REGISTRATION MAPS FOR HETEREGENEOUS UNDERWATER VEHICLES

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ECA GROUP

27/06/2018

OUTLINE

- Introduction
- System overview
- Sonar images and detection
- VARM (Vehicle Adapted Registration Map)
- Path planning under uncertainty
- Conclusion

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INTRODUCTION (1/5)

MCM (Mine CounterMeasure) missions :

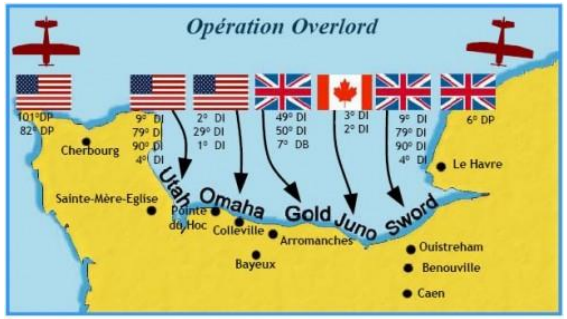
- Map the seabed
- Detect potential dangerous object (mine)
- Neutralize the object

archives.ecapad.fr

commons.wikimedia.org

Interest operations:

- Safe naval transit
- Safe disembarkment area



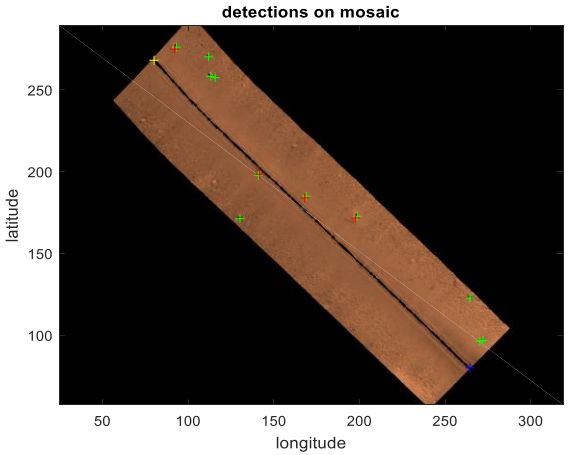
passiongenealogie.hautetfort.com

INTRODUCTION (2/5)

2 phases:

- Survey mission

archives.ecapad.fr



- Revisit of potential dangerous objects

groupedci.com

- ✓ Identification
- ✓ Neutralization

INTRODUCTION (3/5)

Replacement by unmanned underwater robots

- Survey mission

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Autonomous

A9-E from ECA Group

- Revisit of potential dangerous objects

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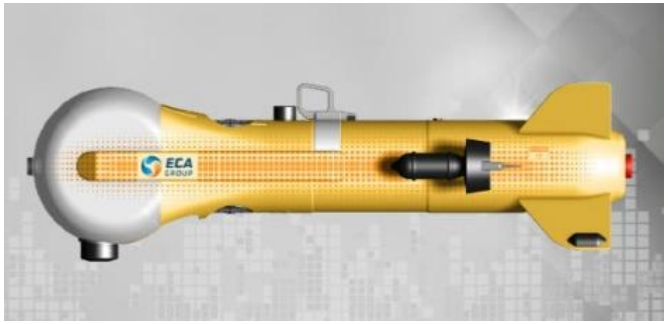
Remotely operated



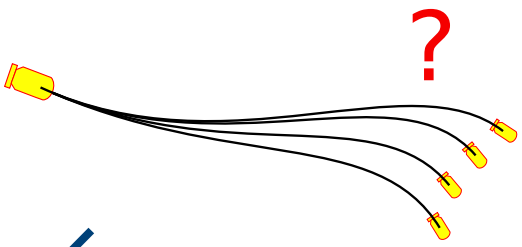
K-STER C from ECA Group

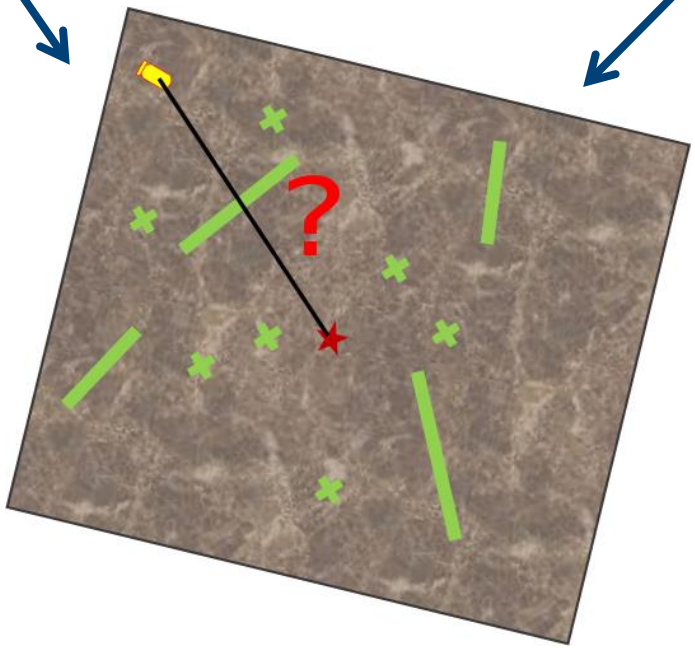
INTRODUCTION (4/5)

Difficulties:

Underwater environment

Drift



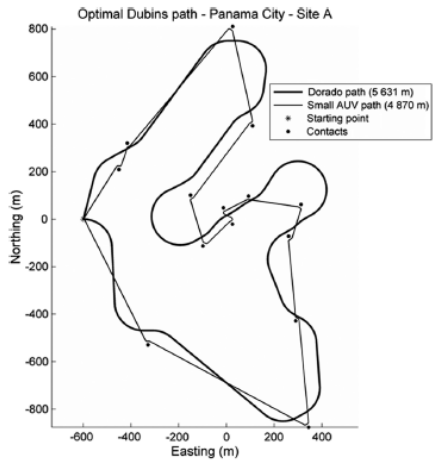


Solution

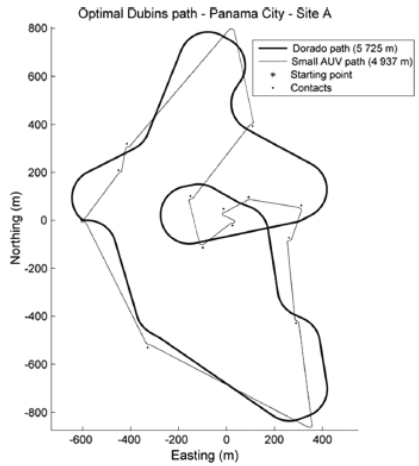
Landmark navigation

INTRODUCTION (5/5)

Revisit to improve the classification



Sequential algorithm. Site A: 14 targets to be revisited.

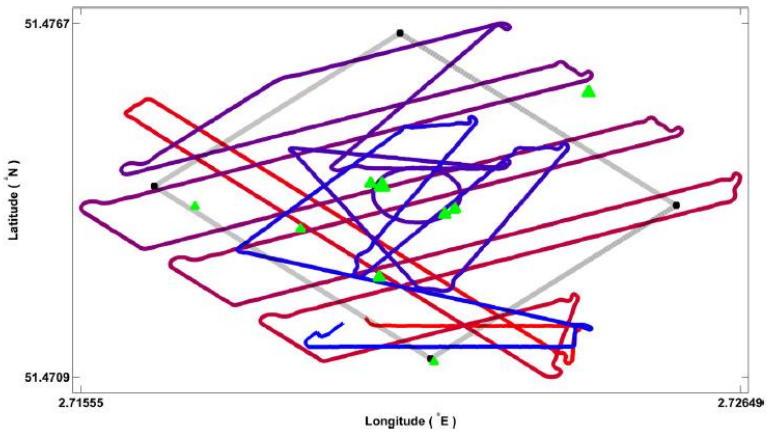


Simulated annealing. Site A: 14 targets to be revisited.

VEHICLE CONSTRAINTS

Operating constraints	Small AUV	DORADO
Minimum turning radius (m)	6	120
Operating speed (knots)	3	8
Minimum range (m)	8	20
Maximum range (m)	15	60
Straight line segments along targets (m)	10	40

M. Couillard, J. Fawcett, and M. Davison, “Optimizing constrained search
patterns for remote mine-hunting vehicles,”IEEE J. Ocean. Eng., vol. 37,no. 1, pp. 75–84, Jan. 2012.



D. Williams, F. Baralli, M. Micheli, and S. Vasoli, “Adaptive underwater sonar surveys in the presence of strong currents,” in Proc. IEEE International Conference on Robotics and Automation (ICRA), 2016, pp.
2604–2611.

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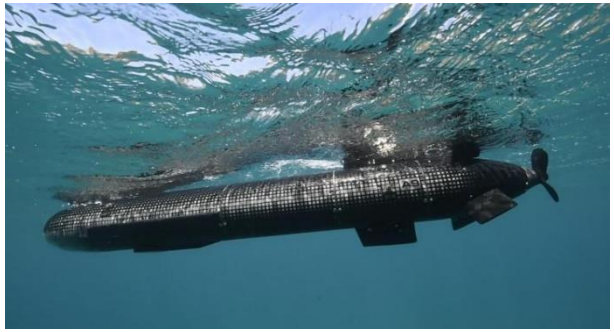
SYSTEM OVERVIEW (1/5)

2 underwater vehicles:

- Survey vehicle (high grade)



A9-M from ECA Group

Reliable navigation (INS+DVL)

Sidescan sonar (SSS)

- Revisit vehicle

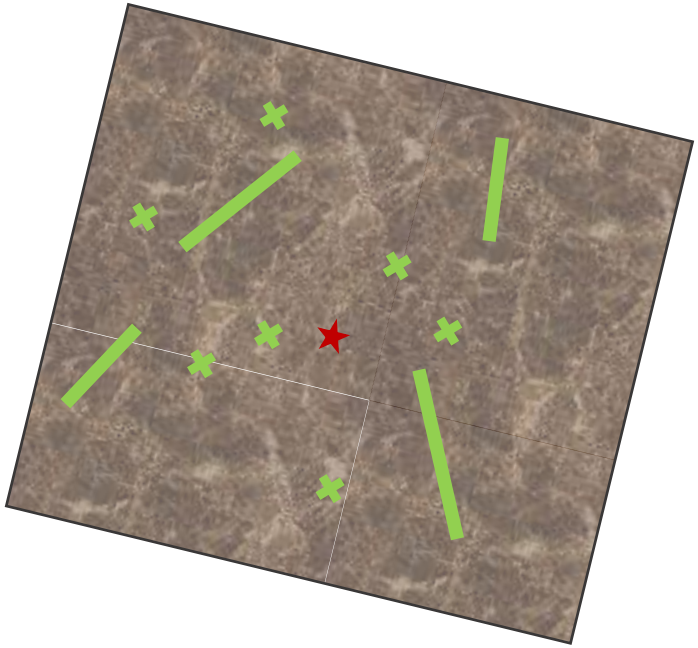
K-STER-I from ECA Group

Non reliable navigation: only a compass

Forward looking sonar (FLS)

SYSTEM OVERVIEW (2/5)

Environment with some landmarks and a potential dangerous object

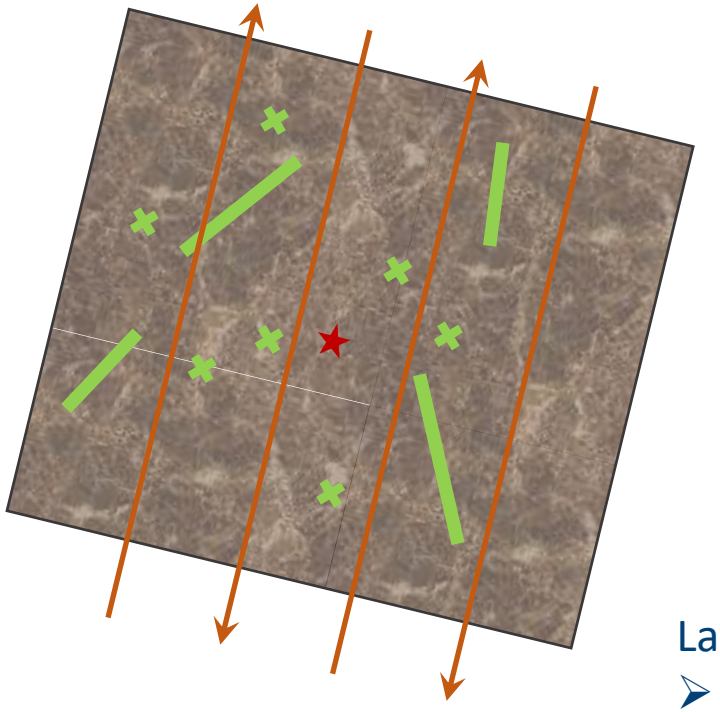


Landmarks (punctual, linear,…)

Potential dangerous object

SYSTEM OVERVIEW (3/5)

Survey mission and detection



Path

Landmarks detected in the sonar images

Potential dangerous object detected in sonar images

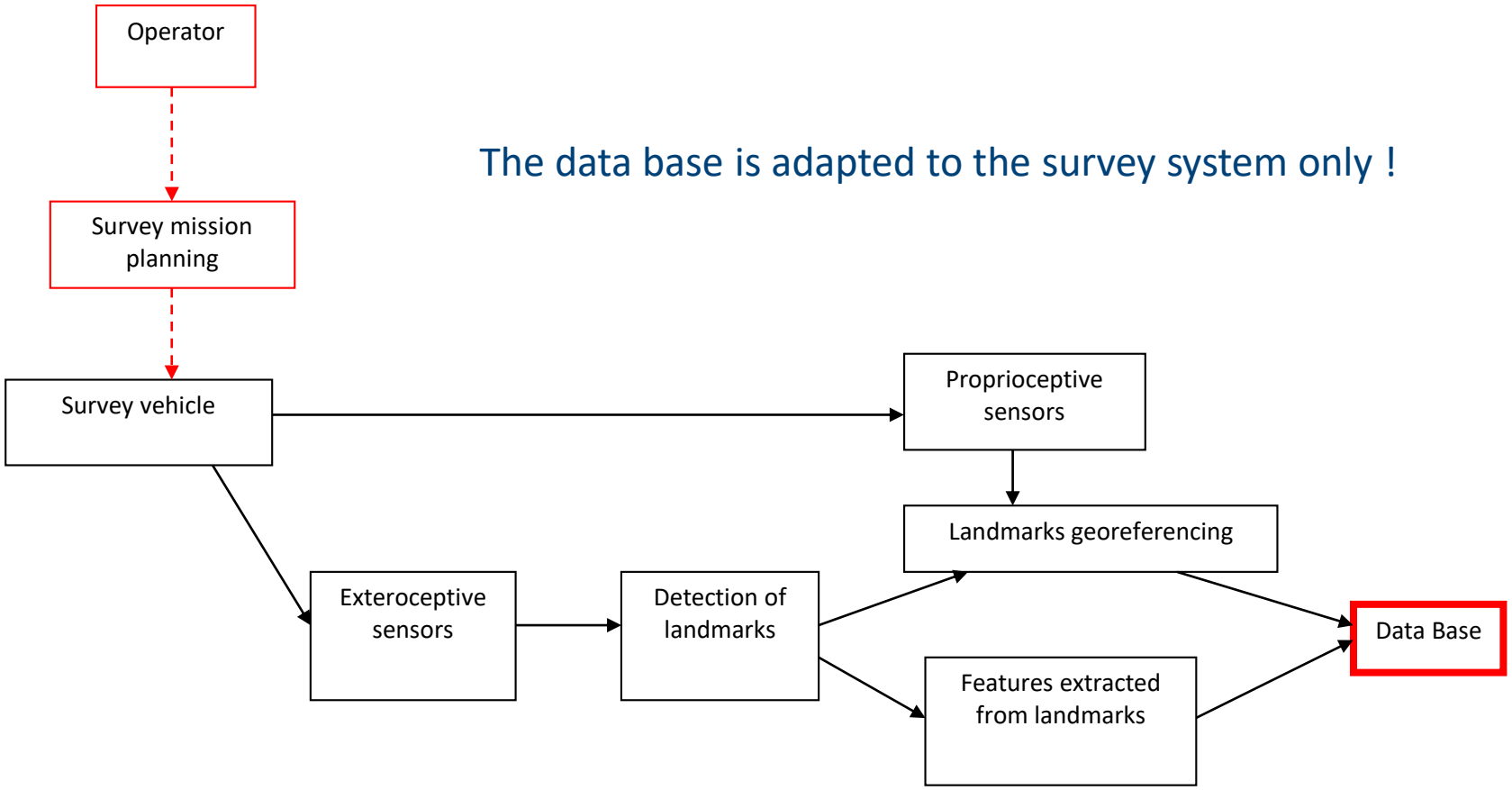
Landmarks detected with specific :

- Vehicle caracteristics (speed, altitude,…)
- Sensor caracteristics (frequency of ping emision, aperture angle,…)

SYSTEM OVERVIEW (4/5)

SURVEY MISSION DIAGRAM

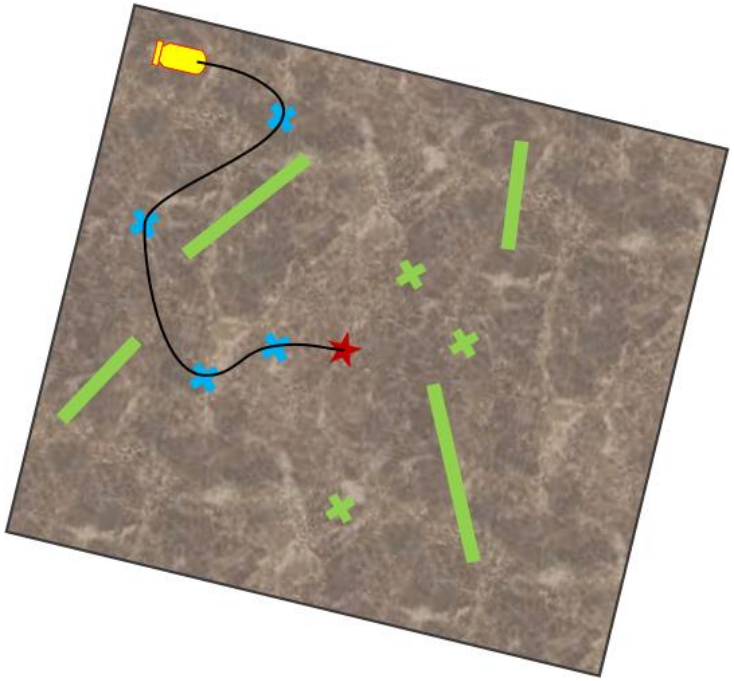
The data base is adapted to the survey system only !



Filter the data base according to the revisit system

SYSTEM OVERVIEW (5/5)

Strategy of revisit



Revisit stategy

Landmark selected for revisit

Potential dangerous object

Create a sequence of landmark revisit

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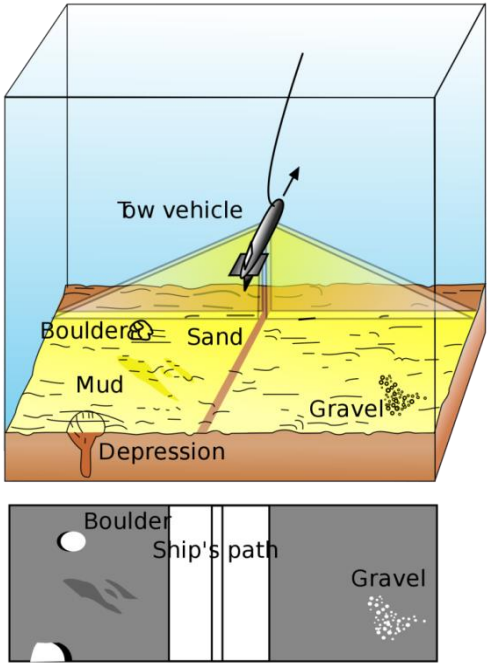
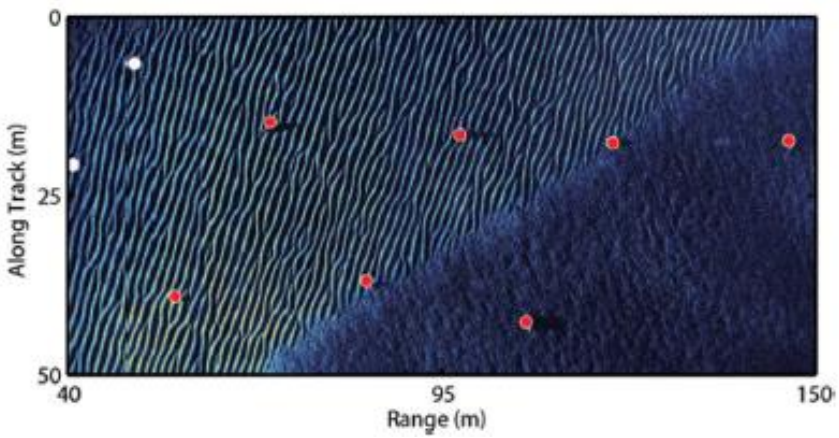
SONAR IMAGES AND DETECTION (1/3)

Survey with a sidescan sonar



wikipedia.fr

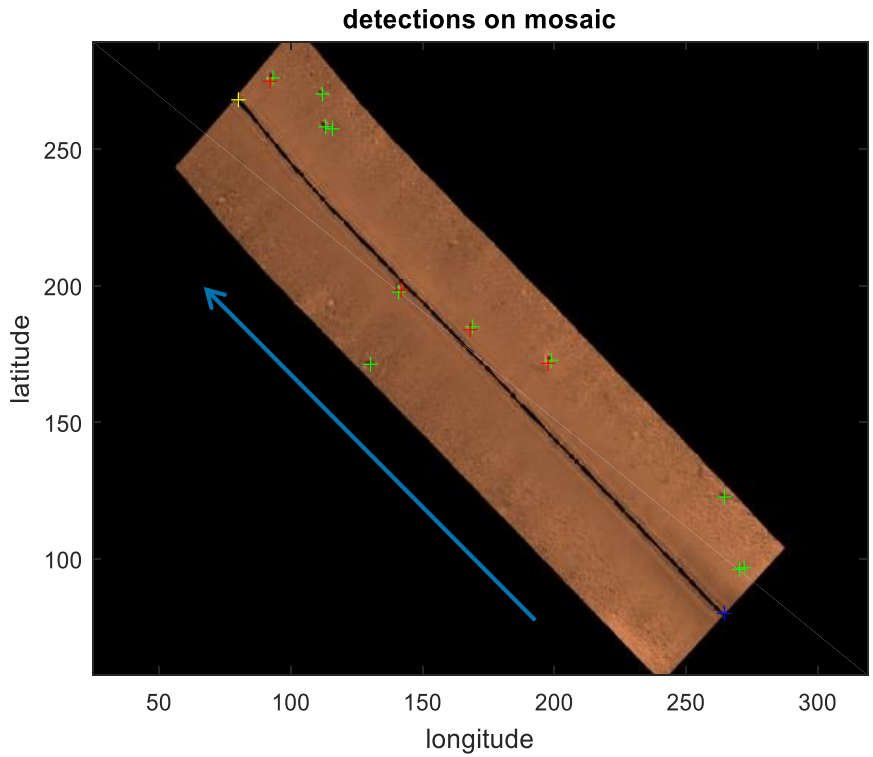
Algorithm of detection inspired by:

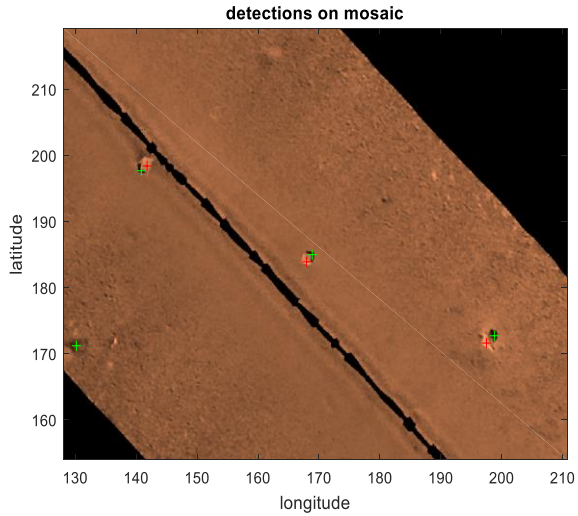


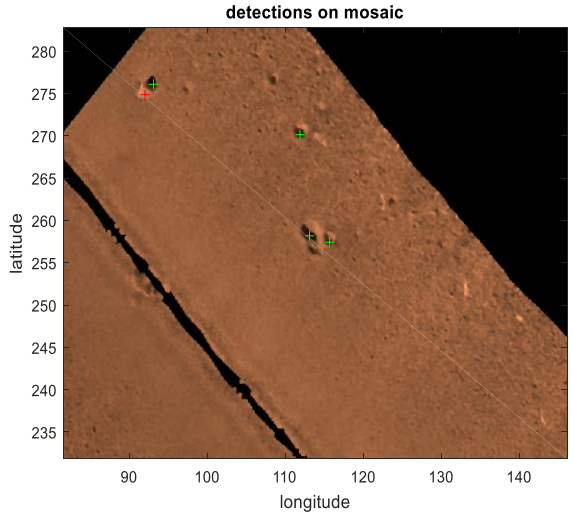
D. Williams, “Fast target detection in synthetic aperture sonar imagery: A new algorithm and large-scale performance analysis,” IEEE Journal of Oceanic Engineering, vol. 40, no. 1, pp. 71–92, 2015.

SONAR IMAGES AND DETECTION (2/3)

Results of the detection algorithm





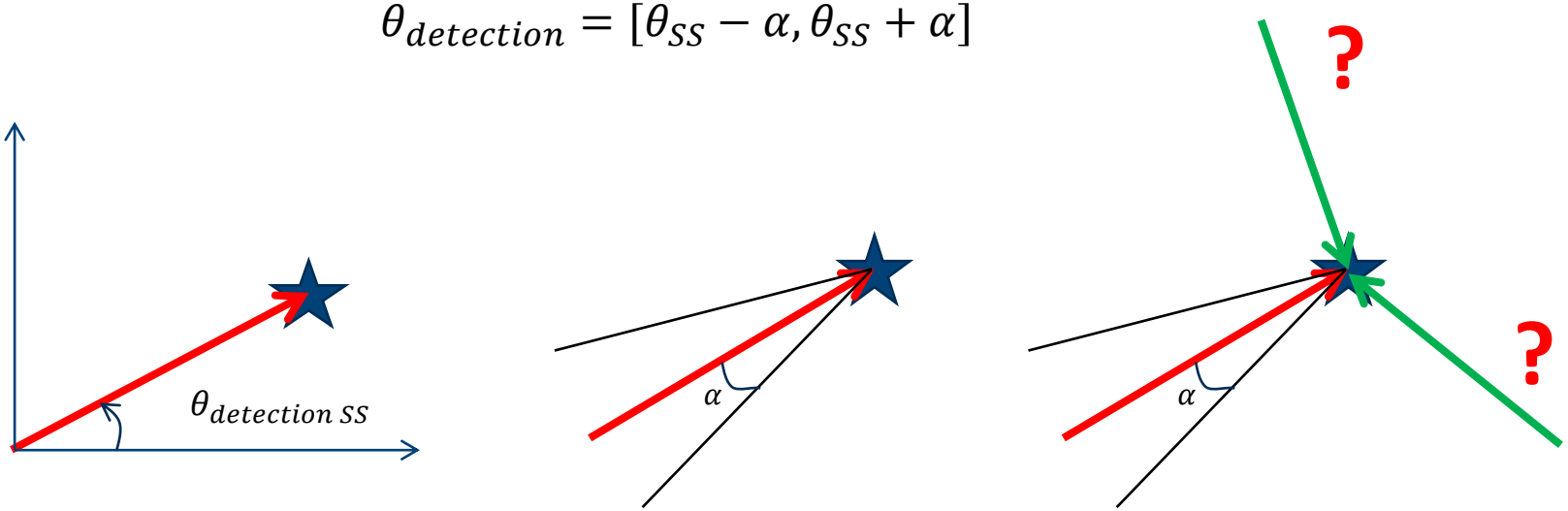


SONAR IMAGES AND DETECTION (2/3)

POINT OF VIEW AND ANGULAR FLEXIBILITY

Angular flexibility : a low flexibility does not change the classification

$$\theta_{detection} = [\theta_{SS} - \alpha, \theta_{SS} + \alpha]$$



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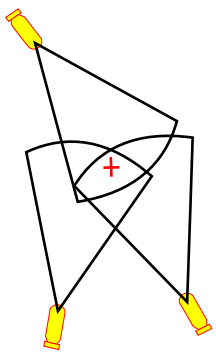
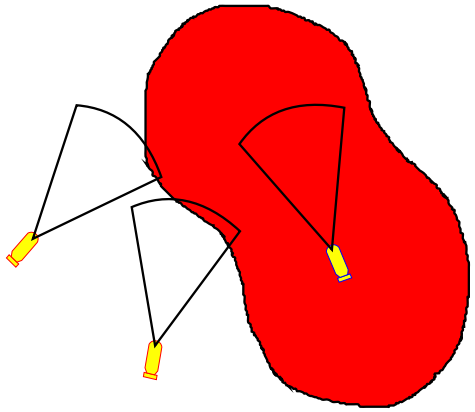
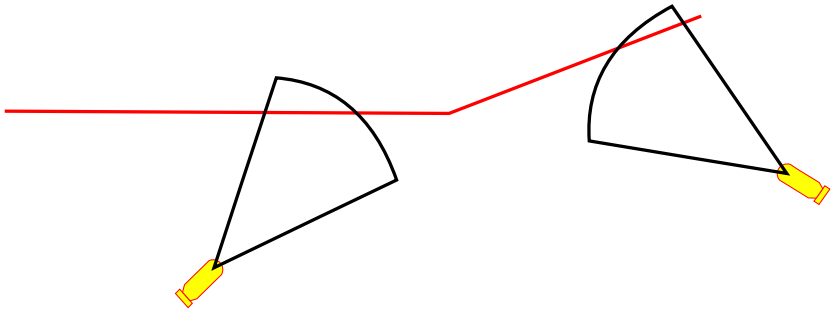
VARM (1/4)

Concept : For a system defined by a robot (speed, altitude,…) and its exteroceptive sensors (SSS, FLS,…), the VARM defines the set of the robot configuration (position and orientation) able to detect with its exteroceptive sensor if possible the landmark considered

Exteroceptive considered: 2D FLS



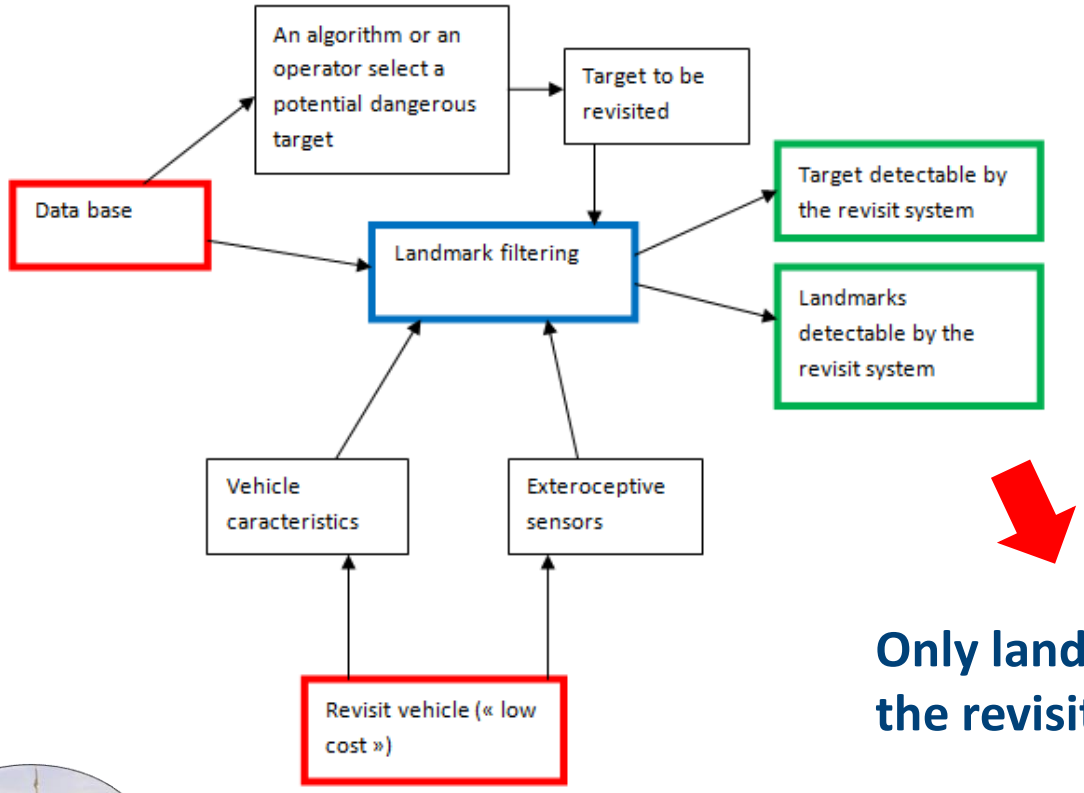




$$\boldsymbol{Visibility} = \left\{ (\boldsymbol{x}, \boldsymbol{y}, \boldsymbol{\theta}) \in \boldsymbol{R}^2 \times \boldsymbol{S}^1 \middle| \, \boldsymbol{landmark} \in \boldsymbol{Sensor\ Field\ of\ view} \right\}$$

VARM (2/4)

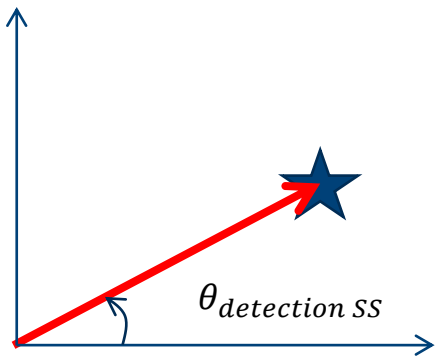
Filtering phase to adapt the data base to the revisit system



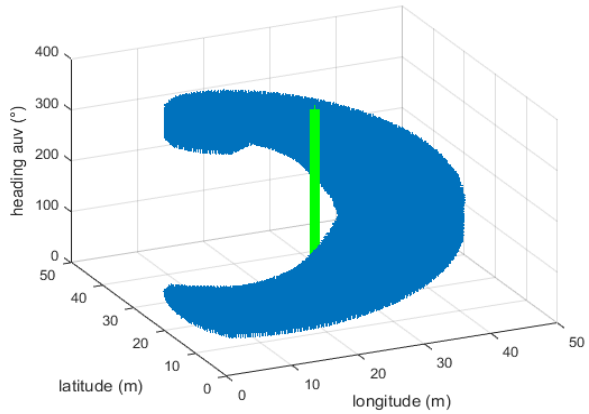
Only landmarks detectable by the revisit system

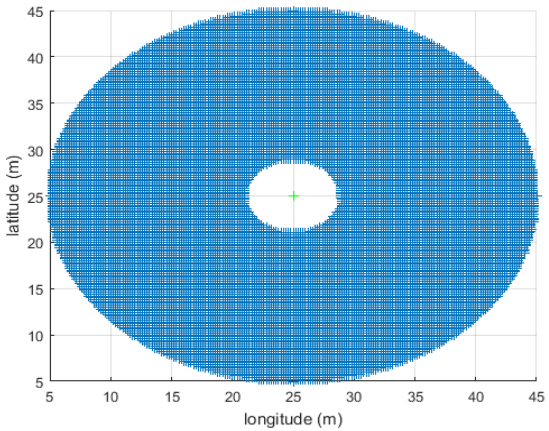
VARM (3/4)

Example with a punctual landmark located at (25,25)



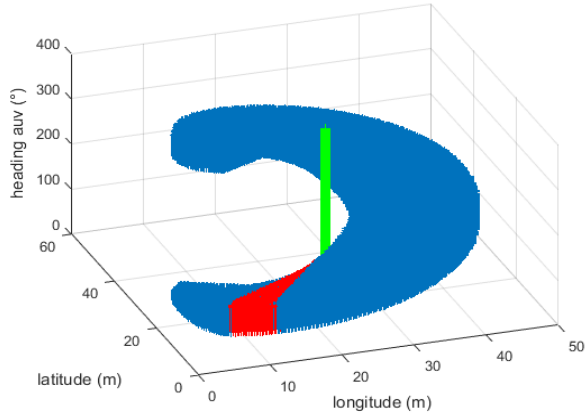
Angular flexibility : $\alpha = 10°$
$\theta_{detection\ SS} = 45°$

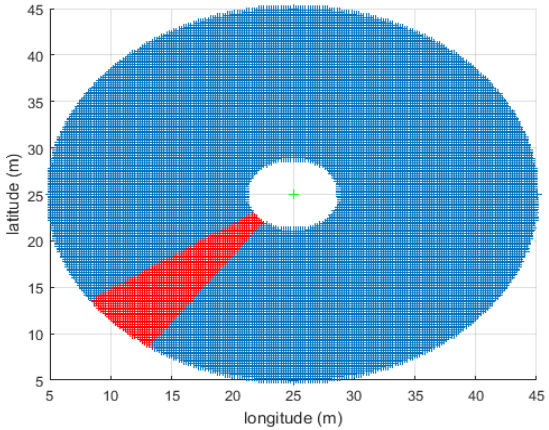




Exteroceptive sensor: FLS

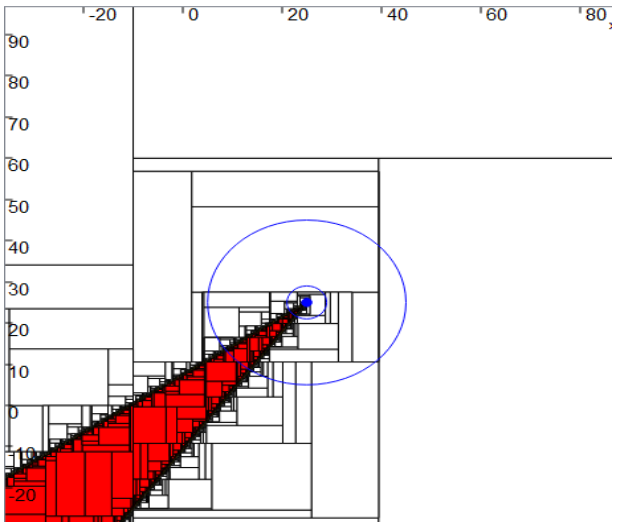
- Range minimum: 4 m
- Range maximum: 20 m
- Aperture angle: 60 °



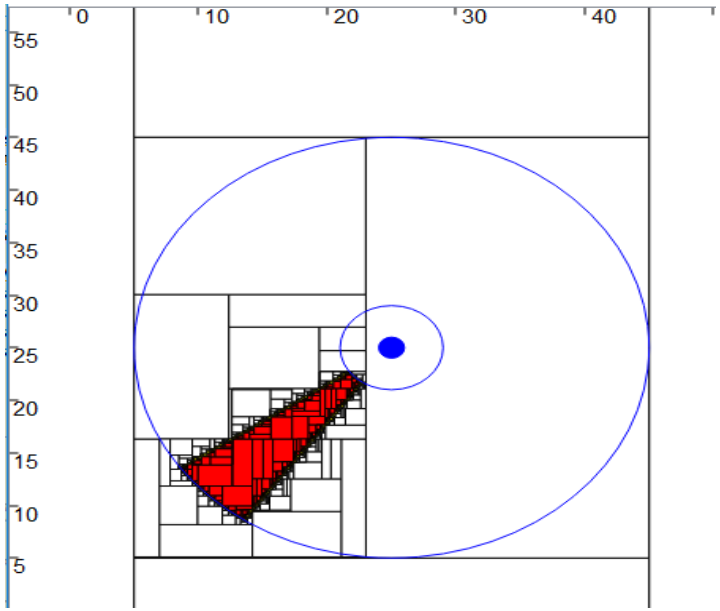


VARM (4/4)

Example with a punctual landmark located at (25,25)



Set membership approach with the use of constraints for the field of view and the angular flexibility



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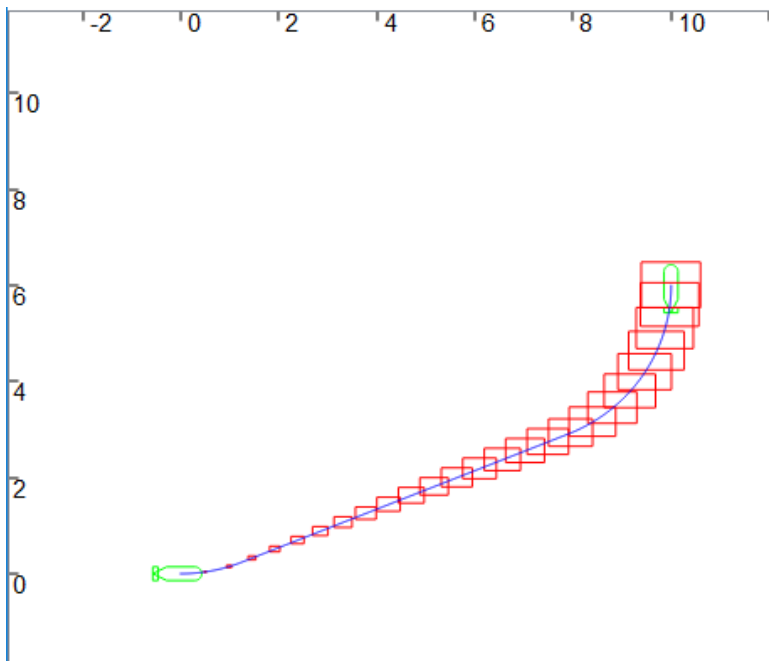
PATH PLANNING UNDER UNCERTAINTY (1/6)

Modelisation of the uncertainties by boxes



Dubin's path

Equation of evolution

$$\begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{pmatrix} = \begin{pmatrix} v \times \cos(\theta) \\ v \times \sin(\theta) \\ w \end{pmatrix}$$

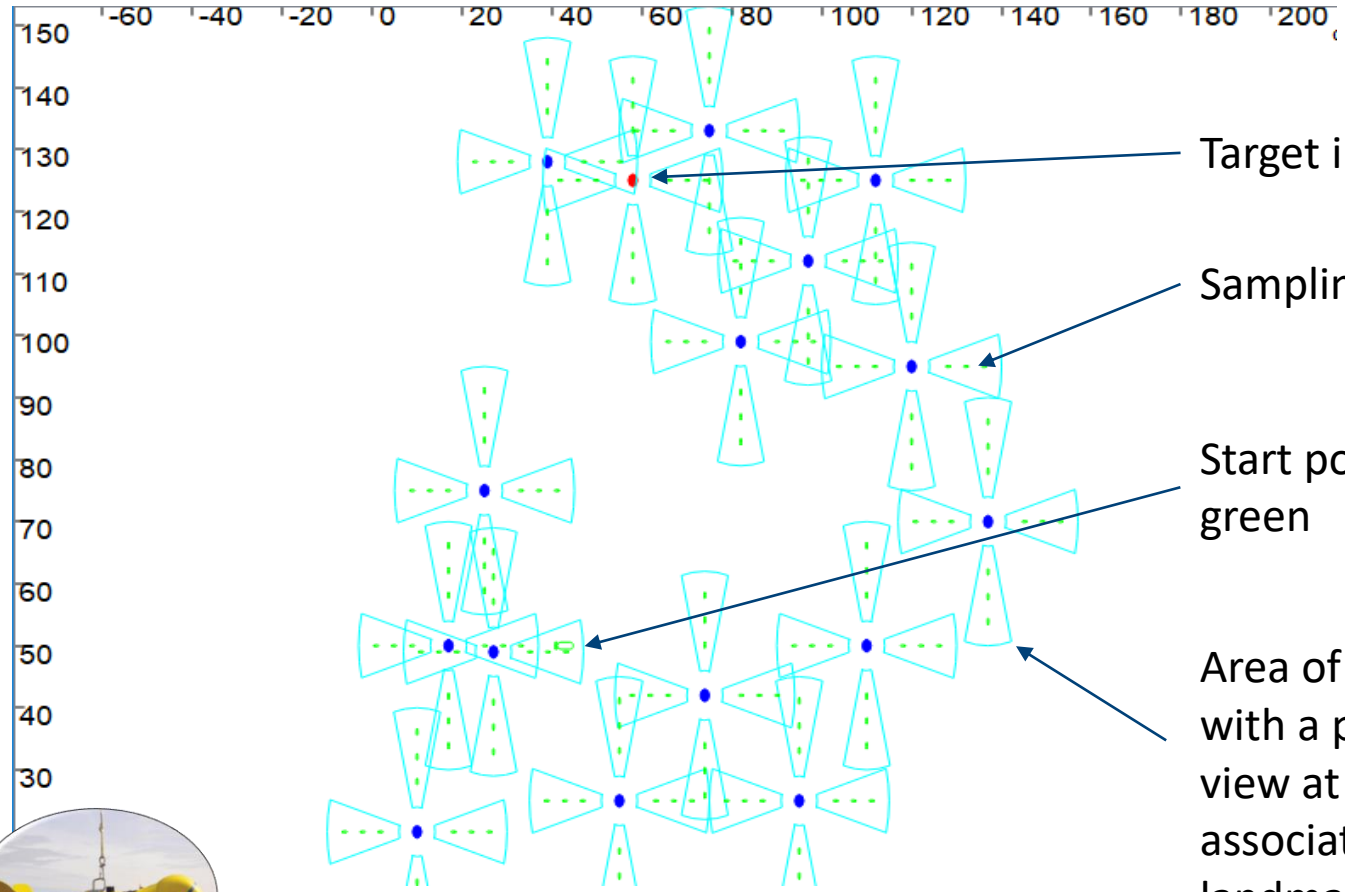
Minimum turning radius

$$r = \frac{V_{linear}}{W_{max}}$$

Uncertainties on V and θ (heading)

PATH PLANNING UNDER UNCERTAINTY (2/6)

Environment of punctual landmarks



Target in red

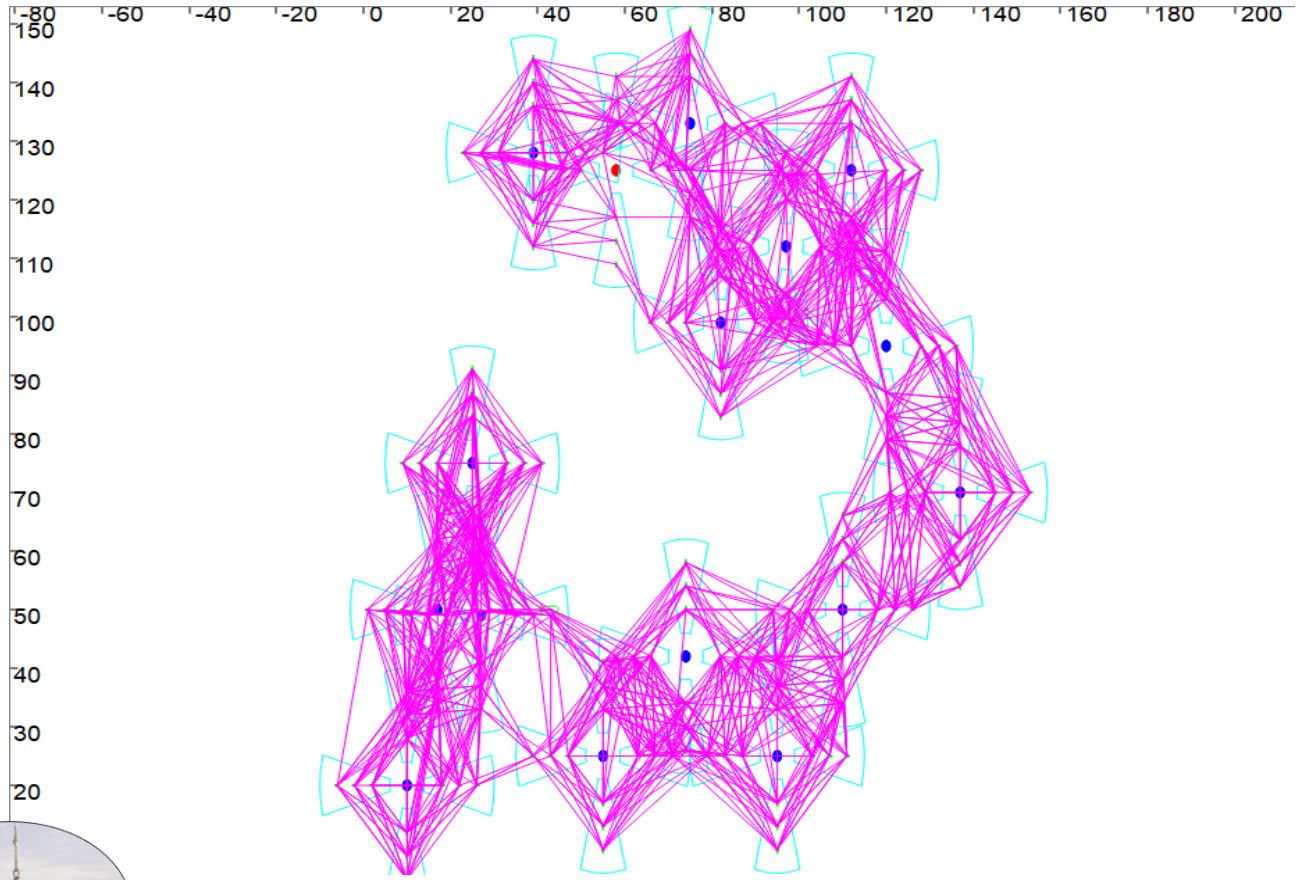
Sampling strategy

Start position in green

Area of relocation with a point of view at 90° for the associated landmark in blue

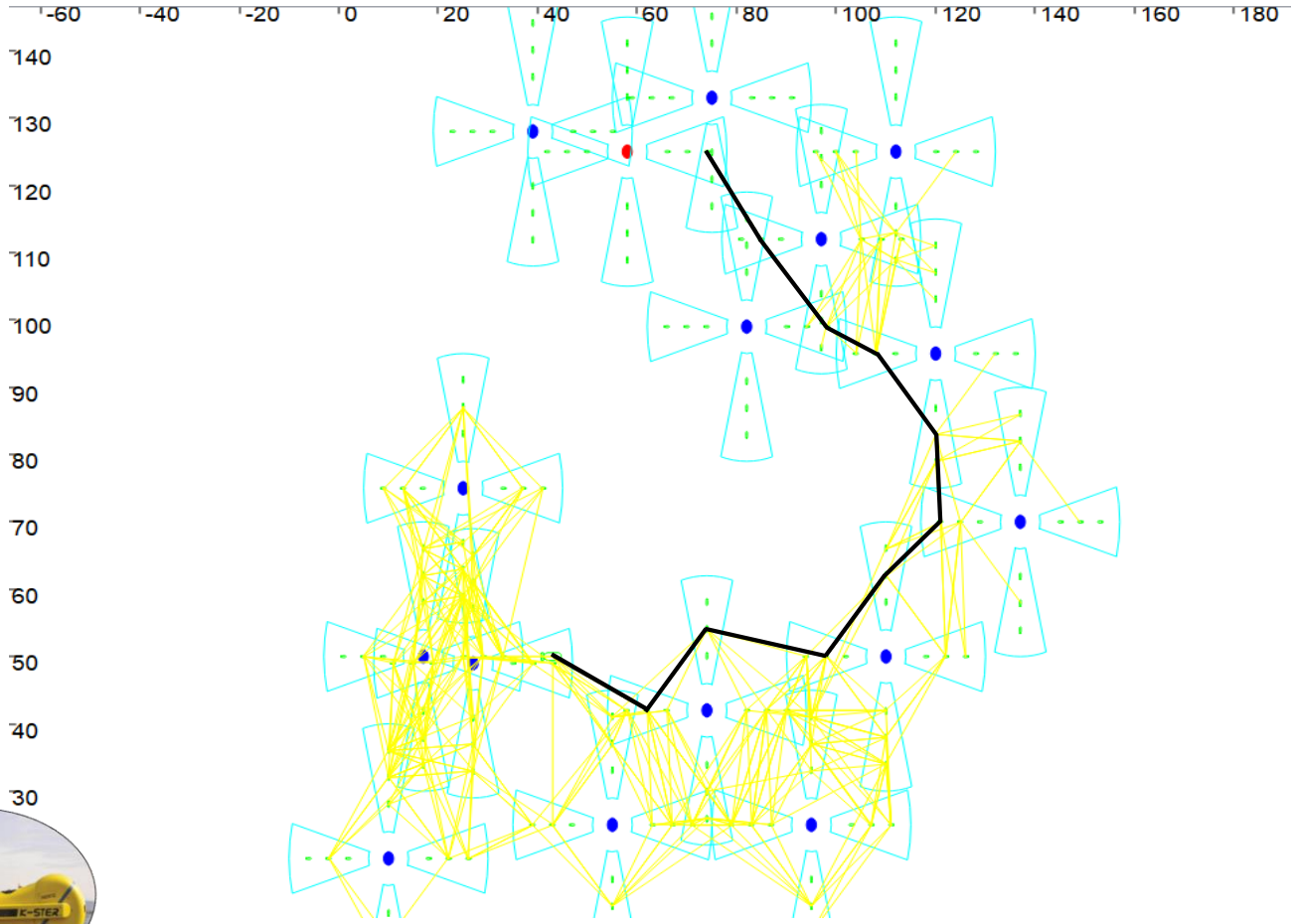
PATH PLANNING UNDER UNCERTAINTY (3/6)

Potential links with K-nearest links based on Dubin's distance



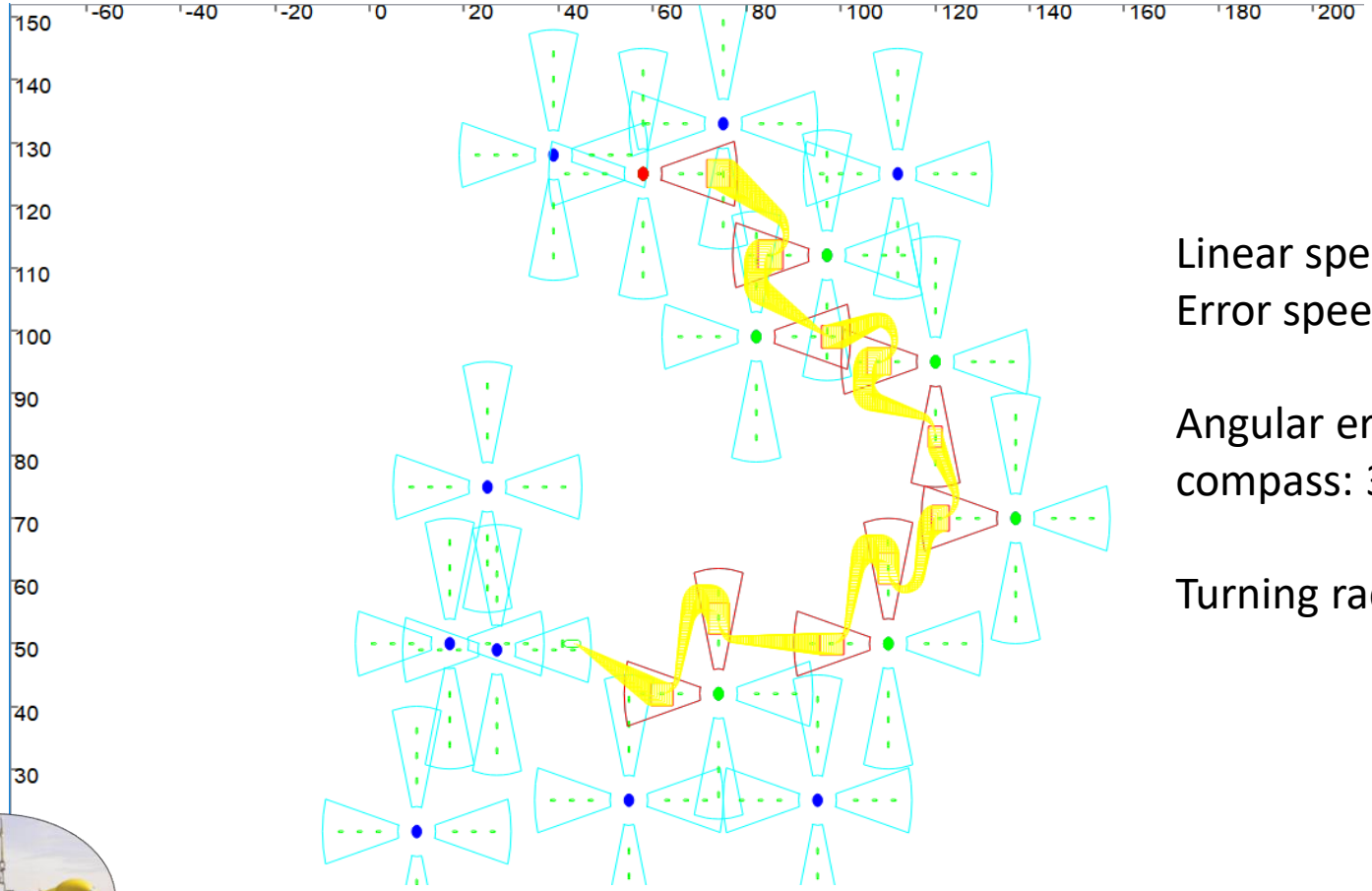
PATH PLANNING UNDER UNCERTAINTY (4/6)

Forward propagation with A* graph search



PATH PLANNING UNDER UNCERTAINTY (5/6)

Path found with uncertainty propagation



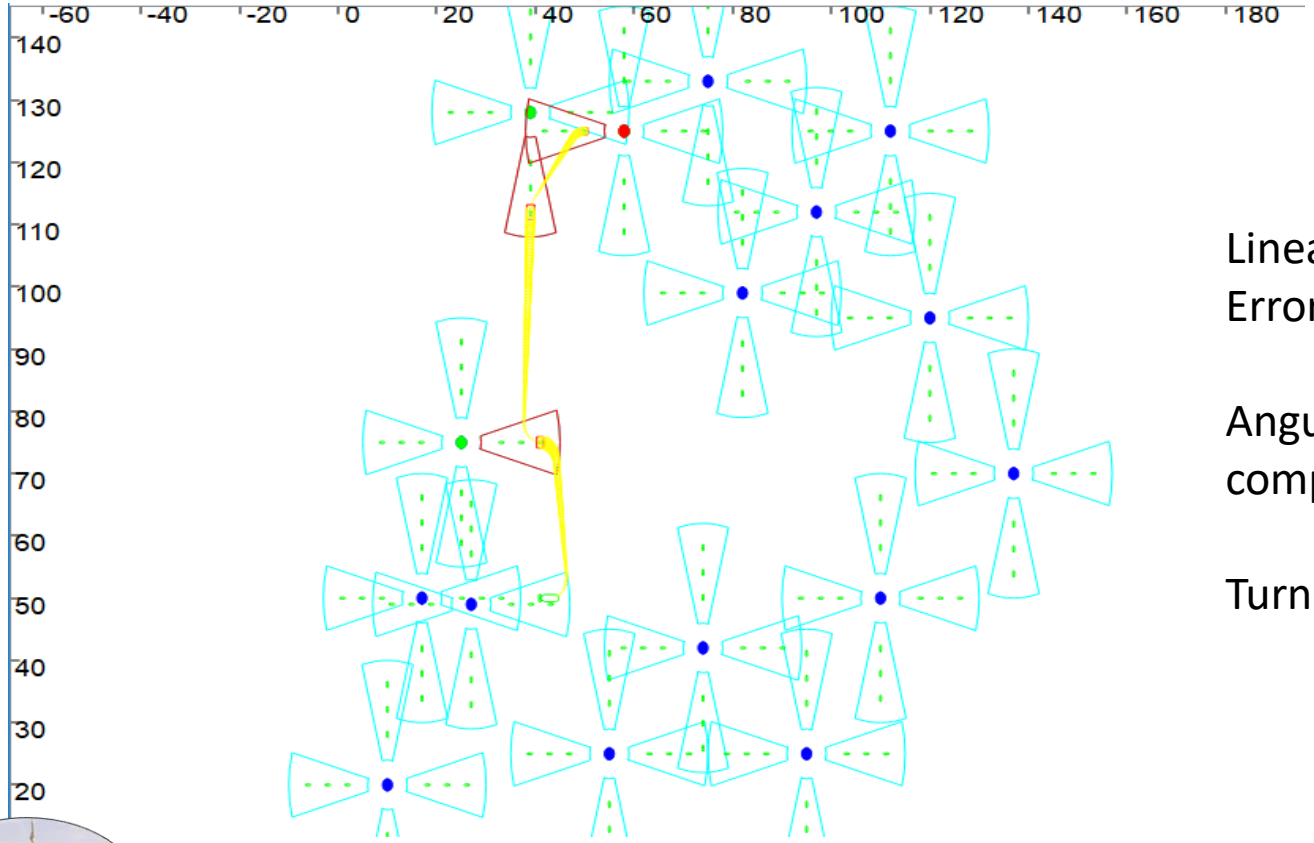
Linear speed v: 1m/s
Error speed: 10%

Angular error on compass: 3°

Turning radius: 3m

PATH PLANNING UNDER UNCERTAINTY (6/6)

Path found with uncertainty propagation



Linear speed v: 1m/s
Error speed: 3%

Angular error on compass: 1°

Turning radius: 3m

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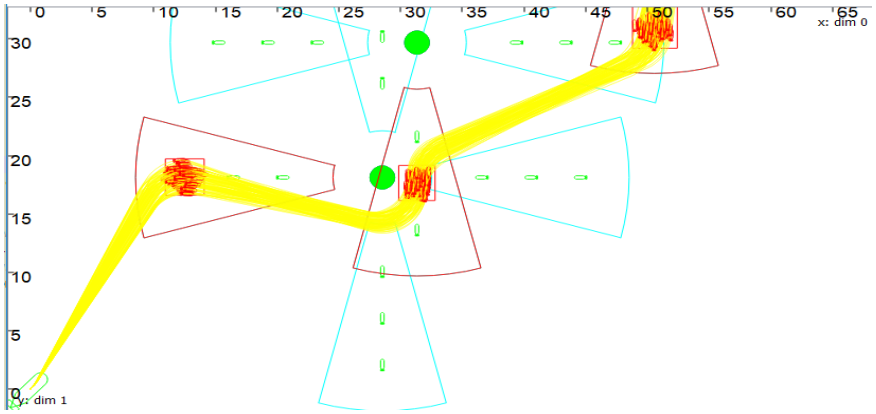
CONCLUSION

The algorithm proposes:

- A multimodality of sensors
- The point of view of landmarks
- VARM according to a second vehicle caracteristics
- Find a path strategy under uncertainty (high drift) to see again a target

Perspective:

- In reality the robot drifts from the trajectory and could miss a relocation area



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make sure

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