COMPUTING γ FOR DP1.

$$\Phi^{DP1} = \bar{a}_j^T A_j^T \cdot A_i \cdot \bar{a}_i$$

$$\frac{d\Phi^{DP1}}{dt} = \bar{a}_j^T \cdot A_j^T \cdot A_i \tilde{\bar{\omega}}_i \bar{a}_i + \bar{a}_i^T A_i^T \cdot A_j \tilde{\bar{\omega}}_j \bar{a}_j$$

Next, take another time derivative. Due to symmetry, only work with half of the terms; the other half is obtained by swappin "i" with "j".

$$\frac{d}{dt}\left[\bar{a}_j^T A_j^T A_i \tilde{\bar{\omega}}_i \bar{a}_i\right] = -\frac{d}{dt}\left[a_j^T A_j^T A_i \cdot \tilde{\bar{a}}_i \bar{\omega}_i\right]$$

$$= - a_j^T A_j^T A_i \tilde{\bar{a}}_i \dot{\bar{\omega}}_i - a_j^T A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{a}}_i \bar{\omega}_i$$

$$- \bar{a}_j^T (A_j \tilde{\bar{\omega}}_j)^T A_i \tilde{\bar{a}}_i \bar{\omega}_i$$

Then half of γ comes as:

$$\bar{a}_j^T A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{a}}_i \bar{\omega}_i + \bar{a}_j^T (A_j \tilde{\bar{\omega}}_j)^T A_i \tilde{\bar{a}}_i \bar{\omega}_i$$

$$= - \bar{a}_j^T A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{\omega}}_i \bar{a}_i - \bar{a}_j^T \tilde{\bar{\omega}}_j A_j^T A_i \tilde{\bar{a}}_i \bar{\omega}_i$$

$$= - \bar{a}_j^T A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{\omega}}_i \bar{a}_i + \bar{\omega}_j \tilde{\bar{a}}_j A_j^T A_i \tilde{\bar{a}}_i \bar{\omega}_i$$

Then,

$$\gamma = - \bar{a}_j^T A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{\omega}}_i \bar{a}_i - \boxed{\bar{a}_i^T A_i^T A_j \tilde{\bar{\omega}}_j \tilde{\bar{\omega}}_j \bar{a}_j}$$

scalar. Its transpose is equal to itself.

$$+ 2\bar{\omega}_j \tilde{\bar{a}}_j A_j^T A_i \tilde{\bar{a}}_i \bar{\omega}_i$$

(See next page)

$$= - a_j^T A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{\omega}}_i a_i - \bar{a}_j^T \tilde{\bar{\omega}}_j \tilde{\bar{\omega}}_j A_j^T A_i \cdot \bar{a}_i$$

$$+ 2 \bar{\omega}_j \cdot \tilde{\bar{a}}_j \cdot A_j^T \cdot A_i \cdot \tilde{\bar{a}}_i \bar{\omega}_i$$

$$= - a_j^T \left[A_j^T A_i \tilde{\bar{\omega}}_i \tilde{\bar{\omega}}_i + \tilde{\omega}_j \tilde{\bar{\omega}}_j \cdot A_j^T \cdot A_i \right] \bar{a}_i$$

$$+ 2 \bar{\omega}_j \cdot \tilde{\bar{a}}_j \cdot A_j^T \cdot A_i \cdot \tilde{\bar{a}}_i \bar{\omega}_i .$$