Roadway Geometry and Coordinate Transform Simulink Blocks

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For the final project, you use the bicycle model, which describes the motion of a simulated vehicle in *X*, *Y* coordinates. Your simulated vehicle rolls around on a two-dimensional plane without any need for a roadway, however since you are interested in driving your vehicle on a road. A roadway is defined simply by a centerline, a path lying on the plane and defined in *X*, *Y* coordinates. To understand your vehicle's lateral (side-to-side) and longitudinal (fore-aft) motion with respect to the roadway, a second coordinate system relative to the road is more convenient. We define a coordinate *S* to be the distance traveled along the road, and another coordinate *N* to be the distance away from the centerline of the road, where the centerline has an *N* coordinate value of zero and the right side of the road has a positive value. See Fig. 1. For a road with smooth curves and that does not intersect itself, and when the vehicle is "close" to the centerline, the mapping from *X*, *Y* to *S*, *N* coordinates is one-to-one and on-to. Despite the fact that the transformation between the coordinate systems is well defined, it is not easily determined.

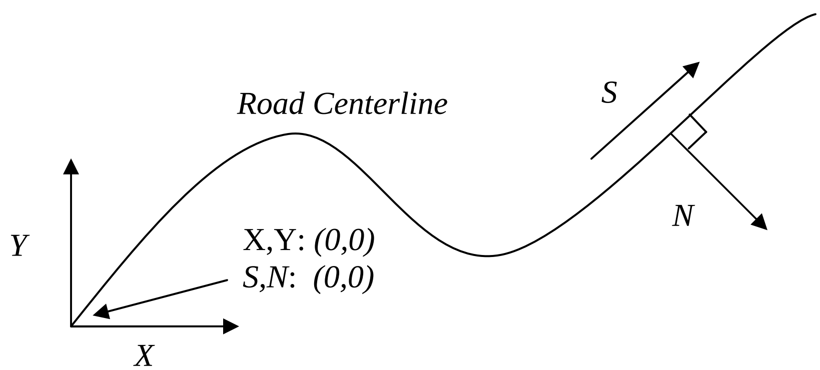

Figure 1. Defined above are coordinate systems *X*, *Y* and *S*, *N* , where the *S* measures the distance along the road centerline and *N* measures the distance to the right of the road The simulated vehicle motion is most easily expressed in *X*, *Y* coordinates, but the vehicles position relative to the road is more conveniently expressed in *S*, *N* coordinates.

We have provided several Simulink blocks that allow you to access the roadway geometry and transform back and forth between *X*, *Y* and *S, N* coordinates. There are three basic blocks for accessing roadway geometry,

- **Road Geometry Centerpoint P**: determines the *X*, *Y* coordinates (*x*, *y*) of a point on the road centerline, a distance *s* down the road from the origin.

- **Road Geometry Right Vector**: determines the *X*, *Y* components (*rx*, *ry*) of a unit vector pointing to the right (perpendicular to the centerline) of a point on the road centerline, a distance *s* down the road from the origin.
- **Road Geometry Curvature:** determines the curvature κ (1/radius of curvature) of the road centerline a distance *s* down the road from the origin.

A fourth roadway geometry block, **Road Geometry Forward Vector**, is the same as **Road Geometry Right Vector** except that it determines a unit vector tangent to the road centerline and pointing in the direction of increasing *S* coordinate values. This block simply rotates the vector from **Road Geometry Right Vector** by 90 degrees using (*fx*,*fy*) = (-*ry*,*rx*).

There are two coordinate transformation blocks; one converts *S*,*N* to *X*,*Y* coordinates and the other block performs the inverse transformation.

- **Roadway Coordinate Transform (s,n)→(x,y):** given *s* and *n*, this block determines *x* and *y*. **Road Geometry Centerpoint P** finds *X*,*Y* coordinates (p*x*,p*y*) for at the center of the road, a distance *s* down the road. **Road Geometry Right Vector** returns a unit vector, which when scaled by *n* and added to (*px*,*py*), equals (*x*, *y*).
- **Roadway Coordinate Transform (x,y)→(s,n)**: given *x* and *y*, this block converges to the correct *s* and *n*. This block is a masked subsystem, so double-click the block to see the implementation. A feedback stabilized closest-point algorithm is used to determine the closest point on the road centerline to the input point (*x*,*y*). This determines the *S* coordinate and then the *N* coordinate is simply the distance from the closest-point on the road center line to the point (*x*,*y*).