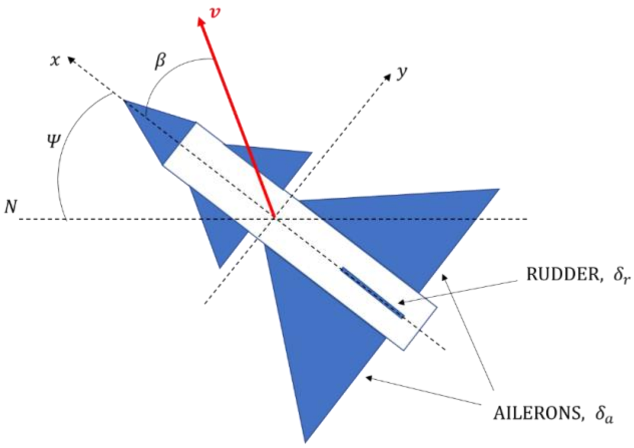
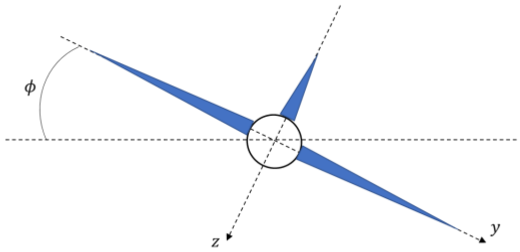
CONTROL OF A GRIPEN AIRCRAFT

TOP VIEW



BACK VIEW



State-space system modelling:

$$\begin{cases} \dot{x} = Ax + Bu \\ y = Cx + Du \end{cases}$$

where

State	Physical Variable	Meaning	Units	Initial Condition
$\boldsymbol{x_1}$	$v_y \simeq \beta\, v$	Velocity (v)	m/s	$5\ m/s$
$\boldsymbol{x_2}$	p	Roll angular rate	rad/s	$0.1\frac{2\pi}{360^\circ}\ rad/s$
$\boldsymbol{x_3}$	r	Turning angular rate	rad/s	$0.1\frac{2\pi}{360^\circ}\ rad/s$
$\boldsymbol{x_4}$	ϕ	Roll angle	rad	$5\cdot\frac{2\pi}{360^\circ}\ rad$
$\boldsymbol{x_5}$	Ψ	Course angle	rad	$5\cdot\frac{2\pi}{360^\circ}\ rad$
$\boldsymbol{x_6}$	δ_a	Aileron angle	rad	$0\ rad$
$\boldsymbol{x_7}$	δ_r	Rudder angle	rad	$0\ rad$

Inputs	Physical Variable	Meaning	Units
$\boldsymbol{u_1}$	δ_a^{cmd}	Aileron reference angle	rad
$\boldsymbol{u_2}$	δ_r^{cmd}	Rudder reference angle	rad

Outputs	Physical Variable	Meaning	Units
$\boldsymbol{y_1 = x_4}$	ϕ	Roll angle	rad
$\boldsymbol{y_2 = x_5}$	Ψ	Course angle	rad

Tasks

Part 1 – Regulator design

Goal: Regulate the system ($\phi^o = 0$ and $\Psi^o = 0$), starting from the initial conditions reported above.

1.
   - Load the file `Gripendata.mat` and analyse the system matrices (A, B, C, D) by plotting the corresponding poles, zeros, and singular values.
   - Design a pole-placement controller (assuming that the states are measurable)
   - Compare the singular values of the system regulated by the pole placement controller to those displayed by the system in open-loop.

2.
   - Assume now that the state is not measurable, i.e. $y \neq x$. Design a state observer using the pole placement approach.
   - Test the closed-loop performances achieved by the pole-placement controller in simulation.

Part 2 – Controller design for reference tracking

Goal: Control the system to track the output references

$$\phi^o = 1.04 \text{ step}(t - 100),$$
$$\Psi^o = -0.52 \text{ step}(t - 150),$$

starting from the initial conditions reported in the table above.

3.
   - Enlarge the system with integrators, so as to guarantee robust asymptotic zero-error regulation.
   - Design a pole placement control law for the enlarged system.
   - Test the closed-loop performances of the resulting control scheme in simulation.

4.
   - Considering that two states are measured (roll and course angle), design a reduced order observer.
   - Test the closed-loop performances of the resulting control scheme in simulation.

5.
   - Design an LQ controller for the enlarged system, applying the technique shown during the lectures to enforce the desired dynamic performances (e.g. closed-loop poles faster than $0.05\ rad/s$).
   - Test the performances of the resulting control scheme in simulation (use the state observer designed in Step 2 or the reduced order observer designed in Step 4).

6. (optional) **Design a Kalman Filter** to estimate the state from the measured output, and test the closed-loop performances of the LQG controller.