



## Radar based Blind Spot Information System

### MBX Operating & Integration Manual

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## MBX Operating & Integration Manual

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### Document purpose

This document provides the specifications to operate and integrate the Blind Spot Detection (BSD) MBX Sensors in a car

### Revision record

Revision	Date	Remarks	Author
1.0	10/10/2011	Creation	E.Amiot
2.0	12/12/2011	Updated version	H Mkinsi
2.1	09/07/2012	Manual requirements see §7	E.Amiot



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### Acronyms

BLIS	Blind Spot Information System
bps	Bits per Second
BSD	Blind Spot Detection System
BSM	Blind Spot Monitoring
BSZ	Blind Spot Zone
CAN	Controller Area Network
CTS	Component Technical Specification
ECU	Electronic Control Unit
EIRP	Effective Isotropic Radiate Power
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
$f_c$	Center frequency of the intentional emission
FoV	Field of View
HMI	Human machine interface
IPM	Instrument Pack Module or Driver Information Center
LED	Electroluminescent icons
MBX	Multi Beam Radar
n.a.	Not applicable
OEM	Original Equipment Manufacturer
PWM	Pulse Wave Modulation
RF	Radio frequency
rBLIS	Radar based Blind Spot Information System
SOD	Side Obstacle Detection
VRS	Valeo-Radar Systems, Inc.



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## Definitions

BSD Sensor:	MBx Sensor
Host vehicle:	the vehicle fitted with the BSD.
Object vehicle:	the vehicle the BSD is searching to.
Vehicle right side:	the side to the right of the driver.
Vehicle left side:	the left of the driver.
Blind spot zone:	a defined area close to the host vehicle where the presence of an object vehicle that meets certain defined criteria causes the BSD to generate a warning.
Human machine interface:	the manner in which the sensor is able to provide information to the driver as well as the means for the driver to send information (or commands) to the sensors.
Field of view:	the area located in front of the sensor that the radar is able to monitor (this area may be much larger than the area that the radar is required to be able to see in order to provide alerts).
Inside alert zone:	an object of interest is considered “inside” the alert zone if any part of it is within the inner tolerance lines.
Outside alert zone:	an object of interest is considered “outside” the alert zone if it is entirely outside the outer tolerance lines.
System latency:	the time delay between an event taking place to the time the response output to the event is seen, heard or felt by the driver.
Update time:	the time between two consecutive measurements of the whole FoV.
Relative speed:	the differential speed between the host and object vehicles.

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## Part I                    Document scope

### 1. MBX principle

The Multi Beam Radar (MBX) is a radar sensor module used to monitor the alert zone (or blind area) of a vehicle, i.e. by sensing the back sides of the vehicle and by reporting to the driver if an object of interest meeting certain criteria in that area is present, or not. A message is transmitted on the CAN bus within the vehicle to indicate detection of an object of interest within the alert zone.

Automotive manufacturers use different terms to describe this function, e.g. Blind Spot Detection System (BSD), Blind Spot Monitoring (BSM), Side Obstacle Detection (SOD), or Blind Spot Information System (BLIS).

Figure 1 shows how the MBR sensors are placed on the vehicle and how the beams cover the alert zones on each side.

#### 1.1. System operation

The Multi Beam Radar Sensor (MBX) modules are to be mounted on each side of a vehicle near the back, behind the left and right hand side of the bumper with their radar beams radiating towards the side of the vehicle. Each radar sensor is operating in a narrow band frequency around of 24.15GHz. Under normal driving conditions, the sensors receive multiple beams of radar data oriented in a fan shaped pattern in order to cover the alert zone as shown in figure 1.

Each sensor is able to search its own field of view (FoV) to determine whether an object of interest (a “licensable vehicle”) is present within the MBX alert zone and determine whether that object should be reported to the driver. If an object of interest is present within the MBX alert zone which needs to be reported, an appropriate message is transmitted over the CAN bus. A notification to the driver will be done with illuminated amber icons or pictograms on the exterior rear view mirrors or on the A-pillar.

This continuous scanning of the traffic on the left and right adjacent lanes is the same for all passenger vehicles, but the shape and size of the blind spot zone

(BSZ) will be different from vehicle to vehicle, i.e. it depends of the vehicle style, body shape and vehicle structure.

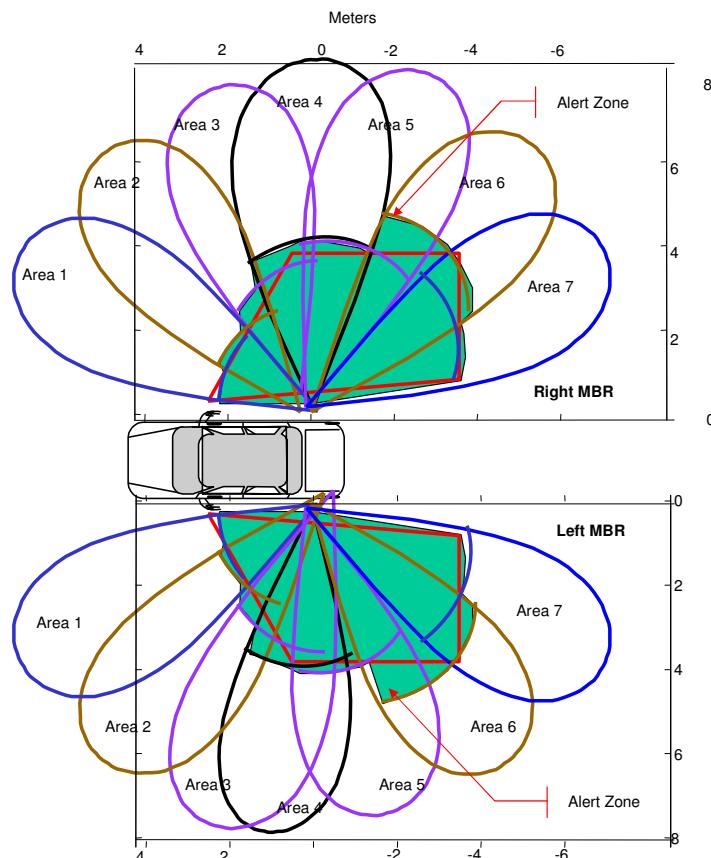


Figure 1: Illustration of the MBX covering area with 7 beams activation.

## 1.2. MBX system architecture

### 1.2.1. BSD system overview

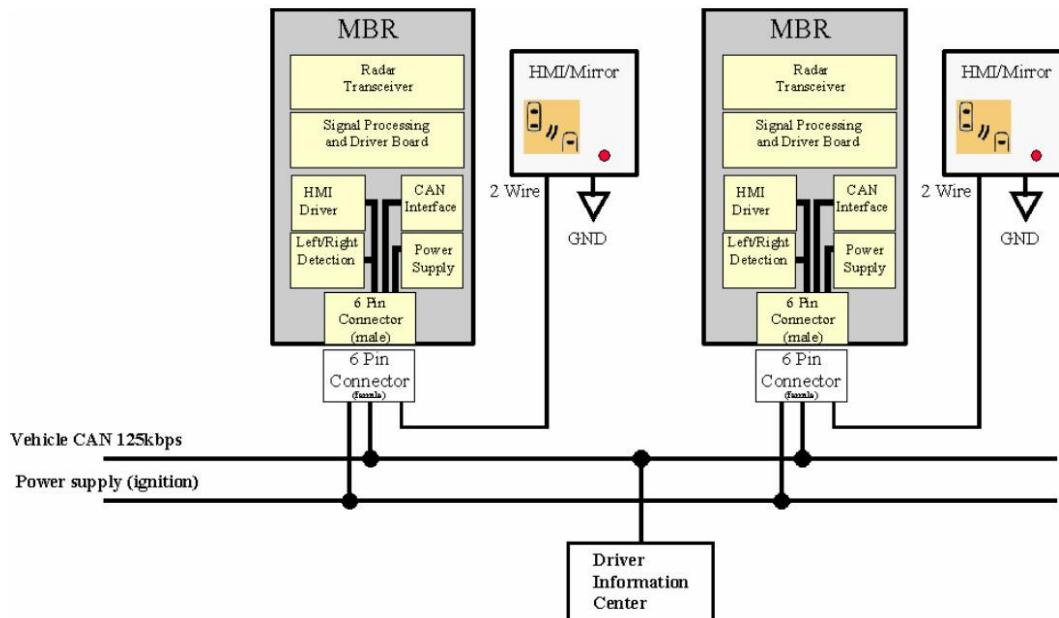


Figure 2: MBX block diagram based on two LEDs implemented in side mirrors  
For the connector, several interfaces/number of pins are available.



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## 2. Applicable documents and specifications

### 2.1. Government regulations and standards

#### 2.1.1. United States of America

- Federal Communications Commission - Code of Federal Regulations - Title 47 / Part 15 – Radio Frequency Devices.
- Federal Communications Commission - Code of Federal Regulations - Title 47 / Part 18 – Industrial, Scientific and Medical (ISM) Equipment.
- Federal Communications Commission FCC/OET TP-3 / FCC Procedure for Measurement of Intentional Radiators (Except for Periodic and Spread Spectrum Devices and Devices Operating Below 30MHz).
- Federal Communications Commission Bulletin FCC OST 55 / Characteristics of Open Field Test Sites.

#### 2.1.2. Canada

- RSS-310 Radio Standards Specification 310 / Issue 1 – September 2005 / Low Power Licence – exempt Radio Communication Devices Category II Equipment.
- RSP-100 Radio Standards Procedure 100 / Issue 8 – Radio Equipment Certification Procedure.

#### 2.1.3. Europe (CEPT countries)

- ERC Recommendation 70-03 relating to the use of short range devices (SRD).
- ETSI EN 300 440-1 & 440 -2 Electromagnetic compatibility and radio spectrum Matters (ERM).



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## 2.2. Restricted countries

### 2.2.1. Frequency regulation

The frequency regulation status must be reviewed for each project with Valeo Raytheon Systems, to define the countries where the sales are allowed, and to define markings and information required in the End User Manual

### 2.2.2. USA export restrictions

The US export restriction law applies to MBX.

## 2.5. Other documents - only for reference

ISO/TC204/WG14/N40.24

Lane Change Decision Aid Systems (Standard working draft).



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### 3. System characterization

### 3.1. Appearance

The Sensors will be invisible and must be mounted behind the non-conductive fascia material. This portion of the rear bumper can be painted. The use of exotic metallic painting shall be used in accordance with VRS.

Appropriated brackets must be designed and realized in such way to avoid any trying of disassembling or any undesirable intrusion from outside of the vehicle, unless the bumper and/or fascia are removed.

### 3.2. Deliverables

### 3.2.1. Physical content

Tables 1 provides an overview of the physical modules and their software elements.

The electrical and mechanical implementation from both left and right BSD Sensors are identical, but the software resident into them is different. Delivered BSD Sensors are able to operate properly as either a left or a right sensor, depending of its location on the vehicle.



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Table 1: Deliverable BSD contents

Part	Part numbers		Description
	Left	Right	
BSD sensor left	X	-	Left side BSD Sensor module
BSD sensor right	-	X	Right side BSD Sensor module
Software strategy	X	X	BSD Sensor module application software (DSP download image)
Primary boot loader	X		Flash resident software for reprogramming
Signal configuration	X	X	Description of CAN signals processed by the unit
Calibration data	X	X	tbd
Secondary boot loader	X	X	Temporary software downloaded into RAM during reprogramming process
ECU configuration	X	X	tbd



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The concept and functionality of the HMI depends on each OEM, as examples:

- HMI in form of telltales on both exterior rear view mirrors: amber for ALERT and red for STATUS.
- HMI only to indicate the ALERT function: a telltale shall be incorporated into the driver information system.
- Activation of ALERT and STATUS signals coming from the CAN. HMI telltales shall be located in the A-pillar on each side.

The functionality of such telltales, when activated directly by the sensors, shall be designed by each OEM according to the data output of each BSD Sensor.

### 3.2.2. Functional content

#### 3.2.2.1. Vehicle packaging

The BSD Sensor bracket and electrical harness must provide the following functions:

- Connect to vehicle electrical system;
- Allow for removal and replacement of sensor;
- Identify sensor as left side or right side;
- Prevent squeak and rattle;
- Fit to fascia or car body;
- Define module position with regard to fascia, car body and car axis;
- If possible, take up harness connector when BSD system is not fitted;
- Prevent contamination and mud build-up, protect against “stone throw” from tires.

#### 3.2.2.2. BSD Sensor module

The BSD Sensor module shall provide the following functions:



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- Determine sensor location on vehicle by detecting resistor connected to ground (left side & right side);
- Determine operating states;
- Perform diagnostics functions;
- Perform communication to the vehicle using 125kbps CAN;
- Detect and report objects of interest in alert zone;
- Transmit / receive 24GHz RF through fascia.

### 3.3. Environmental conditions

#### 3.3.1. General requirements

The BSD Sensor module assembly shall meet the environmental and durability requirements as defined by the OEM.

#### 3.3.2. Weather conditions

BSD sensors should be able to operate in rain, snow conditions but will have limitations like all sensors in certain conditions. Limitations depend on the integration specific to each car and have to be tested.

In extreme conditions the sensors are blocked.

#### 3.3.4. EMC & EMI

The BSD Sensor shall meet the requirements specified by the OEM and the regulations applying.

#### 3.3.5. Painting influence

The BSD Sensor shall operate to requirements when mounted behind a non conductive fascia material that has been painted with metallic or non metallic paint. The bumper used material as well as the used paints have to be measured



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for transmissibility and agreed with VRS before acceptance of BSD on any target program.

### 3.4. Electrical interfaces

#### 3.4.1. External-to-vehicle to BSD

##### 3.4.1.1. Road environment to BSD subsystem

Each BSD Sensor transmits and receives energy reflected from objects within the defined field of view. The table 5 provides an overview with the most important transmission and emission parameters and their typical values. Appendix C shows a graphic outline of the detection zone with its constraints. Section 4. addresses details about possible object vehicles and a geometrical description of the adjacent traffic lanes, where objects of interest are supposed to be detected.

Table 5: BSD Sensor emissions

Parameter	Min	Typ	Max	Unit	Comment
Radiated peak power @ $f_c$			20.00	dBm	Max average 13 dBm
Center frequency $f_c$		24.15		GHz	Frequency locked
Occupied bandwidth		190	200	MHz	Frequency locked

##### 3.4.1.2. Electrical connections to rBLIS subsystem

Each rBLIS Sensor shall to be able to interface with different external devices. Table 6 summarizes into 3 groups the communication capabilities of rBLIS Sensors in different environments: development based testing tools, vehicle manufacturing, and service diagnostic within dealerships.



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Table 6: External electrical connections to BSD

Item	Description	Requirement
A	Plant Diagnostic Tool	The BSD module shall provide the capability to communicate with the communication tool used to perform diagnostics at the vehicle assembly plant during installation and programming (may be also used to reflash and calibrate modules at the plant)
B	Service Diagnostics Tool	The BSD module shall provide the capability to communicate with the communication tool used to perform diagnostics within different dealerships
C	Development Tools	The BSD module shall provide the capability to communicate over CAN with the tools used for debugging and testing activities

#### 3.4.2. Internal-to-vehicle to BSD

##### 3.4.2.1. BSD Sensor to rear fascia

The BSD Sensors must be mounted behind the left and right hand side of the rear bumper. The appropriated mechanical positioning shall to be decided by the OEM, and can be realized directly in the car body or by using a bracket. In both situations the mechanical interface has to satisfy the requirements for a properly detection and reporting of objects of interest within the azimuth and elevation detection zone.

The sensor placement must be symmetrical for both sides of the vehicle. Appendix A provides an installation guide line showing the positioning and orientation for the most types of passenger vehicles.



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#### 3.4.2.2. CAN interface

The BSD Sensors shall to interface at 125kbit/s with the vehicle dual wire CAN bus.

#### 3.4.2.3. CAN communication

The BSD Sensor shall to be conform with the bus communication specification and messages database as specified in the customer requirements.

#### 3.4.2.4. HMI interface

The BSD Sensors interface with a HMI module in the form of telltales. Each of the left and right BSD Sensor hardware shall be capable of driving the LED arrays independent of state of each other. The BSD Sensors shall provide a positive supply voltage to illuminate the LED array and high impedance when the LED is not illuminated.

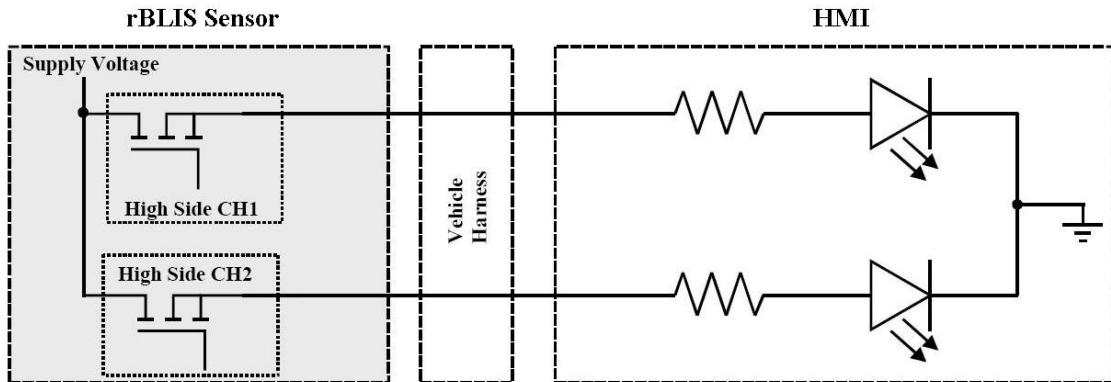


Figure 5: Simplified block diagram of the HMI driver circuitry

### 3.4.2.5. User interface to component

Each BSD Sensor shall provide signals to control an “indicator” and the “driver information system” provided for the driver. The “indicator” is a visual alert indication to warn the driver that there is an object of interest in the alert zone. Another signal allows the appearance of a status message into the “driver information system”, which shows if the BSD system is not available due one of the following reasons:

- it is broken, or faulty;
- it is not receiving the necessary information from the rest of the vehicle;
- it has become blocked;
- it is in park or reverse;
- it is disabled by the driver;
- it is disabled when a trailer is attached.



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### 3.5. Usage definition

#### 3.5.1. System intend usage

The BSD system is designed to alert the driver with a visual indication, to the presence of objects of interest that may be difficult to see using the inside and/or outside rear view mirrors. This system is not designed as a substitute for the driver to look to the side and rear of the vehicle to observe these objects. Its function is limited to supplemental use only.

According to the section 6.1. of ISO draft norm ISO/TC204/WG14/N40.24 (Standard working draft “Lane Change Decision Aid Systems”) the rBLIS system is of type 1, i.e.:

*Type I systems provide the Blind Spot Warning function only. These systems are intended to warn the subject vehicle driver of target vehicles in the adjacent zones. These systems are not required to provide warnings of target vehicles which are approaching the subject vehicle from the rear. The subject vehicle driver shall be made aware of the limitations of this type of system, at least in the owner's manual. In particular, the owner's manual shall include the following statement: "This system provides support only within a limited area beside the vehicle. The system may not provide adequate warning for vehicles approaching from the rear."*

#### 3.5.2. Operating with a trailer

Because of possible field of view obstruction (tight curves or wide trailer), the BSD system may not operate correctly. The vehicle's owner's manual must include a notice stating that the system might not operate correctly when towing a trailer which is of a type not approved by the OEM.

In addition, a trailer effectively increases the length of the host vehicle, and this length is not supported by the BSD Sensor. If the Sensor receives a CAN message indicating a trailer is in tow, the system shall be disabled and the BSD status signal indicates that it is temporally off. If the trailer is a type approved by the OEM, BSD will be disabled when the trailer is attached correctly.

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## 4. Product design

### 4.1. System performance

#### 4.1.1. Determine location (LH/RH) function

The BSD Sensor shall determine by the address input pin whether it is mounted on the left side or right side of the vehicle.

The BSD Sensor shall be reprogrammable to be able to be used on the side on which it is mounted (based on the address pin).

#### 4.1.2. Detect objects function

##### 4.1.2.1. Initialization

The “detect objects” function shall be operational within a few seconds after power supply is stable. Diagnostics will have been performed within this time frame.

##### 4.1.2.2. Objects of interest

Any licensable vehicle (the smallest licensable vehicle is defined as a 125cc motorcycle with rider) with dimensions that meet or exceed the following criteria is considered an object of interest:

- length: 2.0m
- width at its widest point: 0.8m
- height: 1.1m

##### 4.1.2.3. Alert zone definition

Alert zone could differ due to significant differences in the mounting position. The recommended mounting position is shown in Appendix A. The alert zone is defined as illustrated in figure 6. The alert zone dimensions are shown in table 8.

Table 8: Alert zone dimensions

Parameter	Value	Comment
$d_{min}$	$0.5m \pm 0.3m$	
Width	$3.0m \pm 0.3m$	
Length	$5.0m \pm 0.5m$	Applies to BSD scenarios (low relative speed)

The possible shape, width and length of the alert zone depend on the mounting constraints of the sensor and can also be modified by software. The alert zone illustrated in figure 6 is approximated by proper setting of the start and stop ranges for detection in the seven beams and is therefore not as rectangular as drawn.

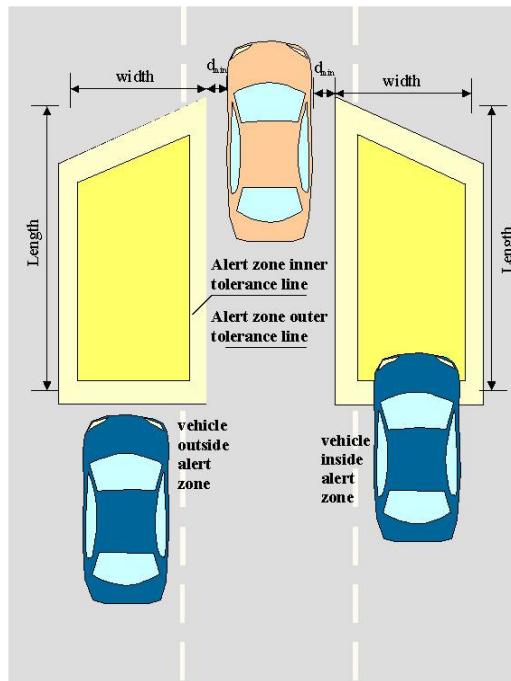


Figure 6: Alert zone definition

### 4.1.2.4. Alert conditions

The system responses to specific scenarios which are defined by OEM (*spec. title from OEMs*). False alerts and missed detections for each scenario need to be evaluated, agreed between VRS and OEM, and documented.

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#### **4.1.2.5. Latency**

The maximum time between an object of interest entering or exiting the alert zone and the signalling of an alert within the BSD Sensor shall be defined between VRS and OEM depending on the system architecture.

#### **4.1.2.6. Maximum relative speed**

Alerts shall be reported for object of interest relative speeds up to Vrmax defined by OEM specifications. However, due to system latencies, for high relative speeds, the difference between the time the vehicle enters the defined zone and the time the alert indication is generated will make it appear as if there was a reduction in the size of the alert zone.

#### **4.1.2.7. Mutual interference**

The BSD Sensor shall not interfere with other systems on the vehicle or other vehicles. The same or similar BSD systems on other vehicles shall not interfere with the proper reporting of alerts by the BSD Sensor.

#### **4.1.2.9. False alert of an object of interest**

A database needs to be created which documents the system performance for each scenario defined by OEM. The performance in terms of missed and false alerts depends on the environment.

### **4.1.3. Determine operating state function**

VRS shall provide to OEM the BSD Sensor operating states and transitions. Each sensor's operating state is determined based on its own operating condition and information received from the vehicle, including the other sensor.



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#### 4.1.3.7.1. Serial data induced fault conditions

The BSD system shall be disabled if any of the following conditions occurs:

- Invalidated signal: a CAN signal, monitored for validity, is invalid (validity signal set to invalid). Validity signals to be monitored have to be specified in the “target vehicle” CAN database.
- Loss of transmission: a required CAN signal is not available or has not been received according to LOSS OF TRANSMISSION timeout. The signals to be monitored for loss of are specified in the “target vehicle” CAN database.

#### 4.1.3.8. STANDBY state

The STANDBY state shall be entered when the vehicle is in park or reverse, or when the parking brake is set. Radar transmission to monitor the field of view is not performed while in this state.

#### 4.1.3.9. SYSTEM ACTIVE state

In this state, the field of view of the sensor is constantly monitored.

#### 4.1.4. HMI output function

Each sensor has CAN signals for independently controlling an alert display and a status message. Each rBLIS Sensor provides independent displays for its own side of the vehicle. No other directly controlled (e.g. audible) alert will be provided.

#### 4.1.5. CAN communication

CAN communication shall be provided through 125kbps two wire transceiver, compliant with the specifications listed in section 2.3. The required CAN messages, CAN-ID and DTC will be specified by the OEMs.



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Signals included in the status message sent by each sensor are:

- Alert
- System status

Required Signals received over the medium speed CAN bus are:

- BSD-LED Status DriverSide
- BSD-LED Status PassSide
- BSM on/off
- Car Mode
- Vehicle speed
- Gear lever position
- Direction indicator switch
- Parking brake active
- Power mode
- Reversed gear
- Steering wheel angle
- Trailer in tow

#### 4.2. Diagnostic functions

There are 3 categories of diagnostic functions for the rBLIS Sensor:

- Power-on self tests are executed once, as part of the sensor power-up initialization;
- Permanent diagnostic tests are executed periodically; and
- Triggered diagnostics tests are initiated by diagnostics.

#### 4.3. Calibration parameters

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Table 13: Main calibration parameters in use

Parameter	Units	Default value	Description
USE_CAN_NOT_HMI	Boolean	False	If true, no direct control of HMI. Alerts and status indication sent only via CAN
<u>MINIMUM SPEED THRESHOLD</u>	Km/h	10	No reporting of alerts below this speed
K_MAX_RELATIVE_SPEED_FS	Km/h	0	Maximum relative speed at start of zone entry to report stagnation
DISPLAY_HOLD_ON_TIME	ms * 10	50	Minimum time alert light will be turned on (default 500ms)

#### 4.4. Mechanical features

The sensors are mechanically and electrically identical on both sides of the vehicle (same part number). The sensor has to be rotated around the vertical axis when mounted to the other side of the vehicle hence will not be symmetrical on both sides. The brackets for mounting the sensors onto the vehicle must be designed to take this into account and the brackets may be different on both sides due to the curvature of the fascia on either side of the vehicle being not symmetrical relative to the sensor.

##### 4.4.1. Dimensions and capacities

The dimensions of the BSD Sensor module are shown in Appendixes D, E and F (according to the OEM).

##### 4.4.2. Mass

rBLIS Sensor module mass shall be less than 400g.

##### 4.4.3. Sensor enclosure

The sensor housing shall be laser welded.

##### 4.4.4. Connector requirements



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The connector is defined by the OEM and has to be compliant with VRS tools.

#### 4.4.5. Mechanical mounting

##### 4.4.5.1. General requirements

Attachment applied force shall not exceed 26N per mounting tab of the BSD Sensor. Retention force of the attachment system shall exceed 110N normal and shear.

##### 4.4.5.2. Sensor to car body attachment

Each BSD Sensor will be directly attached to a bracket using one screw and the 2 tabs. The whole assembly part will then be attached to the car body using 2 screws.

#### 4.4.6. Sensor alignment & test

The BSD Sensors shall not require alignment at the vehicle assembly plant.

#### 4.4.7. Fascia properties

The BSD Sensors shall be compatible with the painted fascia.

For field of view obstruction evaluation, use field of view dimensions from Appendix C. The bumper material as well as the paints has to be measured for transmissibility by VRS and jointly agreed between OEM and VRS.

### 4.5. Electrical features

Table 15: Electrical requirements - General

Description	Parameters	Remarks
<b>Ambient Temperature</b>		
Operating temperature range	–40°C to +85°C	
Storage Temperature range	–40°C to +95°C	Module not powered
<b>Supply voltage</b>		
Operating voltage range	12V ± 1V	Max 16V / Min 9V
<b>Supply current</b>		

**Table 16: Electrical requirements - CAN**

Description	Parameters	Remarks
<b>CAN interface</b>		
CAN speed	125kbps	
Output current with LVDS out (into 75Ω)	max. 200mA (supply voltage of 12V)	
Output current with I2C out	max. 10mA (supply voltage of 12V @ temp of +25 °C)	
Power supply current (-40 °C to +85 °C)	max. 700mA (supply voltage of 12V)	

#### 4.5.1. Power

The BSD Sensor will be powered by the ignition(only powered when ignition is on).

#### 4.5.2. Ground

Ground offsets of up to 0.5V should be expected between modules.

#### 4.5.3. CAN

VRS shall provide CAN serial data interface hardware for electrical integration testing. All electrical requirements related to CAN are specified in item 2.3.2. The OEM is responsible to support the CAN development and provide access to the CAN tools the sensor needs to interface with.

#### 4.5.4. Operating current

The operating current is specified in table 15.

#### 4.5.5. HMI driver

The OEM is responsible for the HMI. The two channels HMI driver per sensor module is realized by using intelligent high side switches designed to drive two LED arrays with common ground.

### 4.6. Maintenance and repairing

Proper orientation of the BSD module must be guaranteed by the dealer after repair. After a crash affecting the vehicle body, the car body should be repaired to guarantee a maximum misalignment of the sensor of  $\pm 2^\circ$ .

The BSD system shall not require scheduled maintenance or service during its target life.



## Radar based Blind Spot Information System

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Remarks:  
Certification Documentation

Revision:  
2.0

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### 5. Materials and processes

Materials and environmental specifications are defined by OEM

### 6. Environmental validation

Defined by OEM



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## 7. End User Manual

### **Manual Requirements according 15.19 / RSS-210**

When

- the device is so small or for such use that it is not practicable to place the statement on it
- and the device is subject to Part 15 of the Federal Rules / RSS-210 of Canadian Rules
- and the device is subject to certification procedure,

below text shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user.

#### **Text for User Manual (blue cursive text)**

##### ***NOTICE:***

*This device complies with Part 15 of the FCC Rules [and with RSS-210 of Industry Canada].*

*Operation is subject to the following two conditions:*

- (1) this device may not cause harmful interference, and*
- (2) this device must accept any interference received, including interference that may cause undesired operation.*

[\*] delete text in brackets if Canadian approval is not requested.

### **Manual Requirements according 15.21**

The users manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

##### ***NOTICE:***

*Changes or modifications made to this equipment not expressly approved by (manufacturer name) may void the FCC authorization to operate this equipment.*

## Appendix

### A. Graphical outline of FoV

Keep out zone for ornamentals and conductive materials on the bumper (2° added on each side of the FoV to cover tolerances)

