Velocity relationship in instrument coordinate and earth coordinate

Denote $V_{instrument}$ the instrument velocity, V_{earth} the velocity in earth coordinate.

The relationship between $V_{instrument}$ and V_{earth} is:

$$V_{earth} = S_{rph} V_{instrument}$$

Here $S_{rph} = R_{heading} \cdot R_{rp}$

$$R_{heading} = \begin{pmatrix} \cos(h) & -\sin(h) & 0 \\ \sin(h) & \cos(h) & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

$$R_{rp} = \begin{pmatrix} A_{11} & A_{12} & A_{13} \\ A_{12} & A_{22} & A_{23} \\ -A_{13} & -A_{23} & A_{33} \end{pmatrix}$$

$$A_{11} = 1 - \sin^2(r)/(\sin^2(r) + \sin^2(p)) \cdot (1 - \sqrt{1 - \sin^2(r) - \sin^2(p)})$$

$$A_{22} = 1 - \sin^2(p)/(\sin^2(r) + \sin^2(p)) \cdot (1 - \sqrt{1 - \sin^2(r) - \sin^2(p)})$$

$$A_{33} = \sqrt{1 - \sin^2(r) - \sin^2(p)}$$

$$A_{12} = \sin(r)\sin(p)/(\sin^2(r) + \sin^2(p)) \cdot (1 - \sqrt{1 - \sin^2(r) - \sin^2(p)})$$

$$A_{13} = \sin(p)$$

$$A_{23} = -\sin(r)$$

Where r, p, h stand for roll, pitch and heading respectively.