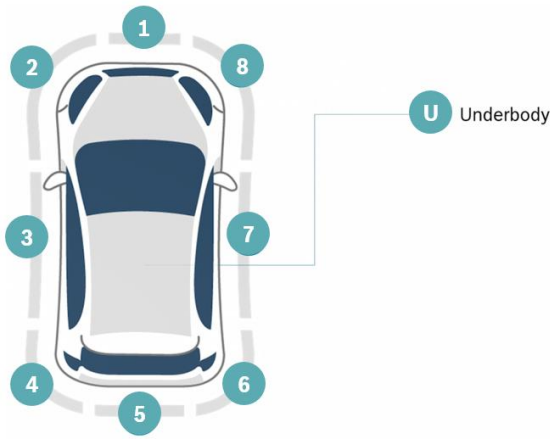
Significant Damages: Damages that could require a repair but most likely the vehicle can still be driven.

Cosmetic Damages: Scratches and other cosmetic damages that do not need an inspection or repair but still reduce the vehicles residual value. Most often, those damages are not reported by the driver.

Decisive for the damage detection is the impact on the automotive body and depends on several factors like the vehicle type, speed or the type of damage event. If the damage event does not cause any impact that can be measured by the IVS device, the damage detection is not possible (e.g. stone chipping on windshield). Bosch is continuously improving the detection i.e. of small (cosmetic) damages with internal damage testing and by analyzing the data out of the field. A detailed overview of the most typical small damage events and the current detection confidence by Bosch is provided within the Small Damage Catalogue attached to this TCD.

The IVS device not only detects the damage class but also the damage location. Therefore the vehicle is divided into 9 different areas. Each damage event notification contains the damage class & damage location.

Please note: Underbody damages are reported as harsh driving events.



2.2.3 Interior smoke detection

The IVS device continuously measures the quantity of micro-particles of varying sizes at its location inside the vehicle during vehicle operation in one second intervals. This sequence of measurements is constantly being evaluated by a smoke algorithm running in the device to determine if the measurements represent a potential smoke event or are representative of the current background levels of particles. A potential smoke event is identified when the device detects particle levels significantly above the background for at least 30 sec. Once a smoke event is detected, data is recorded until either the measured values fall below a background dependent threshold, 10 minutes elapse from the start of the event, or the measurement device becomes inactive, whichever comes first. This recording represents a smoke trace. This smoke trace is then evaluated parametrically and morphologically with respect to true typical smoke events and assigned a relative confidence metric.

Parameters include minimum peak, average, duration, and total smoke. Morphology includes shape, number of puffs and spacing between puffs. All events that meet a minimum confidence threshold are sent to the cloud. Only those events that meet a predefined threshold are forwarded to the customer.

Some smoke events can last longer than 10 minutes or there can be multiple smokers. In all cases, 10 minutes is more than enough time to detect a smoke event. Longer events are broken up into consecutive events shorter or equal to 10 minutes. In many cases the succeeding events are assigned a lower confidence, because they represent rather the presence of smoke than active smoking.

The detection of smoke events is only possible in the active mode of the IVS device. As described in chapter 2.1, the active mode is triggered when the device detects a movement. The active mode has a minimum duration of 15 minutes. If someone smokes in a parked situation, the device may still detect the smoke event, as the vehicle motion or occupant actions (e.g. open/close the door) will trigger or extend the duration of the active mode.

The detection of smoke events is possible irrespectively of the vehicle condition (e.g. doors/windows open, AC on). The IVS device continuously measures the amount of particles inside the vehicle.

2.2.4 Harsh driving detection

The IVS device detects harsh driving maneuvers in three cases: harsh acceleration, harsh braking, harsh cornering. In addition, underbody impacts are reported as harsh driving events (even though detected via the damage detection algorithm – please see chapter 2.2.2). Therefore, the IVS devices measures the acceleration on all three axes of the vehicle. To account for the different windshield and road slopes, the three signals are rotated to match the vehicle coordinate system. To eliminate the effect of road slopes, the collected data is differentiated and immediately integrated in intervals of one second, to obtain offset free acceleration values. Also, the algorithm takes into consideration the driven speed of the vehicle when a harsh driving event is detected. All detected events are categorized according to their intensity: slight, significant & severe. The significant and severe events are reported in real-time to the MSP (via notification and in the Bosch Customer Dashboard). The slight harsh driving events are stored in the IVS backend and not submitted to the MSP. All events are used for the calculation of the wear condition index (please see chapter 2.2.5).
Please note: Bosch does not know at any time, who was causing the harsh driving event. The mapping of a harsh driving event to a driver can only be done by the MSP.

2.2.5 Analysis of vehicle condition & fleet status

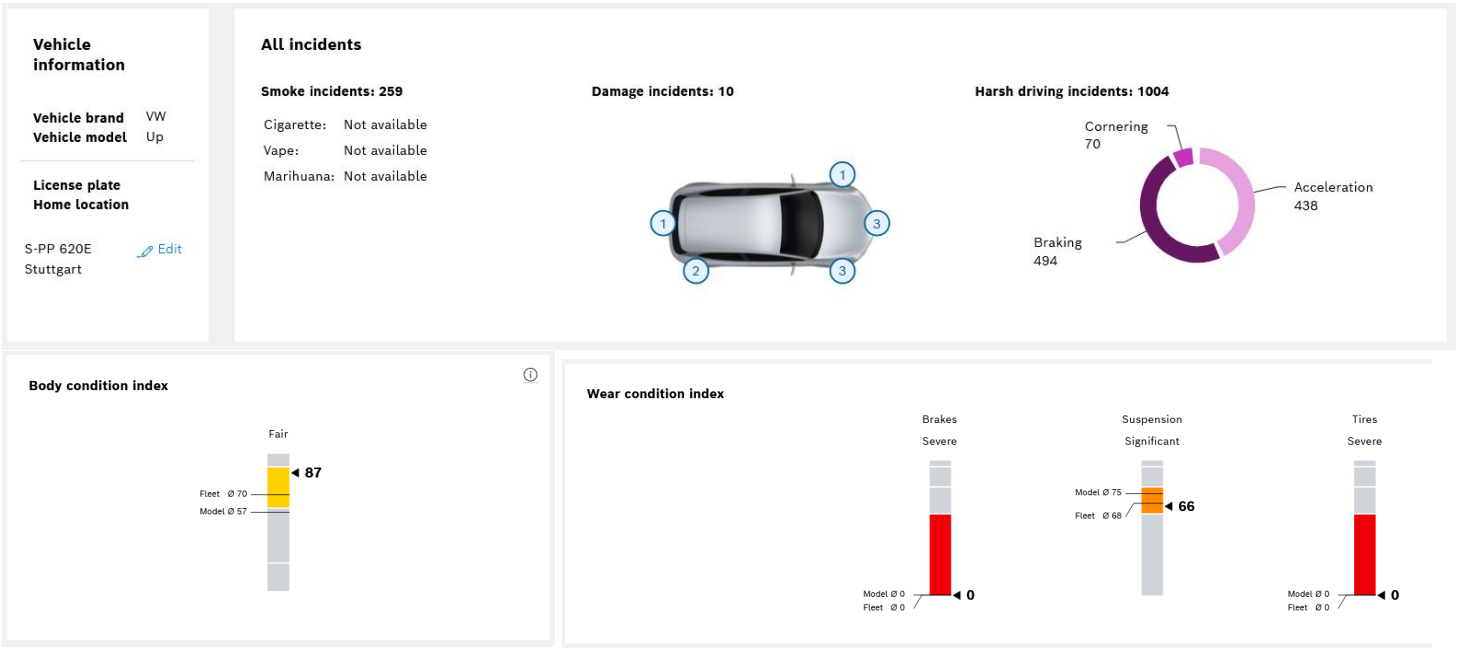
Besides the reliable detection of damage and harsh driving events, RideCare insight uses the event data to analyze the vehicle condition and therefore enables the MSP to get a deeper insight into the fleet status.

Body condition index
The detected damage events are used to derive a body condition index. Therefore, not only the severity of a damage event (cosmetic, significant, severe) is considered, but also the total amount of damages. The body condition index shall give an indication about the depreciation of the vehicle due to the accumulation of damages. In other words, the first damage to a vehicle has a greater impact on its depreciation than subsequent damages.

Wear condition index
The detected harsh driving events are used to derive a wear condition index for each of the three vehicle components: tires, brakes, and suspension. Therefore, not only the severity (slight, significant, severe) is considered, but also how a specific event affects a specific wear part. A braking event – for example – has an impact on the brakes and suspension, while an acceleration event has an impact on the tires and suspension. The formula to derive the wear condition index calculates the additional wear that is inflicted on the respective part. Based on the average maintenance interval of a wear part, an indication is given on the overall status of the wear part.

Please note: Bosch can only give an indication on the wear condition of the respective component as only the MSP can check the actual status of a wear part (e.g., low tread depth on tires).

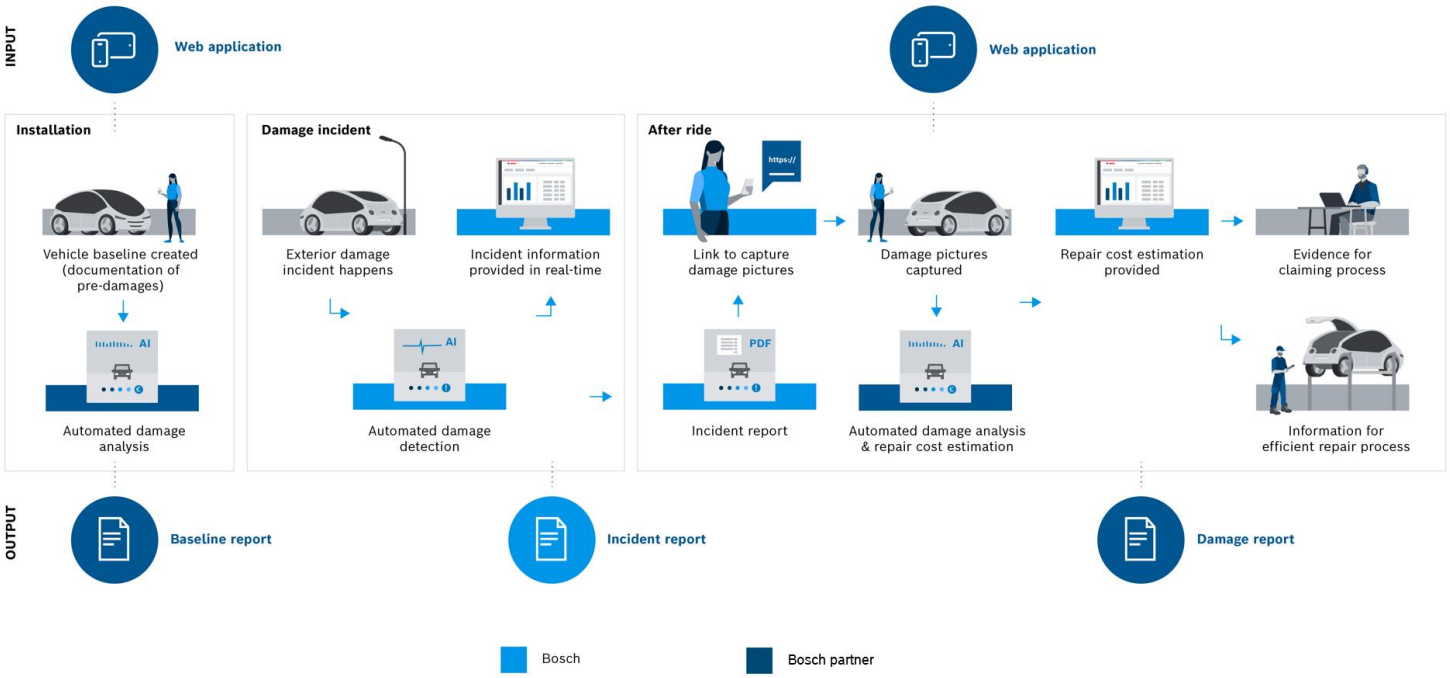
Example body condition & wear part index:



2.2.6 Damage analysis & repair cost estimation

RideCare insight enables the reliable detection of damages, smoke, and harsh driving events. Besides the reliable damage detection, it is necessary to inspect the vehicle and document a new damage before the vehicle is rented out again. Also, it is necessary to document the pre-damages of a vehicle (vehicle baseline). Bosch recommends using the Bosch web application to capture the vehicle baseline and document new damages. By doing so there is a direct link between the detected damage and the inspected damage. In addition, Bosch uses the vehicle baseline to compare the new damage with the existing damages and provides an automated repair cost estimation. This not only provides additional evidence for claiming but also allows a faster handling of repairs and better planning in the repair shop.

Please note: This is an optional feature.



2.2.7 Software update over the air (SOTA)

The IVS device can be updated over the air. Software updates can be needed due to:

- Maintain and optimize existing features
- Update auxiliary software
- Update cyber security (e.g., new certificates)
- Provide new features

Bosch can apply software updates whenever needed. The customer shall only be informed prior about an update, if there is an impact during and/or after the update on the service offering.
An approval by the customer is never needed. Please see also Service Level Agreement.

2.2.8 Bosch Customer Dashboard

Besides the notification in real-time, RideCare insight offers a Customer Dashboard. Within the dashboard, all events are listed up, additional details are provided, and the download of the reports is possible (e.g., baseline report, damage report, repair cost estimation). Also, the MSP can give feedback and add new users.

The following information will be available:

- Fleet & couple overview (Which device is installed in which vehicle?)
- Device status (online, offline, connected, disconnected)
- Event overview
- Event details:
    - Smoke Events: e.g., Timestamp, Duration, Total smoke, Background air quality, Smoke diagram (particles over time), Smoke report
    - Damage Events: e.g., Timestamp, Damage class, Damage location, GPS-position, GPS-speed, Street view, Damage diagrams (acceleration over time), Damage report
    - Harsh Driving Events: e.g., Timestamp, Classification, Affected parts, Severity, Driven speed, Speed limit, GPS-position, Street View, Harsh driving report
- Vehicle status (Incident history, Vehicle usage, Body condition index, Wear condition index, Baseline report)

2.3 Version History

DATE	VERSION	CHANGES	RESPONSIBLE
17.07.2020	v1.7	Initial TCD	Grewe
24.08.2020	v1.8	Extended version of v1.7	Grewe
26.03.2021	v2.0	Update with new features	Grewe
20.05.2021	v2.1	Update as no Bosch Global ID is needed anymore	Grewe
28.07.2021	v2.2	Addition of details for damage detection feature	Grewe
07.12.2021	v2.3	Update of details for smoke detection feature	Grewe
19.08.2022	v3.0	New product name, new features, increased service scope	Brueckner

2.4 Signatures

ROBERT BOSCH TECHNICAL RESPONSIBILITY	ROBERT BOSCH COMMERCIAL RESPONSIBILITY
pki, BOSCH, US, P, H, Philip.Ventimiglia Digitally signed by pki, BOSCH, US, P, H, Philip.Ventimiglia Date: 2022.08.19 07:20:48 -04'00'	Alexander Djordjevic Digital unterschrieben von Alexander Djordjevic Datum: 2022.08.19 14:04:45 +02'00'

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