$L := 290\ m$ $d := 16\ m$ $B := 47.5\ m$ $C_b := 0.805$ $V := 15\ knot$

(Fn = 0.145)

$\rho := 1.025\ \frac{tonne}{m^3}$

$x_t := \frac{-L}{2} = -145\ m$ $x'_t := \frac{x_t}{L} = -0.5$

$\Delta := C_b \cdot L \cdot B \cdot d \cdot \rho = 181858\ tonne$

$T := 10\ kN$ $T' := \frac{T}{\frac{1}{2} \cdot \rho \cdot L^2 \cdot V^2} = 3.896 \cdot 10^{-6}$

Clarke coefficients (linear velocity and acceleration)

$Y'_{vdot} := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(1 + 0.16 \cdot C_b \cdot \frac{B}{d} - 5.1 \cdot \left(\frac{B}{L}\right)^2\right)$ $Y'_{vdot} = -0.012$

$Y'_{rdot} := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(0.67 \cdot \frac{B}{L} - 0.0033 \cdot \left(\frac{B}{d}\right)^2\right)$ $Y'_{rdot} = -7.713 \cdot 10^{-4}$

$N'_{vdot} := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(1.1 \cdot \frac{B}{L} - 0.041 \cdot \frac{B}{d}\right)$ $N'_{vdot} = -5.59 \cdot 10^{-4}$

$N'_{rdot} := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(\frac{1}{12} + 0.017 \cdot C_b \cdot \frac{B}{d} - 0.33 \cdot \frac{B}{L}\right)$ $N'_{rdot} = -6.685 \cdot 10^{-4}$

$Y'_v := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(1 + 0.40 \cdot C_b \cdot \frac{B}{d}\right)$ $Y'_v = -0.019$

$$Y'_r := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(-0.5 + 2.2 \cdot \frac{B}{L} - 0.08 \cdot \frac{B}{d}\right) \qquad Y'_r = 0.004$$

$$N'_v := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(0.5 + 2.4 \cdot \frac{d}{L}\right) \qquad N'_v = -0.006$$

$$N'_r := -\pi \cdot \left(\frac{d}{L}\right)^2 \cdot \left(0.25 + 0.039 \cdot \frac{B}{d} - 0.56 \cdot \frac{B}{L}\right) \qquad N'_r = -0.003$$

$$Y'_\delta := 3168 \cdot 10^{-6} \qquad N'_\delta := -1402 \cdot 10^{-6} \qquad m' := 14622 \cdot 10^{-6} \qquad mxG' := 365 \cdot 10^{-6} \qquad I'_{zz} := 766 \cdot 10^{-6}$$

$$M' := \begin{bmatrix} -Y'_{vdot} + m' & \left(-Y'_{rdot} + mxG'\right) \cdot 1 \\ -N'_{vdot} + mxG' & -N'_{rdot} + I'_{zz} \end{bmatrix} \qquad D' := \begin{bmatrix} -Y'_v & -Y'_r + m' \\ -N'_v & -N'_r + mxG' \end{bmatrix} \qquad R' := \begin{bmatrix} Y'_\delta \\ N'_\delta \end{bmatrix} \qquad Thrust := \begin{bmatrix} T' \\ T' \cdot x'_t \end{bmatrix}$$

Решатель Начальные условия Ограничения

$$M' \cdot \begin{bmatrix} x1'(t) \\ x2'(t) \end{bmatrix} + D' \cdot \begin{bmatrix} x1(t) \\ x2(t) \end{bmatrix} = R' \cdot \delta + Thrust$$

$$x1(0) = 0 \qquad x2(0) = 0$$

$$\begin{bmatrix} v \\ r \end{bmatrix} := \text{odesolve}\left(\begin{bmatrix} x1(t) \\ x2(t) \end{bmatrix}, 30\right)$$

$A1 := M'_{0,0}$ $B1 := M'_{0,1}$ $C1 := D'_{0,0}$ $D1 := D'_{0,1}$ $E1 := R'_0 + Thrust_0$

$A2 := M'_{1,0}$ $B2 := M'_{1,1}$ $C2 := D'_{1,0}$ $D2 := D'_{1,1}$ $E2 := R'_1 + Thrust_1$

Начальные приближения

Ограничения

$A1 \cdot (x1(t))' + B1 \cdot (x2(t))' + C1 \cdot x1(t) + D1 \cdot x2(t) = E1$

$A2 \cdot (x1(t))' + B2 \cdot (x2(t))' + C2 \cdot x1(t) + D2 \cdot x2(t) = E2$

$x1(0) = 0.2$ $x2(0) = -0.01$

Решатель

$\begin{bmatrix} u \\ r \end{bmatrix} := \text{odesolve}\left(\begin{bmatrix} x1(t) \\ x2(t) \end{bmatrix}, 10\right)$