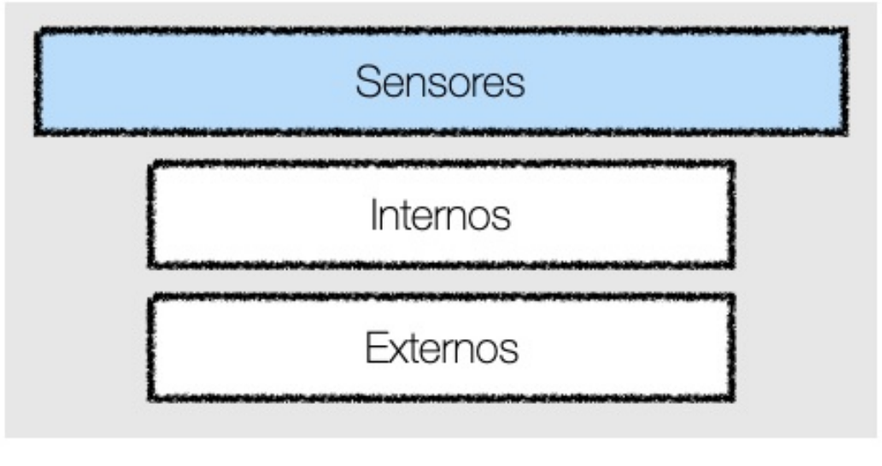
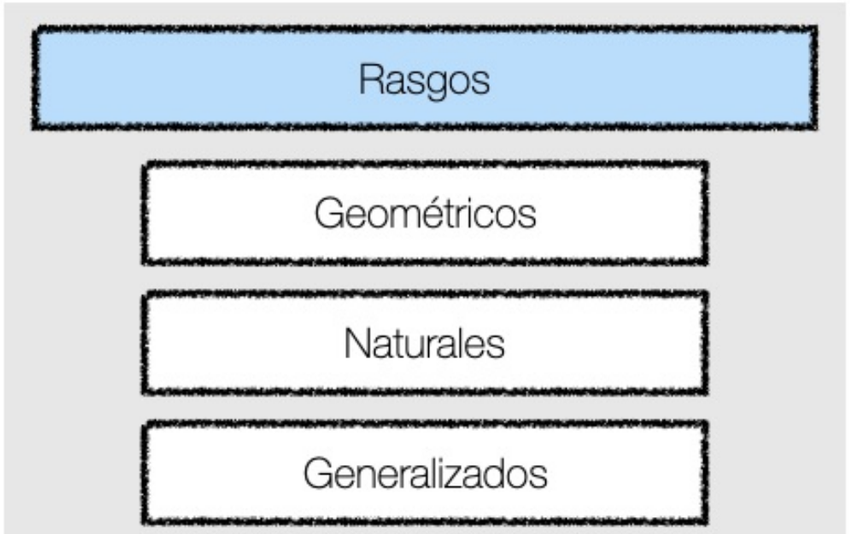
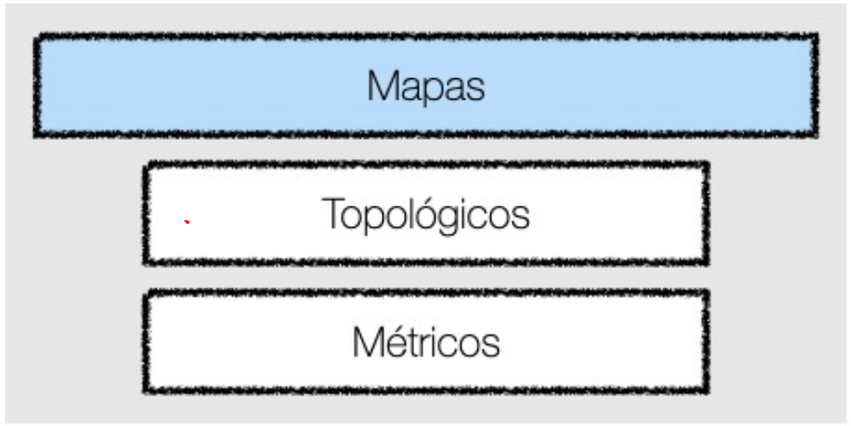
Sensores

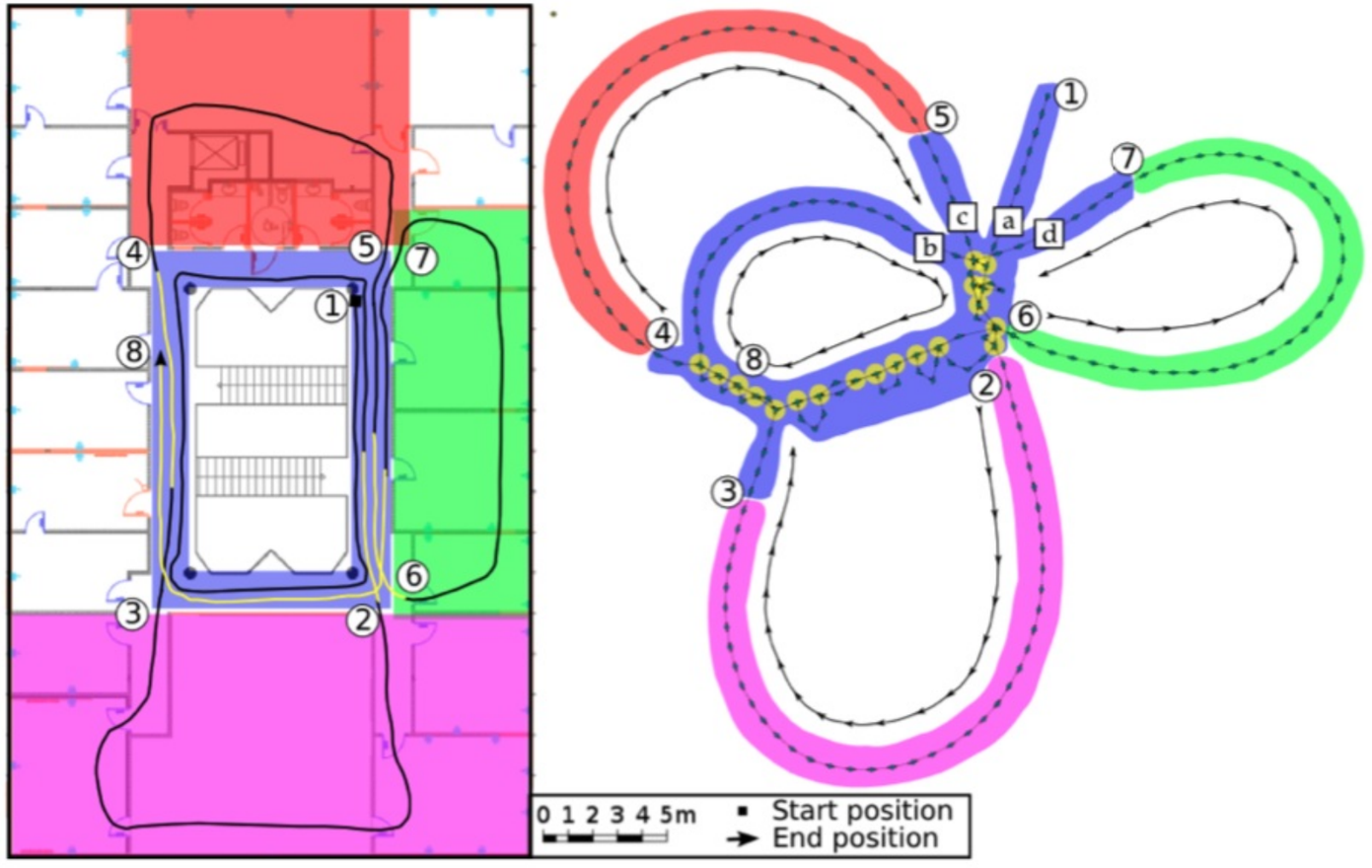


Rasgos

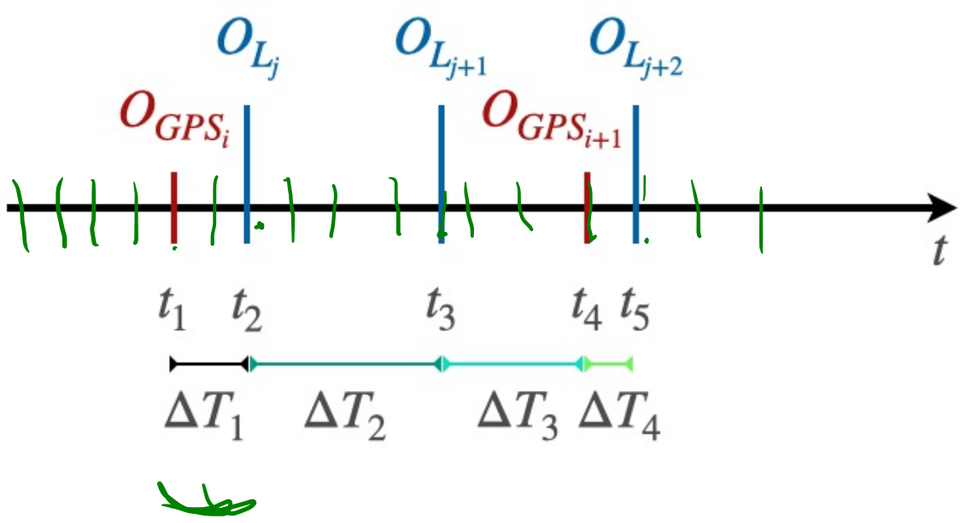


Mapas


Mapas
Topológicos
Métricos


0 1 2 3 4 5m
Start position
End position

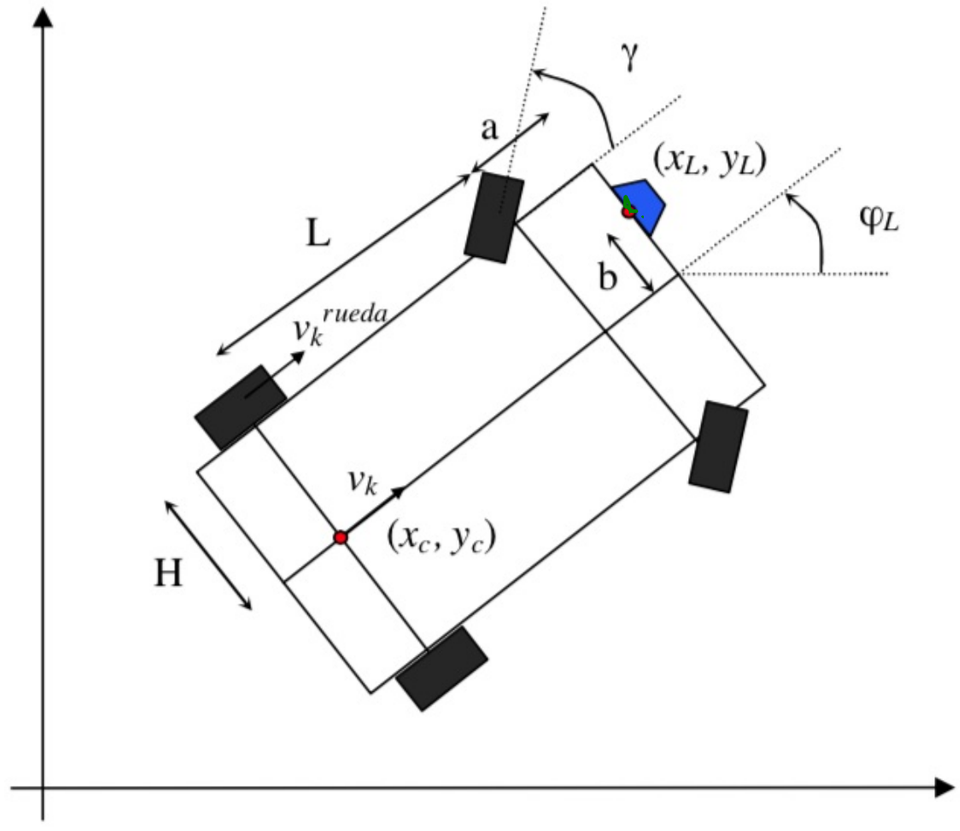
Integración GPS con otros sensores externos



Predicción

$$\hat{\mathbf{x}}_{k|\,k-1} = \mathbf{f}\,[\hat{\mathbf{x}}_{k-1|\,k-1}, \mathbf{u}_k]$$
$$\mathbf{P}_{k|\,k-1} = \nabla\mathbf{f}_{\mathbf{x}}\mathbf{P}_{k-1|\,k-1}\nabla\mathbf{f}_{\mathbf{x}}^{T} + \nabla\mathbf{f}_{\mathbf{u}}\mathbf{U}_k\nabla\mathbf{f}_{\mathbf{x}}^{T} + \mathbf{Q}_k$$

$$\mathbb{G} = \left(1 - \frac{b\tan(\gamma_k)}{L}\right)$$
$$\mathbb{H} = \frac{(L+a)\tan(\gamma_k)}{L}$$

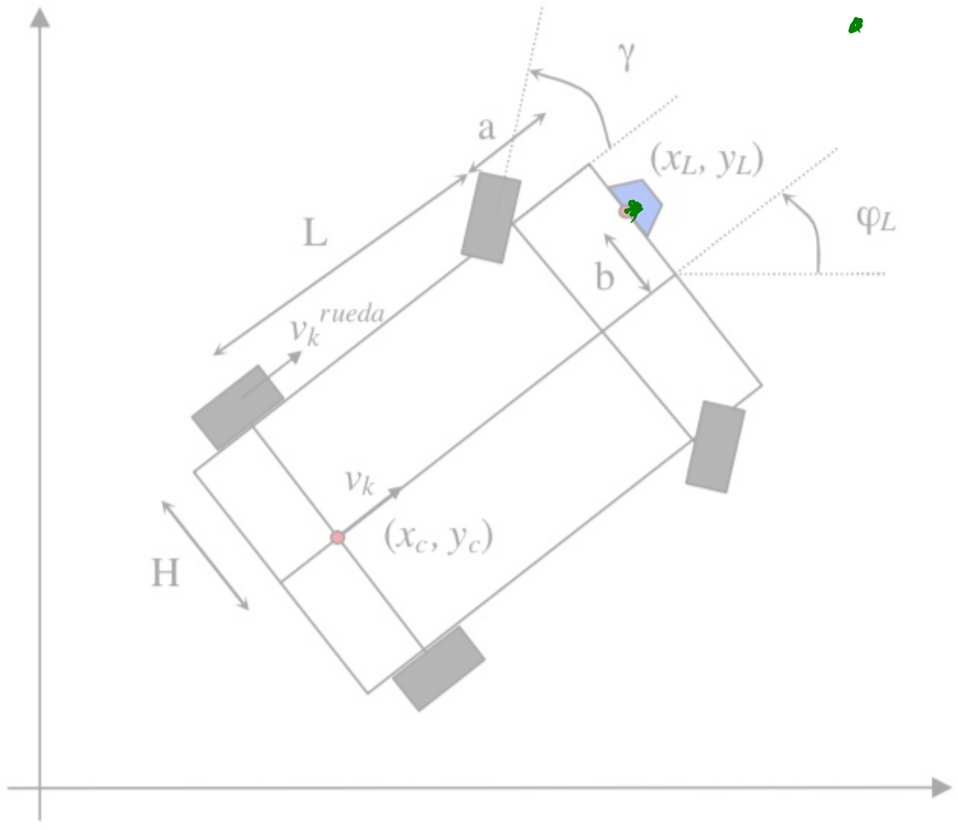


$$\begin{bmatrix} x_{Lk} \\ y_{Lk} \\ \varphi_{Lk} \end{bmatrix} = \begin{bmatrix} x_{Lk-1} + \triangle t \cdot v_k \cdot [\mathbb{G}\cos(\boldsymbol{\varphi}_{Lk-1}) - \mathbb{H}\,\mathrm{sen}(\boldsymbol{\varphi}_{Lk-1})] \\ y_{Lk-1} + \triangle t \cdot v_k \cdot [\mathbb{G}\,\mathrm{sen}(\boldsymbol{\varphi}_{Lk-1}) + \mathbb{H}\cos(\boldsymbol{\varphi}_{Lk-1})] \\ \varphi_{Lk-1} + \triangle t \cdot \frac{v_k}{L} \cdot \tan(\gamma_k) \end{bmatrix}$$

Predicción

$$\hat{\mathbf{x}}_{k|\,k-1} = \mathbf{f}\,[\hat{\mathbf{x}}_{k-1|\,k-1}, \mathbf{u}_k]$$

$$\mathbf{P}_{k|\,k-1} = \nabla\mathbf{f}_{\mathbf{x}}\mathbf{P}_{k-1|\,k-1}\nabla\mathbf{f}_{\mathbf{x}}^{T} + \nabla\mathbf{f}_{\mathbf{u}}\mathbf{U}_k\nabla\mathbf{f}_{\mathbf{x}}^{T} + \mathbf{Q}_k$$



$$\mathbb{G} = \left(1 - \frac{b\tan(\gamma_k)}{L}\right)$$

$$\mathbb{H} = \frac{(L+a)\tan(\gamma_k)}{L}$$

$$\begin{bmatrix} x_{Lk} \\ y_{Lk} \\ \varphi_{Lk} \end{bmatrix} = \begin{bmatrix} x_{Lk-1} + \Delta t \cdot v_k \cdot [\mathbb{G}\cos(\varphi_{Lk-1}) - \mathbb{H}\,\mathrm{sen}(\varphi_{Lk-1})] \\ y_{Lk-1} + \Delta t \cdot v_k \cdot [\mathbb{G}\,\mathrm{sen}(\varphi_{Lk-1}) + \mathbb{H}\cos(\varphi_{Lk-1})] \\ \varphi_{Lk-1} + \Delta t \cdot \frac{v_k}{L} \cdot \tan(\gamma_k) \end{bmatrix}$$

Predicción

$$\hat{\mathbf{x}}_{k|k-1} = \mathbf{f}\left[\hat{\mathbf{x}}_{k-1|k-1}, \mathbf{u}_k\right]$$
$$\mathbf{P}_{k|k-1} = \nabla\mathbf{f}_{\mathbf{x}}\mathbf{P}_{k-1|k-1}\nabla\mathbf{f}_{\mathbf{x}}^{T} + \nabla\mathbf{f}_{\mathbf{u}}\mathbf{U}_k\nabla\mathbf{f}_{\mathbf{x}}^{T} + \mathbf{Q}_k$$

$$\begin{aligned}
\mathbb{A} &= \mathbb{G}\cos\left(\varphi_{Lk-1}\right) - \mathbb{H}\,\mathrm{sen}\left(\varphi_{Lk-1}\right)\\
\mathbb{B} &= \mathbb{G}\,\mathrm{sen}\left(\varphi_{Lk-1}\right) + \mathbb{H}\cos\left(\varphi_{Lk-1}\right)\\
\mathbb{C} &= -b\cos\left(\varphi_{Lk-1}\right) - (L+a)\,\mathrm{sen}\left(\varphi_{Lk-1}\right)\\
\mathbb{D} &= -b\,\mathrm{sen}\left(\varphi_{Lk-1}\right) + (L+a)\cos\left(\varphi_{Lk-1}\right)
\end{aligned}$$

$$\nabla\mathbf{f}_{\mathbf{x}} = \begin{bmatrix} 1 & 0 & -\triangle t\cdot\nu_k\cdot\left[\mathbb{G}\,\mathrm{sen}\left(\varphi_{Lk-1}\right) - \mathbb{H}\cos\left(\varphi_{Lk-1}\right)\right] \\ 0 & 1 & \triangle t\cdot\nu_k\cdot\left[\mathbb{G}\cos\left(\varphi_{Lk-1}\right) + \mathbb{H}\,\mathrm{sen}\left(\varphi_{Lk-1}\right)\right] \\ 0 & 0 & 1 \end{bmatrix}$$

$$L = 2{,}38\mathrm{m}$$
$$a = 0{,}95\mathrm{m}$$
$$b = 0{,}5\mathrm{m}$$
$$H = 0{,}75\mathrm{m}$$

$$\nabla\mathbf{f}_{\mathbf{u}} = \begin{bmatrix} \frac{\triangle t\cdot\mathbb{A}}{1-\frac{H}{L}\tan(\gamma_k)} & \frac{\triangle t\cdot\nu_k^{rueda}\cdot\frac{H}{L}\cdot\mathbb{A}}{\left(1-\frac{H}{L}\tan(\gamma_k)\right)^2\cdot\cos^2(\gamma_k)} + \frac{\triangle t\cdot\nu_k\mathbb{C}}{L\cos^2(\gamma_k)} \\ \frac{\triangle t\cdot\mathbb{B}}{1-\frac{H}{L}\tan(\gamma_k)} & \frac{\triangle t\cdot\nu_k^{rueda}\cdot\frac{H}{L}\cdot\mathbb{B}}{\left(1-\frac{H}{L}\tan(\gamma_k)\right)^2\cdot\cos^2(\gamma_k)} + \frac{\triangle t\cdot\nu_k\mathbb{D}}{L\cos^2(\gamma_k)} \\ \frac{\triangle t\cdot\tan(\gamma_k)}{L\cdot\left(1-\frac{H}{L}\tan(\gamma_k)\right)} & \frac{\triangle t\cdot\nu_k^{rueda}\cdot\frac{H}{L}\cdot\tan(\gamma_k)}{L\cdot\left(1-\frac{H}{L}\tan(\gamma_k)\right)^2\cdot\cos^2(\gamma_k)} + \frac{\triangle t\cdot\nu_k}{L\cos^2(\gamma_k)} \end{bmatrix}$$

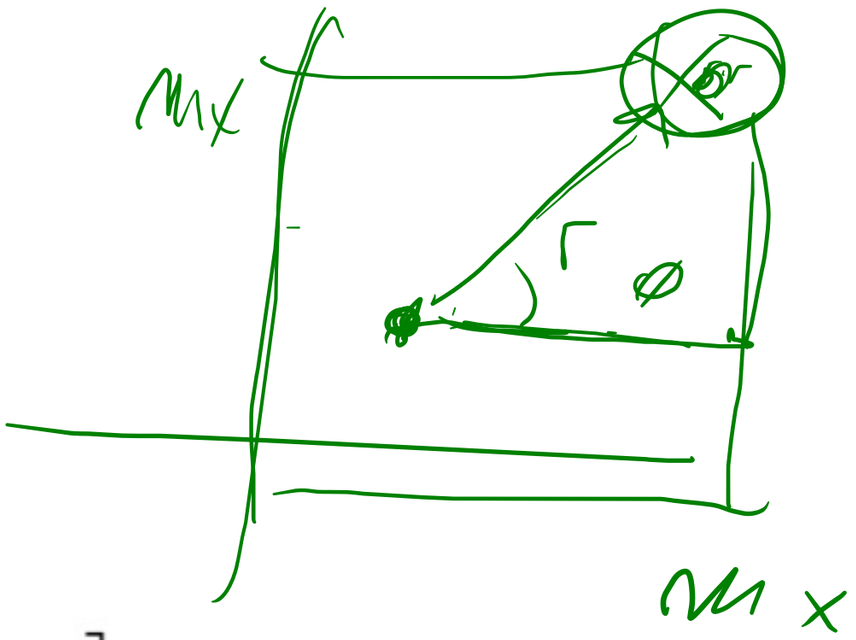
Actualización Laser

$$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{W}_k \left(\mathbf{z}_k - \mathbf{h}[\hat{\mathbf{x}}_{k|k-1}]\right)$$

$$\mathbf{P}_{k|k} = \mathbf{P}_{k|k-1} - \mathbf{W}_k \mathbf{S}_k \mathbf{W}_k^T$$

$$\mathbf{W}_k = \mathbf{P}_{k|k-1} \nabla \mathbf{h}_x^T \mathbf{S}_k^{-1}$$

$$\mathbf{S}_k = \nabla \mathbf{h}_x \mathbf{P}_{k|k-1} \nabla \mathbf{h}_x^T + \mathbf{R}_k$$



$$\mathbf{h}[\hat{\mathbf{x}}_{k|k-1}] = \begin{bmatrix} \cos(\varphi_{L\,k-1}) & -\text{sen}(\varphi_{L\,k-1}) \\ \text{sen}(\varphi_{L\,k-1}) & \cos(\varphi_{L\,k-1}) \end{bmatrix} \cdot \begin{bmatrix} m_{xi} - x_L \\ m_{yi} - y_L \end{bmatrix}$$

$$\mathbf{z}_k = \begin{bmatrix} z_{x,k} \\ z_{y,k} \end{bmatrix} = \begin{bmatrix} z_{r,k} \cos(z_{\theta,k}) \\ z_{r,k} \,\text{sen}(z_{\theta,k}) \end{bmatrix}$$

Actualización Laser

$$\mathbf{W}_k = \mathbf{P}_{k|k-1} \nabla \mathbf{h}_x^T \mathbf{S}_k^{-1}$$

$$\mathbf{S}_k = \nabla \mathbf{h}_x \mathbf{P}_{k|k-1} \nabla \mathbf{h}_x^T + \mathbf{R}_k$$

$$\nabla \mathbf{h}_x = \begin{bmatrix} -\cos(\varphi_{Lk-1}) & -\text{sen}(\varphi_{Lk-1}) & \mathbb{K}_1 \\ \text{sen}(\varphi_{Lk-1}) & -\cos(\varphi_{Lk-1}) & \mathbb{K}_2 \end{bmatrix}$$

$$\begin{aligned} \mathbb{K}_1 &= -(m_{xi} - x_L)\,\text{sen}(\varphi_{Lk-1}) + (m_{yi} - y_L)\cos(\varphi_{Lk-1}) \\ \mathbb{K}_2 &= (m_{xi} - x_L)\cos(\varphi_{Lk-1}) - (m_{yi} - y_L)\,\text{sen}(\varphi_{Lk-1}) \end{aligned}$$

$$\mathbf{R}_k = \nabla \mathbf{z}_{z_{r,k}, z_{\theta,k}} \cdot \begin{bmatrix} \sigma^2_{z_{r,k}} & 0 \\ 0 & \sigma^2_{z_{\theta,k}} \end{bmatrix} \cdot \nabla \mathbf{z}^T_{z_{r,k}, z_{\theta,k}}$$

$$\nabla \mathbf{z}_{z_{r,k}, z_{\theta,k}} = \begin{bmatrix} \cos(z_{\theta,k}) & -z_{r,k}\,\text{sen}(z_{\theta,k}) \\ \text{sen}(z_{\theta,k}) & z_{r,k}\cos(z_{\theta,k}) \end{bmatrix}$$

Actualización GPS

$$\hat{\mathbf{x}}_{k|k} = \hat{\mathbf{x}}_{k|k-1} + \mathbf{W}_k \left(\mathbf{z}_k - \mathbf{h}[\hat{\mathbf{x}}_{k|k-1}]\right)$$

$$\mathbf{P}_{k|k} = \mathbf{P}_{k|k-1} - \mathbf{W}_k \mathbf{S}_k \mathbf{W}_k^T$$

$$\mathbf{W}_k = \mathbf{P}_{k|k-1} \nabla \mathbf{h}_x^T \mathbf{S}_k^{-1}$$

$$\mathbf{S}_k = \nabla \mathbf{h}_x \mathbf{P}_{k|k-1} \nabla \mathbf{h}_x^T + \mathbf{R}_k$$

$$\mathbf{z}_k = \begin{bmatrix} z_{x,k} \\ z_{y,k} \end{bmatrix}$$

$$\mathbf{h}[\hat{\mathbf{x}}_{k|k-1}] = \begin{bmatrix} \hat{x}_{L_{k|k-1}} \\ \hat{y}_{L_{k|k-1}} \end{bmatrix}$$

Resultado

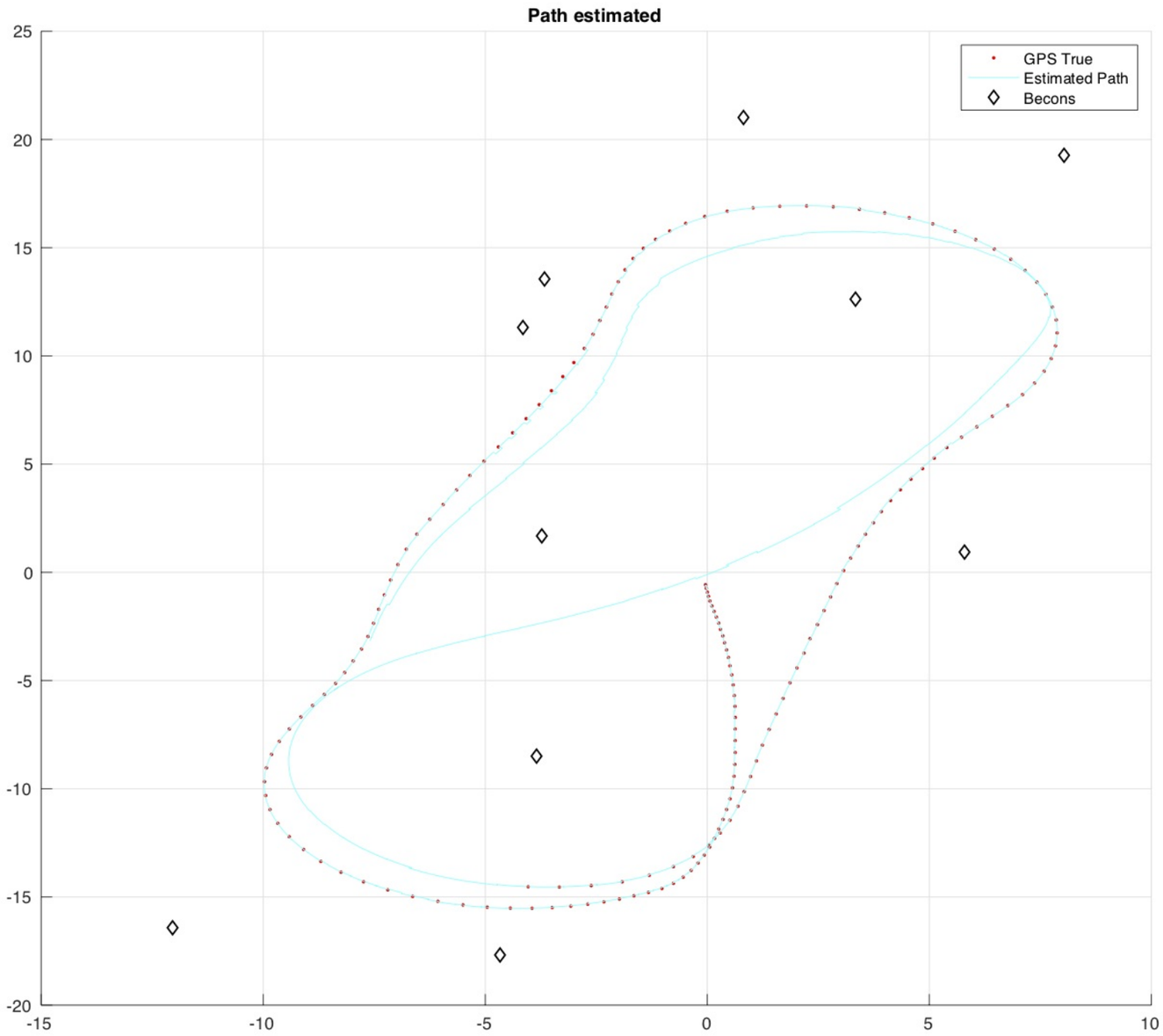

Enlace Radio DGPS
Inercial, Compás
GPS
Láser
Computadora
Codificador
Óptico
Incremental

Resultado

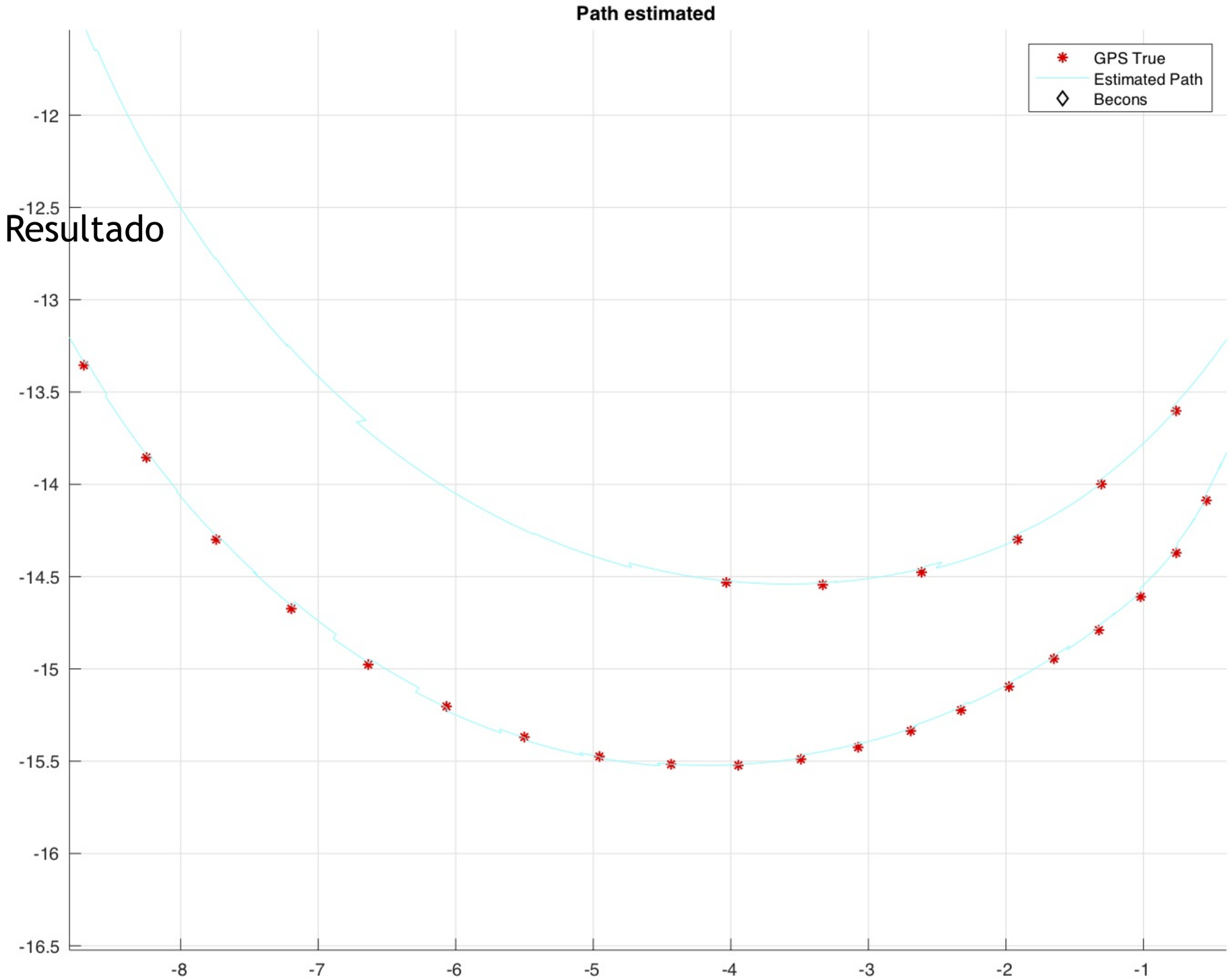

END

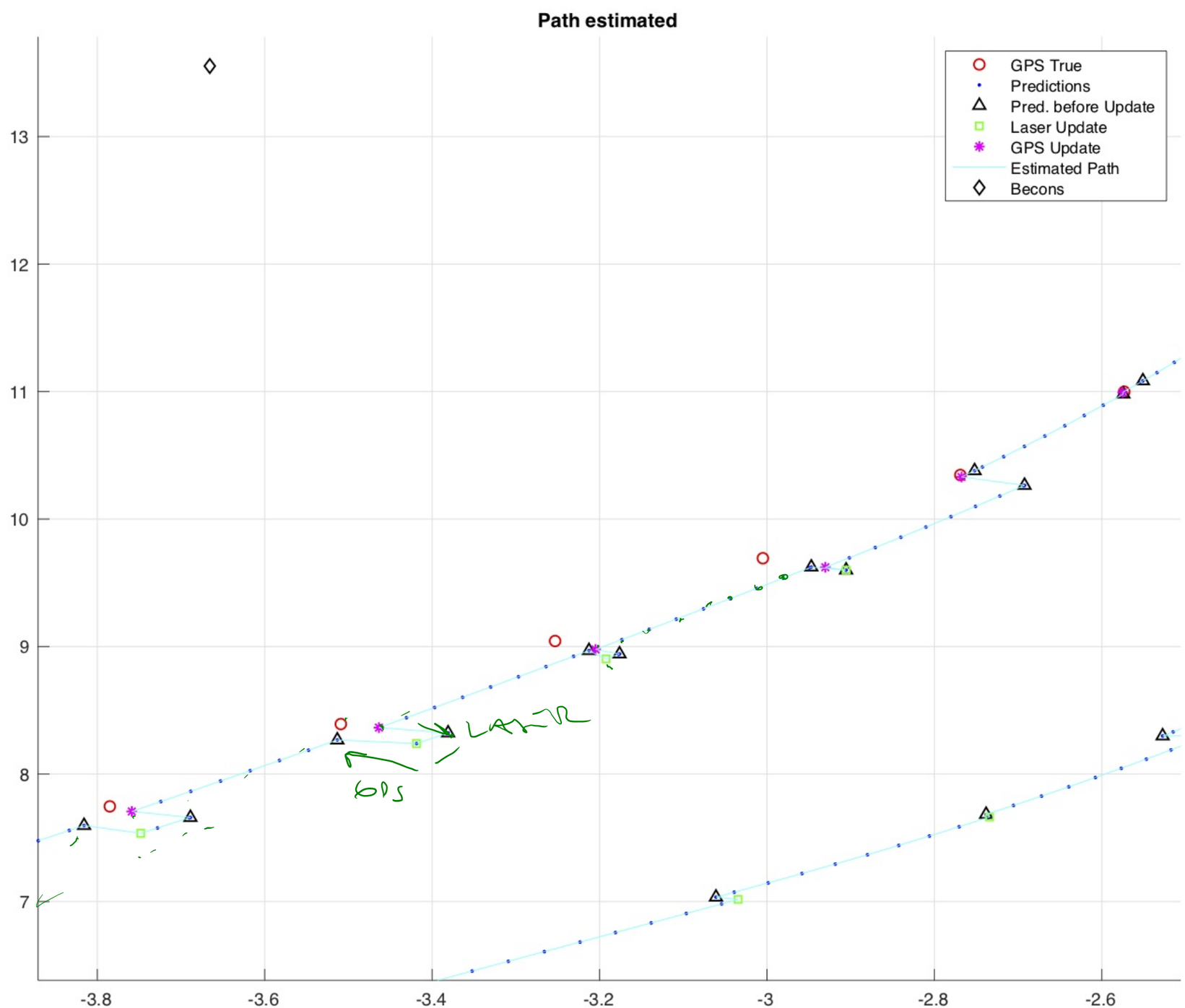

Cleveland St
Cleveland St
11
Shepherd St
Shepherd Street Carpark
Vine St
Shepherd St
Shepherd St
108
118
nautical

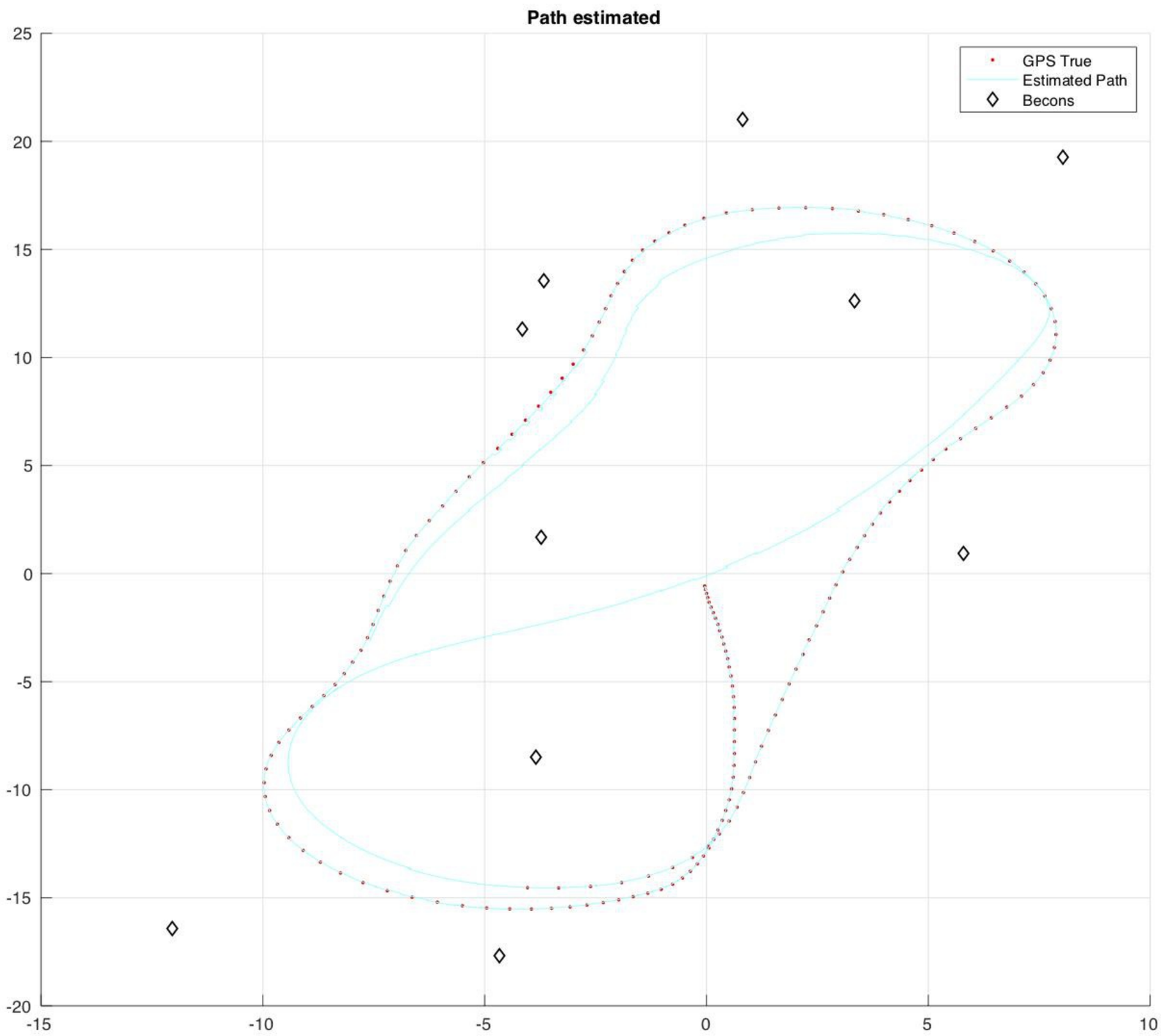
Resultado


Path estimated
GPS True
Estimated Path
Becons
25
20
15
10
5
0
-5
-10
-15
-20
-15
-10
-5
0
5
10

Resultado


Path estimated
GPS True
Estimated Path
Becons
-12
-12.5
-13
-13.5
-14
-14.5
-15
-15.5
-16
-16.5
-8
-7
-6
-5
-4
-3
-2
-1


Path estimated
GPS True
Predictions
Pred. before Update
Laser Update
GPS Update
Estimated Path
Becons
13
12
11
10
9
8
7
-3.8
-3.6
-3.4
-3.2
-3
-2.8
-2.6


Path estimated
GPS True
Estimated Path
Becons
25
20
15
10
5
0
-5
-10
-15
-20
-15
-10
-5
0
5
10

Path estimated

GPS True
Predictions
Pred. before Update
Laser Update
GPS Update
Estimated Path
Becons

-14
-14.1
-14.2
-14.3
-14.4
-14.5

-6
-5.5
-5
-4.5
-4
-3.5
-3
-2.5

Path estimated

GPS True
Predictions
Pred. before Update
Laser Update
GPS Update
Estimated Path
Becons

-6.1
-6.2
-6.3
-6.4
-6.5
-6.6
-6.7
-6.8

0.5
0.55
0.6
0.65
0.7