RoboCup Rescue 2022
Draft Rulebook
Part 6: Exploration and Mapping

Version 2022-04-20.

History

- 2022-04-16 Added comments (Johannes)
- 2022-04-20 Reworked structure and added format specifications (Martin)

Exploration and Mapping Tests:

5 tests for mapping, object/terrain recognition and detection (all tests are considered for a robot to win Best in Class Autonomy, but only if the tests are performed autonomously). These tests will only be available at the in-person event. A separate test suite for remote participation is described in Distributed Exploration and Mapping Tests.

For the mapping tasks (EXP1, EXP2 and EXP3) the following rules apply:
- Provide a map as geotiff in the correct format (see Map Format). We will only accept a single 2D map per repetition; if your robot produces multiple maps, provide us with the best one. Turn in the file not later than 10 minutes after you finished your mission on a USB stick provided by the organizers.
- Areas mapped in 3D will get extra points. For that provide 2 files: 1) a 3D point cloud either as (pcd) [http://www.pointclouds.org/documentation/tutorials/pcdfileformat.php] or as (Octomap .ot or .bt) [https://github.com/OctoMap/octomap]. 2) provide a slice of a 2D map in geotiff at a height of 2.2m.

(EXP 1) Map on Continuous Ramps

Motivation:
Create a 2D and/or 3D map of a dark labyrinth while traversing modest ground complexity. This capability has to be an autonomous background service for teleop or autonomous robots. Inside the arena, half round shaped fiducials will be placed on opposite sides of walls and on different heights. These fiducials have to be clearly visible as a full circle on the 2D map. Maps

will only be scored, if they are not broken (wrong geometry, double walls, strongly curved walls). Extra points for 3D mapping will be awarded by additionally scoring the upper level maps.

Procedure:
1. Ready the robot in the start square.
2. The trial starts once the start signal is given or the timer is started.
3. Drive through the arena to map the environment.
4. The repetition is finished when the robot has created a complete map of the arena.
5. Record one scored point per full fiducial circle in the map. Score may be counted after the mission based on the provided maps.
6. Save and clear the map, then start a new repetition from the current position of the robot.
7. Repeat until the end signal or the timer has elapsed. Unfinished maps do not contribute towards the score.

(EXP 2) Map on Crossing Ramps

Motivation:
Create a 2D and/or 3D map of a dark labyrinth while traversing increased ground complexity. This capability has to be an autonomous background service for teleop or autonomous robots.

Procedure: Same as EXP 1

(EXP 3) Recognize Objects

Motivation:
Detect and locate different objects of interest in a maze. This capability has to be an autonomous background service for teleop or autonomous robots. Some items will be in the maze multiple times (e.g. hazmat signs), others rather rare (e.g. door). Show the detection live in the GUI and identify the object by name, e.g. "Oxidizer". Points will be adjusted accordingly (for example, hazmats might get 1 point, doors 5 points). The points are doubled if the identified object is marked at the correct location in the map (within 1 m of the true position). Points will be deducted for wrongly detected or located objects. The identified objects in the map have to be numbered and colored according to the standard (see Mapping Capabilities and 2D Map Format). There has to be a corresponding text file with the object number, the object type, the time they were found and location (see Identified Objects Format).

Objects for EXP 3 to be recognized in 2022:
● Fire Extinguisher
● Door
● Valves
● Baby dolls
● Hazmat Signs (see list on the RRL web site)

- QR codes (read the QR code)
- Exit signs; green (according to the standard of the country the competition is held in; 2019 for example: https://www.australiansafetysigns.net.au/products/exit-landscape-exit-symbol-left-arrow)
- Fire Extinguisher signs; red (according to the standard of the country the competition is held in; 2019 for example https://www.australiansafetysigns.net.au/products/fire-fire-extinguisher),
- Heat source

Procedure:
1. Ready the robot in the start square.
2. The trial starts once the start signal is given or the timer is started.
3. Drive through the arena and recognize objects.
4. Each successfully detected (and optionally located) object will be recorded on the scoresheet. For practicality reasons, scoring can also be done after the mission based on the provided maps.
5. Once the arena is fully traversed, recorded maps and objects are cleared and a new repetition is started.
6. Repeat until the end signal or the timer has elapsed. Unfinished maps do not contribute towards the score.

(EXP 4) Avoid Holes

Motivation:
Drive along a narrow path while avoiding amorphous negative obstacles (holes) along the robot's path. This is for autonomous robots only.

Procedure:
1. Ready the robot in the start square.
2. The trial starts once the start signal is given or the timer is started.
3. The operator is allowed to mark the goal point for the robot.
4. Traverse to the goal square.
5. A successful repetition is counted when the robot is completely inside the goal square.
6. Start a new repetition by traversing back to the start square.
7. Repeat until the end signal or the timer has elapsed.

Faults:
In addition to the standard faults:
- The robot falls off the path
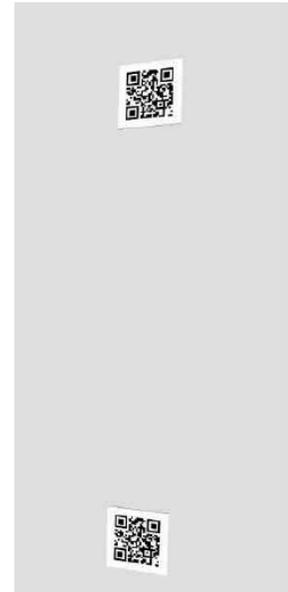
(EXP 5) Avoid Terrains

Motivation:
Drive along a narrow path while avoiding amorphous terrain obstacles without enclosing walls
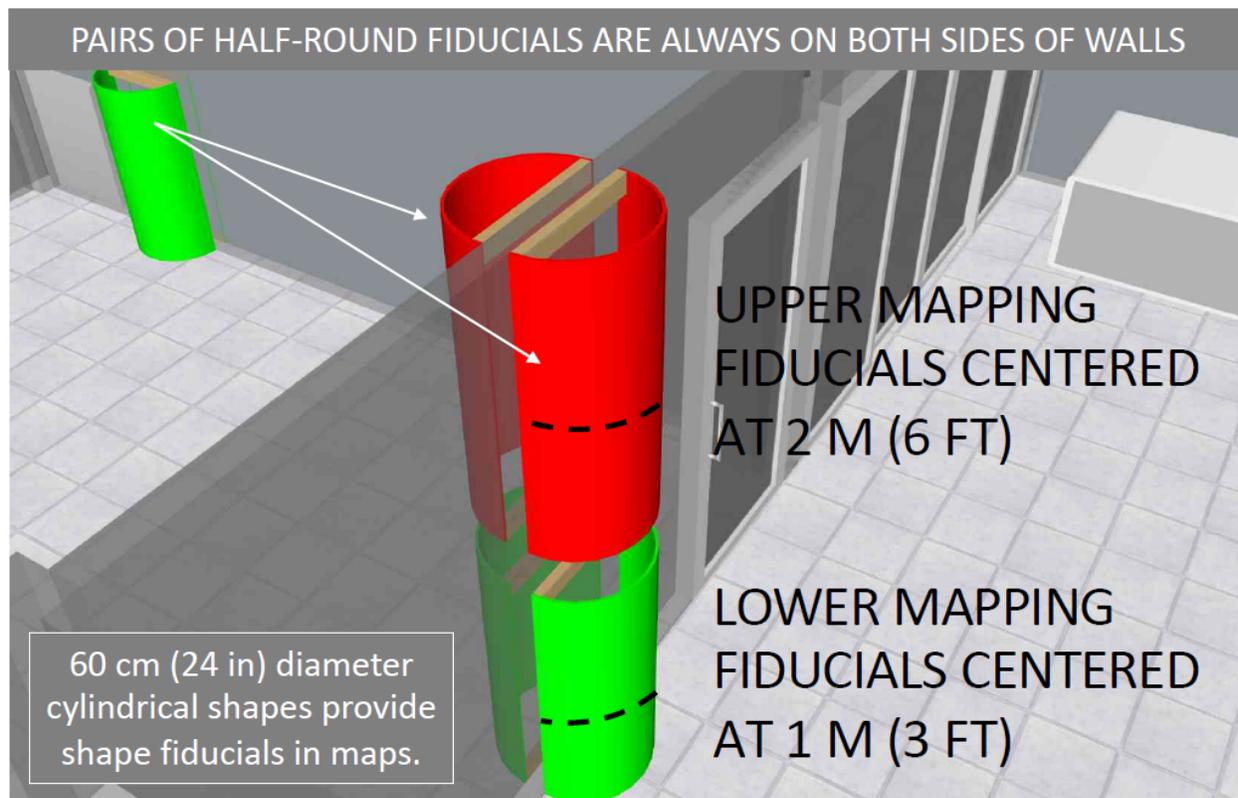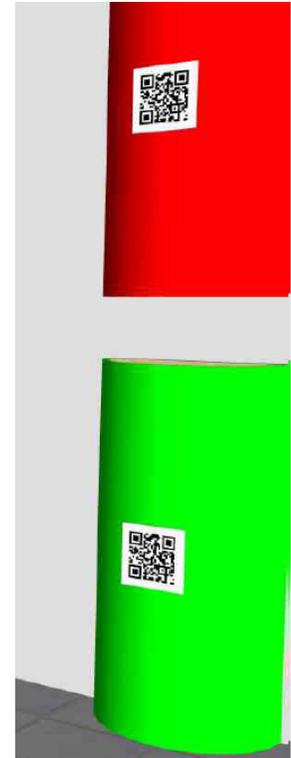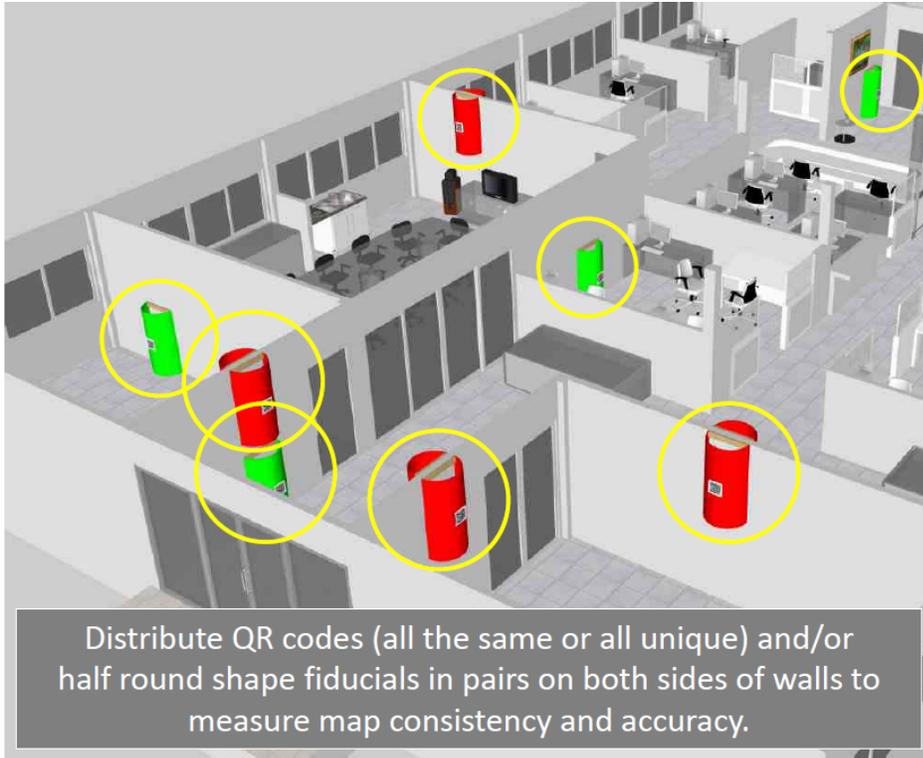(e.g. stepfields, small obstacles, up and down ramps). This is a test for autonomous robots only.

Procedure: Same as EXP 4

Distributed Exploration and Mapping Tests:

● Validate easy to replicate exploration and mapping tests in YOUR scenarios.
● Focus on reconfigurable task apparatuses that are easy to lay out temporarily and store
between trials.
● Compare your 2D and 3D map results over time in variable/repeatable layouts within the
same scenario.
● Try different scenarios using all the same layout rules, in houses, workplaces, industrial
facilities, outdoor settings.

Fiducial Distribution:

Distribute QR codes (all the same or all unique) and/or half round shape fiducials in pairs on both sides of walls to measure map consistency and accuracy.

PAIRS OF HALF-ROUND FIDUCIALS ARE ALWAYS ON BOTH SIDES OF WALLS

UPPER MAPPING FIDUCIALS CENTERED AT 2 M (6 FT)

LOWER MAPPING FIDUCIALS CENTERED AT 1 M (3 FT)

60 cm (24 in) diameter cylindrical shapes provide shape fiducials in maps.

(5) Upper fiducials
(5) Lower fiducials

Example Workplace Scenario

FIDUCIALS ALWAYS ON BOTH SIDES OF WALLS

UPPER MAPPING
FIDUCIALS CENTERED
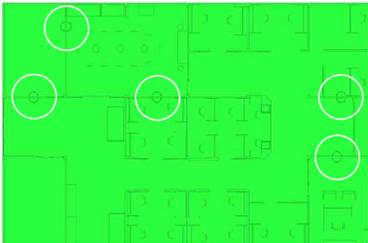AT 2 M (6 FT)

LOWER MAPPING
FIDUCIALS CENTERED
AT 1 M (3 FT)

Mapping:

Lower Fiducial Map
5 pairs of fiducials shown in a 3D map layer at 1 m (3 ft) elevation. The fiducial pairs should form circles in 2D maps.
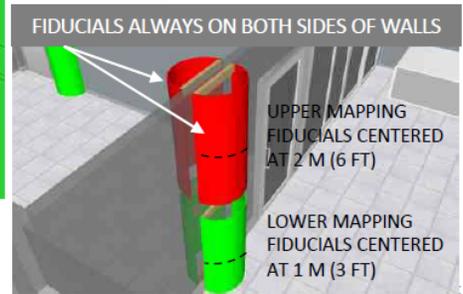
Map Metrics:
- Coverage (how many of 10 are visible?)
- Consistency (how close are the pairs?)
- Local Accuracy (by room)
- Global accuracy (average overall)

(5) Upper fiducials
(5) Lower fiducials

Example Workplace Scenario

FIDUCIALS ALWAYS ON BOTH SIDES OF WALLS

UPPER MAPPING
FIDUCIALS CENTERED
AT 2 M (6 FT)

LOWER MAPPING
FIDUCIALS CENTERED
AT 1 M (3 FT)

Example Workplace Map

FIDUCIALS ALWAYS ON BOTH SIDES OF WALLS

UPPER MAPPING FIDUCIALS CENTERED AT 2 M (6 FT)

LOWER MAPPING FIDUCIALS CENTERED AT 1 M (3 FT)

<u>Upper Fiducial Map</u>
5 pairs of fiducials shown in a 3D map layer at 2 m (6 ft) elevation. The fiducial pairs should form circles in 2D maps.
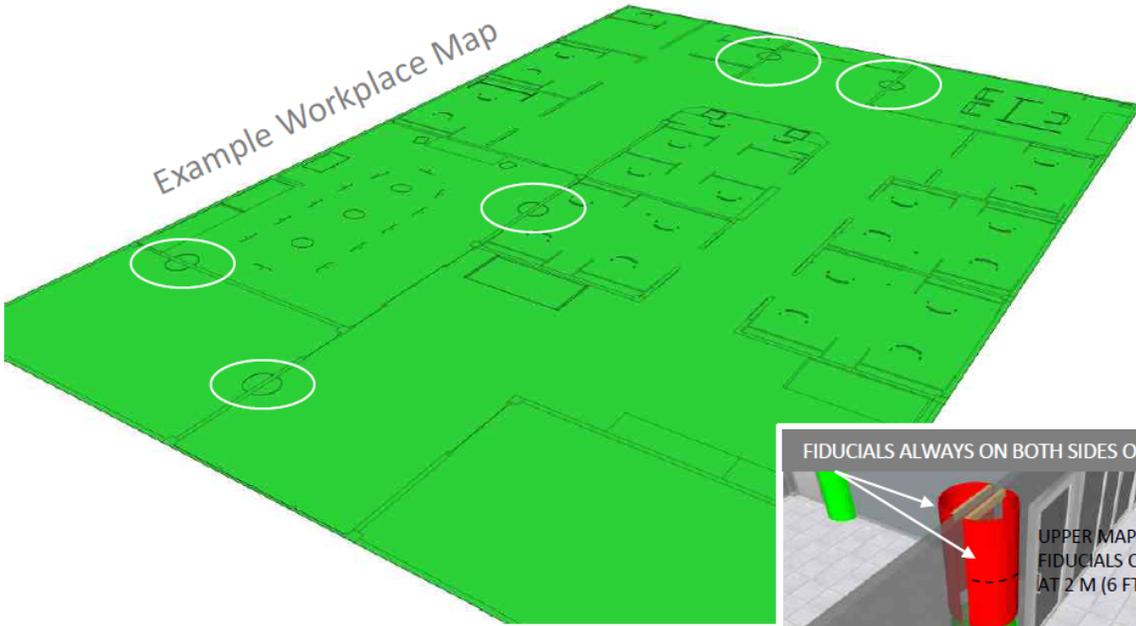
<u>Map Metrics:</u>
- Coverage (how many of 10 are visible?)
- Consistency (how close are the pairs?)
- Local Accuracy (by room)
- Global accuracy (average overall)
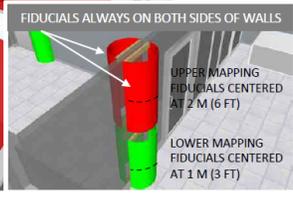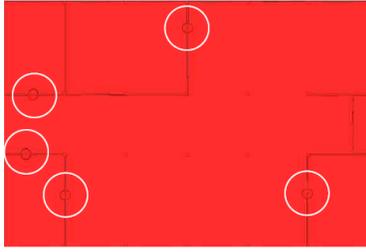
(5) Upper fiducials
(5) Lower fiducials

Example Workplace Scenario

FIDUCIALS ALWAYS ON BOTH SIDES OF WALLS

UPPER MAPPING FIDUCIALS CENTERED AT 2 M (6 FT)

LOWER MAPPING FIDUCIALS CENTERED AT 1 M (3 FT)

See construction guide for details regarding construction of the fiducials.

Mapping Capabilities and 2D Map Format

Map Format

- Fileformat: Geotiff
- FILENAME: DARK BLUE (RGB: 0, 44, 207) TEXT For example, "RoboCup2019-TeamName-Mission1.tiff" displayed in the upper left corner to identify the map, make it sort properly in a directory, and findable on a computer.
- MAP SCALE: DARK BLUE (RGB: 0, 50, 140) TEXT AND EXACTLY 1 METER LONG LINE Display this in the upper right corner to indicate the scale of the map.
- MAP ORIENTATION: DARK BLUE (RGB: 0, 50, 140) TEXT ("X" AND "Y") AND ABOUT 50 cm LONG ARROWS Display this next to the map scale. It gives the orientation for the victim location in the victim file. Must be a right handed coordinate system: X points upwards, Y to the left.
- UNEXPLORED AREA GRID: LIGHT/DARK GREY (RGB: 226, 226, 227/RGB: 237, 237, 238) CHECKERBOARD WITH 100CM SQUARES This solid checkerboard pattern should show the unexplored area and provide scale on all sides of the mapped area. It should also print in black and white without ambiguity with other areas potentially turned grey in the process.

- EXPLORED AREA GRID: BLACK (RGB: 190,190,191) GRID WITH 50CM GRID AND ABOUT 1 CM THICK LINES (use a one pixel line in the map) This grid should only appear in the explored area, behind any walls, victim locations, or other information. The grid should be aligned with the checkerboard pattern of the unexplored area, but twice as fine to allow visual inspection of wall alignments.
- INITIAL ROBOT POSITION: YELLOW (RGB: 255, 200, 0) ARROW This should mark the initial position of the robot and always be pointed toward the top of the map.
- WALLS AND OBSTACLES: DARK BLUE (RGB: 0, 40, 120) FEATURES This should indicate the walls and other obstacles in the environment. The color should make the walls stand out from everything else.
- SEARCHED AREA: WHITE CONFIDENCE GRADIENT (RGB: 128, 128, 128 to RGB: 255, 255, 255) This should be based on the confidence that the area is really free. It should produce a clean whitewhen seen as free by all measurements and nearly untouched when undecided, that is, nearly equally seen as occupied as free, to produce a dither effect.
- CLEARED AREA: LIGHT GREEN CONFIDENCE GRADIENT (RGB: 180, 230, 180 to RGB: 130, 230, 130) This should be based on a history of 1-50 scans to show the area cleared of victims with confidence. This should also factor in the actual field of view and range of onboard victim sensors – noting that victim sensors don't typically see through walls!
- VICTIM LOCATION: SOLID RED (RGB: 240, 10, 10) CIRCLE WITH ABOUT 35CM DIAM CONTAINING WHITE (RGB) TEXT "#" This should show the locations of victims with a victim identification number such as "1" in the order they were found. Additional information about this victim should be in the victim file noted below. Make sure the victim location is always on top of everything else!
- HAZARD LOCATION: SOLID ORANGE (RGB: 255, 100, 30) DIAMOND WITH ABOUT 30CM SIDES CONTAINING WHITE (RGB) TEXT "#" This should show the locations of hazards with an identification number such as "1" in the order they were found. Additional information about this hazard should be in the hazard file noted below.
- ROBOT PATH: MAGENTA (RGB: 120, 0, 140) LINE ABOUT 2CM THICK This should show the robot path.

Example map of EXP 3:
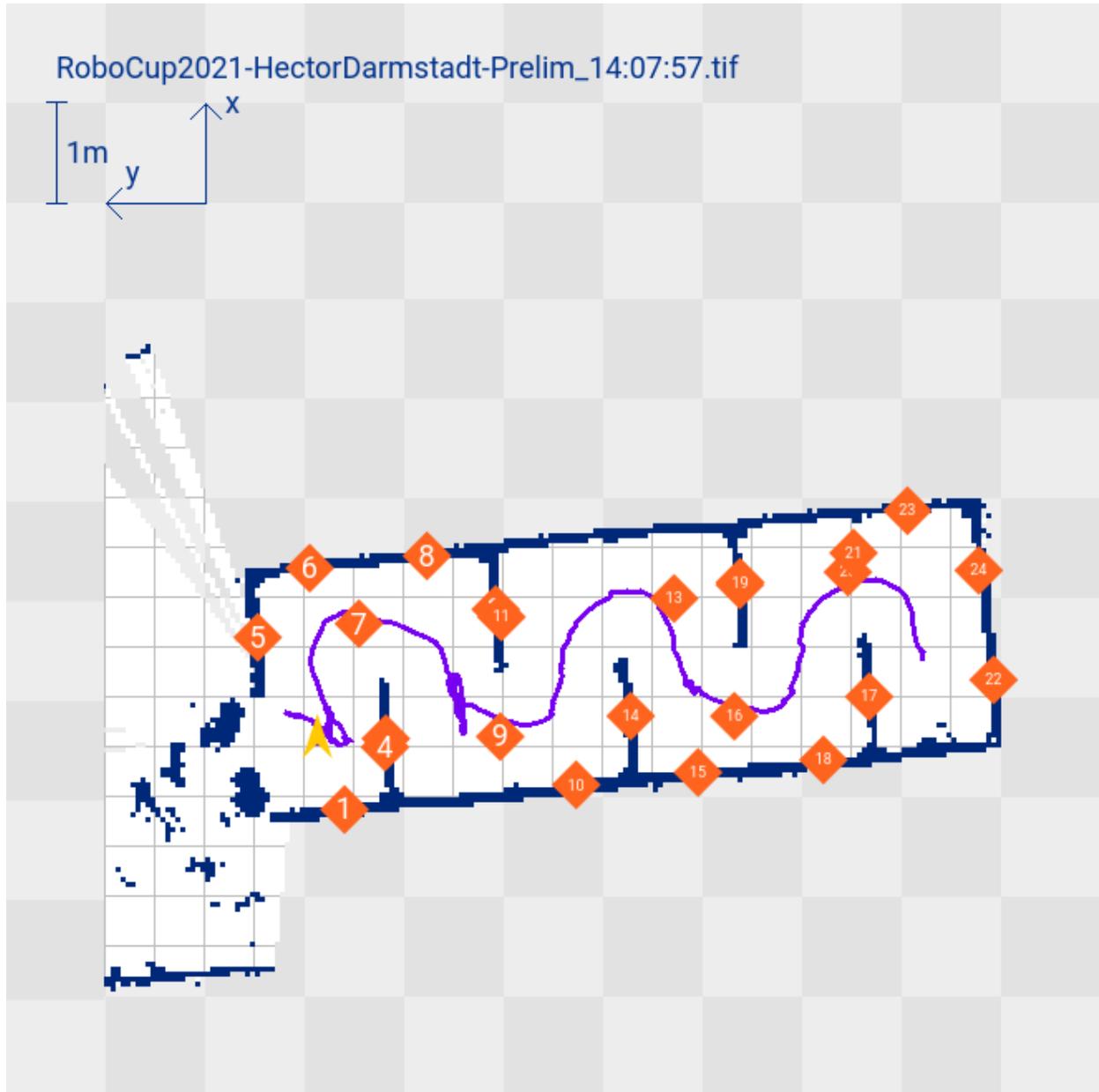
An open-source implementation for ROS is available at http://wiki.ros.org/hector_geotiff.

Identified Objects Format

- Naming convention for the file: RC[Year][Teamname][Mission]pois.csv` where Mission is Prelim1, Prelim2, Semi1, Semi2, Final, BCAutonomy and so on. Format for the file header:

```
"pois"
"1.2"
"[Your team name]"
"[Your country]"
"[Start Date]"
"[Start Time]"
"[Mission]"


id,time,text,x,y,z,robot,mode,type
```

Replace the placeholders [...] with your data. Please use the quotes in the file, but not the brackets.
The file body contains one line for each found object in the following format:

```
[id],[time],[text],[x],[y],[z],[robot],[mode],[type]
```

- [id]: Unique ID for each object that is also printed on the geotiff map
- [time]: Time stamp when the object was found
- [text]: QR code text if applicable
- [x], [y], [z]: Coordinates of the object in meters
- [robot] Name of the robot that found the object
- [mode]: Mode of the robot when it found the object: A for autonomous, T for teleoperated
- [type]: Type of the object: victim, qrcode, door, hazmatsign,...

Strings which include spaces should be enclosed with double quotes. Example for a QR code file which might be named *'RC2018ReskoKoblenzSemi2_pois.csv'*:

```
"pois"
"1.2"
"Resko Koblenz"
"Germany"
"2018-06-23"
"14:37:03"
"Semi2"

id,time,text,x,y,z,robot,mode,type
1,14:28:01,,-8.29994,-2.29014,0.4,"Robbie 1",A,victim
2,14:28:02,Y_1_2_chair_yokel,-8.29994,-2.29014,0.45610,"Robbie 2",T,qrcode
3,14:28:05,,-5.74523,-7.08499,0.21304,"Robbie 1",A,door
4,14:30:14,Y_2_1_ball_yeahs,-6.08457,-0.125154,0.35610,"Robbie 1",A,qrcode
5,14:32:56,Y_3_1_table_yolks,-9.28176,0.0496882,0.75610,"Robbie 2",T,qrcode
```