TOULOUSE INP N7

Modifying the trajectory of a drone following a reconfiguration of the airspace

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Context of the project

- Increase in the use of drones :
  - surveillance
  - mapping
  - data collection
  - delivery…
- Any regulations ?
  - yes, for civilians
  - unclear for large number of drones
  - or for automated / out of sight drones

A need for new regulations : U-Space project

U-space

European Commission

sesar
JOINT UNDERTAKING

EASA
European Aviation Safety Agency

The U-Space services

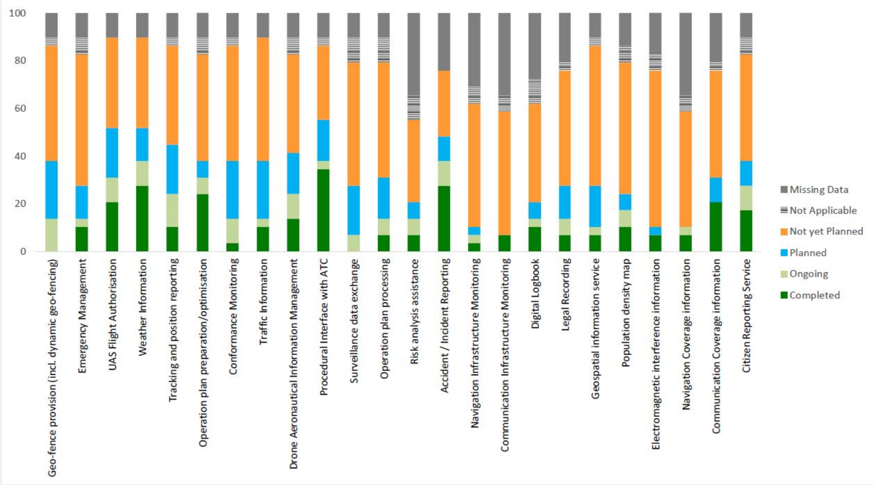
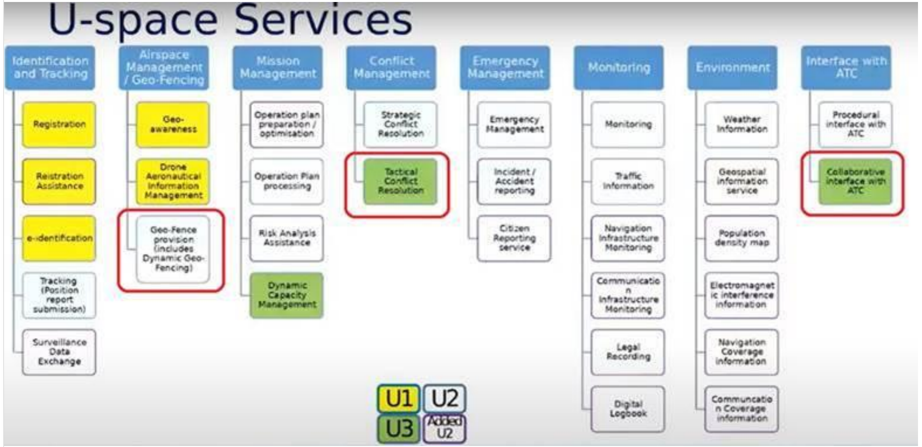


Figure 2. U2 services – readiness to implement



U-space Services

Identification and Tracking
- Registration
- Reistration Assistance
- e-identification
- Tracking (Position report submission)
- Surveillance Data Exchange

Airspace Management / Geo-Fencing
- Geo-awareness
- Drone Aeronautical Information Management
- Geo-Fence provision (includes Dynamic Geo-Fencing)

Mission Management
- Operation plan preparation / optimisation
- Operation Plan processing
- Risk Analysis Assistance
- Dynamic Capacity Management

Conflict Management
- Strategic Conflict Resolution
- Tactical Conflict Resolution

Emergency Management
- Emergency Management
- Incident / Accident reporting
- Citizen Reporting service

Monitoring
- Monitoring
- Traffic Information
- Navigation Infrastructure Monitoring
- Communicatio n Infrastructure Monitoring
- Legal Recording
- Digital Logbook

Environment
- Weather Information
- Geospatial information service
- Population density map
- Electromagnet ic interference information
- Navigation Coverage information
- Communcatio n Coverage information

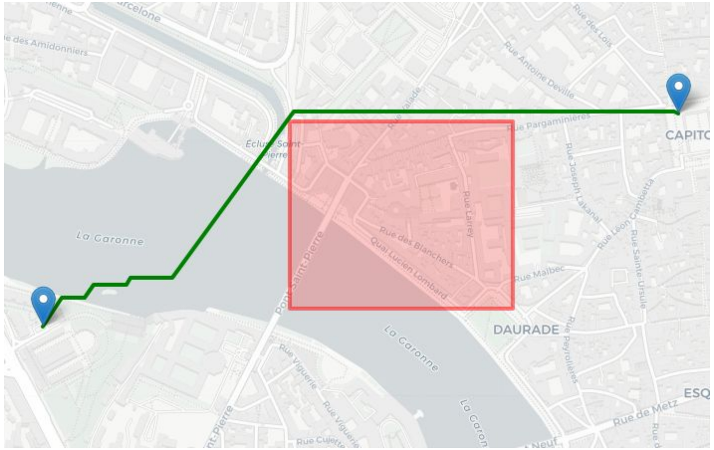
Interface with ATC
- Procedural interface with ATC
- Collaborative interface with ATC

U1 U2
U3 Added U2

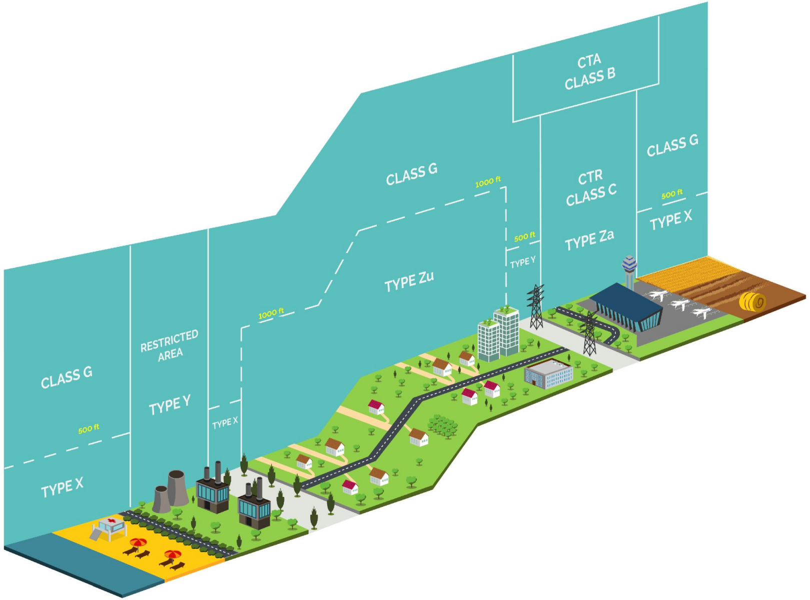
Graph of the readiness of U2 services

Chart of the U-Space services

Objectives and scope



Trajectory modification



Geofencing

Plan

1 - Introduction

2 - Work Organization and task planning

3 - Development Tools and versioning

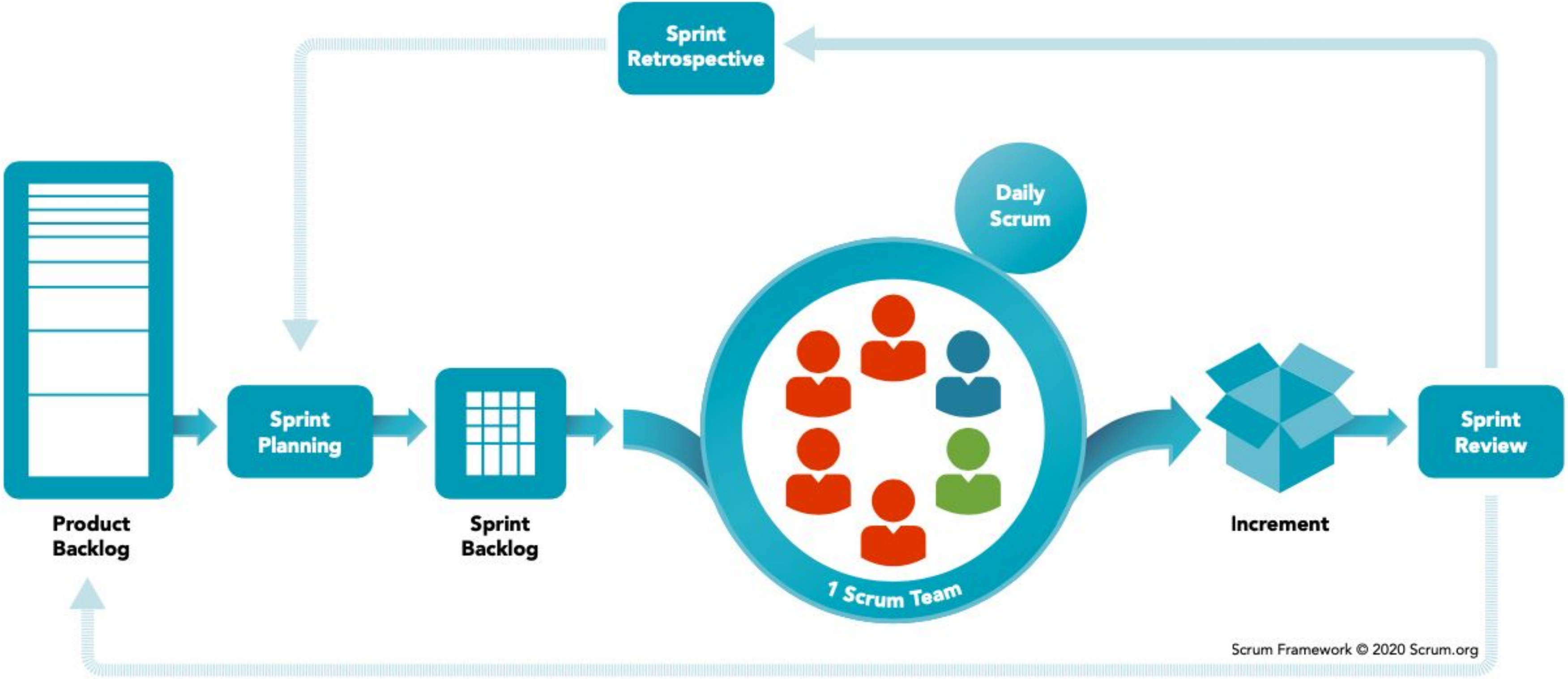
4 - Algorithm

5 - Demonstration

6 - Conclusion

Work Organization and Task Planning

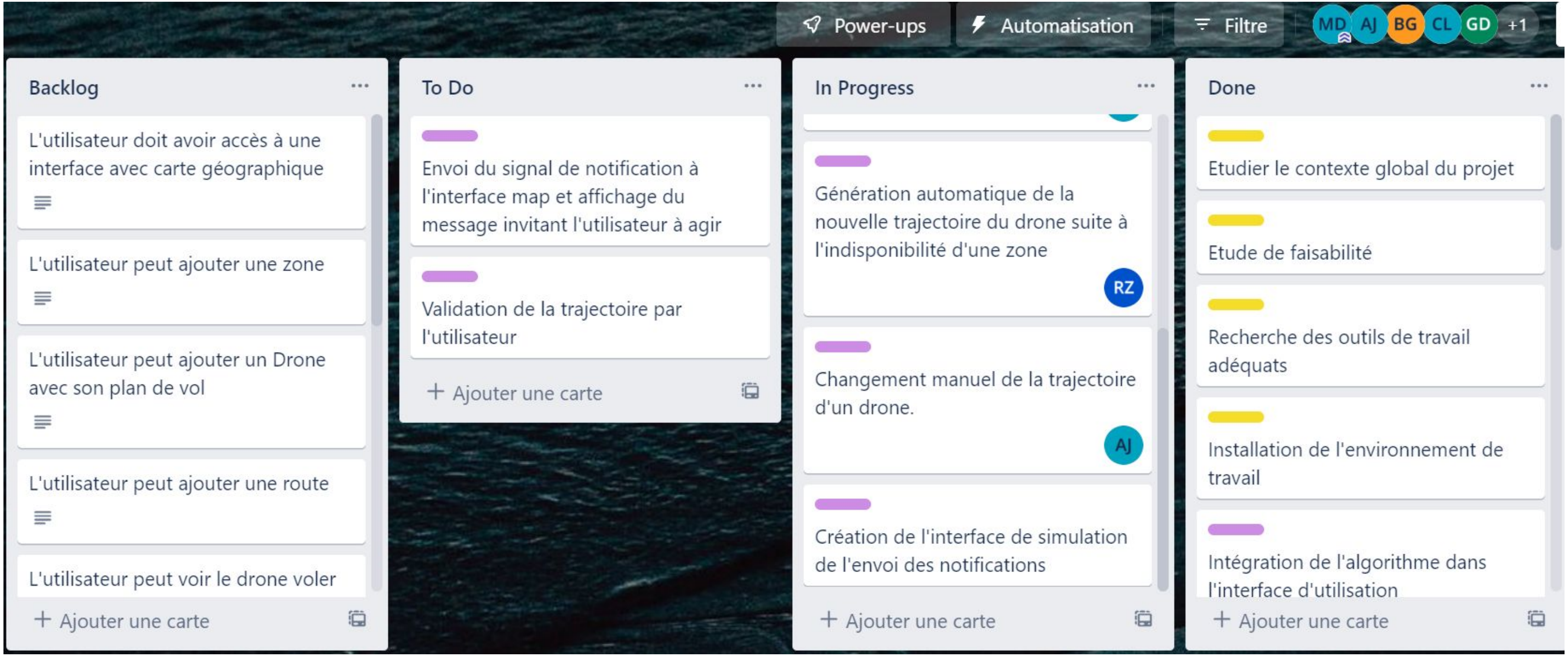
Development Cycle : Agile methodology (Scrum)



Scrum Framework © 2020 Scrum.org

Development cycle

Trello



Power-ups

Automatisation

Filtre

MD AJ BG CL GD +1

Backlog

- L'utilisateur doit avoir accès à une interface avec carte géographique
- L'utilisateur peut ajouter une zone
- L'utilisateur peut ajouter un Drone avec son plan de vol
- L'utilisateur peut ajouter une route
- L'utilisateur peut voir le drone voler

+ Ajouter une carte

To Do

- Envoi du signal de notification à l'interface map et affichage du message invitant l'utilisateur à agir
- Validation de la trajectoire par l'utilisateur

+ Ajouter une carte

In Progress

- Génération automatique de la nouvelle trajectoire du drone suite à l'indisponibilité d'une zone RZ
- Changement manuel de la trajectoire d'un drone. AJ
- Création de l'interface de simulation de l'envoi des notifications

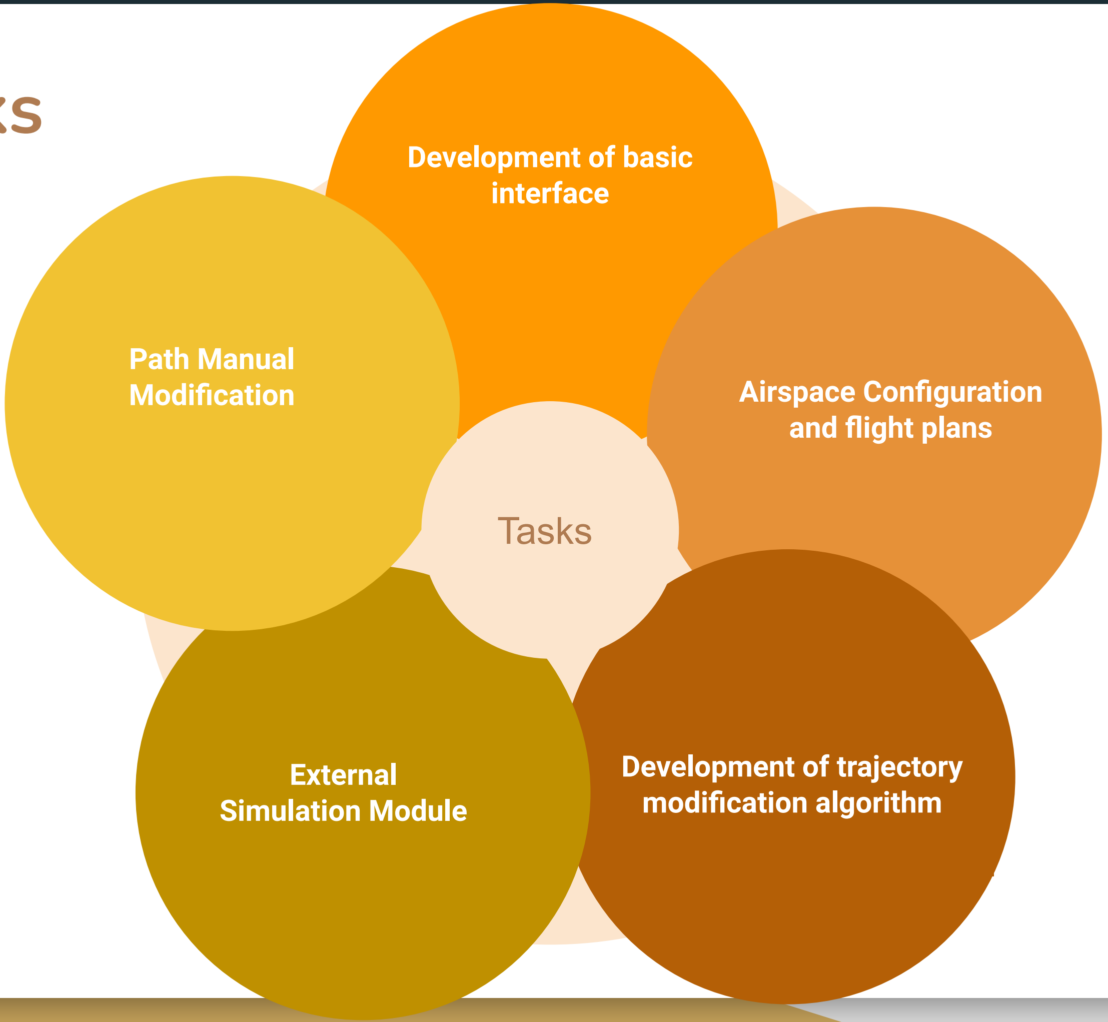
+ Ajouter une carte

Done

- Etudier le contexte global du projet
- Etude de faisabilité
- Recherche des outils de travail adéquats
- Installation de l'environnement de travail
- Intégration de l'algorithme dans l'interface d'utilisation

+ Ajouter une carte

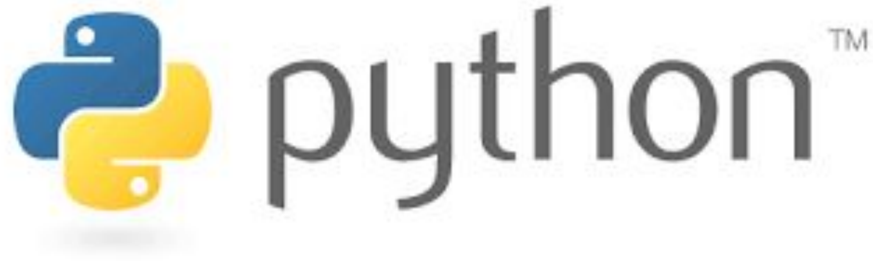
Parallelized Tasks


Development of basic interface
Path Manual Modification
Airspace Configuration and flight plans
Tasks
External Simulation Module
Development of trajectory modification algorithm

Development Tools

Main development Language

- – Simple
- – Versatile
- – Ease of development



GUI

PyQt was used as a framework for the GUI ,since

the development was used with Python,PyQt was the

optimal answer as it is a Python GUI library

that creates rich and interactive interfaces for python

applications .

API used to display interactive maps

Leaflet.js offers an easy to use and interact with maps,it’s also very lightweight and fast,plus it has great synergy with Qt channel ,which enables us to visualize geospatial data in PyQt applications .

Versioning

– Track and manage changes to our codebase .

–Three main branches:

- Master branch which holds the official release

history and the release tag that identifies the different releases.

- Dev branch contains all new features being developed and merged.
- Feat branch which spawns feature branches following a naming convention : feat/featureName.

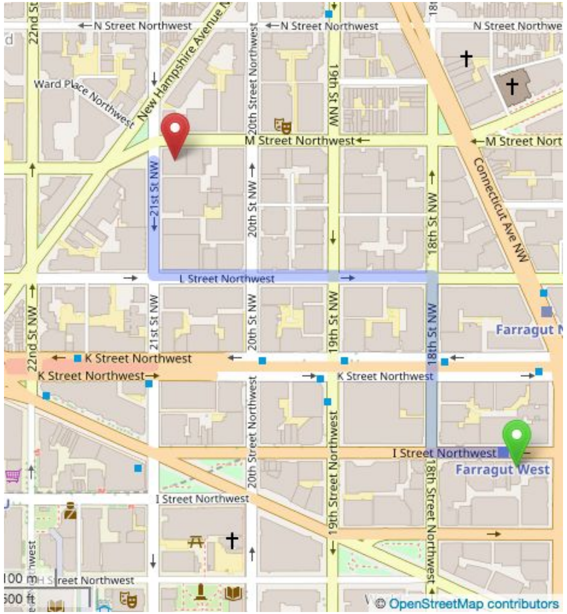
Path Finding Algorithm

What is the A* Algorithm ?

- A* is an extended BFS algorithm that finds the shortest path from a point A to a point B in a graph.

- A* is optimal.(gives the best solution).

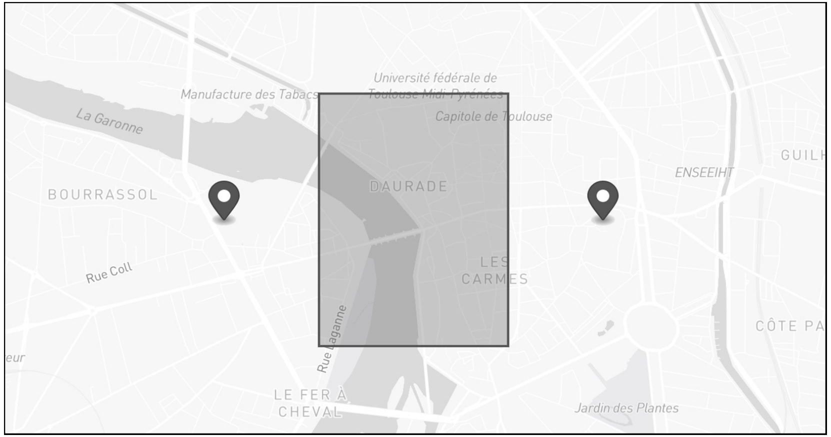
- A* is complete(finds all the possible solutions).

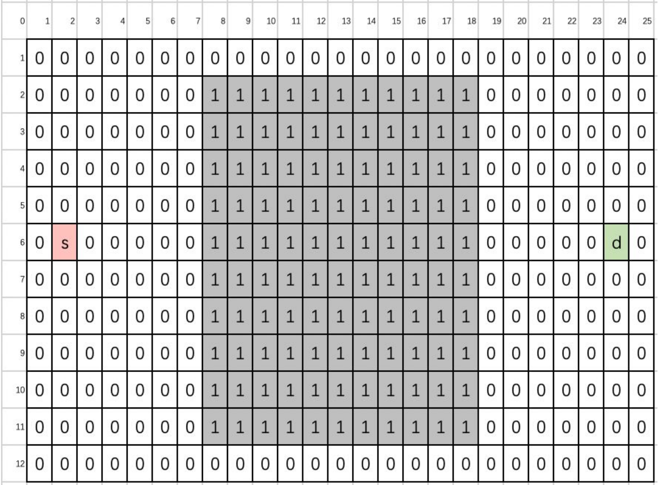


How does the A* work?

It uses a heuristic function to estimate the cost of reaching the target node for example euclidean distance.
The algorithm maintains a priority queue to explore neighboring nodes in order of their estimated cost.
It avoids exploring already explored nodes and updates the priority of nodes with lower estimated cost.
The A* algorithm maintains a closure set to keep track of nodes that have already been explored and ensures that each node is explored only once.

Implementation of A* algorithm in a grid





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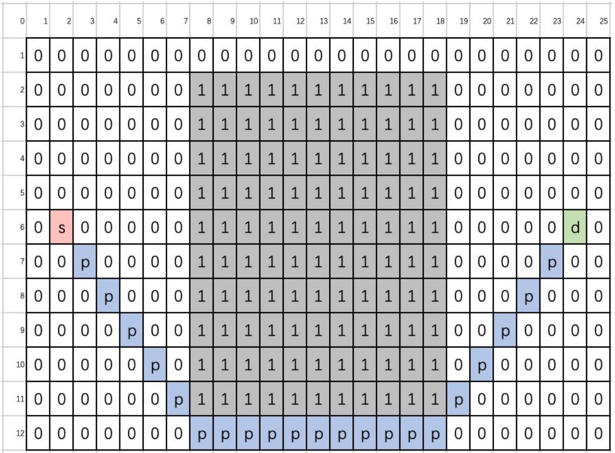
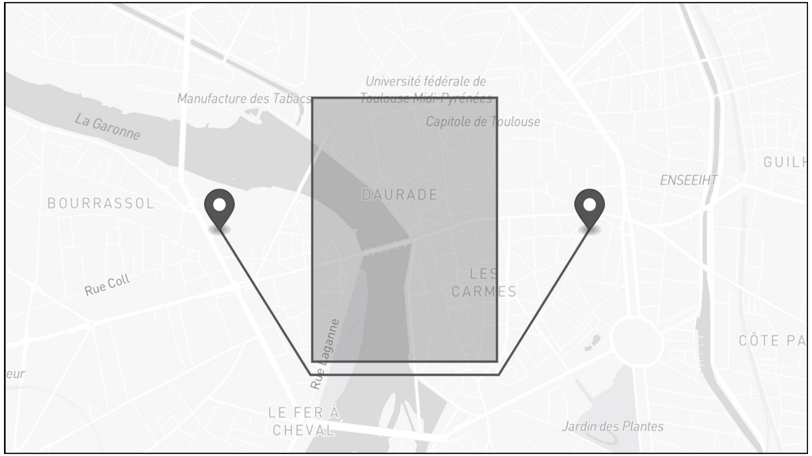
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
6	0	s	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	d	0
7	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Visualization of the grid and the A* algorithm



0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
6	0	s	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	d	0
7	0	0	p	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	p	0	0
8	0	0	0	p	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	p	0	0	0
9	0	0	0	0	p	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	p	0	0	0	0
10	0	0	0	0	0	p	0	1	1	1	1	1	1	1	1	1	1	1	0	p	0	0	0	0	0
11	0	0	0	0	0	0	p	1	1	1	1	1	1	1	1	1	1	1	p	0	0	0	0	0	0
12	0	0	0	0	0	0	0	p	p	p	p	p	p	p	p	p	p	p	0	0	0	0	0	0	0



Complexity

Metric	Complexity
Time	O(b^d)
Space	O(n)

Where:

b: branching factor (maximum number of successors for any node)
d: depth of the shortest path from start node to goal node
n: number of nodes explored in the search

Demonstration

Conclusion

Overall..

- A functional GUI
- Create drones’ paths
- Create obstacles
- Simulate and control drones’ flight in real time
- Modify drones’ flight plan mid-flight

Future prospects

- Integration of a notification system
- Upgrading to a 3D map
- Simulation of multiple drones

Soft skills

- Communication
- Collaboration and conflict resolution
- Time management
- Flexibility

Thank you for your attention!