[1] $$\frac{\partial}{\partial t}\frac{\partial L}{\partial[\dot{travel}]} - \frac{\partial L}{\partial[travel]} = (Vf + Vb)Kf\, L_a \sin(pitch(t))$$

[2] $$T_1^{mc} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(elev(t)) & \sin(elev(t)) & Lwcos(elev(t)) \\ 0 & \sin(elev(t)) & \cos(elev(t)) & Lwsin(elev(t)) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

[3] $$T_1^{hb} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(elev(t)) & \sin(elev(t)) & Lacos(elev(t)) \\ 0 & \sin(elev(t)) & \cos(elev(t)) & Lasin(elev(t)) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

[4] $$T_{hb}^{f} = \begin{bmatrix} \cos(pitch(t)) & 0 & \sin(pitch(t)) & Lhcos(pitch(t)) \\ 0 & 1 & 0 & 0 \\ \sin(pitch(t)) & 0 & \cos(pitch(t)) & Lhsin(pitch(t)) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

[5] $$T_{hb}^{b} = \begin{bmatrix} \cos(pitch(t)) & 0 & \sin(pitch(t)) & Lhcos(pitch(t)) \\ 0 & 1 & 0 & 0 \\ \sin(pitch(t)) & 0 & \cos(pitch(t)) & Lhsin(pitch(t)) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

[6] $$\begin{aligned} T_{mc} &= T_0^1 T_1^{mc} \\ T_{hb} &= T_0^1 T_1^{hb} \\ T_f &= T_{hb} T_{hb}^{f} \\ T_b &= T_{hb} T_{hb}^{b} \end{aligned}$$

[7] $$\begin{aligned} pe_{mc} &= mc\, g\, p_z^{mc} \\ pe_f &= mf\, g\, p_z^{f} \\ pe_b &= mf\, g\, p_z^{b} \end{aligned}$$

[8] $$\begin{aligned} ke_{mc} &= 0.5\, mc\left({v_x^{mc}}^2 + {v_y^{mc}}^2 + {v_z^{mc}}^2\right) \\ ke_f &= 0.5\, mf\left({v_x^{f}}^2 + {v_y^{f}}^2 + {v_z^{f}}^2\right) \\ ke_b &= 0.5\, mb\left({v_x^{b}}^2 + {v_y^{b}}^2 + {v_z^{b}}^2\right) \end{aligned}$$

$$ke = ke_{mc} + ke_f + ke_b$$
$$pe = pe_{mc} + pe_f + pe_b$$
[9] $$L = ke - pe$$

[10] $$\frac{\partial}{\partial t}\frac{\partial L}{\partial[\dot{elev}]} - \frac{\partial L}{\partial[elev]} = L_a\, Kf\left(V_f + V_b\right)$$

[11] $$\frac{\partial}{\partial t}\frac{\partial L}{\partial[tr\dot{a}vel]} - \frac{\partial L}{\partial[travel]} = \left(Vf + Vb\right)Kf\, L_a \sin\left(pitch(t)\right)$$

[12] $$\frac{\partial}{\partial t}\frac{\partial L}{\partial[\dot{p}itch]} - \frac{\partial L}{\partial[pitch]} = Kf\left(Vf - Vb\right)L_h$$

$$F_1\left(elev,\ pitch,\ travel\right) = G_1\left(V_f,\ V_b\right)$$
$$F_2\left(elev,\ pitch,\ travel\right) = G_2\left(V_{f,}\ V_b\right)$$
[13] $$F_3\left(elev,\ pitch,\ travel\right) = G_3\left(V_f,\ V_b\right)$$

$$\dot{\varepsilon} = R\left(\varepsilon,\ p,\ \lambda, V_{f,V_b}\right)$$
$$\ddot{p} = R\left(\varepsilon,\ p,\ \lambda,\ V_{f,}\ V_b\right)$$
[14] $$\ddot{\lambda} = R\left(\varepsilon,\ p,\ \lambda,\ V_{f,}\ V_b\right)$$

[15] $$Q = \left|\varepsilon = 0,\ p = 0,\ \lambda = 0,\ \dot{\varepsilon} = 0,\ \dot{p} = 0,\ \dot{\lambda} = 0,\ V_f = V_q,\ V_b = V_q\right|$$

[16] $$V_q = \frac{g\left(Lwmc - 2Lamf\right)}{2Kf}$$

[17] $$\begin{bmatrix}\dot{\varepsilon}\\ \dot{p}\\ \dot{\lambda}\\ \ddot{\varepsilon}\\ \ddot{p}\\ \dot{\lambda}\\ \dot{\zeta}\\ \dot{\gamma}\end{bmatrix} = A\begin{bmatrix}\varepsilon\\ p\\ \lambda\\ \dot{\varepsilon}\\ \dot{p}\\ \dot{\lambda}\\ \zeta\\ \gamma\end{bmatrix} + B\begin{bmatrix}V_f\\ V_b\end{bmatrix}$$

$$A = \begin{bmatrix} 0.00 & 0.00 & 0.00 & 1.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 1.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 1.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.60 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 1.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \\ 0.00 & 0.00 & 1.00 & 0.00 & 0.00 & 0.00 & 0.00 & 0.00 \end{bmatrix}$$

$$B = \begin{bmatrix} 0.00 & 0.00 \\ 0.00 & 0.00 \\ 0.00 & 0.00 \\ 0.15 & 0.15 \\ 1.02 & 1.02 \\ 0.00 & 0.00 \\ 0.00 & 0.00 \\ 0.00 & 0.00 \end{bmatrix}$$

[18]

[19] $$K = \begin{bmatrix} 18.30 & 10.14 & 17.55 & 12.02 & 3.52 & 26.00 & 3.54 & 1.12 \\ 18.30 & 10.14 & 17.55 & 12.02 & 3.52 & 26.00 & 3.54 & 1.12 \end{bmatrix}$$