eVECTORS

Coordinate Systems Specification

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Approval Sheet

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Revision Sheet

Issue	Date	Change
1.0	20/05/2025	Initial Issue
2.0	05/09/2025	Background information removed

Contents

1 SCOPE OF DOCUMENT

The aim of this document is to define the different coordinate system used in eVECTORS project.

International Standard ISO 8855 – 2011 – Road vehicles -Vehicle dynamics and road-holding ability – Vocabulary is used for the general definition.

2 COMPUTED ADDED DESIGN CS - CADCS

This coordinate system is used for:

- 3D modeling of the vehicle. This model is used to define the location of the different units.

The CADCS is defined by three planes which are:

Road plane	horizontal plane tangent to the wheel lower edge
Longitudinal plane	vertical longitudinal symmetry plane
Rear plane	vertical plane tangent to the rear most part of the vehicle

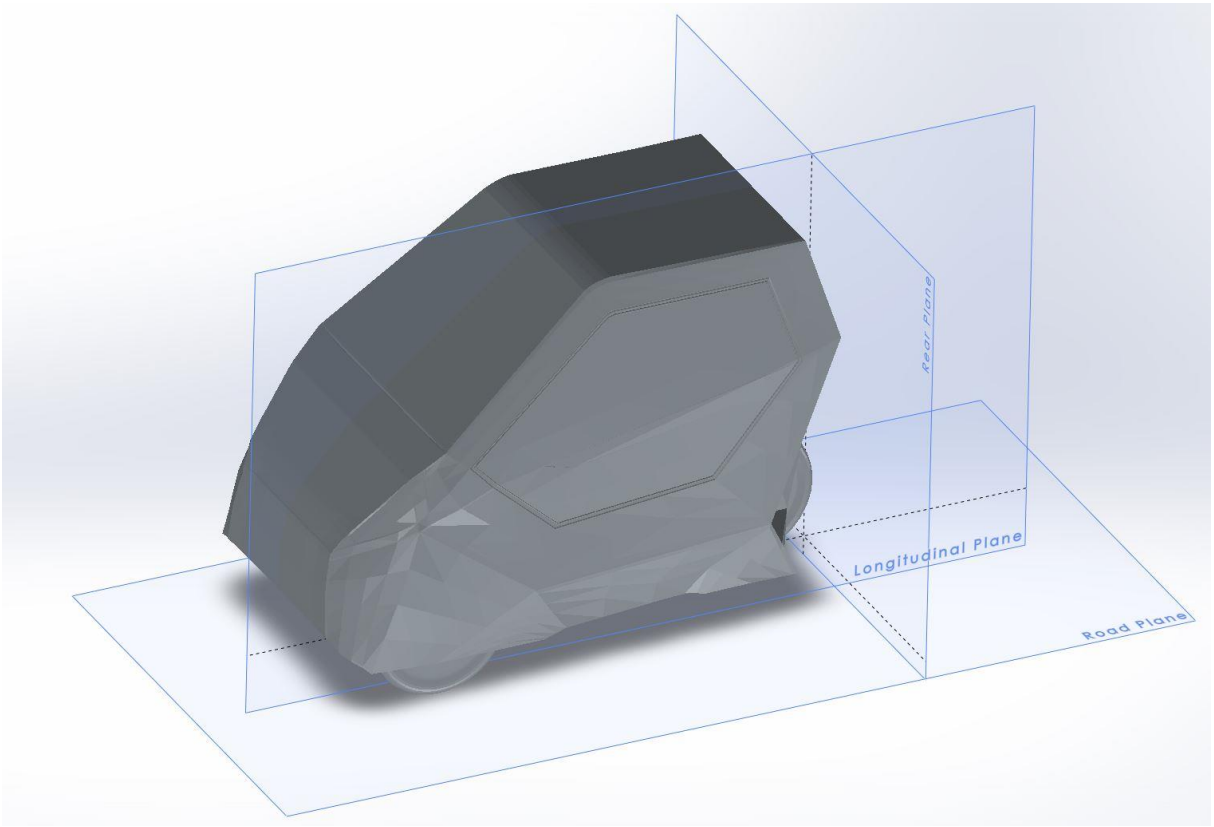

Figure 1 : CAD CS reference planes

The CAD CS is defined as follows:

O_{CAD}	Origin of the CS is located at the intersection of three planes:
x_{CAD}	x axis at the intersection of the longitudinal and road planes, and is oriented forward
y_{CAD}	y axis at the intersection of the rear and road planes, and is oriented to the left
z_{CAD}	z axis at the intersection of the longitudinal and rear planes, and is oriented upward

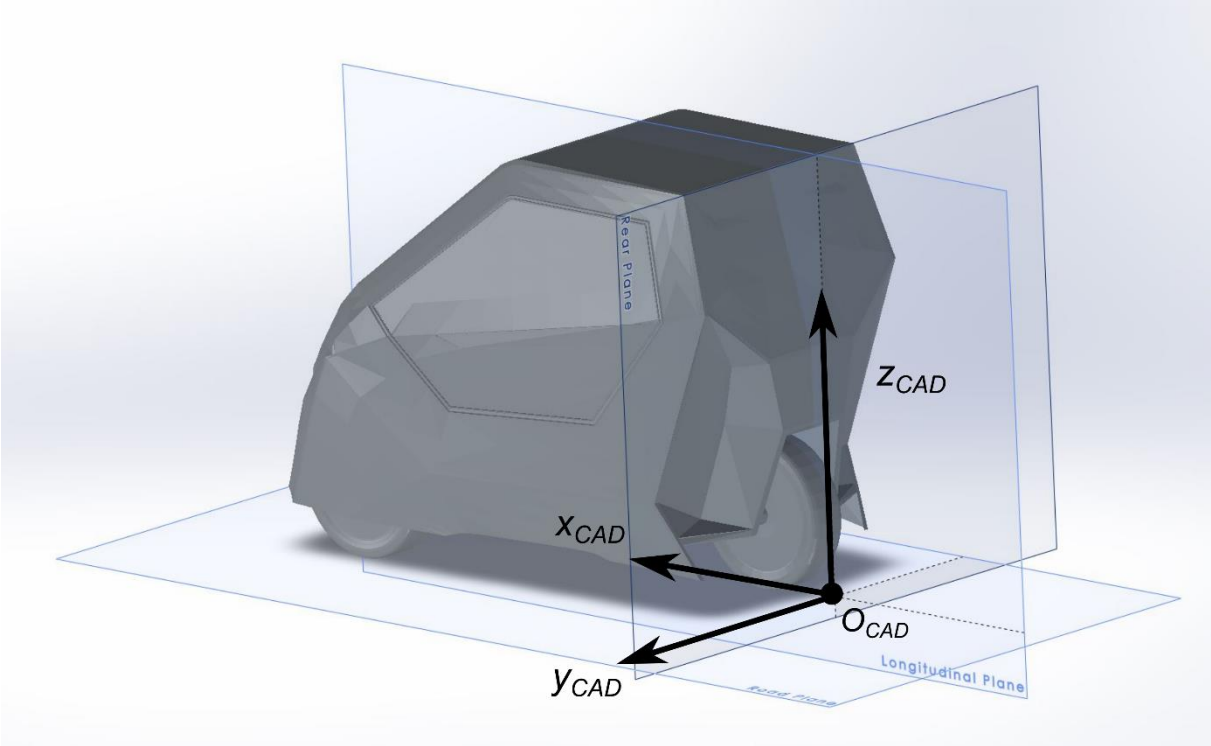

Figure 2 : CAD Coordinate System

3 VEHICLE COORDINATE SYSTEM – VCS

The definition as per ISO 8855-2011, §2.11 is applicable.

The VCS is defined as follows:

O_V The origin is located at the vehicle sprung mass center of gravity. The sprung mass is the mass that is supported by the suspension, i.e. the total vehicle mass less the unsprung mass. The unsprung mass is the mass that is not carried by the suspension, but is supported directly by the tyres.

x_V x axis is parallel to the road plane and parallel to the vehicle's longitudinal plane of symmetry, and oriented forward

y_V y axis is parallel to the road plane and parallel to the vehicle's rear plane, and oriented to the left

z_V z axis is perpendicular to the road plane.

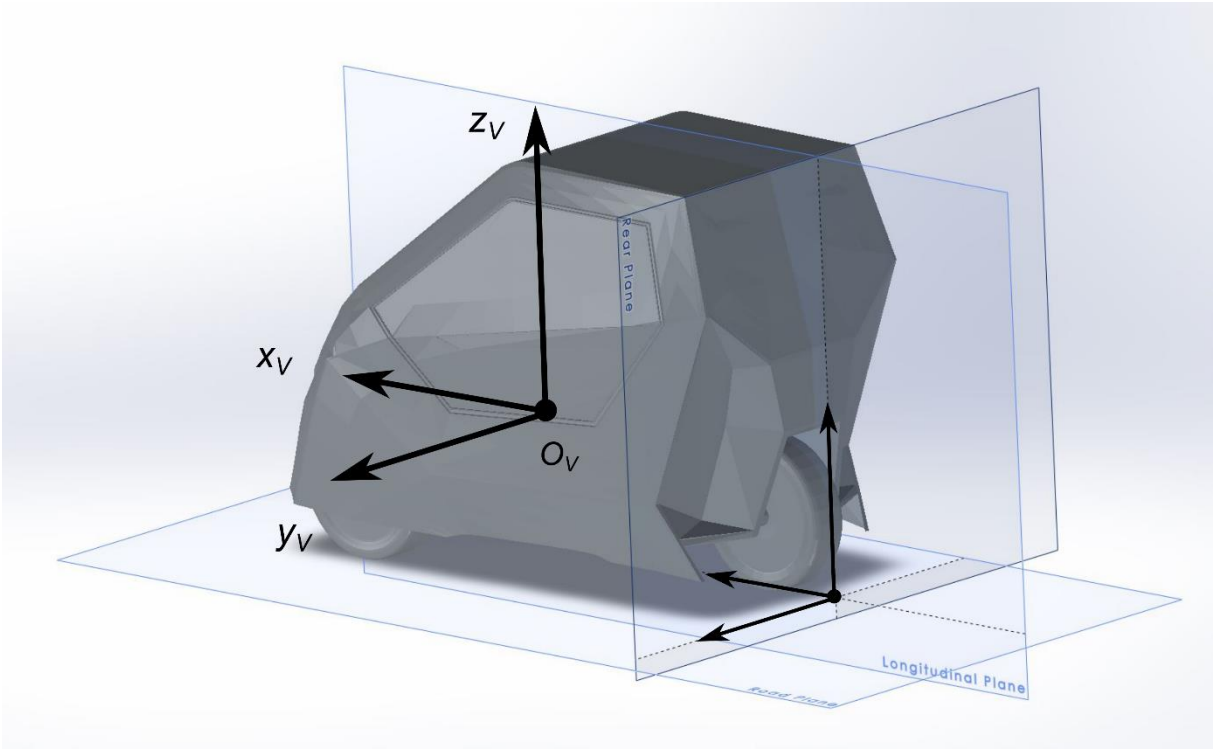

Figure 3 : Vehicle Coordinate System

4 EARTH-FIXED COORDINATE SYSTEM -ECS

The definition as per ISO 8855-2011, §2.9 is applicable.

The ECS is a cartesian reference frame the is assumed to have zero linear and angular acceleration and zero angular velocity. It is a Newtonian reference frame.

The ECS is defined as follows:

O_E The origin is located on the ground plane and placed at the start of the modeled event (start of dynamic simulation, start of a GPS track). The ground plane is a plane that is normal to the gravity vector.

x_E x axis is parallel to the ground plane, oriented to the East

y_E y axis is parallel to the ground plane, oriented to the North

z_E z axis is parallel to the gravity, oriented Up

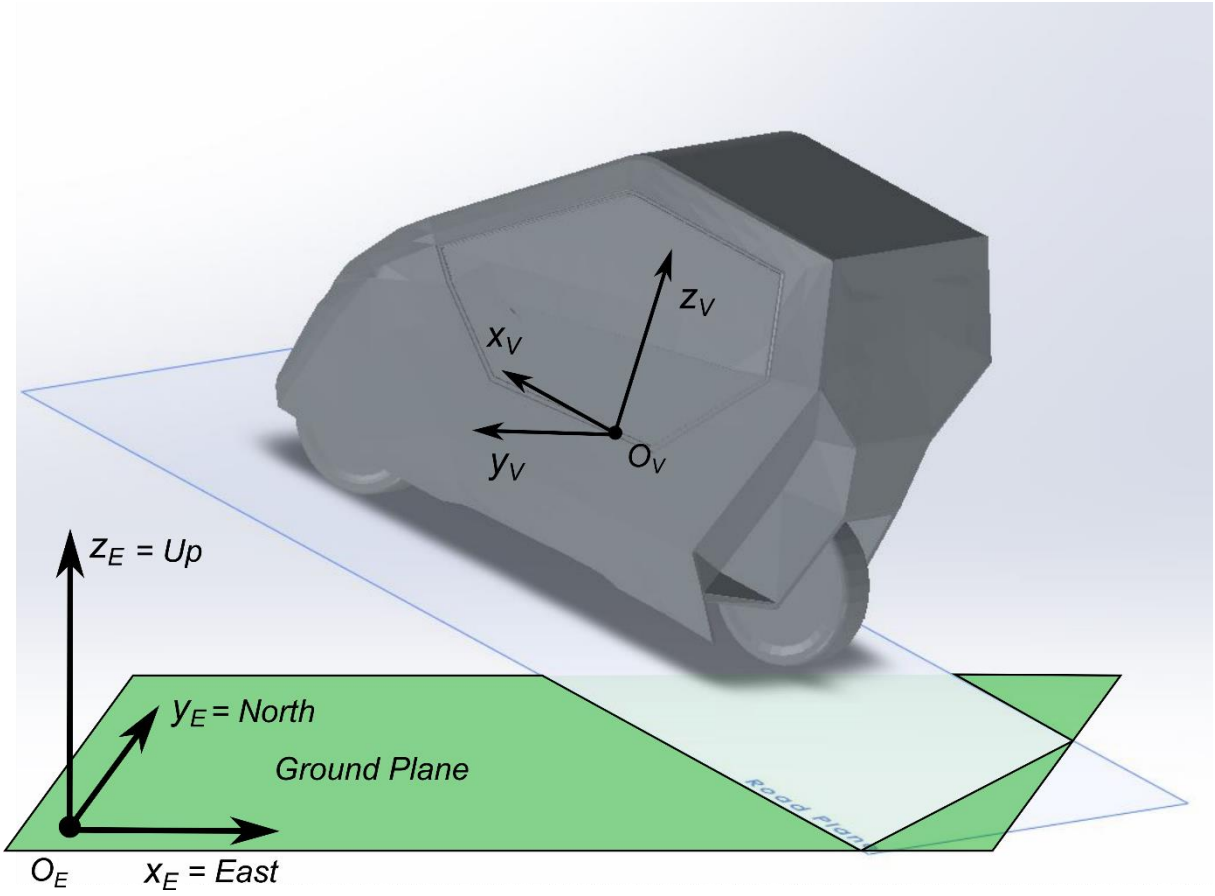

Figure 4 : Earth-fixed coordinate system

4.1 Tait-Bryan Angles

The angles defined in ISO 8855 follows the Tait-Bryan formalism. The three rotations to characterize the vehicle coordinate system with regard to the Earth-fixed CS are as shown in the following table.

Table 1 : Rotation convention

Rotation order	Angle name	Symbol	Explantion
1st rotation	Yaw	ψ	Rotation about the z_E axis (z on figure)
2nd rotation	Pitch	θ	Rotation about the rotated y_V' ($N(y')$ on figure)
3rd rotation	Roll	ϕ	Rotation about the rotated twice x_V'' (X on figure)

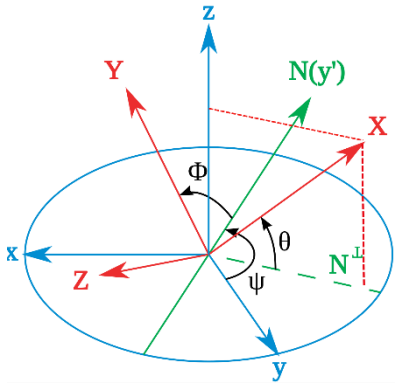

Figure 5 : Tait-Bryan angles from wikipedia. Note that XYZ is the final rotated CS and xyz is the initial reference CS.

4.2 Yaw Angle ψ

The yaw angle is defined as the angle between the x_E East axis and the projection of the x_V axis to the Ground Plane. It is given by following expression:

$$\psi = \arcsin\left(\frac{x_{2V.E}}{\sqrt{1 - x_{3V.E}^2}}\right)$$

Where $x_{1V.E}$ and $x_{3V.E}$ are the first and third coordinate of the x_V axis in the Earth-fixed coordinate system.

4.3 Pitch Angle θ

The pitch angle is defined as the angle between the x_V axis and the projection of the x_V axis to the Ground Plane. It is given by following expression:

$$\theta = \arcsin\left(-x_{3V.E}\right)$$

Where $x_{3V.E}$ is the third coordinate of the x_V axis in the Earth-fixed coordinate system.

4.4 Roll Angle ϕ

The roll angle is defined as the angle between the y_V axis and the projection of the y_V axis to the $y_E z_E$-plane. It is given by following expression:

$$\phi_V = \arcsin\left(\frac{y_{3V.E}}{\sqrt{1 - x_{3V.E}^2}}\right)$$

Where $y_{3V.E}$ is the third coordinate of the y_V axis in the Earth-fixed CS and $x_{3V.E}$ is the third coordinate of the x_V axis in the Earth-fixed CS.