BOSCH RADARS ECHO CAR PRESENTATION

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Bosch Radar
Agenda

- Bosch Radars Sensor
- Radar Sensor – Field of View
- Radar Network – Object Data
- Radar Network – Monitoring
- Radar Network – Target Object Data
- Radar Sensor – Configuration

BOSCH RADARS AND FIELD OF VIEW

Bosch Radar Sensors
MRRevo14 Front Sensor

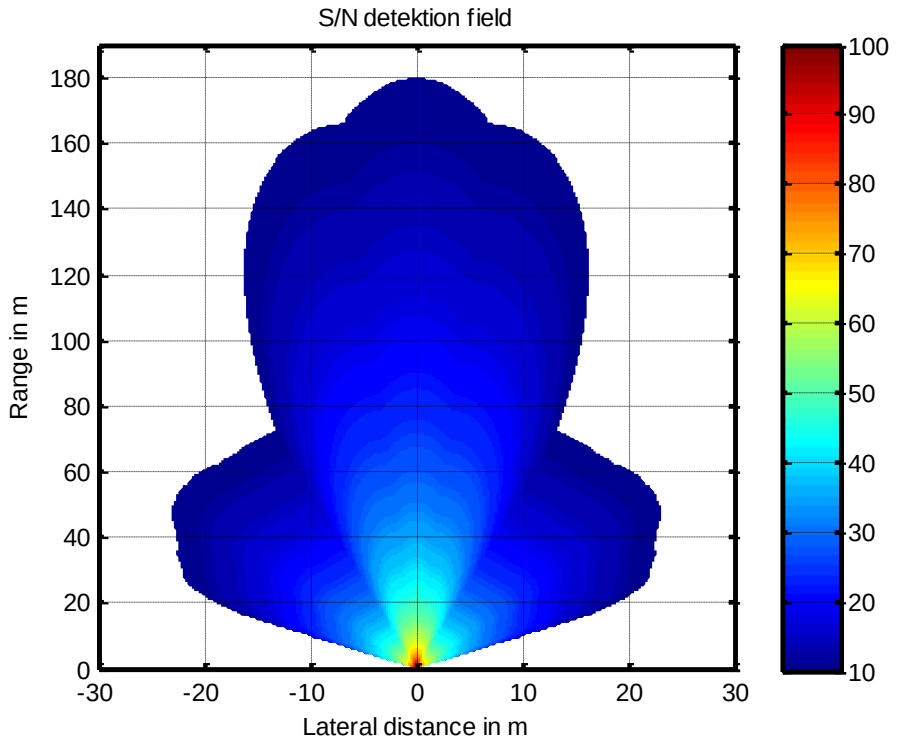
MRR Evo14 Front

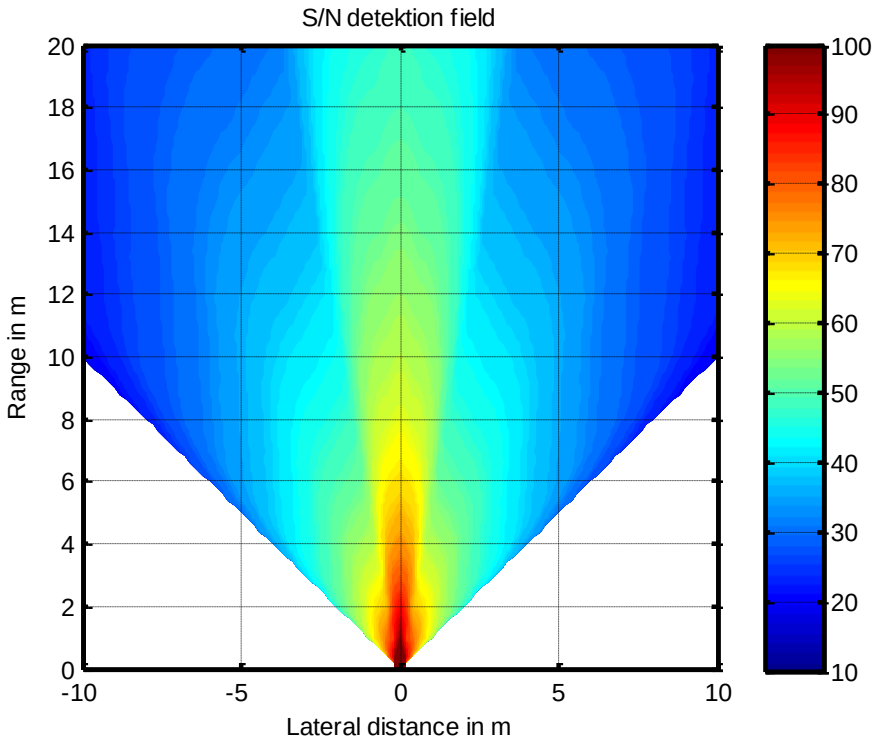
- Range: up to 160 m
- Opening Angle: 90°

MRR Rear / Corner

- Range: up to 100 m
- Opening Angle: 150°

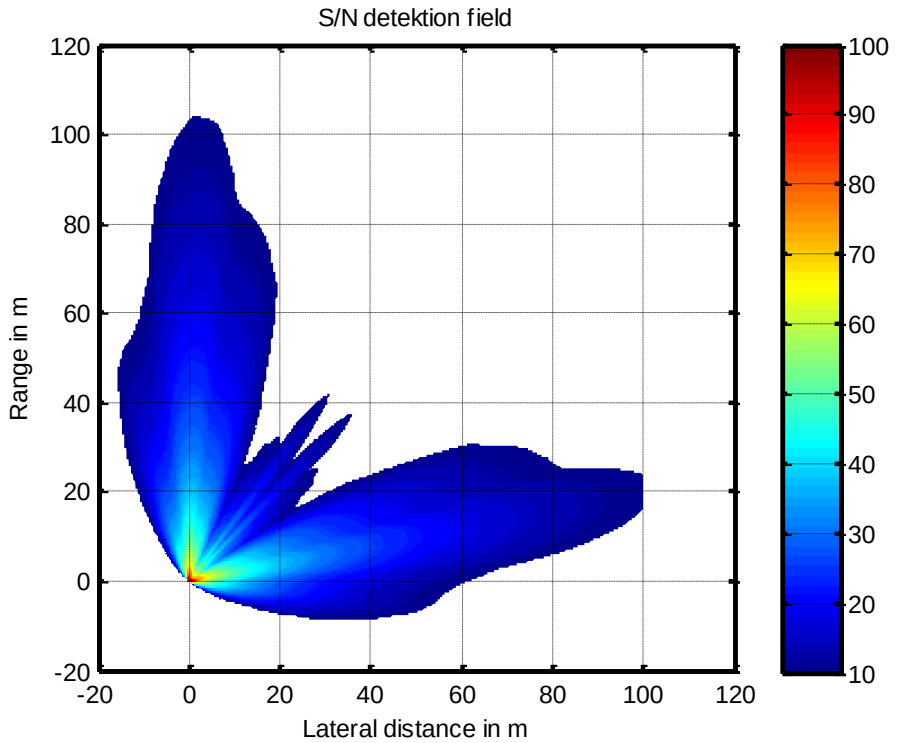
Bosch Radar Sensor
Field of View MRR Evo14F

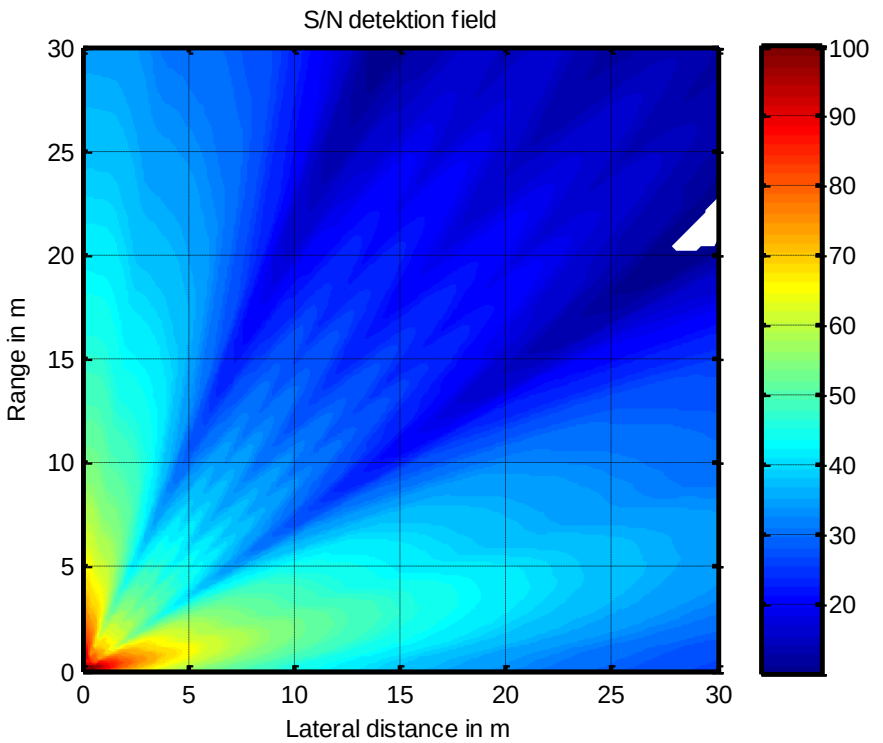




90 degree opening angle

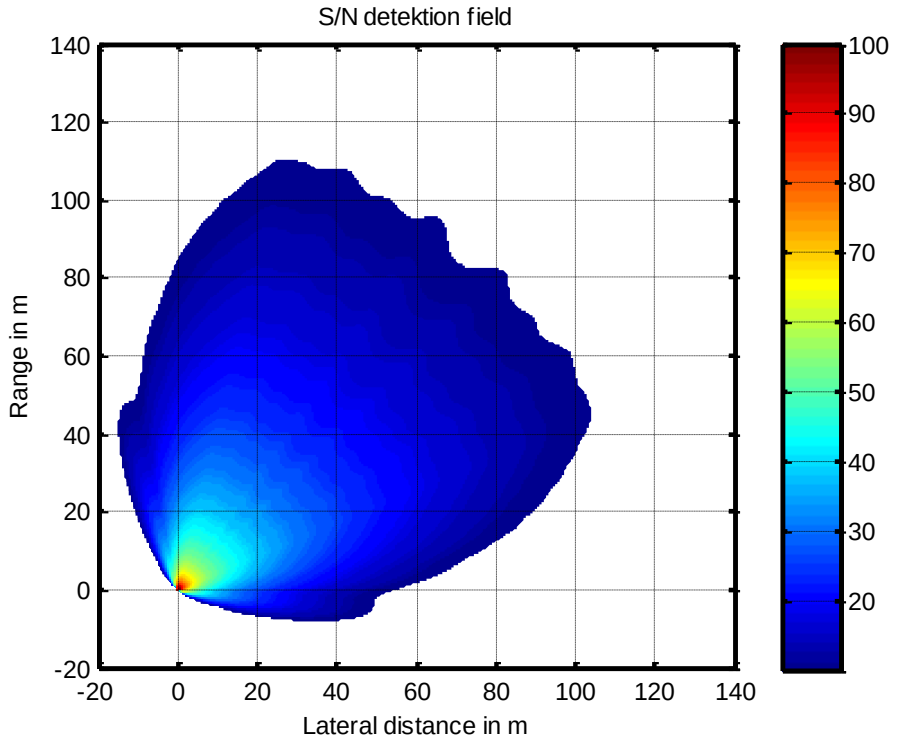
Bosch Radar Sensor
Field of View MRR Rear Corner

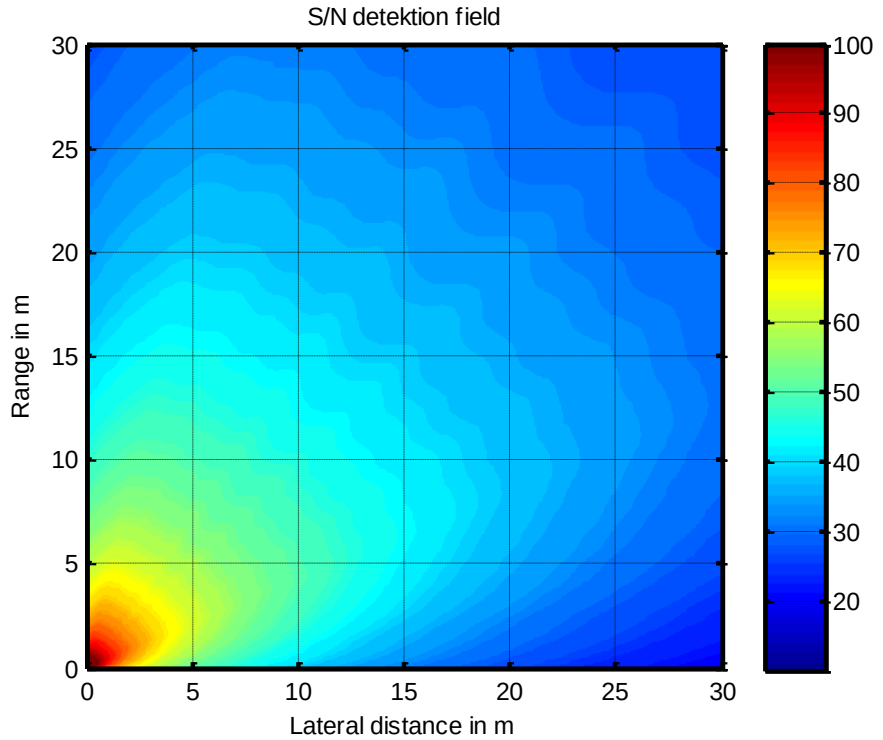




150 degree opening angle

Bosch Radar Sensor
Field of View MRR Front Corner





150 degree opening angle

RADAR NETWORK OBJECT DATA AND MONITORING

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Radar Network
Object Data

What is Radar Object data?

- Radar object data is created from several radar reflection combined to represent an object. It provides quantitative attributes about the object such as it's velocity, acceleration, distance, angle, etc.

Radar Network
Object Data - Transmit CAN Messages

- Rear/Corner radar transmits a total of 79 CAN messages.
  - 64 object messages that have 2 messages per object for 32 objects.
  - 12 target object messages that have 2 messages per object for 6 target objects.
  - 1 starter message
  - 1 ender message
  - 1 radar status message
- Messages are triggered.
- Messages are sent as a data packet.
- Dbc file defines front center radar as Radar_1.
- Dbc file defines left rear/corner radar as Radar_1.
- Dbc file defines right rear/corner radar as Radar_2.

Radar Network
Object Data - Message Signals

- Object vx – Relative longitudinal velocity of target object.
- Object vy – Relative lateral velocity of target object.
- Object dx – Object position in x-direction.
- Object dy – Object position in x-direction.
- Object ax – Object acceleration.
- Object wExist - Existence probability of the object (i.e. an object that reflects radar exists, regardless of whether it is an obstacle).
- Object ax, dx, dy, and vx sigma – Standard deviations.
- Object Flag valid – A flag indicating that the object is valid for use.
- Object Flag History – A flag indicating that the object is previously present or new this cycle.
- Object Flag Measured – A flag indicating whether the object was measured in this cycle.
- Consistency Bit – Indicator for data consistency. A 1 bit value that flips each cycle.

Radar Network
Object Data - Starter/Ender

- Starter message indicates a start of a data packet.
- Ender message indicated the end of the data packet.
- All object messages will be transmitted between the starter and ender message.
- Starter message will contain ego vehicle information.
  - Ego Acceleration, Ego Velocity, Ego Yaw Rate and Slip Angle
- Ender message will contain data packet information.
  - Object timestamp, packet checksum

Radar Network
Monitoring – Fault Monitoring

- Hardware Failures
- SGU Failures
  - CAN Network
    - Bus Off
    - Message Timeout
    - Data Length Check (DLC)
    - Message Counter
    - Cyclical Redundancy Check (CRC)
  - Sensor Blindness
  - Alignment (+/- 3 Degrees)
- If any fault occurs the sensor will no longer modulate and there will be no objects set on the CAN bus.
- Most SGU failures are recoverable meaning once the condition is resolved the sensor will modulate.

Radar Network
Monitoring- Radar Status Message

- Absorption Blindness – Power of radar beams is damped, so that the sensor range is reduced (e.g. wet snow, mush of snow, mud).
- Distortion Blindness – disturbance of radar reflections, so that objects are measured with false angles (e.g. ice, multi-path-propagation, partly coverage).
- Horizontal Misalignment – Estimated horizontal misalignment indicator.
- Hardware Failure – Hardware failure flag indicator.
- SGU Failure – Radar functionality failure flag indicator.
- ITC Info – Internal trouble code information indicator.

Radar Network
Monitoring - Message Consistency

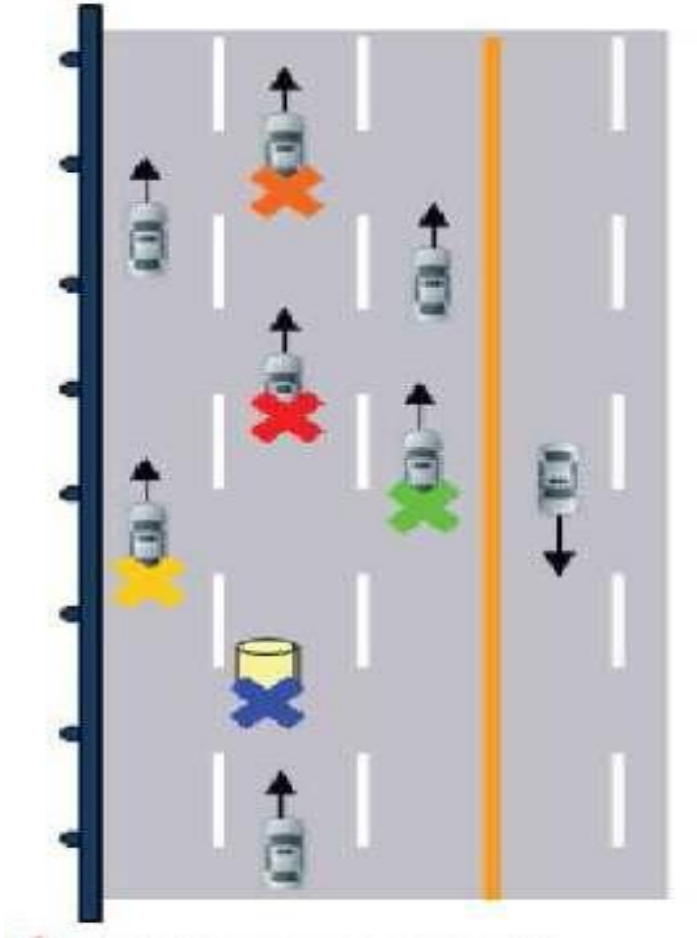
- Consistency Bit – Each message in the data packet has 1 bit that flips each cycle.
- Message Counter – A 4 bit signal that increments by 1 each cycle. The value will overflow to 0 when max value has been reached.
- CRC Calculation – A redundancy check that is calculated before the message is transmitted, the value is sent in the message. When the message is received the value is calculated and compared to the received value. If the values match then the message was received successfully.
- Packet Checksum – Summation of all the bytes in the data packet.

Radar Network
Object Data - Target Object Data

- Target data provides object level data that the radar regards as the most relevant objects of interest.
  - The front center sensor transmits 4 dynamic SGU objects and 1 stationary SGU object of relevance.
  - The rear/corner sensors transmits 6 dynamic SGU objects in order of distance and lane priority.
    - Left lane highest priority
    - Right lane lowest priority
- Target data is used to develop algorithms specific features, such as Automated Cruise Control, Blind Spot detection.

Radar Network

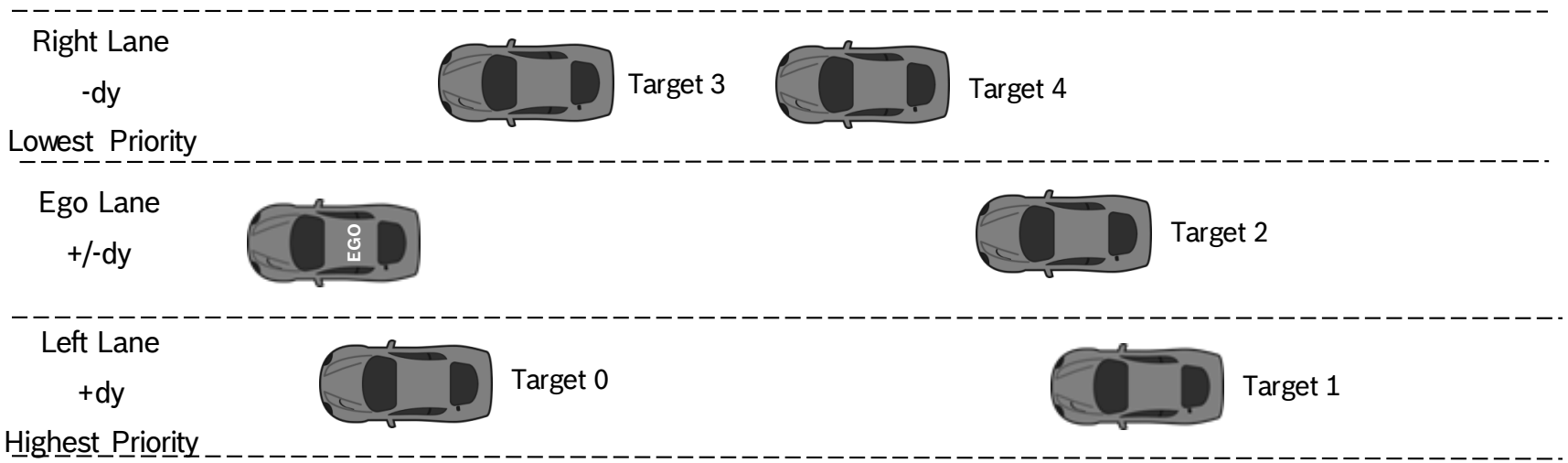
Object Data – Front Center Radar Target Object Data



- X Target Object 00 (Closest Ego Lane)
- X Target Object 01 (Ego Lane In Front 00)
- X Target Object 02 (Closest Left Lane)
- X Target Object 03 (Closest Right Lane)
- X Target Object 04 (Closest Stationary)

Radar Network

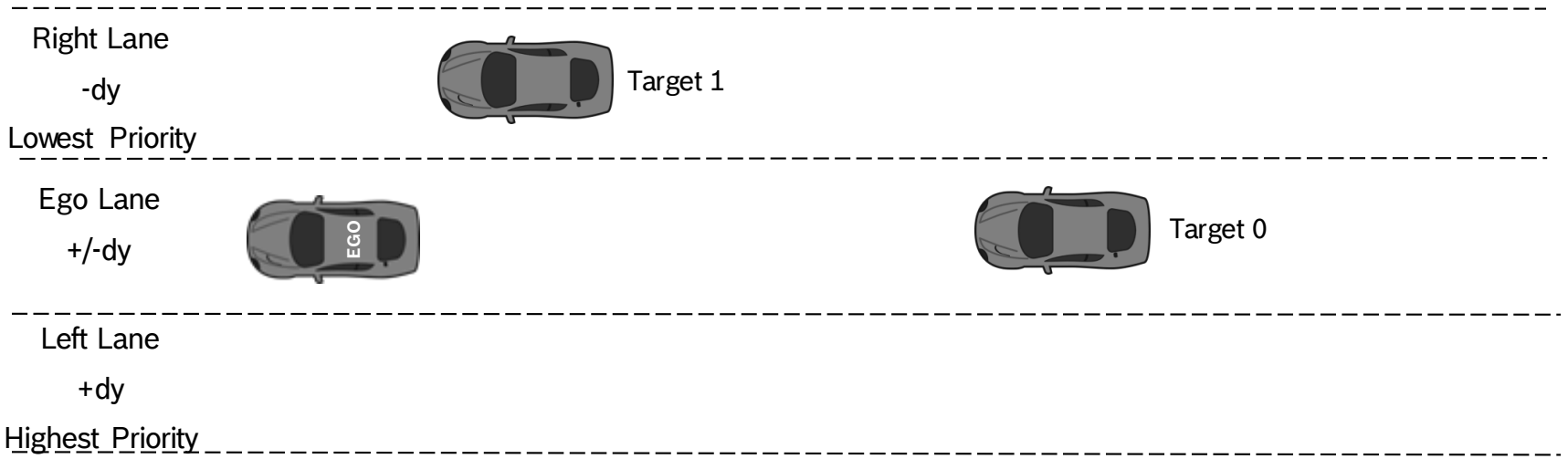
Object Data – Rear/Corner Radar Target Object Data – All Lanes



- Two closets objects per lane.
- Left lane has highest priority.

Radar Network

Object Data – Rear/Corner Radar Target Object Data – Two Lanes



RADAR CONFIGURATION

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Radar Configuration
Sensor Configuration - Receive CAN Messages

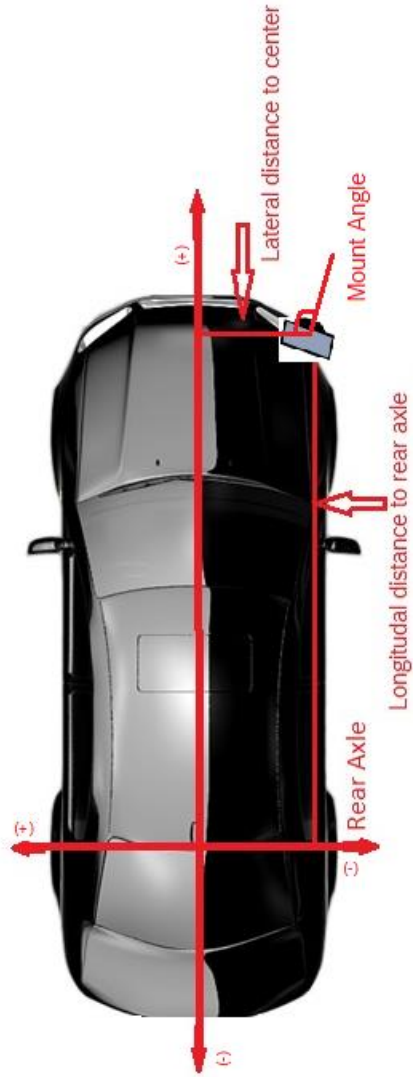
- Radar needs to receive 4 CAN messages.
  - 1 message for radar mounting information
  - 2 message for vehicle configuration/dimensions
  - 1 message for vehicle dynamic data
- Messages are cyclical.
- Message monitoring is performed (TO, DLC, MC, CRC).

Radar Configuration
Sensor Configuration - Dynamic Data

- Wheel Slip Event – ABS, ESP, ASR, MSR event.
- PRNDL State – PRND-lever position.
- Standstill – Ego vehicle is at standstill.
- Steering Angle – Current steering wheel angle.
- Use Steering Angle – Do not use steering wheel angle in tracking (use yaw rate only).
- Ego Vehicle Velocity – Ego vehicle velocity.
- Ego Vehicle Yaw Rate – Ego vehicle yaw rate.

Radar Configuration
Sensor Configuration - Radar Mounting Inform

- Sensor Height – Height of the sensor from the ground plane.
- Sensor Mount Angle – Angle from y-axis to center of radar.
- Lateral Sensor Mount To Center – Lateral mounting position with respect to the center of the vehicle, positive values are to the left.
- Longitudinal Sensor Mount To Rear Axle – Longitudinal distance between sensor and rear axle of the vehicle, positive values are forward the rear axle.
- Sensor Orientation – Direction the connector is pointing up or down.



Radar Configuration
Sensor Configuration - Vehicle Dimensions

- Longitudinal Front Bumper Position – Position of the front bumper in the vehicle coordinate system.
- Longitudinal Rear Bumper Position – Position of the rear bumper in the vehicle coordinate system.
- Minimum Width – Minimum width of the vehicle.
- Maximum Width – Maximum width of the vehicle.
- Track Width – Distance between the center line of each of the two wheels on the same axle.
- Wheel Base – Distance between the centers of the front and rear wheels
- Steering Angle Ratio – Vehicle steering wheel angle ratio.