AN-019 Traffic Monitor Mounting Guidelines

OmniPreSense radar sensors provide a solid solution for monitoring vehicle traffic. Not only can the speed of passing cars be reported but counting them and providing traffic statistics is easily achieved. When using OmniPreSense radar sensors for traffic monitoring, care should be taken with the mounting position of the radar sensor to optimize the return signal and detection distance. This application note provides a guide for basic mounting positions to optimize overall performance.

Mounting Position Goals

The primary goals for mounting a radar sensor is to provide the best view of the vehicle traffic in order to maximize the return signal and provide the most accurate information. For traffic monitoring, having a steady stream of data to process is desirable and overall detection range is less important. Applications such as radar signs need to report back to the driver and such detection range is more important. Finally, the position selected should consider keeping the sensor out of the way of any passerby who may try to damage or move the sensor.

Mounting Goals

- Clear View of Vehicle Traffic
- Solid Data Reporting (Traffic Monitor)
- Detection Range (Radar Speed Sign)
- Keep Sensor Safe, Away from People

To meet the first two goals, a basic guideline is to focus the radar sensor beam width or field of view (FOV) towards the center of the lane of traffic for which you want to detect as shown in Figure 1. Keep in mind the beam width is different between sensors. Some sensors such as the OPS241 and OPS242 have wide FOV at 76-78° while the OPS243 has a much narrower 20° FOV.

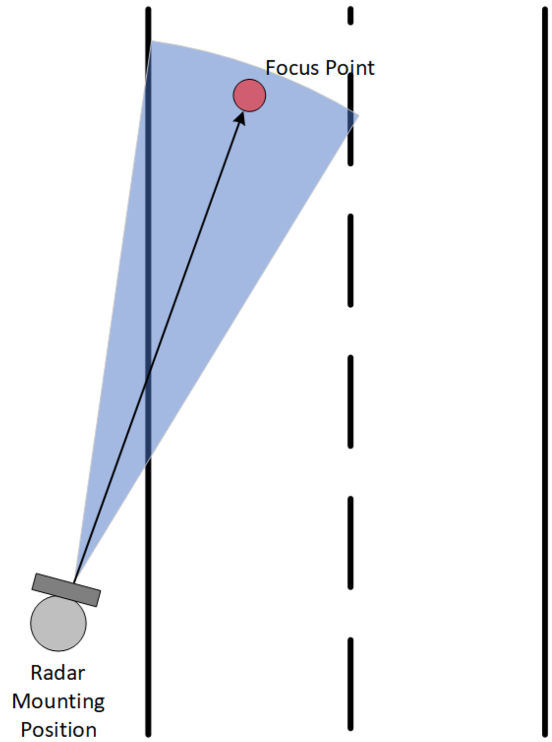

Figure 1. Radar Sensor Focus

Mounting Location Options

The most likely place to mount the radar sensor for traffic monitoring is on a street light pole or similar. On the pole there's are multiple options for where to mount the sensor which all play into the configuration settings for optimizing the data reported.

The key locations to place the sensor are either on the side of the road or up above the roadway as shown in Figure 2. Radar speed signs almost always want to be placed on the side of the road to provide as large of a sign as possible for driver feedback.

When placing the sensor on the side of the road, to maximize the radar return signal its best to angle the sensor into the roadway as discussed later. There are more options with sensor mounting height when mounting to the roadway side. When mounting the sensor over the roadway, the height is typically set by the arm height and the primary concern will be angling the sensor to look down into the road and not over the top of the vehicles.

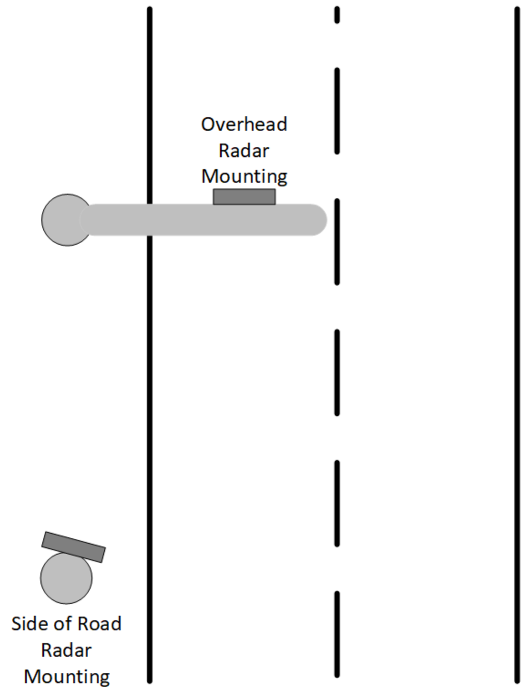

Figure 2. Radar Traffic Monitor Mounting Options

Roadway Dimensions

Before considering placement of the radar sensor, the dimensions of the roadway should be known. The lane width, offset from the curb, and if any parking or bicycle lane is present should be measured. Typical widths for vehicle lanes in the US and Europe are shown here.

Table 1. Typical Lane Widths

	US	**Europe**
Vehicle Lane	3.7m (12 ft.)	2.5-3.3m
Bike Lane	1.5-1.8m (5-6 ft.)	1.2-2.0m
Parking Lane	2.1-3.0m (7-10 ft.)	2.0-3.0m

Horizontal (X, Y-Axis) Mounting Guidelines

With the goal of focusing the FOV on the center of the lane of detection, the x and y-dimensions in Figure 3 should be known. The z-axis or height is also of importance but to make the calculations simpler, we'll work with the x, y-axis first and then the z-axis.

The y-axis dimension is set based on the radar sensors capability for detecting a vehicle. For example, the OPS243-A detects vehicles in the 75-100m range. These are maximum detection ranges and are dependent on the size of the vehicle (car versus bus). To maximize data accuracy, a shorter range of 50m is better to use for calculations.

The x-axis dimension is made up of the curb offset, any parking or bicycle lane width, and ½ the width of the lane of interest. If traffic over two lanes is desired, then the focus should be at the dividing line between the lanes.

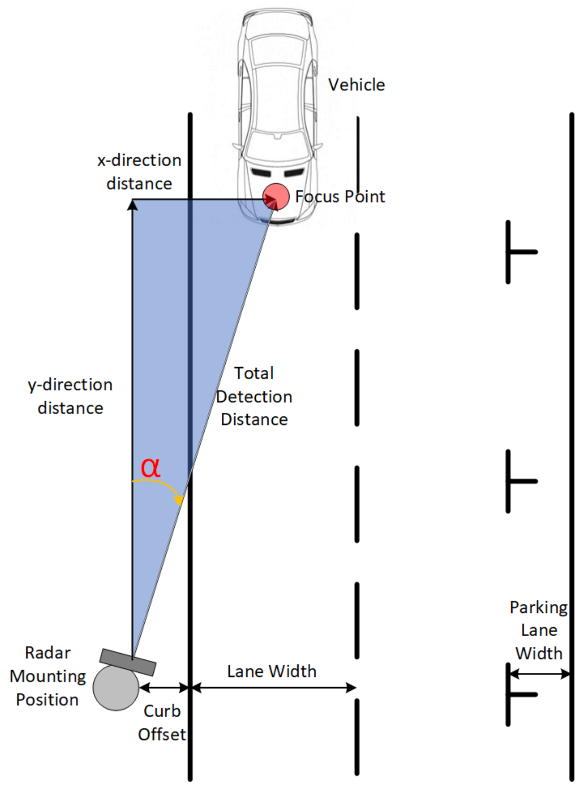

Figure 3. Road Dimensions for Focus Point

The angle α that the radar sensor makes looking into the roadway determines what the data looks like that the sensor reports back. To simplify the discussion, we'll focus on 3 angles to work with, 15˚, 30˚, and 45˚. If maximizing detection distance for say a radar speed sign, you should choose 15˚. This will generally focus the sensor FOV farther down the road and there is less cosine error in the initial reading. An error of only a few percent is typical.

For traffic monitoring, 30˚ or 45˚ are better mounting angles. These do not provide as far of detection range, but the data reported will be more consistent, have fewer dropouts, and easier to accurately count vehicles. When looking across 2 lanes of traffic, 45˚ is probably a better choice to provide more coverage of the 2nd lane which will be farther from a roadside mounted sensor.

The above guidance is not critical for an overhead mounted radar sensor as it's expected its FOV will be directly down a lane or directly between two lanes. In this case the cosine error is minimized in the x-axis direction and the z-axis is the main concern.

Height (Z-Axis) Mounting Guidelines

The mounting height is determined by the available height and guidelines for keeping the sensor away from people. Generally, mounting the sensor at least a minimum of 2m high (~7 ft.) is a good rule of thumb. This will keep it above people's head and arms reach while providing a solid view of on-coming traffic. Heights above this are fine but the higher the sensor is the more of an effect the cosine angle will come into play. For this reason, the sensor should be pointed with a slight down angle into the street, focusing the signal in a similar manner as in the x, y-axis positioning.

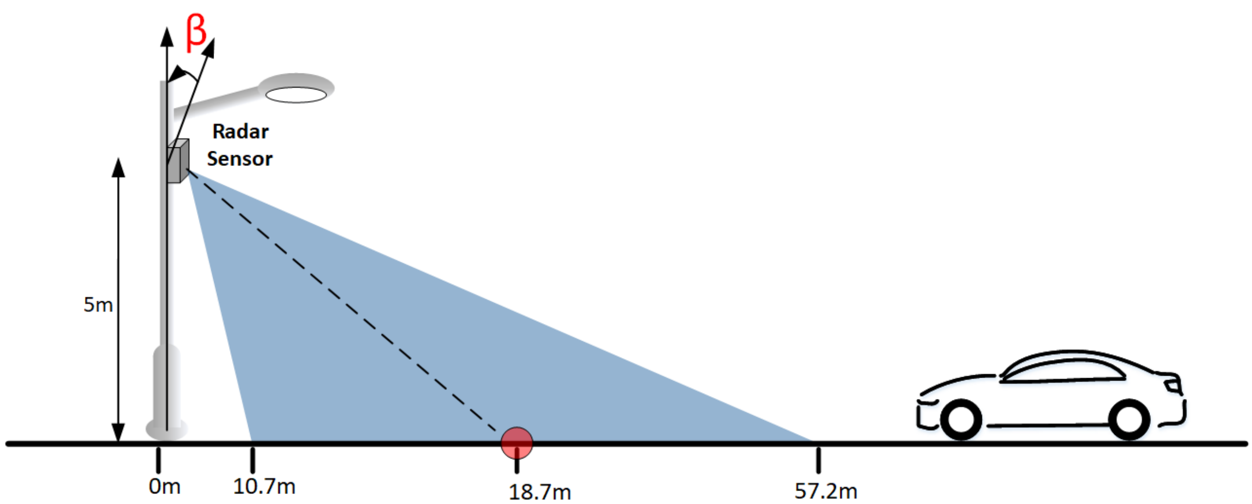

Figure 4. Height Mounting Guidelines

Figure 4 provides an example of the vertical or z-axis mounting of the radar sensor for traffic monitoring. In the example shown, an OPS243 sensor is mounted at a 5m height. With the sensor facing downward by 15˚, the focus of the FOV is 18.7m from the mounting position. Taking ½ of the 20˚ beam width of the OPS243 and applying it to either side of the 18.7m focus point gives you the edges of the FOV at 10.7m (-10˚) and 57.2m (+10˚). This provides a nice coverage for vehicle detection which is over 47m long. In the Appendix is a simple look up table for various mounting heights and downward facing angles to determine the overall focus point.

Cosine Error

If accurate speed reporting is required, the cosine error should be considered in the mounting position. As described in AN-11 Cosine Error (video), radar sensors will report the speed of a vehicle adjusted by the cosine error the vehicle makes with the sensor when the speed is captured.

For example, take a radar sensor that is pointed parallel to a road with a vehicle traveling 25 mph towards it (Figure 5). The radar sensor is mounted 5m (16 ft.) from the center of the lane the vehicle is traveling in, and the vehicle is first detected 25m (82 ft.) away. The angle made with the vehicle is a little more than 11.3°. Thus, the radar sensor will report a speed of 24.5 mph or 2% error. As the vehicle moves closer to the radar sensor location, that angle made increases and the error in the reported speed increases. If the initial reporting range is known, the cosine error can be corrected for and the correct speed reported.

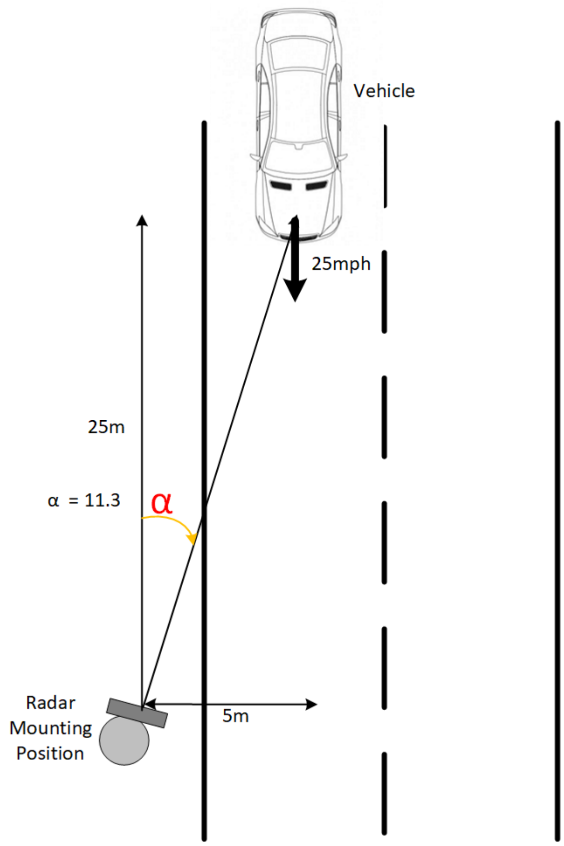

Figure 5. Cosine Error Example

The cosine error in the above example includes the x and y-axis components in the angle made. The z-axis also provides an error and should be considered as well. When the radar sensor is mounted over head and in line with the lane, only the z-axis needs to be considered.

Taking just the horizontal mounting (x, y-axis dimensions), the typical cosine value for initial vehicle detection can be calculated. Knowing this angle provides a means of adjusting for the measured speed if increased accuracy is desired. Use Equation 1 to calculate the cosine angle. To correct for the actual speed, use Equation 2, where v_m is the measured speed from the radar sensor, α is the angle made for the initial reading, and v_a is the actual speed of the vehicle. Typically, the smaller α is, the more accurate is the initial reading of the radar sensor.

Equation 1.
$$Angle\ \alpha = tan^{-1}\left(\frac{x\text{−}axis\ dimension}{y\text{−}axis\ dimension}\right)$$

Equation 2.
$$v_a = \frac{v_m}{cos\,(\alpha)}$$

Correcting for the x, y, and z-axis is a more complicated set of equations and will be addressed in a future update.

Appendix

OPS243 FOV based on Vertical Down Angle

Down Angle	**10˚**			**15˚**			**30˚**			**45˚**		
	Radar beam FOV along street (m)											
Sensor height from ground (m)	**Max Beam Angle (+10˚)**	**Center (0˚)**	**Min Beam Angle (-10˚)**	**Max Beam Angle (+10˚)**	**Center (0˚)**	**Min Beam Angle (-10˚)**	**Max Beam Angle (+10˚)**	**Center (0˚)**	**Min Beam Angle (-10˚)**	**Max Beam Angle (+10˚)**	**Center (0˚)**	**Min Beam Angle (-10˚)**
2	∞	11.3	5.5	22.9	7.5	4.3	5.5	3.5	2.4	2.9	2	1.4
3	∞	17.0	8.2	34.3	11.2	6.4	8.2	5.2	3.6	4.3	3	2.1
4	∞	22.7	11.0	45.7	14.9	8.6	11.0	6.9	4.8	5.7	4	2.8
5	∞	28.4	13.7	57.2	18.7	10.7	13.7	8.7	6.0	7.1	5	3.5
6	∞	34.0	16.5	68.6	22.4	12.9	16.5	10.4	7.2	8.6	6	4.2
7	∞	39.7	19.2	80.0	26.1	15.0	19.2	12.1	8.3	10.0	7	4.9
8	∞	45.4	22.0	91.4	29.9	17.2	22.0	13.9	9.5	11.4	8	5.6
9	∞	51.0	24.7	102.9	33.6	19.3	24.7	15.6	10.7	12.9	9	6.3
10	∞	56.7	27.5	114.3	37.3	21.4	27.5	17.3	11.9	14.3	10	7.0
11	∞	62.4	30.2	125.7	41.1	23.6	30.2	19.1	13.1	15.7	11	7.7
12	∞	68.1	33.0	137.2	44.8	25.7	33.0	20.8	14.3	17.1	12	8.4
13	∞	73.7	35.7	148.6	48.5	27.9	35.7	22.5	15.5	18.6	13	9.1
14	∞	79.4	38.5	160.0	52.2	30.0	38.5	24.2	16.7	20.0	14	9.8

Revision History

Version	Date	Description
A	April 12, 2020	Initial release.