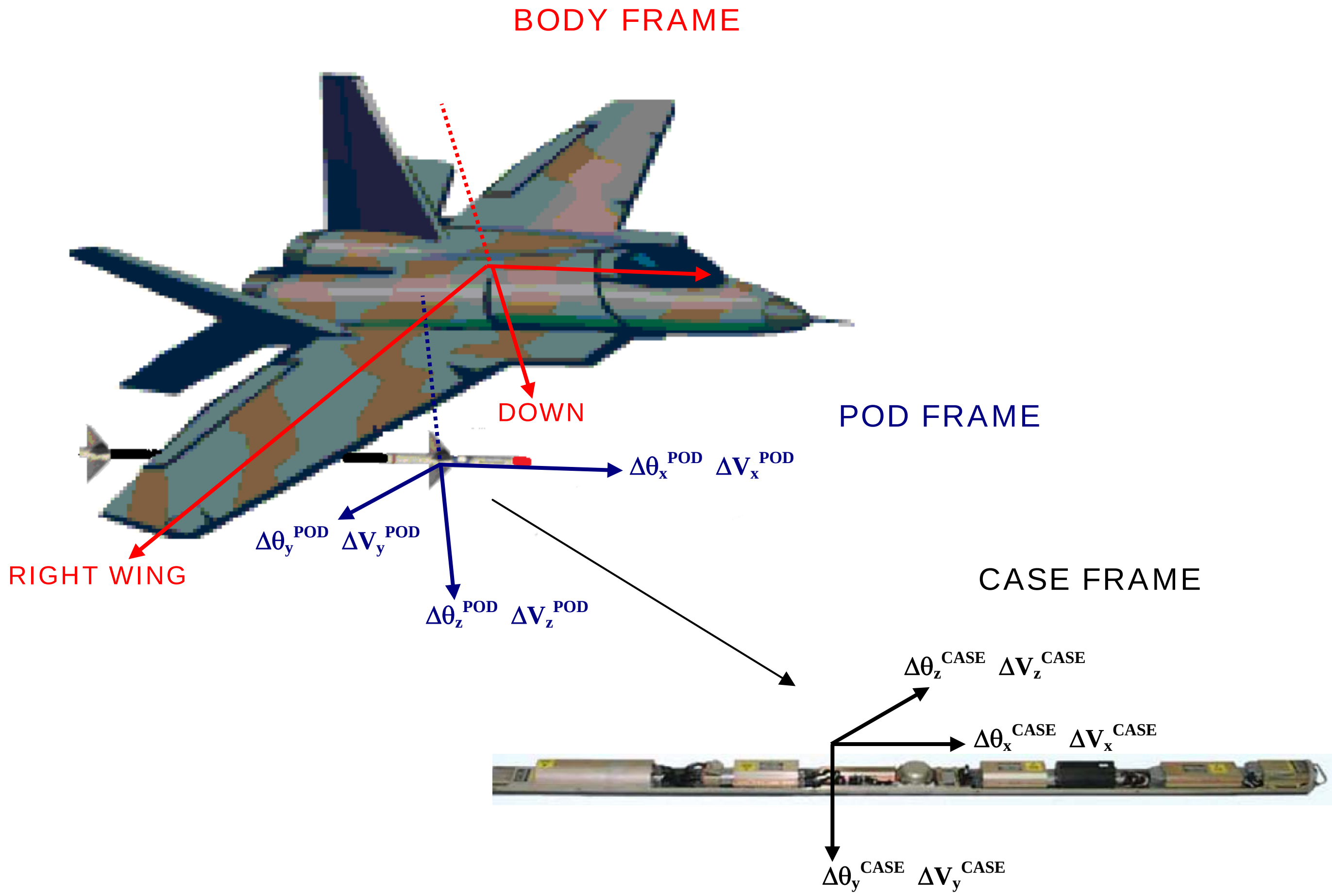
IMU MATRIX CONVENTIONS



The incremental velocity and attitude measurements are output by the User Equipment in the *Sensor Case Frame*. This is a right-handed frame we designate as XYZ. The CASE Frame orientation to the Tapestry BODY frame is – in principal - arbitrary. The rotation matrix from the Tapestry BODY Frame (Nose, Right Wing, Down) to the UE-CASE frame is vehicle specific and is not known by us apriori. It depends upon how the IMU is to be mounted in the vehicle.

The BODY to CASE Alignment allows the user to transform from the Tapestry convention to that implemented on your vehicle platform. Review you vehicle documentation to ascertain the rotation angles that transform our system into yours. For example; if you're Sensor is mounted with the X axis (positive) towards the back of the Vehicle, Y Axis (positive) facing down towards the ground and Z axis (positive) facing out along the Right Wing. One parameterization is:

$$\mathbf{R_N(180)R_W(0)R_D(180) = R_{NWD}}$$

To obtain the measurements output by YOUR system in the CASE frame we mechanize a straightforward matrix multiplication: (same processing for $\Delta\theta$)

$$\begin{vmatrix} \Delta V_x \\ \Delta V_y \\ \Delta V_z \end{vmatrix} = R_B^C \begin{vmatrix} \Delta V_N \\ \Delta V_W \\ \Delta V_D \end{vmatrix} \quad \text{with} \quad R_B^C = R_{NOSE}\, R_{RWING}\, R_{DOWN}$$

The three rotation matrices are defined as;

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$$R_{NOSE} = \begin{vmatrix} 1 & 0 & 0 \\ 0 & COS(\phi_R) & SIN(\phi_R) \\ 0 & -SIN(\phi_R) & COS(\phi_R) \end{vmatrix} \qquad R_{WING} = \begin{vmatrix} COS(\phi_P) & 0 & -SIN(\phi_P) \\ 0 & 1 & 0 \\ SIN(\phi_P) & 0 & COS(\phi_P) \end{vmatrix}$$

$$R_{DOWN} = \begin{vmatrix} COS(\phi_Y) & SIN(\phi_Y) & 0 \\ -SIN(\phi_Y) & COS(\phi_Y) & 0 \\ 0 & 0 & 1 \end{vmatrix}$$

where the sense of the rotation is given by the right-hand-rule, and the product matrix convention is: $\mathbf{R_D}$ then $\mathbf{R_W}$ then $\mathbf{R_N}$ (321 convention).

Explicitly:

Given the three Euler Angles: $[\, \boldsymbol{\phi_{ROLL}, \phi_{PITCH}, \phi_{YAW}}] = [\phi_{Nose}, \phi_{Right}, \phi_{Down}]$

1. Rotation about the DOWN-axis by the YAW angle $\mathbf{[R_D(\phi_Y)]}$
2. Rotation about the new (once-rotated) RIGHTWING-axis by the PITCH angle $\mathbf{[R_W(\phi_P)]}$
3. Rotation about the new (twice-rotated) NOSE-axis by the ROLL angle $\mathbf{[R_N(\phi_R)]}$

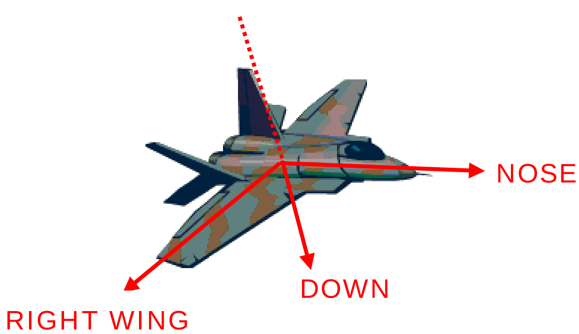
Remember, the output IMU data is in the CASE frame, the transformation matrix converts from our N, RW, D convention to your X, Y, Z convention. The error models are applied in the CASE and not the BODY frame. If you enter 0 for the angles, the *Tapestry*-BODY and CASE frames are aligned

$$\left|\begin{array}{c} \Delta\theta_x \;/\; \Delta V_x \\ \Delta\theta_y \;/\; \Delta V_y \\ \Delta\theta_z \;/\; \Delta V_z \end{array}\right|^{\textbf{CASE}} = \left(R^{C}_{B} \right) \left|\begin{array}{c} \Delta\theta_N \;/\; \Delta V_N \\ \Delta\theta_W \;/\; \Delta V_W \\ \Delta\theta_D \;/\; \Delta V_D \end{array}\right|^{\textbf{BODY}}$$

Tapestry BODY Frame

Output IMU Data via this [PINOUT]

BODY FRAME



IMU CASE (SENSOR) FRAME