

Table 2. Coordinate frame definitions

Symbol	Description
<i>E</i>	<p>Name: Earth</p> <p>Position: The origin coincides with Earth's centre (geometrical centre of ellipsoid model).</p> <p>Orientation: The x-axis is along the Earth's rotation axis, pointing north (the yz-plane coincides with the equatorial plane), the y-axis points towards longitude $+90^\circ$ (east).</p> <p>Comments: The frame is Earth-fixed (rotates and moves with the Earth). The choice of axis directions ensures that at zero latitude and longitude, N (described below) has the same orientation as E. If roll/pitch/yaw are zero, also B (described below) has this orientation. Note that these properties are not valid for another common choice of the axis directions, denoted e (lower case), which has z pointing north and x pointing to latitude = longitude = 0.</p>
<i>B</i>	<p>Name: Body (typically of a vehicle)</p> <p>Position: The origin is in the vehicle's reference point.</p> <p>Orientation: The x-axis points forward, the y-axis to the right (starboard) and the z-axis in the vehicle's down direction.</p> <p>Comments: The frame is fixed to the vehicle.</p>
<i>N</i>	<p>Name: North-East-Down (local level)</p> <p>Position: The origin is directly beneath or above the vehicle (B), at Earth's surface (surface of ellipsoid model).</p> <p>Orientation: The x-axis points towards north, the y-axis points towards east (both are horizontal), and the z-axis is pointing down.</p> <p>Comments: When moving relative to the Earth, the frame rotates about its z-axis to allow the x-axis to always point towards north. When getting close to the poles this rotation rate will increase, being infinite at the poles. The poles are thus singularities and the direction of the x- and y-axes are not defined here. Hence, this coordinate frame is not suitable for general calculations.</p>
<i>L</i>	<p>Name: Local level, Wander azimuth</p> <p>Position: The origin is directly beneath or above the vehicle (B), at Earth's surface (surface of ellipsoid model).</p> <p>Orientation: The z-axis is pointing down. Initially, the x-axis points towards north⁴, and the y-axis points towards east, but as the vehicle moves they are not rotating about the z-axis (their angular velocity relative to the Earth has zero component along the z-axis).</p> <p>Comments: The L-frame is equal to the N-frame except for the rotation about the z-axis, which is always zero for this frame (relative to E). Hence, at a given time, the only difference between the frames is an angle between the x-axis of L and the north direction; this angle is called the <i>wander azimuth</i> angle. The L-frame is well suited for general calculations, as it is non-singular.</p>

⁴ Any initial horizontal direction of the x - and y -axes is valid for L , but if the initial position is outside the poles, north and east are usually chosen for convenience.

