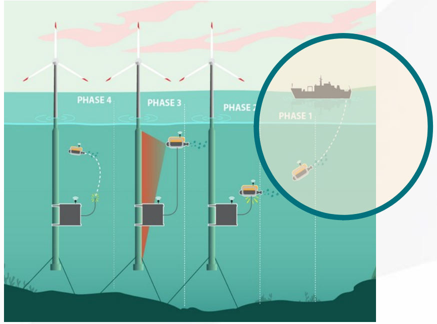


Example 3

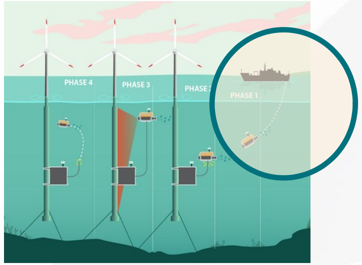
Ship borne tracking of AUV position
from USBL and GPS measurements (2D)

USBL – AUV position wrt ship measurements

GPS-based Ship position measurements

Filtering Structure

Position and velocity estimates



Example 3

p_m obtained from USBL and GPS data

$$p = (x, y)^T$$

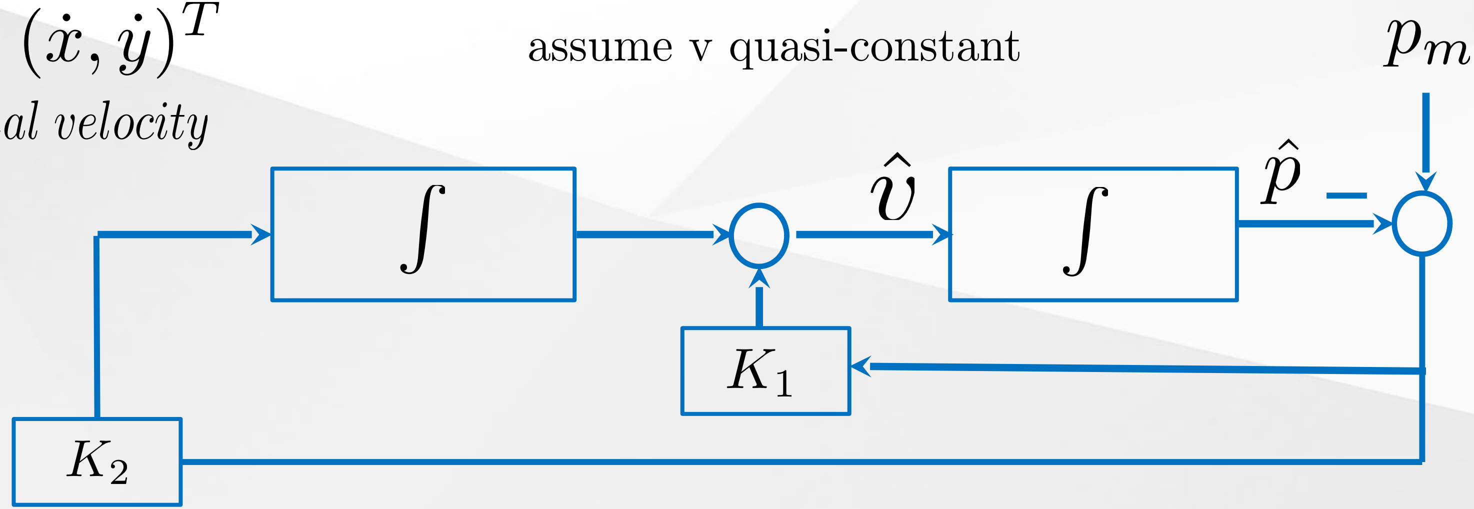
inertial position

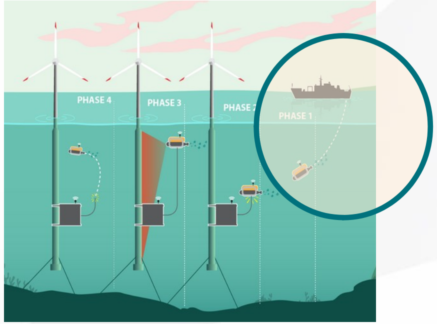
$$v = (\dot{x}, \dot{y})^T$$

inertial velocity

there is no direct or indirect measurement of v !

assume v quasi-constant





Example 3

$$p = (x, y)^T$$

inertial position

$$v = (\dot{x}, \dot{y})^T$$

inertial velocity

there is no direct or
indirect measurement of v !

Underlying Design Model

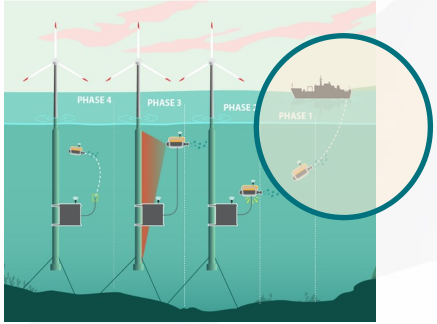
$$\frac{d}{dt}p = v + \xi_1 \longleftarrow$$

state noise

$$\frac{d}{dt}v = 0 + \xi_2 \longleftarrow$$

$$p_m = p + \eta \longleftarrow$$ **Measurement noise**

p_m obtained from
USBL and GPS data



Example 4

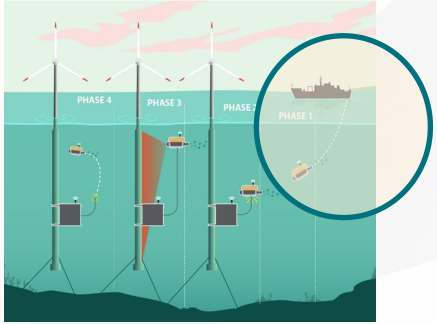
Ship borne tracking of AUV position
from USBL and GPS measurements (2D)

USBL – AUV position wrt ship measurements

GPS-based Ship position measurements

Filtering Structure

Position / velocity +
Yaw / Yaw rate estimates



Example 4

Underlying Design Model (small sideslip angle) *

$$\frac{d}{dt}p = \mathcal{R}(\psi)(u,0)^T + \xi_p$$

$$\frac{d}{dt}x = u\cos(\psi) + \xi_x$$
$$\frac{d}{dt}y = u\sin(\psi) + \xi_y$$

$$p = (x,y)^T$$
inertial position

$\psi - \textit{yaw angle}$

$r - \textit{yaw rate}$

$u - \textit{surge speed}$

$$\frac{d}{dt}u = 0 + \xi_u$$

$$\frac{d}{dt}\psi = r + \xi_\psi$$

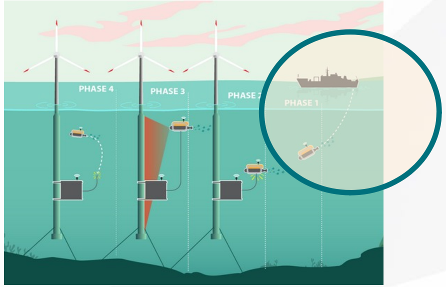
state noise

$$\frac{d}{dt}r = 0 + \xi_r$$

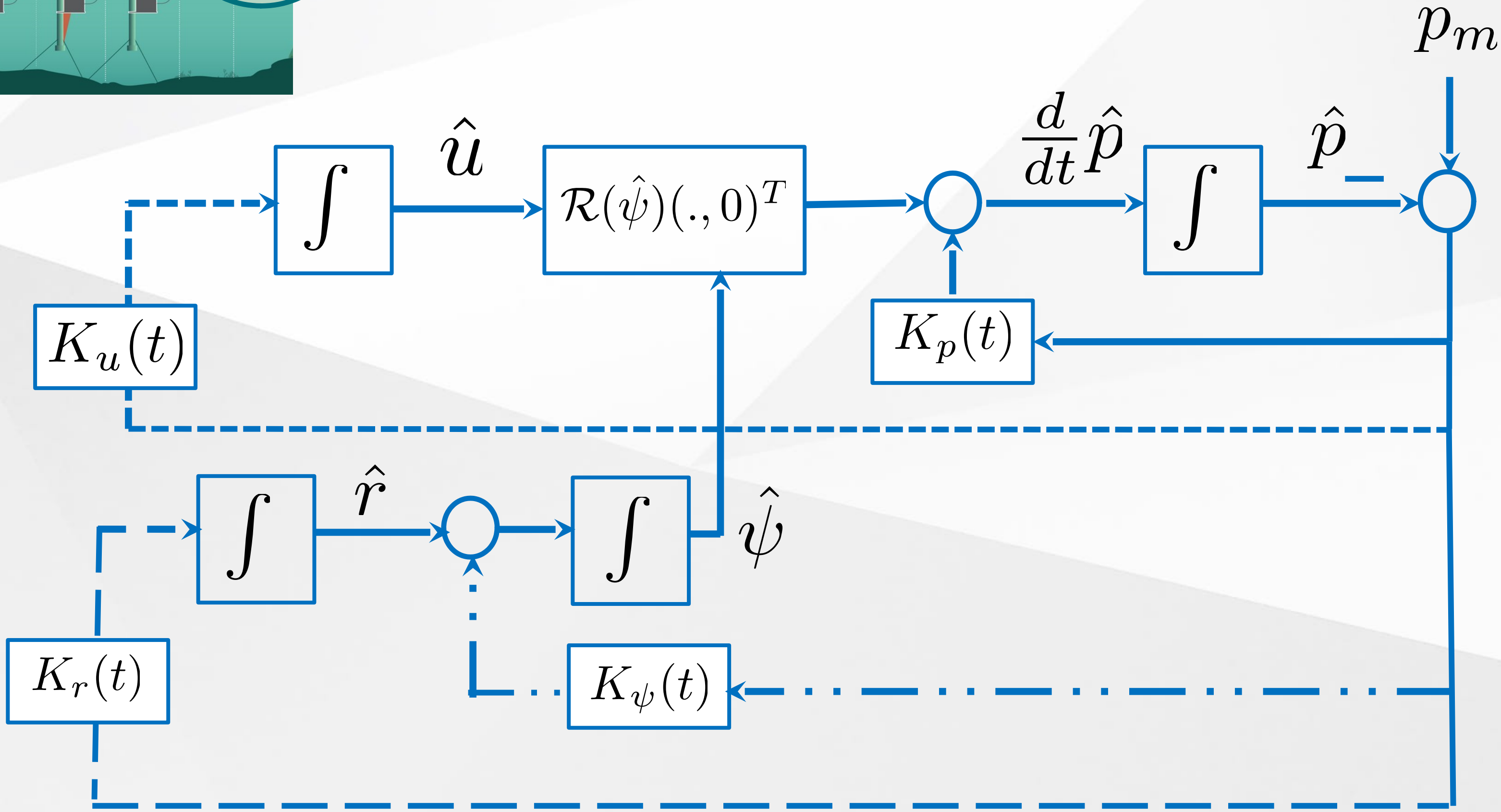
$$p_m = p + \eta$$

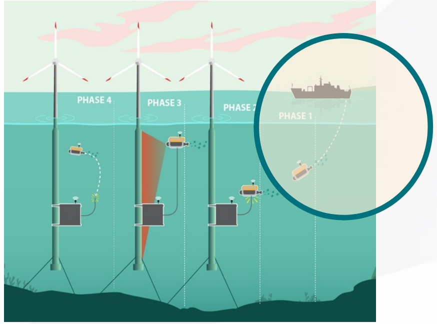
Measurement noise

* A rigorous interpretation is to view *u* as the absolute value of the total velocity vector and ψ as the course angle


PHASE 4
PHASE 3
PHASE 1

Example 4


p_m
$\hat{u}$
$\mathcal{R}(\hat{\psi})(.,0)^T$
$\frac{d}{dt}\hat{p}$
$\hat{p}$
$-$
$\int$
$K_u(t)$
$K_p(t)$
$\hat{r}$
$\hat{\psi}$
$K_r(t)$
$K_\psi(t)$



Example 5

AUV-borne position estimation from Doppler, AHRS, and measurements of ranges-only to known beacon (e.g. on docking station)

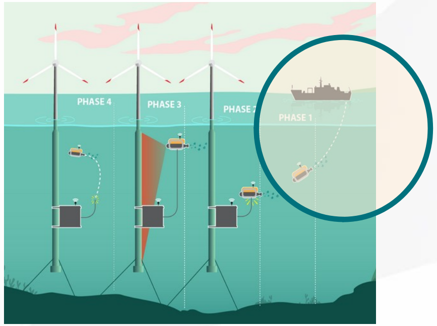
Doppler – velocity measurements

Yaw measurements (AHRS)

Range measuring device – measurements of range wrt fixed beacon

Filtering Structure

Position and velocity estimates



Example 5

Complementary Filter Structure

Underlying Design Model

current velocity

Doppler measurement

$$v_m = v_w = v - v_c$$

$$v = v_w + v_c$$

$$p = (x, y)^T$$

inertial position

$$v = (\dot{x}, \dot{y})^T$$

inertial velocity

p_b – *beacon position*

r_m - range measurement

$$\frac{d}{dt}p = v_c + v_w + \xi_1$$

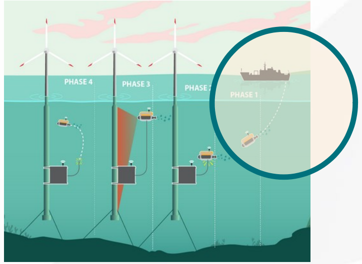
$$\frac{d}{dt}v_c = 0 + \xi_2$$

state noise

$$r_m = ||p - p_b|| + \eta$$

measurement noise

Example 5



$p = (x, y)^T$

inertial position

$v = (\dot{x}, \dot{y})^T$

inertial velocity

Complementary Filter Structure $v_m = v_w = v - v_c$

$$v = v_w + v_c$$