# Indoor “GPS”

(with ±2cm precision)

# Placement Manual

v2020_07_13

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# Version changes

2020_07_13_v0.09: Renamed “Room with columns (IA, 2D, TDMA)” -> “Full overlapping submaps (IA, 2D, TDMA)”

2019_08_15_v0.08: Added slides Tunnel 1200x25m, autonomous inspection (NIA, 2D)

2019_07_15_v0.07: Added slides Room with columns (IA, 2D, TDMA), Rooms + corridor (IA, 2D, TDMA), Rooms with columns + corridor (IA, 2D, TDMA), Autonomous inspection drone (IA, 2D, TDMA, Vertical-XZ)

2018_11_07_v0.06: Added slide Real-time tracking: reducing the delay

2018_10_03_v0.05: Added slide Steps beyond default settings

2018_06_25_v0.04: Added slide set Area of 100x100m with tracking using submaps

2018_06_25_v0.04: Added slide set Long distance tracking – 30x30m area

2018_06_19_v0.03: Added case Multi-modem 1.5D – tracking vehicles underground

2018_06_07_v0.02: Added case Business center

2018_05_30_v0.01: Initial release

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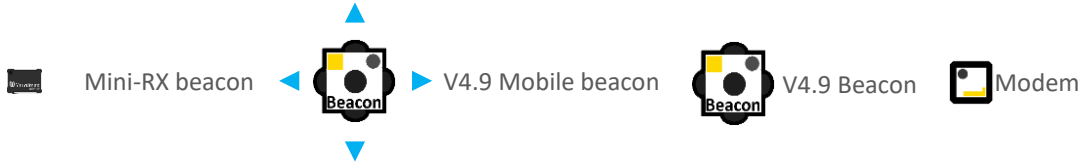
# Description

The manual gives practical advices and examples of how to mount the Marvelmind Indoor “GPS” system to achieve the best performance in different applications and configurations

# Contents




**Conventions:**




Submap/zone

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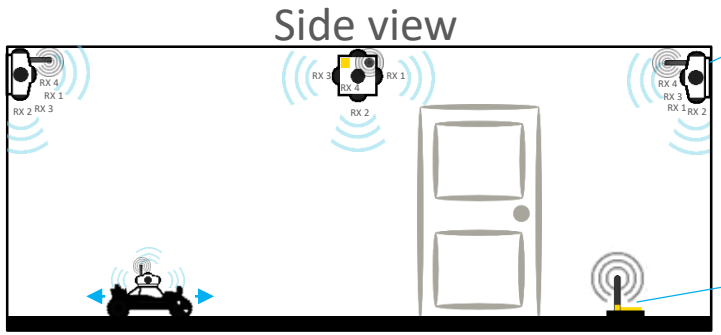
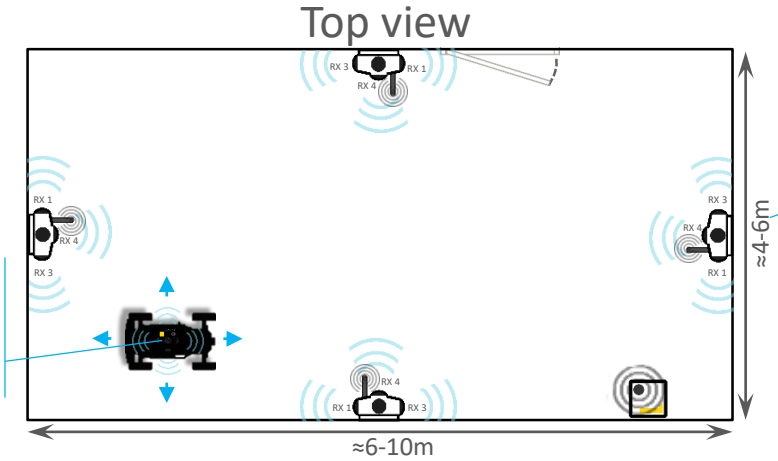
# 01: Starter Set HW v4.9 – simple 3D installation




**Stationary beacon**
- Shall be placed on walls or ceiling – to minimize shadows in ultrasonic coverage
- Enable only required sensors – to improve sensitivity and external noise immunity. Each sensor has ~90deg beam

**Modem**
- Must be always powered, when tracking is needed
- May be placed up to tens to hundreds meters away from beacons depending on the resulting RSSI




**Mobile beacon**
- Placed on a forklift/robot, person

**Room**
- Start with a midsize map of 6x4 to 6-10m or so
- Maximum size of the map for Starter Set is up to 1000m²

## Configuration:

- Starter Set – HW v4.9:
  - 4 x stationary beacon
  - 1 x mobile beacon
  - 1 x modem

## Notes:

- Designed for fast overall evaluation of the Precise (±2cm) Indoor "GPS"
- Supports 3D (X,Y,Z) + 1 redundancy, for example:
  - One forklift and warehouse
  - One-wheeled robot
  - One drone
  - One person
  - Tracking of one VR helmet

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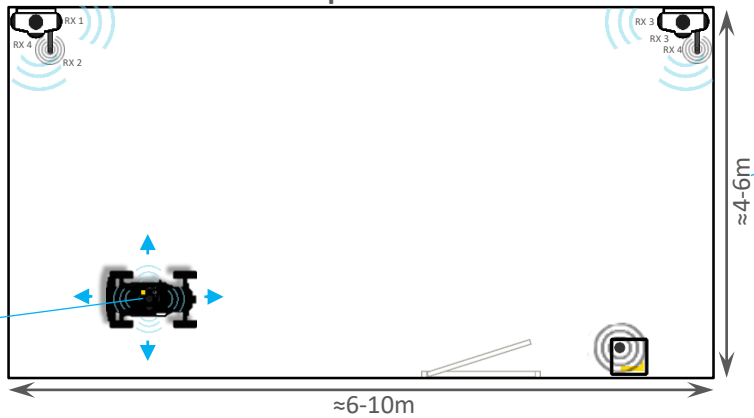
# 01a: Simple 2D Tracking – for example, RC car indoor

Side view


**Stationary beacon**
- Shall be placed on walls or ceiling – to minimize shadows in ultrasonic coverage
- Enable only required sensors – to improve sensitivity and external noise immunity. Each sensor has ~90deg beam

**Modem**
- Must be always powered, when tracking is needed
- May be placed up to tens to hundreds meters away from beacons depending on the resulting RSSI

Top view




**Mobile beacon**
- Placed on a forklift/robot, person

**Room**
- Start with a midsize map of 6x4 to 6-10m or so
- Maximum size of the map for Starter Set is up to 1000m²

**Configuration:**
- Starter Set – HW v4.9:
  - 2 x stationary beacon
  - 1 x mobile beacon
  - 1 x modem

**Notes:**
- Designed for 2D tracking (X,Y)
  - One RC car in room
  - One-wheeled robot
  - One person
- Not suitable for drones – 3D (X,Y,Z) tracking is required

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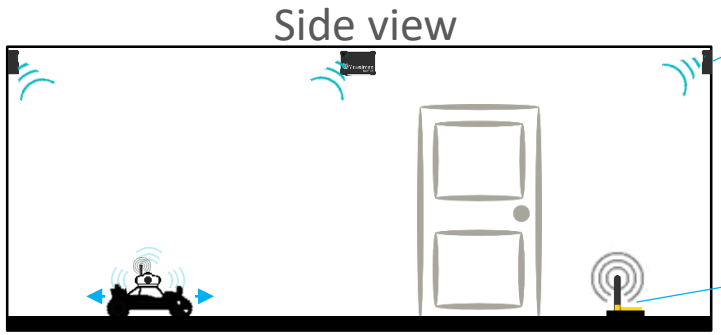
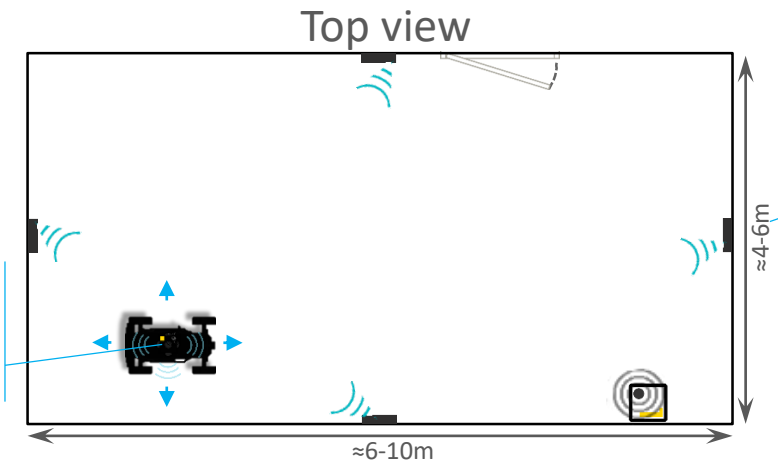
# 01b: Mini-RX Starter Set – simple 3D installation




**Mini-RX beacon as stationary**
- Shall be placed on walls or ceiling – to minimize shadows in ultrasonic coverage
- Has high-performance digital microphone
- Only "listens" the ultrasound

**Modem**
- Must be always powered, when tracking is needed
- May be placed up to tens to hundreds meters away from beacons depending on the resulting RSSI




**Mobile beacon**
- Placed on a forklift/robot, person

**Room**
- Start with a midsize map of 6x4 to 6-10m or so
- Maximum size of the map for Starter Set is up to 1000m²

## Configuration:

- Starter Set NIA-01:
  - 4 x Mini-RX as a stationary beacon
  - 1 x v4.9 as a mobile beacon
  - 1 x modem

## Notes:

- Designed for fast overall evaluation of the Precise (±2cm) Indoor "GPS"
- Supports 3D (X,Y,Z) + 1 redundancy, for example:
  - One forklift and warehouse
  - One-wheeled robot
  - One drone
  - One person
  - Tracking of one VR helmet

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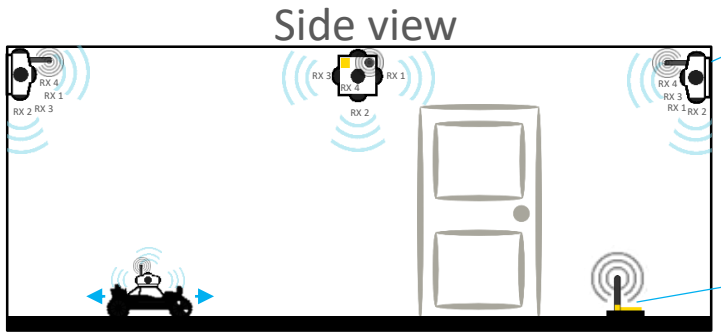
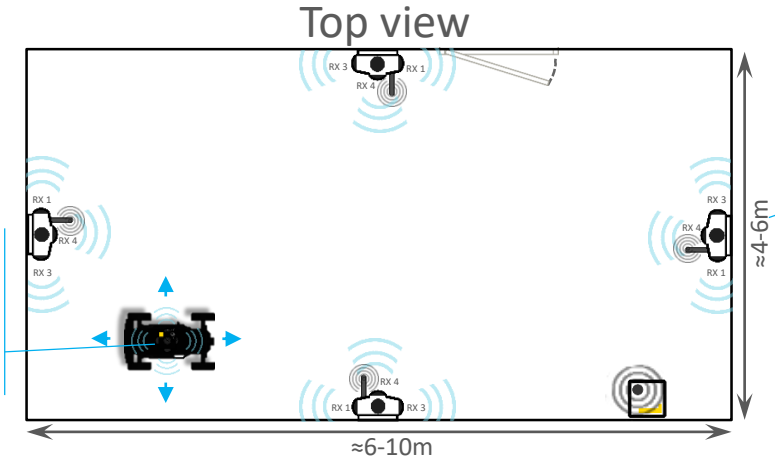
# 02: Starter Set + IMU – settings and recommendation




**Stationary beacon**
- Shall be placed on walls or ceiling – to minimize shadows in ultrasonic coverage
- Enable only required sensors – to improve sensitivity and external noise immunity. Each sensor has ~90deg beam

**Modem**
- Must be always powered, when tracking is needed
- May be placed up to tens to hundreds meters away from beacons depending on the resulting RSSI




**Mobile beacon + IMU**
- Placed on a forklift/robot, person

**Room**
- Start with a midsize map of 6x4 to 6-10m or so
- Maximum size of the map for Starter Set is up to 1000m²

## Configuration:

- Starter Set – HW v4.9 + IMU:
  - 4 x stationary beacon
  - 1 x mobile beacon + IMU
  - 1 x modem
- Embedded IMU: 3D accelerometer + 3D gyroscope + 3D magnetometer (compass)

## Notes:

- Supports 3D (X,Y,Z) + 1 redundancy
- Designed for fast evaluation of the Precise (±2cm) Indoor "GPS" with IMU:
  - Drones
  - VR helmets
  - Systems requiring either fast update rate or working challenging environment, when ultrasonic-based navigation must be verified with IMU based navigation
  - IMU+ultrasonic sensor fusion => can support up to 100Hz update rate
  - Useful for additional filtering of location jumps in challenging environment
  - When IMU is needed overall

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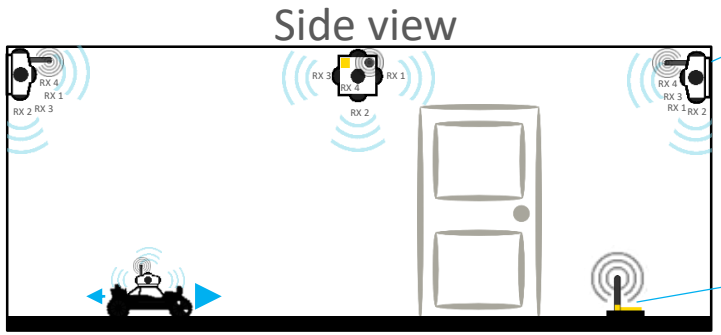
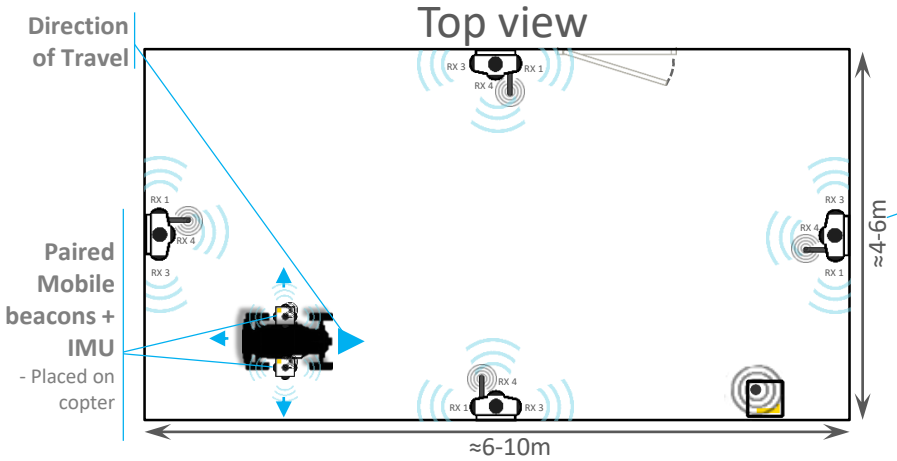
# 03: Paired beacons – location + direction




**Stationary beacon**
- Shall be placed on walls or ceiling – to minimize shadows in ultrasonic coverage
- Enable only required sensors – to improve sensitivity and external noise immunity. Each sensor has ~90deg beam

**Modem**
- Must be always powered, when tracking is needed
- May be placed up to tens to hundreds meters away from beacons depending on the resulting RSSI




**Room**
- Start with a midsize map of 6x4 to 6-10m or so
- Maximum size of the map for Starter Set is up to 1000m²

## Configuration:

- Starter Set – HW v4.9 + IMU + Beacon – HW v4.9 + IMU – plastic housing:
  - 4 x stationary beacon
  - 2 x mobile beacon + IMU
  - 1 x modem

## Notes:

- Has all functionality of Starter Set + IMU + direction
- Designed for the cases, when not only location, like in a regular GPS, but also a direction is required
- Uses paired mobile beacons install on the robot/drone and doesn't rely on compass that may give indoor with much metal around wrong results
- The larger base between the mobile beacons, the more precise direction can be achieved. Reasonable directional precision with the base >20cm. Strongly recommended – 0.5m or more
- Demo video on setting up the feature

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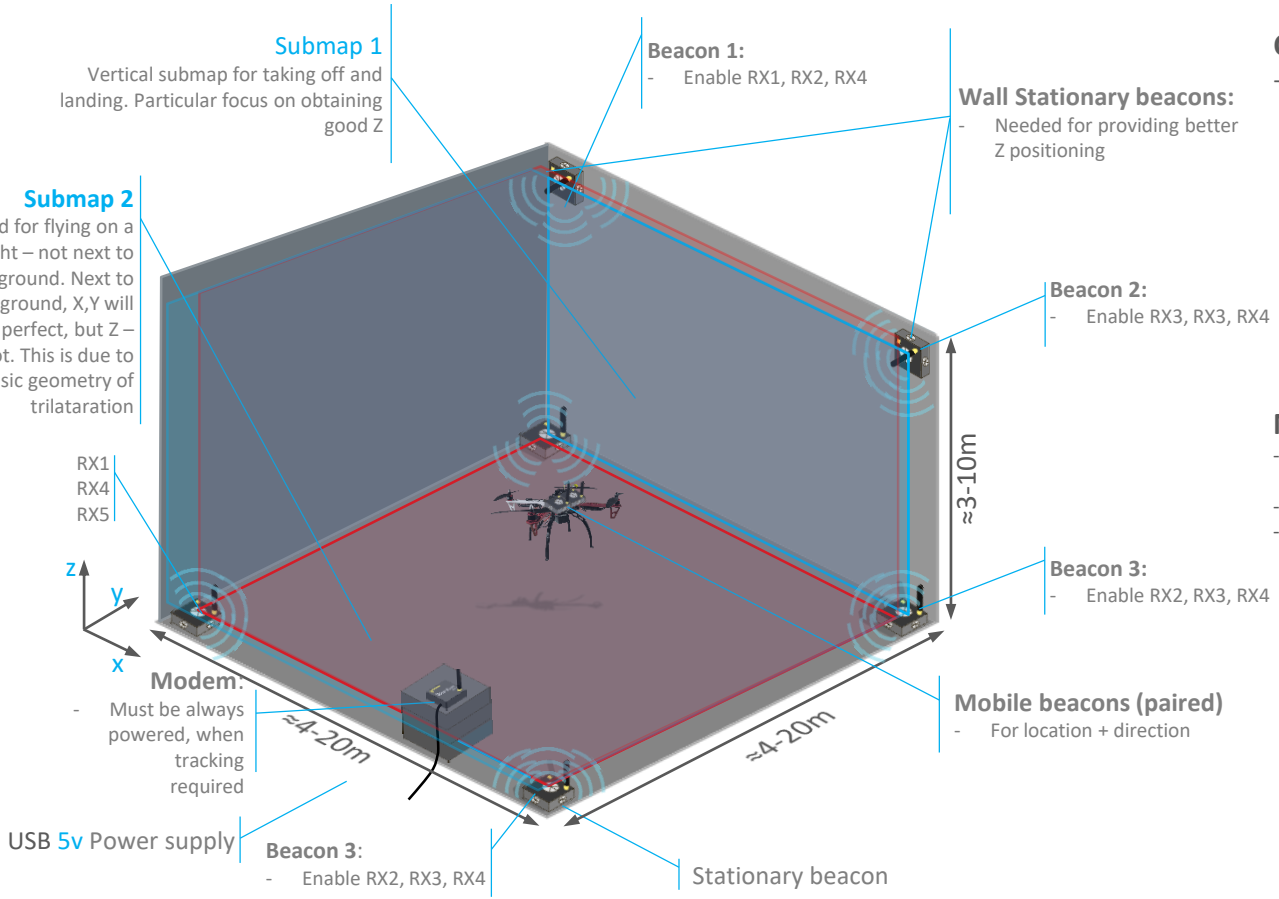
# 04: Stable “Z” for drone – settings and recommendations




## Configuration:

- Starter Set – HW v4.9 + IMU + Beacon – HW v4.9 – plastic housing:
  - 6 x stationary beacon
  - 1 x mobile beacon + IMU
    (Or 2 mobile beacons with IMU to support Paired Beacon feature – you’ll get location + direction)
  - 1 x modem

## Notes:

- Designed for flying autononomous drones indoor and good Z tracking on all heights
- Supports 3D (X,Y,Z) + N redundancy
- Detailed video help: Help: Z-coordinates for copters

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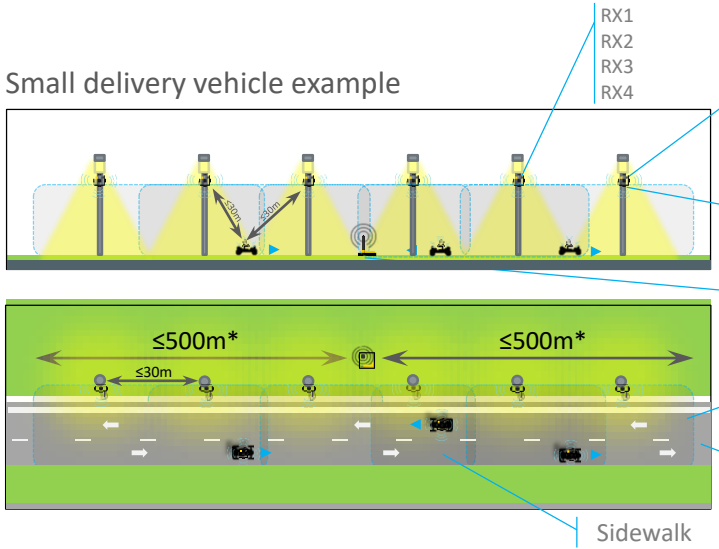
# 05: Tracking sidewalks, tunnels, metros, mines in 2D

Small delivery vehicle example




**Stationary beacon**
- Shall be placed high on lamp poles – to minimize shadows in ultrasonic
- Enable only required sensors – to improve sensitivity and external noise immunity

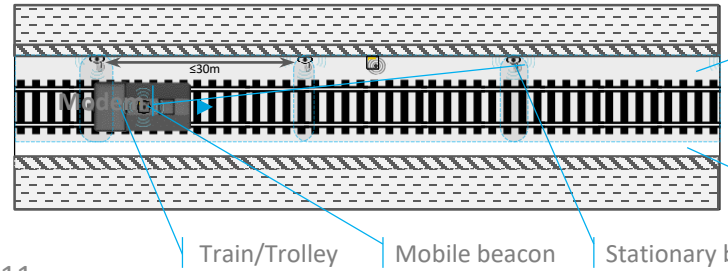
Light pole

**Modem**
- Must be always powered, when tracking is needed
- May be placed up to tens to hundreds meters away from beacons

Slightly overlapping submaps

Sidewalk area

Underground railway transport example




Submap

Tunnel (Underground, mine, etc.)

**Configuration:**
- Starter Set – HW v4.9 + IMU + N x Beacon – HW v4.9 + IMU – plastic housing:
  - N x stationary beacon
  - N x mobile beacon + IMU
  - 1 x modem

**Notes:**
- Outdoor cases: Park, parking lot, railway
- Indoor cases: Subway, tunnel, long warehouse
- 2D tracking (linear placement)

* Radio limited up to a few tens to a few hundreds of meters in open space – strongly depends on interference, antenna alignments, etc.
- Can be further extended in Multi-modem systems

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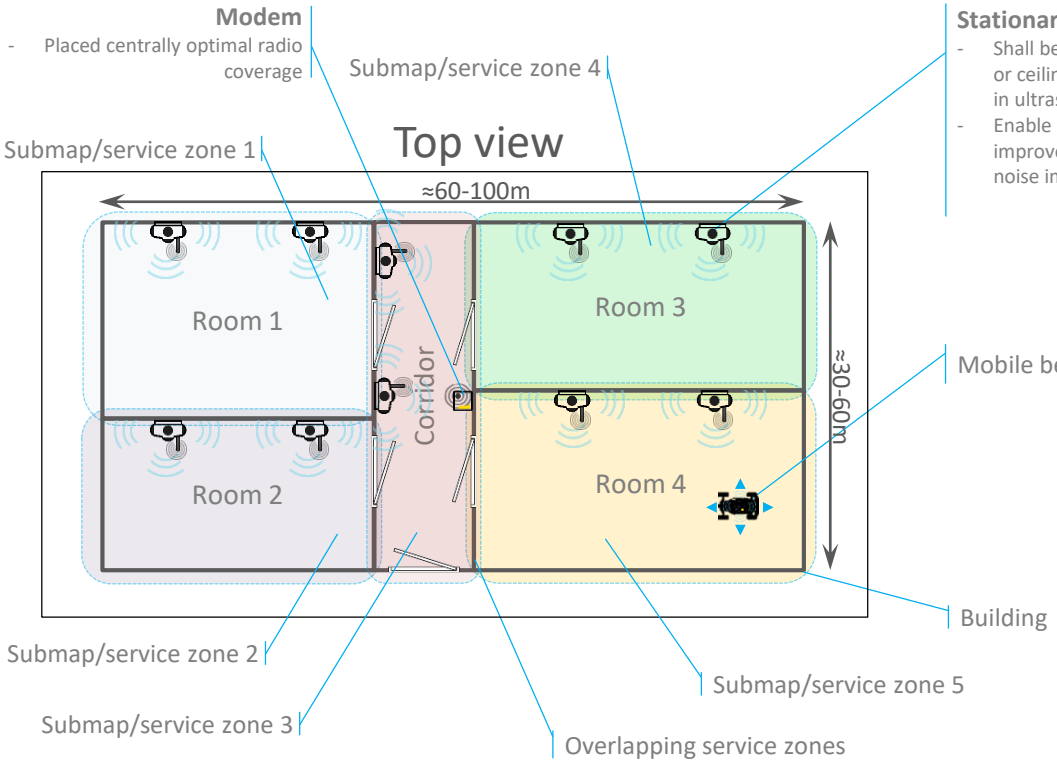
# 06: Submaps in 2D




## Configuration:

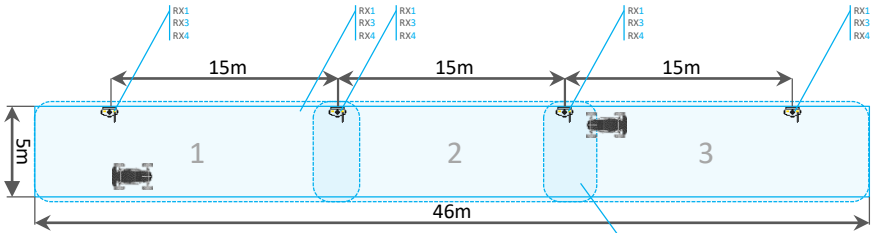
- Starter Set – HW v4.9 + Beacon – HW v4.9 – plastic housing:
  - 10 x stationary beacon
  - 1 x mobile beacon
  - 1 x modem

## Notes:

- Designed for multi-room buildings
- This particular configuration supports 2D tracking. Can be made in 3D too, if instead of 2D submaps, 3D submaps are built Check Simple 3D Tracking
- Check Operating Manual
- Check Submaps Help Video
- Check Simple 2D Tracking to build correct 2D maps

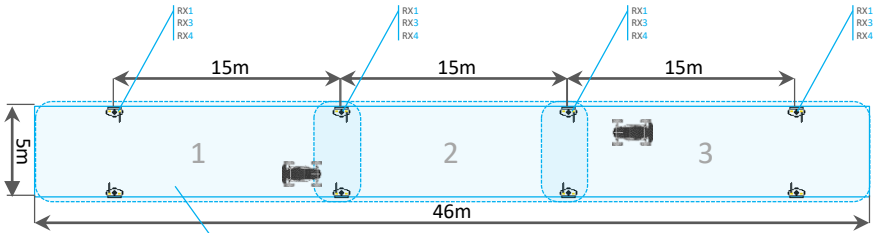
# 07: Wheeled robot in 46x5m area (2D navigation)

## Option 1: Optimal conservative, 2D



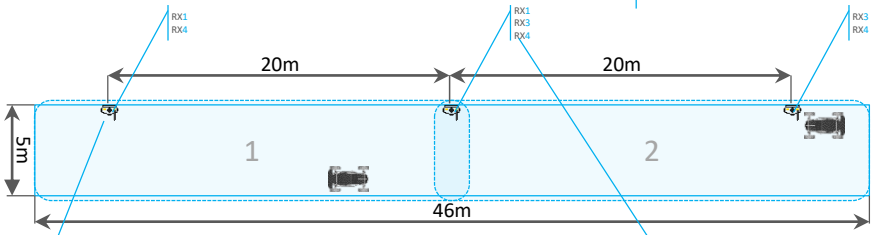

Submap/service zones overlapping for smooth handover between submaps

## Option 3: Optimal conservative, 3D



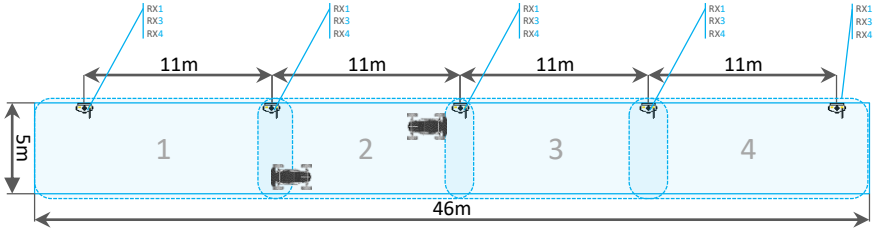

How to build submaps and service zones:
https://www.youtube.com/watch?v=FXvlDZkxkUU

## Option 2: Stretching, 2D




Enable RX1 (right-facing) and RX4 (front-facing). And disable RX2/RX3/RX5. They are facing down, left, up where the robot cannot be. Disabling of unnecessary sensors increases sensitivity/range and decreases the amount of noise/echo the beacon will pickup

## Option 4: Conservative, 2D




Place stationary beacons with USB at the bottom. Enable only required sensors per beacon. Here, for example, enable RX1 (right-facing), RX4 (front-facing), RX3 (left-facing). And disable RX2/RX5. They face up and down where the robot cannot be. Disabling of unnecessary sensors increases sensitivity/range and decreases the amount of noise/echo the beacon will pickup

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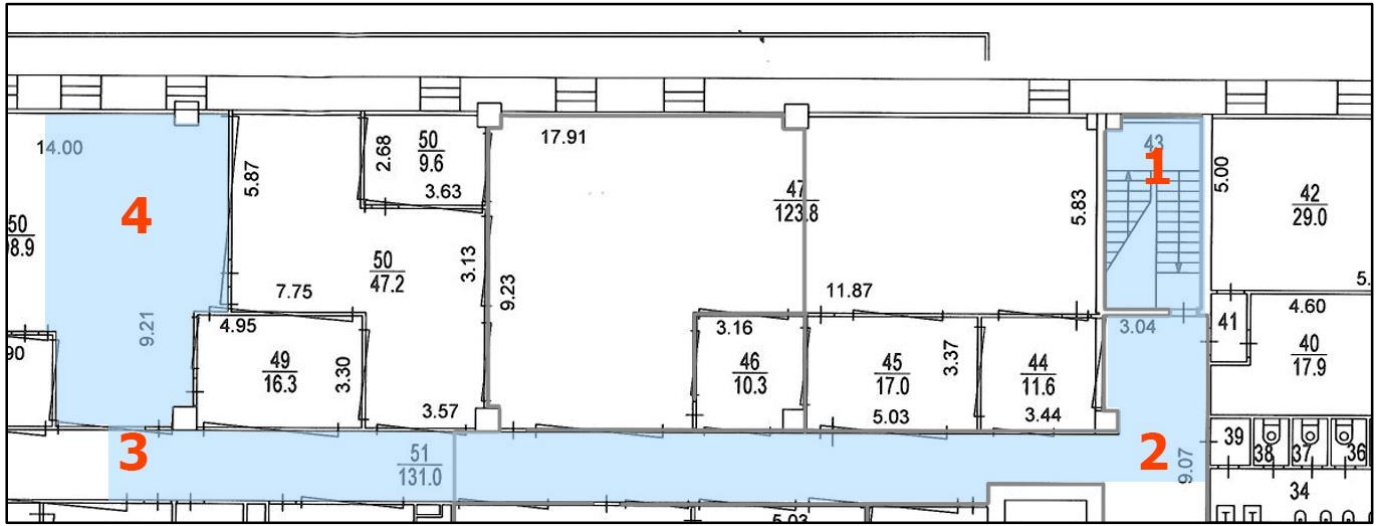
# 08a: Business center area – Tracking people in 2D




**Customer expectations:**

- Cover all blue zones with Marvelmind Indoor GPS Tracking System in order to track people
- Show how to place beacons correctly
- Show submaps
- Show sensor settings
- Zones 1 and 4 have to be covered with 3D tracking
- Zones 2 and 3 have to be covered with 2D tracking

*All the distances are given in meters



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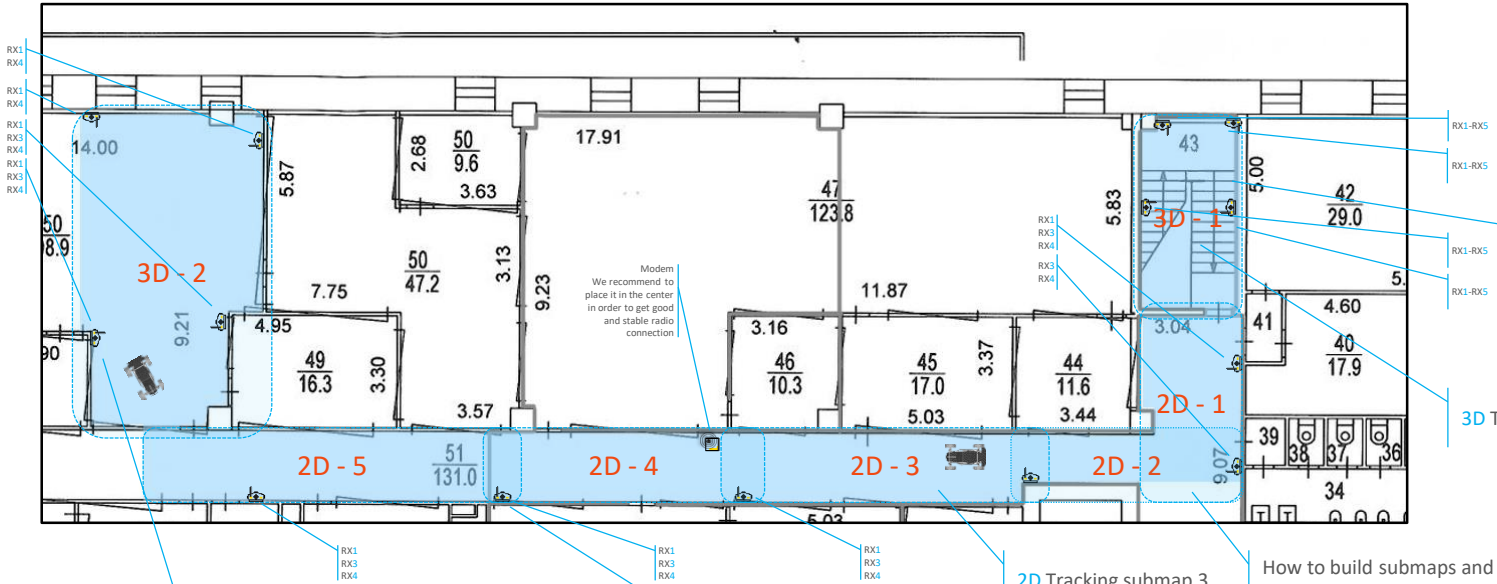
# 08b: Business center area – Tracking people in 2D




**Configuration:**

- 14 x Beacon – HW v4.9
- 1 x Modem – HW v4.9

We recommend to turn on all the sensors in case of different heights and close distances.
3D tracking is required in order to track height changes, while walking through stairs

3D Tracking submap 1

2D Tracking submap 3

How to build submaps and service zones:
https://www.youtube.com/watch?v=FXvlDZkxkUU

Enable RX1 (right-facing) and RX4 (front-facing). And disable RX2/RX3/RX5. They are facing down, left, up where the robot cannot be. Disabling of unnecessary sensors increases sensitivity/range and decreases the amount of noise/echo the beacon will pickup

Place stationary beacons with USB at the bottom. Enable only required sensors per beacon. Here, for example, enable RX1 (right-facing), RX4 (front-facing), RX3 (left-facing). And disable RX2/RX5. They face up and down where the robot cannot be. Disabling of unnecessary sensors increases sensitivity/range and decreases the amount of noise/echo the beacon will pickup

*All the distances are given in meters

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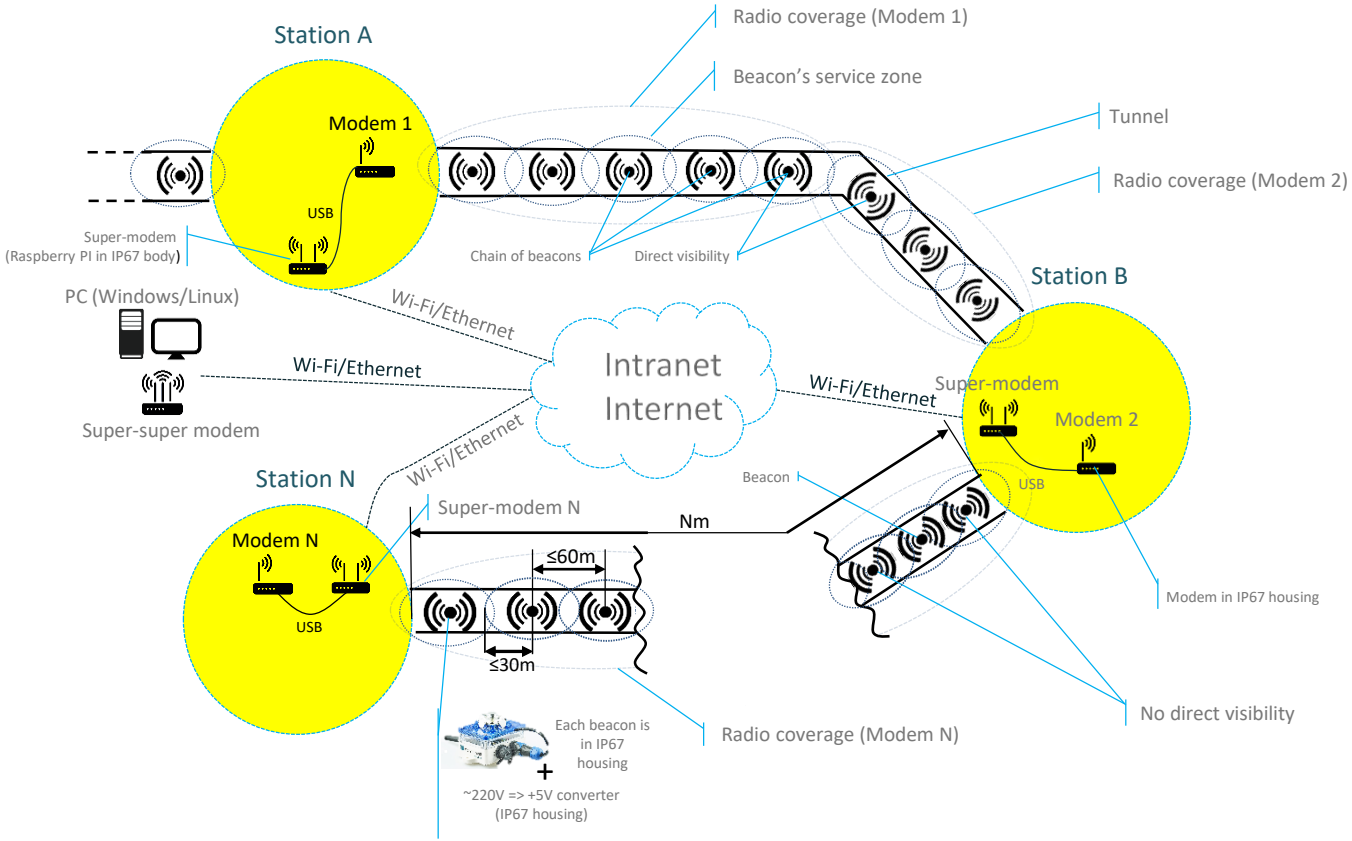
# 09: Multi-modem 1.5D – tracking vehicles underground




**Configuration:**

- Starter Set – HW v4.9 + Beacon – HW v4.9 + Modem – HW v4.9:
  - N x stationary beacon
  - N x mobile beacon
  - 3 x modem

**Notes:**

- Indoor cases: Subway, tunnel, mines
- 1.5D tracking (linear placement)

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# 10: Tracking in 30x30m area

The next several slides give instructions of setting up and mounting the system to cover a 30x30m open space area.

It has different configurations:

1. 2D (x, y)
2. 3D (x, y, z)

Choose one, which suits your requirements.

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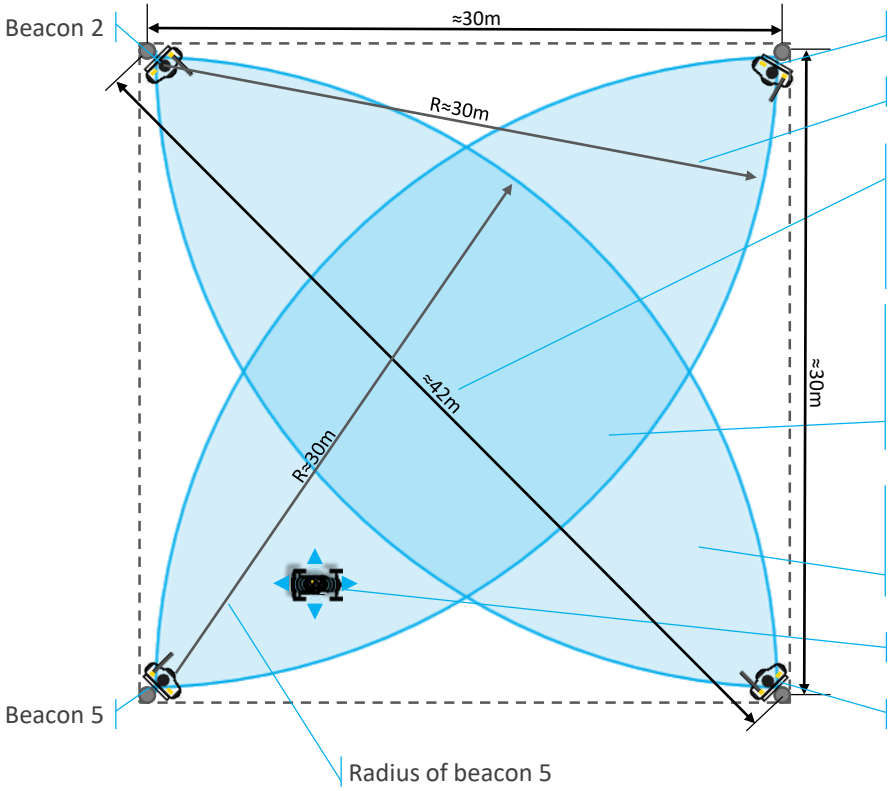
# 10: Tracking in 30x30m area - zones




**Potentially, too long distance**
The map is able to be built automatically, but as the distance is more than 30m, it may be complicated or even not possible. In this case use some other ways to measure it (laser distance meter, tape, etc.)

**Tracking zone with 3+1 redundancy**
Mobile beacon must be seen at least by 3 stationary beacons. Tracking zone with 3+1 redundancy means the zone, where the mobile beacon is seen by 4 stationary beacons. And if one of them is blocked, you would still have stable 3D (x, y, z) tracking

**Tracking zone without redundancy**
The zone where mobile beacon is seen by 3 stationary beacons. If one of the beacon is blocked – tracking will be jumping

Tracked object

## Configuration:

- Starter Set – HW v4.9 :
  - 4 x stationary beacon
  - 1 x mobile beacon
  - 1 x modem

## Notes:

- Supports 3D (X,Y,Z) + 1 redundancy
- Supports 2D (X, Y)

See the instructions on the next slides

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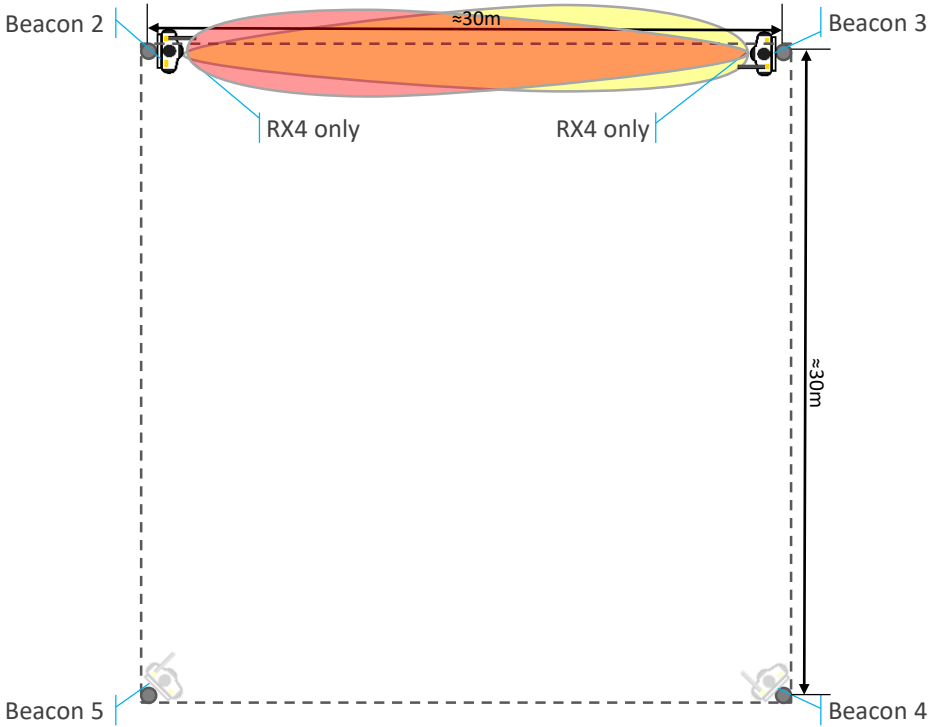
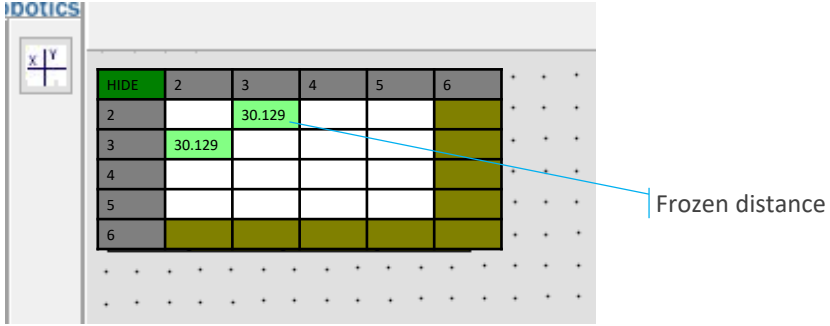
# 10.1: Step 1: Building the distances map (2, 3)



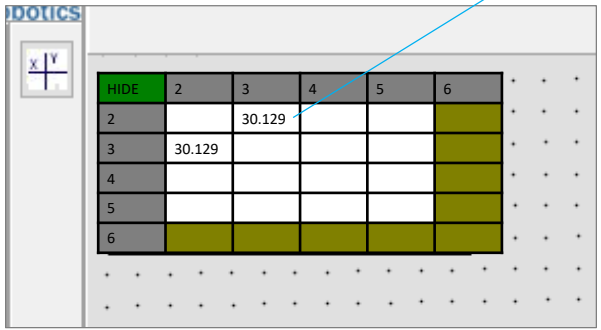

**Finding distance between beacon 2 and beacon 3**

- Face beacons to each other (facing RX4 sensor)
- Turn on RX4 sensor only
- Set the number of periods =100
- Set limitations of distances =45m
- Freeze the distance. How to do it see on the next slide…

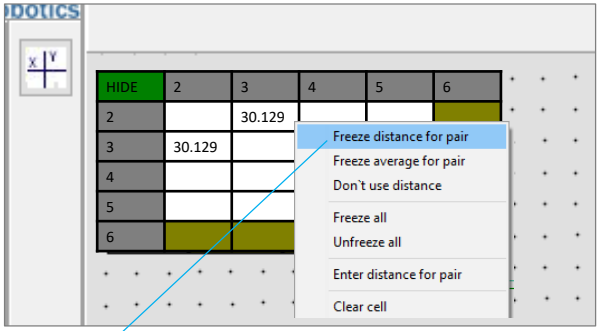


# 10.1a: How to freeze distance for pair

Wait when the distance tab became white → Right mouse button click on the distance tab



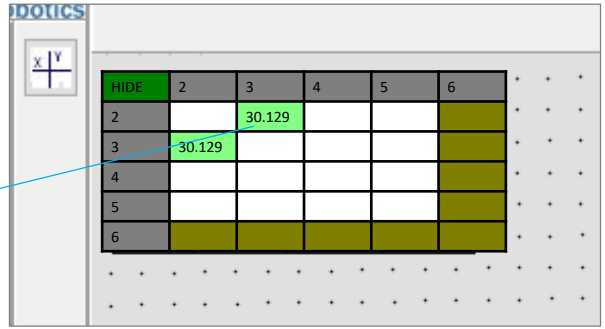

1




2

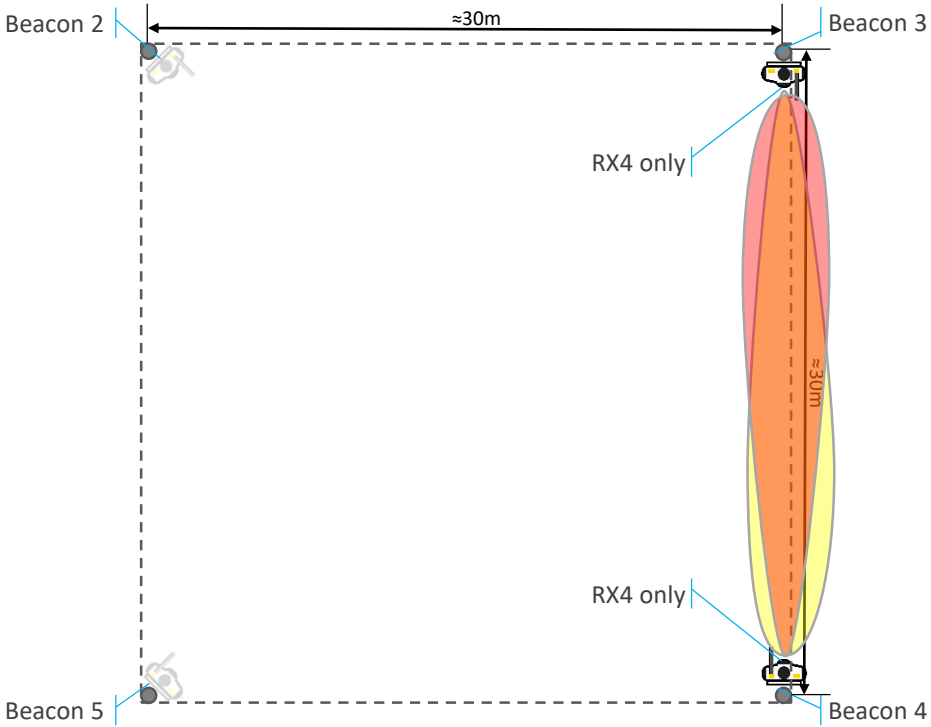
Click **Freeze distance for pair**

Now it's frozen



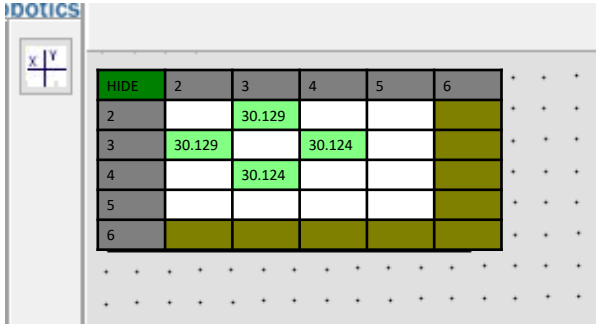

3

# 10.2: Step 2: Building the distances map (3, 4)

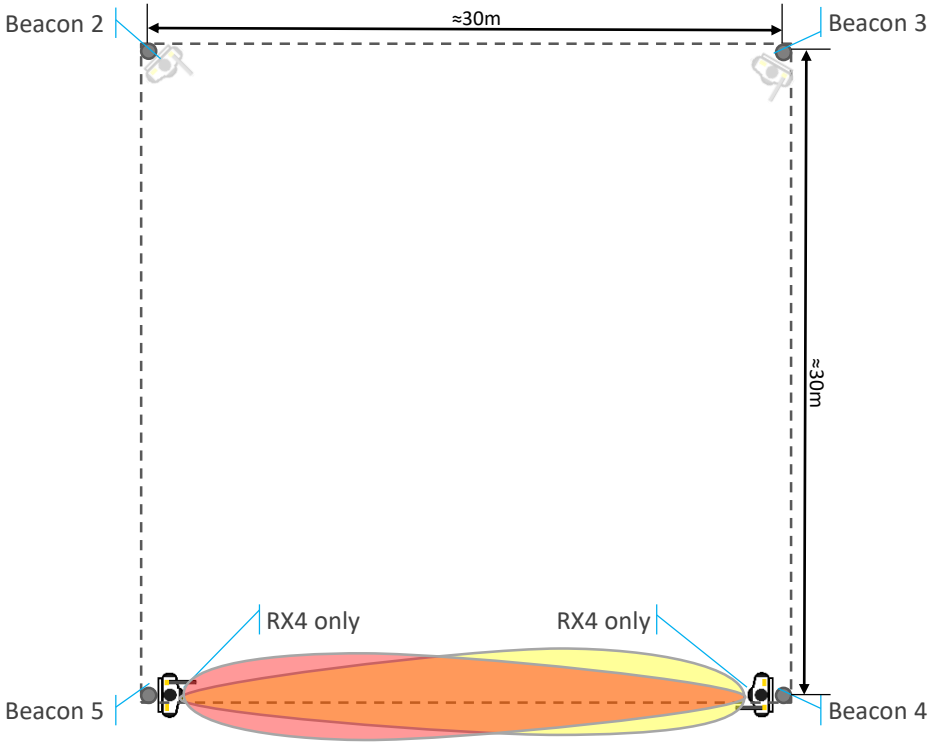



**Finding distance between beacon 3 and beacon 4**

- Face beacons to each other (facing RX4 sensor)
- Turn on RX4 sensor only
- Set the number of periods to 100
- Don’t forget to rise up all the limitations of distances (about 45m)
- Freeze the distance. How to do it see on [this slide…]

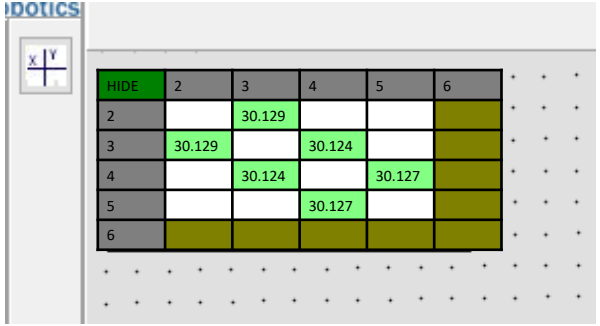


# 10.3: Step 3: Building the distances map (4, 5)



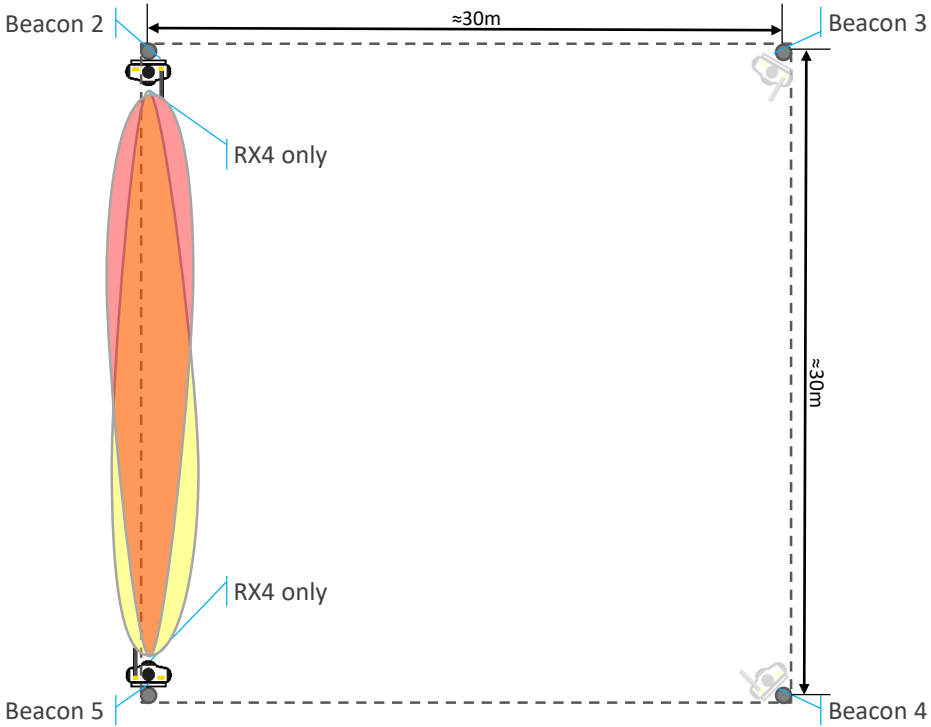

**Finding distance between beacon 4 and beacon 5**

- Face beacons to each other (facing RX4 sensor)
- Turn on RX4 sensor only
- Set the number of periods to 100
- Don’t forget to rise up all the limitations of distances (about 45m)
- Freeze the distance. How to do it see on [this slide…]



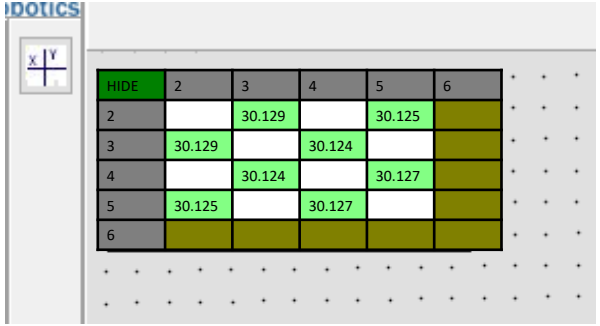
| HIDE | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 2 | | 30.129 | | | |
| 3 | 30.129 | | 30.124 | | |
| 4 | | 30.124 | | 30.127 | |
| 5 | | | 30.127 | | |
| 6 | | | | | |

# 10.4: Step 4: Building the distances map (2, 5)



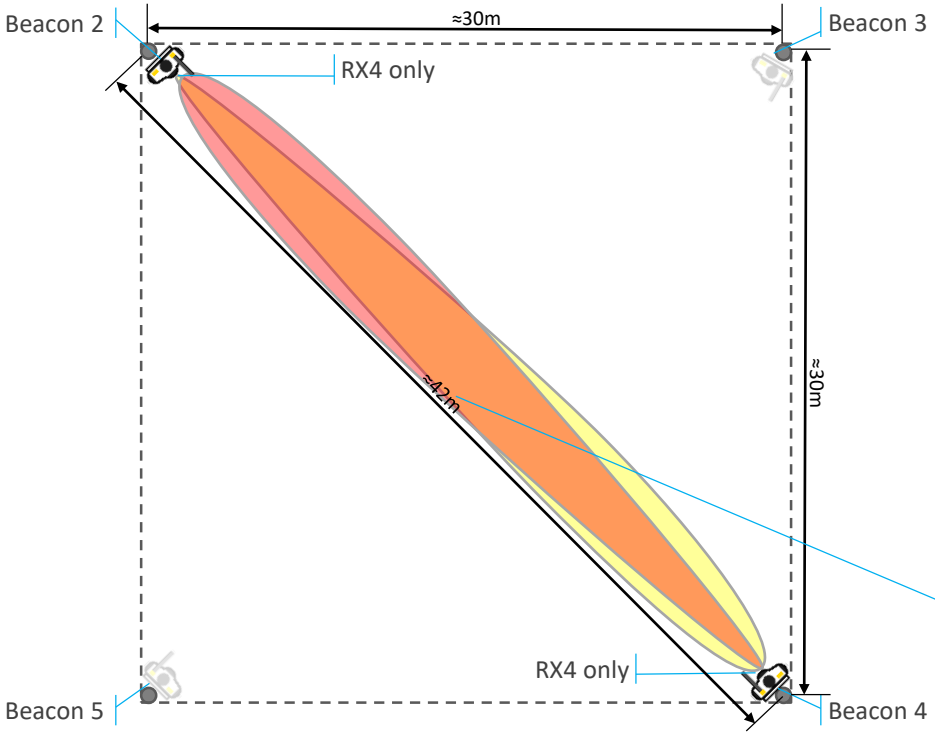

**Finding distance between beacon 2 and beacon 5**

- Face beacons to each other (facing RX4 sensor)
- Turn on RX4 sensor only
- Set the number of periods to 100
- Don’t forget to rise up all the limitations of distances (about 45m)
- Freeze the distance. How to do it see on [this slide…]



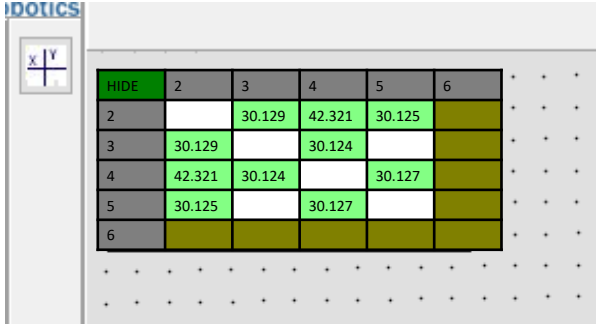
| HIDE | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 2 | | 30.129 | | 30.125 | |
| 3 | 30.129 | | 30.124 | | |
| 4 | | 30.124 | | 30.127 | |
| 5 | 30.125 | | 30.127 | | |
| 6 | | | | | |

# 10.5: Step 5: Building the distances map (2, 4)




**Finding distance between beacon 2 and beacon 4**

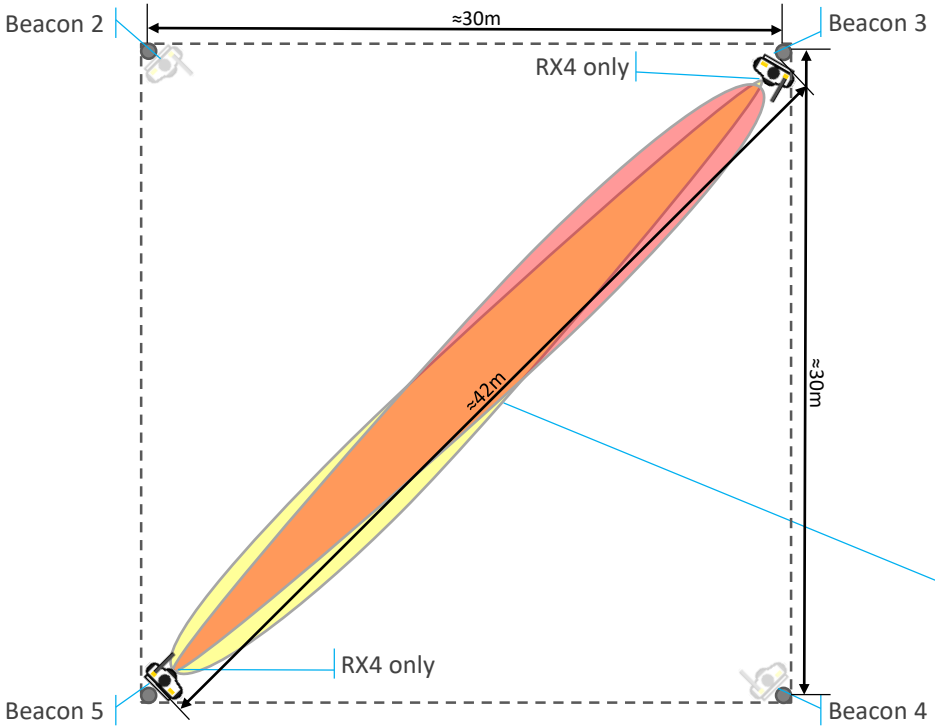
- Face beacons to each other (facing RX4 sensor)
- Turn on RX4 sensor only
- Set the number of periods to 100
- Don’t forget to rise up all the limitations of distances (about 45m)
- Freeze the distance. How to do it see on this slide…



| HIDE | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 2 | | 30.129 | 42.321 | 30.125 | |
| 3 | 30.129 | | 30.124 | | |
| 4 | 42.321 | 30.124 | | 30.127 | |
| 5 | 30.125 | | 30.127 | | |
| 6 | | | | | |

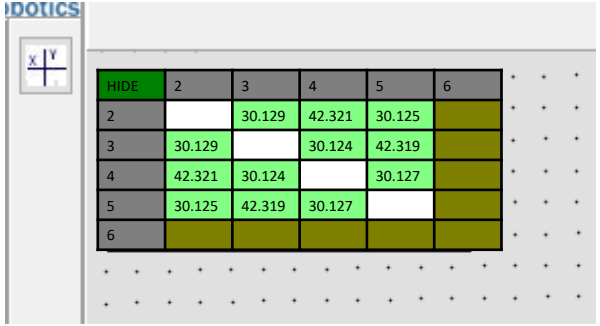
The map is still able to be built automatically, but as the distance is more than 30m, it may be complicated. In this case use some other ways to measure it (laser distance meter, tape, etc.).
Then input it manually

# 10.6: Step 6: Building the distances map (3, 5)




**Finding distance between beacon 3 and beacon 5**

- Face beacons to each other (facing RX4 sensor)
- Turn on RX4 sensor only
- Set the number of periods to 100
- Don’t forget to rise up all the limitations of distances (about 45m)
- Freeze the distance. How to do it see on this slide…

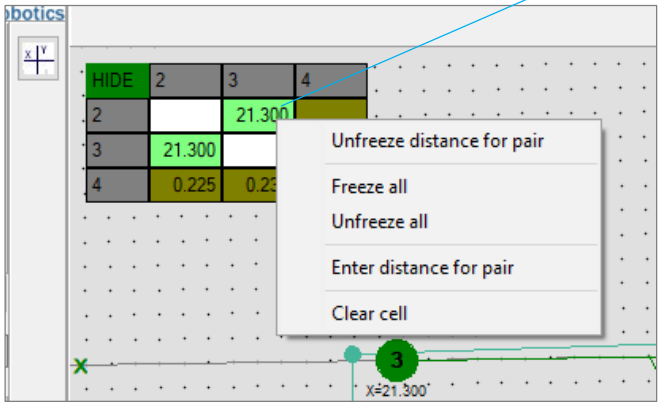


| HIDE | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 2 | | 30.129 | 42.321 | 30.125 | |
| 3 | 30.129 | | 30.124 | 42.319 | |
| 4 | 42.321 | 30.124 | | 30.127 | |
| 5 | 30.125 | 42.319 | 30.127 | | |
| 6 | | | | | |

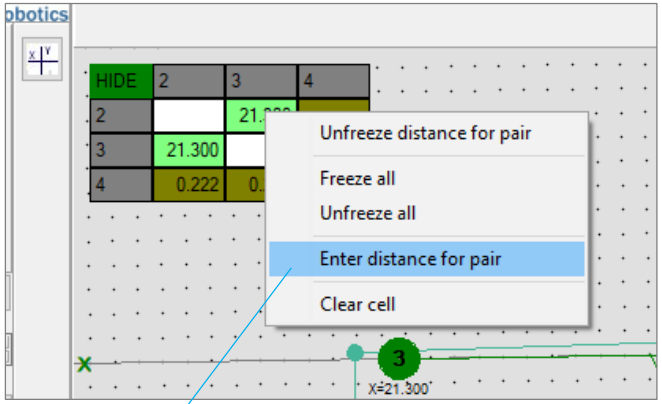
The map is still able to be built automatically, but as the distance is more than 30m, it may be complicated. In this case use some other ways to measure it (laser distance meter, tape, etc.).
Then input it manually

# 10.6a: Manual distance input

Right mouse button click on the distance tab

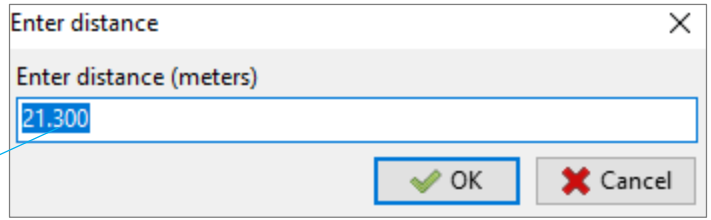



1




2

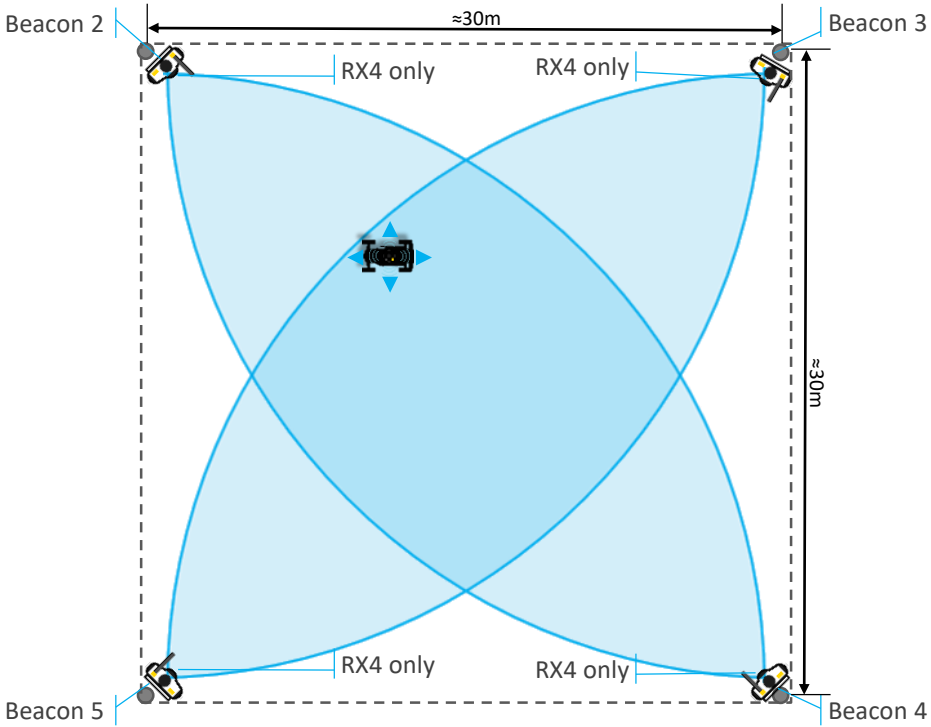
Click **Enter distance for pair**




Enter the distance

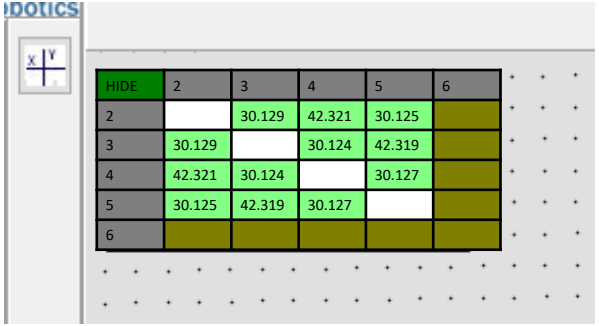
3

# 10.7: Step 7(a): The final configuration (3D tracking)




**Final configuration for 3D**

- Face beacons to the center
- Turn on RX4 sensor only – you will have the highest sensitivity and the highest noise resistance from other directions
- Freeze the map




Now, we finished installation and setting up.

That gave us an opportunity to track in a large area in 3D mode (x, y, z) with 3+1 redundancy in some zone.

Tracking zone is not really limited by 30m, but within 30m it is more confident, stable and reliable.

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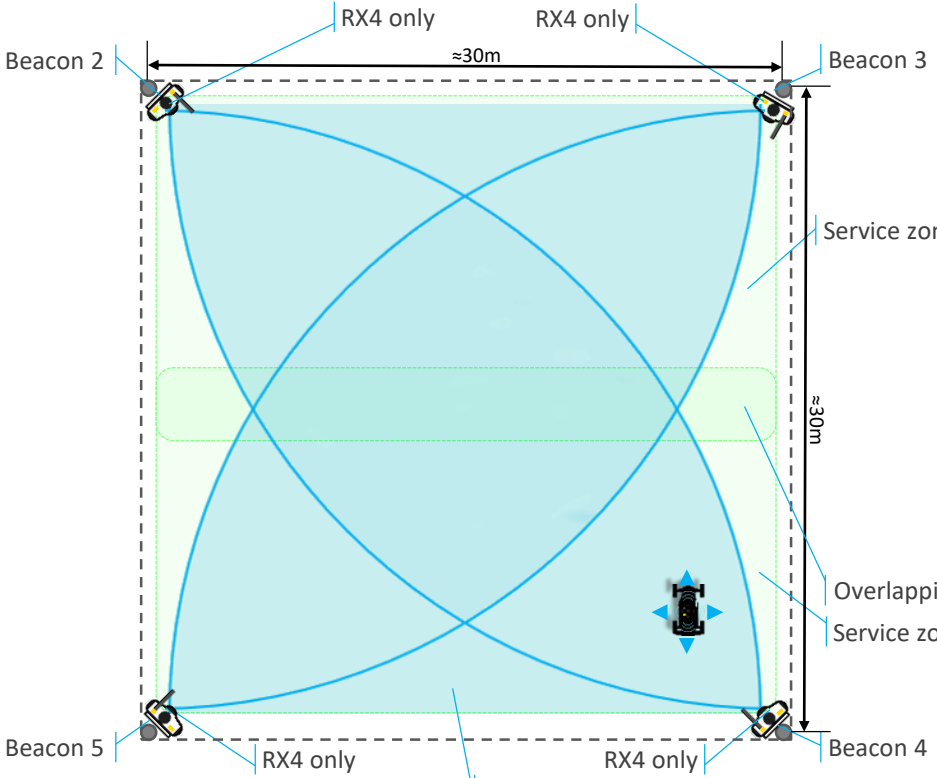
# 10.8: Step 7(b): The final configuration (2D tracking)




**Larger coverage**

As we can see, the tracking area of 2D configuration is bigger, but it doesn't provide Z (height) and redundancy. Choose the configuration, which suits your case

**Final configuration for 2D**

- Face beacons to the center (facing RX4 sensor
- Turn on RX4 sensor only (another option is turn on RX1, RX3, RX4. Depends on the situation)
- Build two submaps. Building submaps video: https://www.youtube.com/watch?v=FXvlDZkxkUU&t=313s
- Track robot, person, autonomous car and anything else

Now, we finished installation and setting up.

That gave us an opportunity to track in a large area in 2D mode (x, y).

Possible tracking zone in 2D is bigger than 3D – see the blue zones, but it has no Z axis measurement and redundancy.

Tracking zone is not really limited by 30m, but within 30m it is more confident, stable and reliable.

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# 11: Area of 100x100m with tracking using submaps

The next slides explain settings for tracking in a large open-spaced warehouses by using Marvelmind indoor “GPS” with submap feature.

It also contains some mounting hints and setting instructions.  We give some examples, their pros and cons and budgetary pricing.

Since the system is rather flexible, various options are presented.

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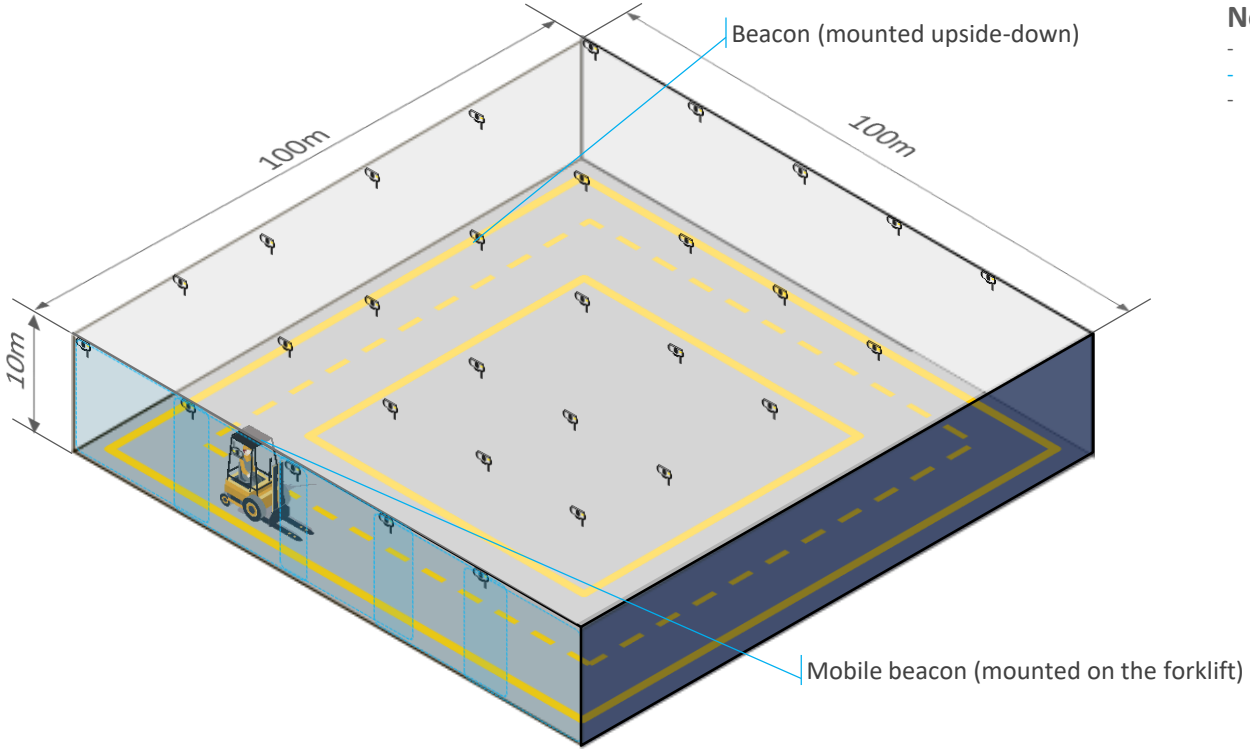
# 11.1: Large 2D (100x100m) tracking – multiple submaps

Here is an example of tracking in open-spaced warehouse. Stationary beacons mounted on the celling upside down. Mobile beacon is mounted on a forklift facing up. The system provides precise (±2cm) real-time position of the mobile beacon (forklift) in real time (1-6Hz), stores its path and all location in a .CSV for post processing and analyzing. It also allows real-time alarms and two-ways communication (up to 1-2kbps) from the system to forklift and back.




**Notes:**

- Cases: big open-spaced warehouses
- 2D (x, y) tracking
- Multiple submaps

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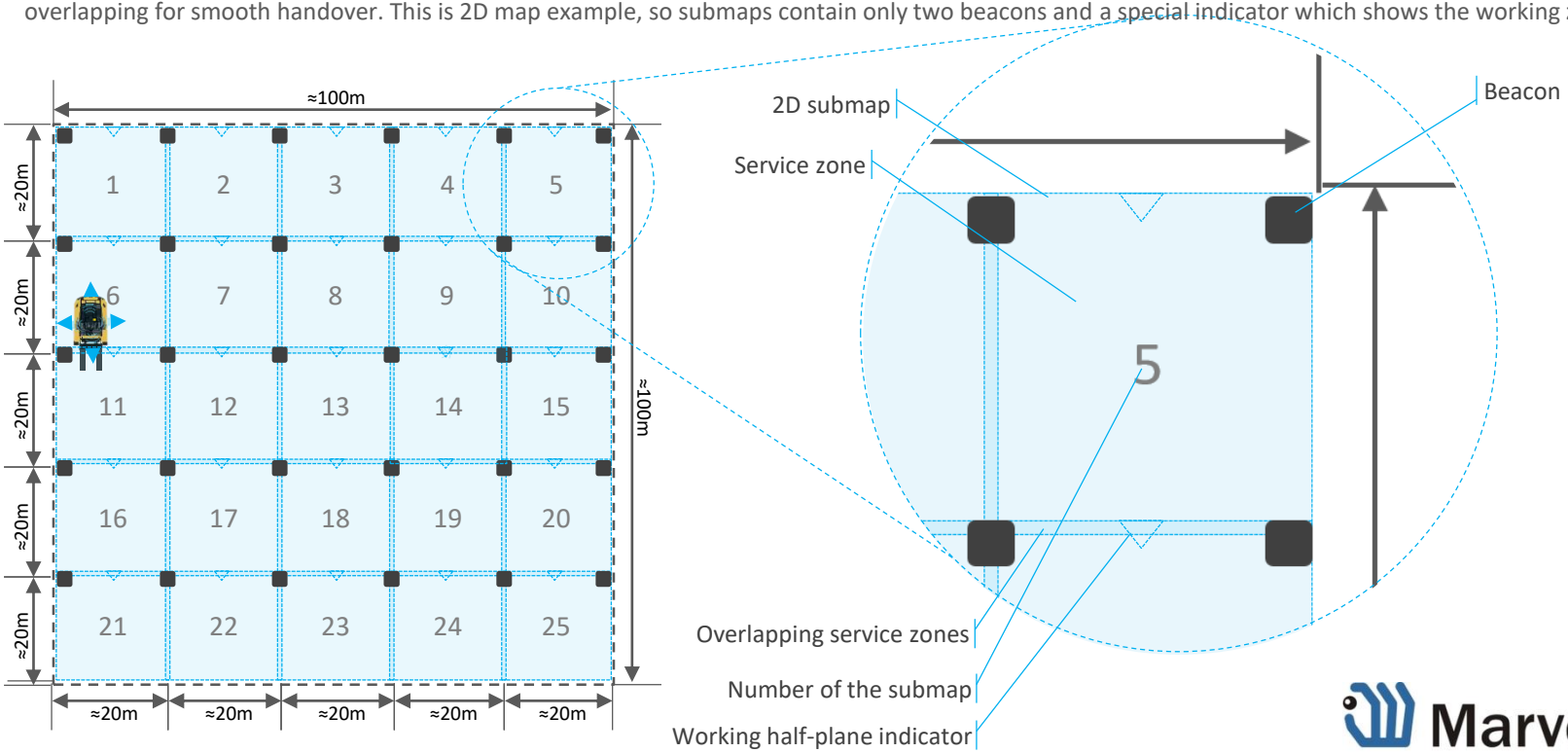
# 11.2: Detailed system view

All track-needed territory is covered with stationary beacons. The beacons are placed on the ceiling with a grid that allows the distance of less than 30m from 2 or more stationary beacons on the ceiling to a mobile beacon on the forklift at any point, where the tracking is required. Service zones are overlapping for smooth handover. This is 2D map example, so submaps contain only two beacons and a special indicator which shows the working zone.

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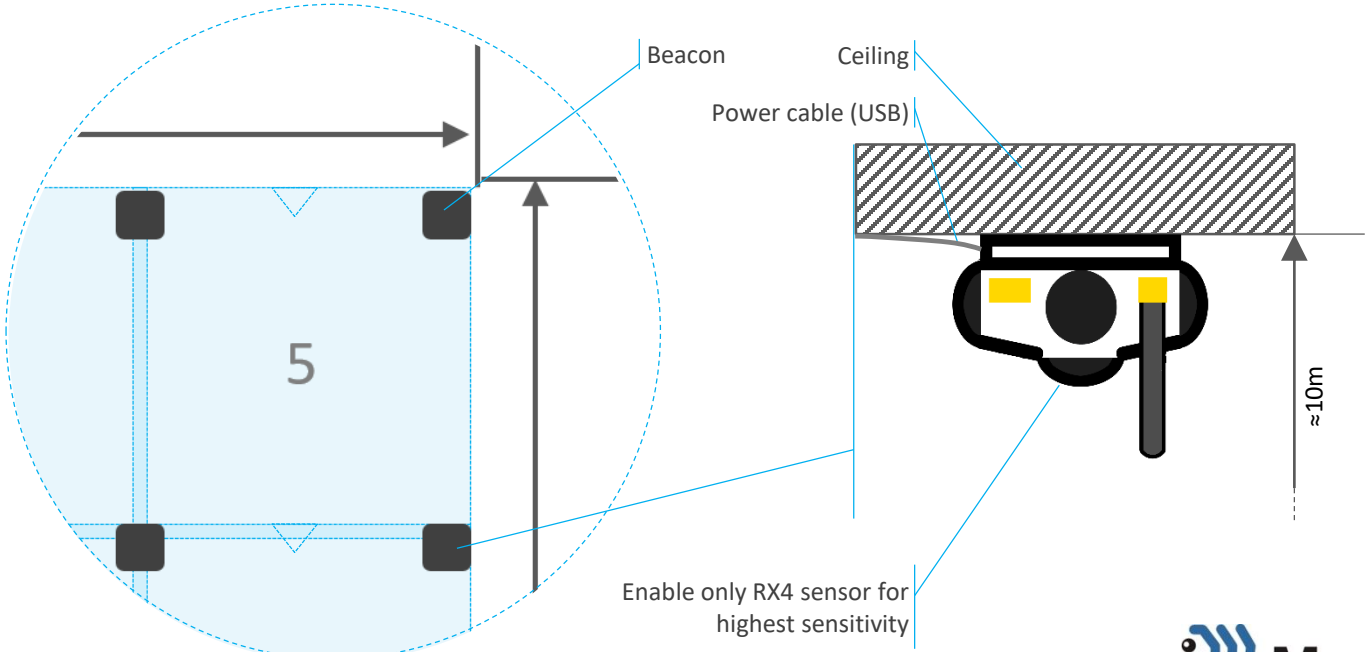
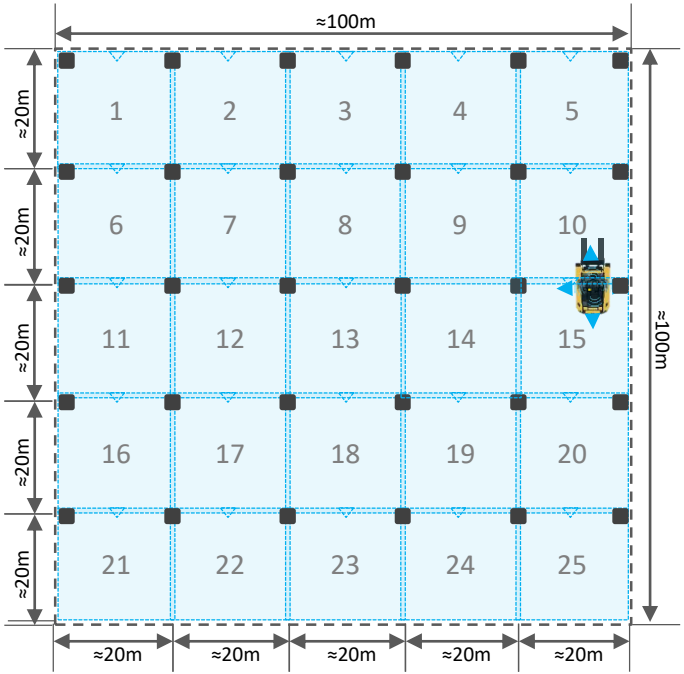
# 11.3: Detailed beacon mounting view

Beacons are placed on the ceiling upside down. Working sensor is RX4. When other sensors (RX1, RX2, RX3, RX5) are disabled, the beacon has the highest sensitivity in RX4 direction and noise resistance from other directions. The height in the example is 10m.

Beacons can work from the embedded LiPol battery, but it is recommended to provide an external power source (regular USB) or a converter ~110/220=>5V USB



# 11.4: 2D optimal configuration




**Notes:**

Configuration “2D optimal” is balanced in price-performance ratio.
Since the configuration is for 2D, it gives only X and Y coordinates.
The configuration is designed for tracking, for example, forklifts in open-spaced warehouses without tall shelfs.

**Pros:**

- Solid tracking
- Very precise (±2cm)
- Designed for forklifts

**Cons:**

- More beacons (price) than in stretched configurations

**Budgetary pricing:**

100x100m “2D optimal”:

- 30 x $69 Beacon – HW v4.9 – 30 x $69 = $2 070
- 1 x mobile beacon – 1 x $69 = $69
- 1 x Modem – HW v4.9 - 1 x $69 = $69

**Total:**

$2 208 per 100x100m with precise (±2cm) and solid (X,Y) tracking

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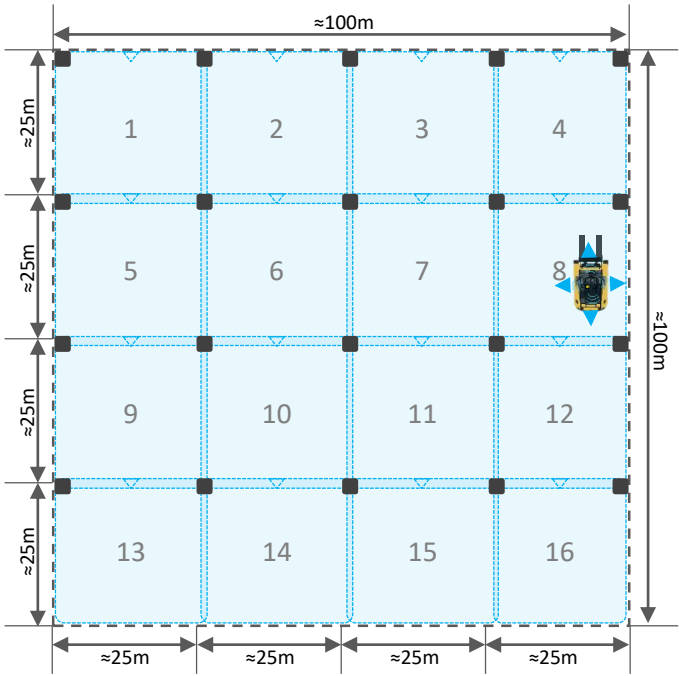
# 11.5: 2D stretched




**Notes:**

Configuration “2D stretched” is actually the same as “2D optimal”, but works with a longer distances between beacon. That gives an advantage in price, but tracking can be interrupted with external noise or by just too weak ultrasonic signal.
It is also in 2D, so it gives only X and Y coordinates.

**Pros:**

- Lower total cost than the 2D Optimal configuration

**Cons:**

- Potentially, less solid tracking than the 2D Optimal configuration

**Budgetary pricing:**

100x100m “2D stretched”:

- 20 x $69 Beacon – HW v4.9 - 20 x $69 = $1 380
- 1 x mobile beacon – 1 x $69 = $69
- 1 x Modem – HW v4.9 - 1 x $69 = $69

**Total:**

Only $1 518 per 100x100m of precise (±2cm) (X,Y) tracking

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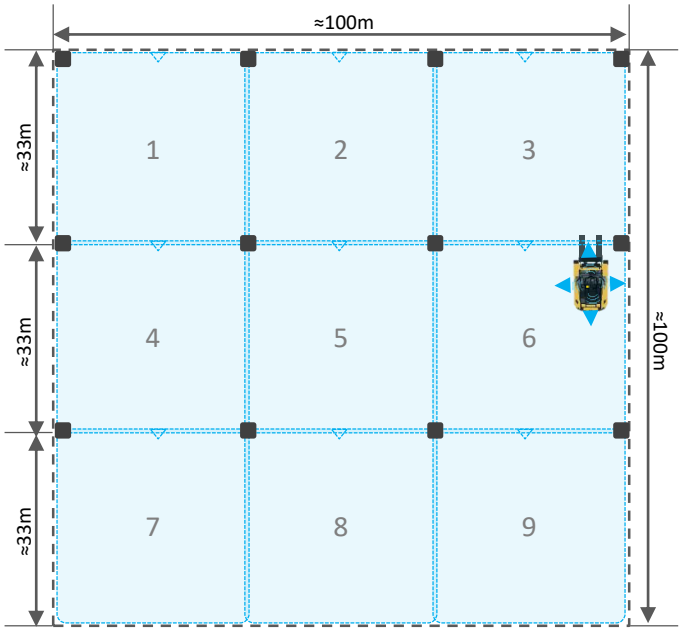
# 11.6: 2D super-stretched




**Notes:**

Configuration “2D super-stretched” has the best price as the distances are the largest, but it is mostly designed for future HW/SW version.
It is 2D, so it gives only X and Y coordinates.

**Pros:**

- The lowest total cost among the three configurations

**Cons:**

- Will be available with future SW upgrade (or even with new HW of beacons)
- May require more manual and fine settings than other configurations

**Budgetary pricing:**

100x100m “2D super-stretched”:

- 12 x $69 Beacon – HW v4.9 - 12 x $69 = $828
- 1 x mobile beacon – 1 x $69 = $69
- 1 x Modem – HW v4.9 - 1 x $69 = $69

**Total:**

Only $966 per 100x100m of precise (±2cm) (X,Y) tracking

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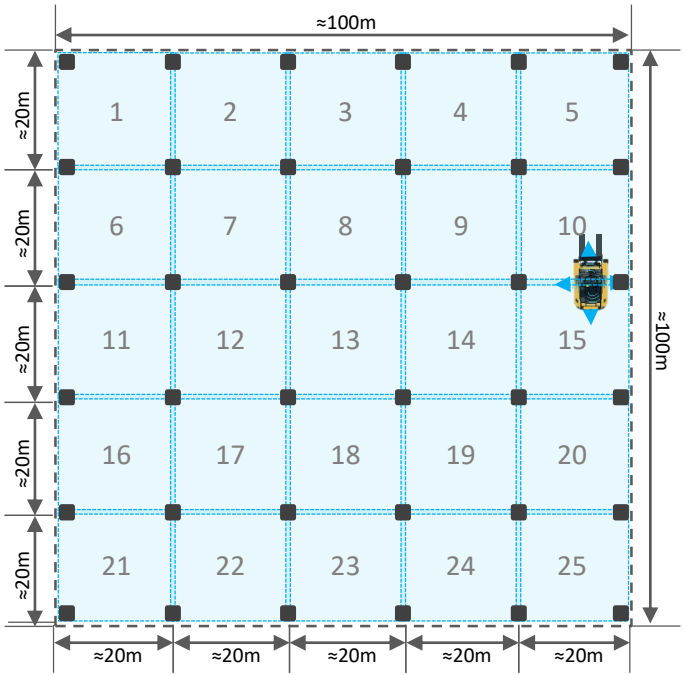
# 11.7: 3D optimal




**Notes:**

Configuration “3D optimal” is balanced in price-performance ratio.
The configuration is 3D, so it gives (X,Y,Z) positioning.
It has 3+1 redundancy. That means that, if 1 of 4 beacons in submap is blocked, 3D tracking is still exists.
The configuration is suitable for tracking, for example, not only forklifts, but also drones in open-spaced warehouses without tall shelfs.

**Pros:**

- Solid tracking
- Suitable for drones – gives 3D (x, y, z)

**Cons:**

- More beacons/price than in stretched configurations

**Budgetary pricing:**

100x100m “3D optimal”:

- 36 x $69 Beacon – HW v4.9 - 36 x $69 = $2 484
- 1 x mobile beacon – 1 x $69 = $69
- 1 x Modem – HW v4.9 - 1 x $69 = $69

**Total:**

$2 622 per 100x100m precise (±2cm) and solid (X,Y,Z) tracking

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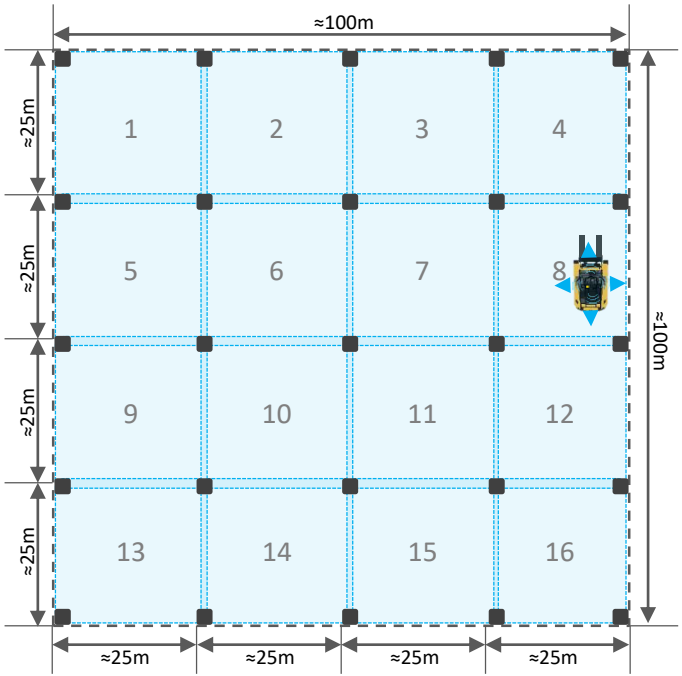
# 11.8: 3D stretched




**Notes:**

Configuration “3D stretched” is actually the same as “3D optimal”, but works with a longer distances. That gives an advantage in price, but tracking can be interrupt with noise. The configuration is 3D, so it gives (X,Y,Z) positioning.

It has 3+1 redundancy. That means that, if 1 of 4 beacons in submap is blocked, 3D tracking is still exists.

The configuration is suitable for tracking, for example, not only forklifts, but also drones in open-spaced warehouses without tall shelfs.

**Pros:**

- Lower costs than in 3D optimal configuration

**Cons:**

- More complex settings and less solid performance than in the 3D optimal configuration

**Budgetary pricing:**

100x100m “2D stretched”:

- 25 x $69 Beacon – HW v4.9 - 25 x $69 = $1 725
- 1 x mobile beacon – 1 x $69 = $69
- 1 x Modem – HW v4.9 - 1 x $69 = $69

**Total:**

Only $1 863 per 100x100m precise (±2cm) and good (X,Y,Z) tracking

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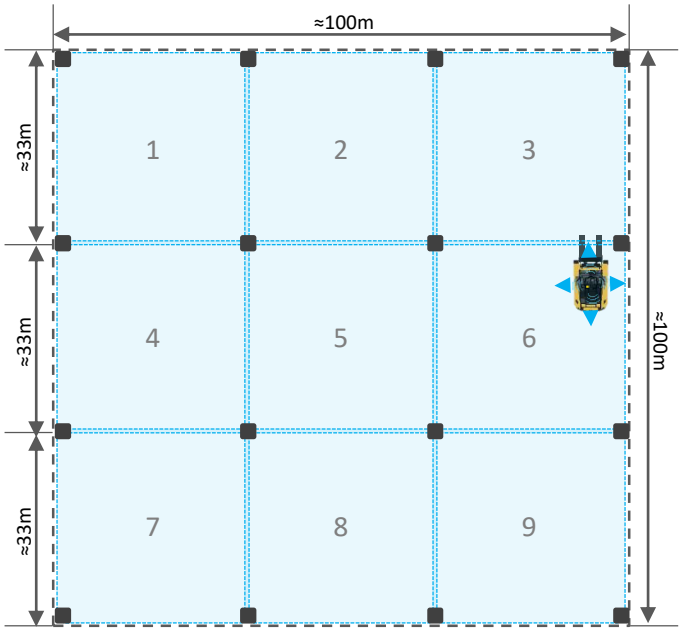
# 11.9: 3D super-stretched




**Notes:**

Configuration “3D super-stretched” has the best price as the distances are the largest, but it is mostly designed for future HW/SW version.
It is 3D, so it gives us only X and Y coordinates.
It has 3+1 redundancy. That means that, if 1 of 4 beacons in submap is blocked, tracking is still exists.

**Pros:**

- The lowest total cost among the three configurations

**Cons:**

- Will be available with future SW upgrade (or even with new HW of beacons)
- May require more manual and fine settings than other configurations

**Price:**

100x100m “2D super-stretched”:

- 16 x $69 Beacon – HW v4.9 - 16 x $69 = $1 104
- 1 x mobile beacon – 1 x $69 = $69
- 1 x Modem – HW v4.9 - 1 x $69 = $69

**Total:**

Only $1 242 per 100x100m precise (±2cm) and (X,Y,Z) tracking

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# 11.10: Summary – 100x100m area

We presented different configurations of tracking mobile assets (vehicles, forklifts, drones) in 100x100m warehouse with ±2cm precision.
We also gave some recommendations of mounting and setting up the system:

- 2D optimal
- 2D stretched
- 2D super-stretched (future release)
- 3D optimal
- 3D stretched
- 3D super-stretched (future release)

Prices for the same area: $966 - $2 622

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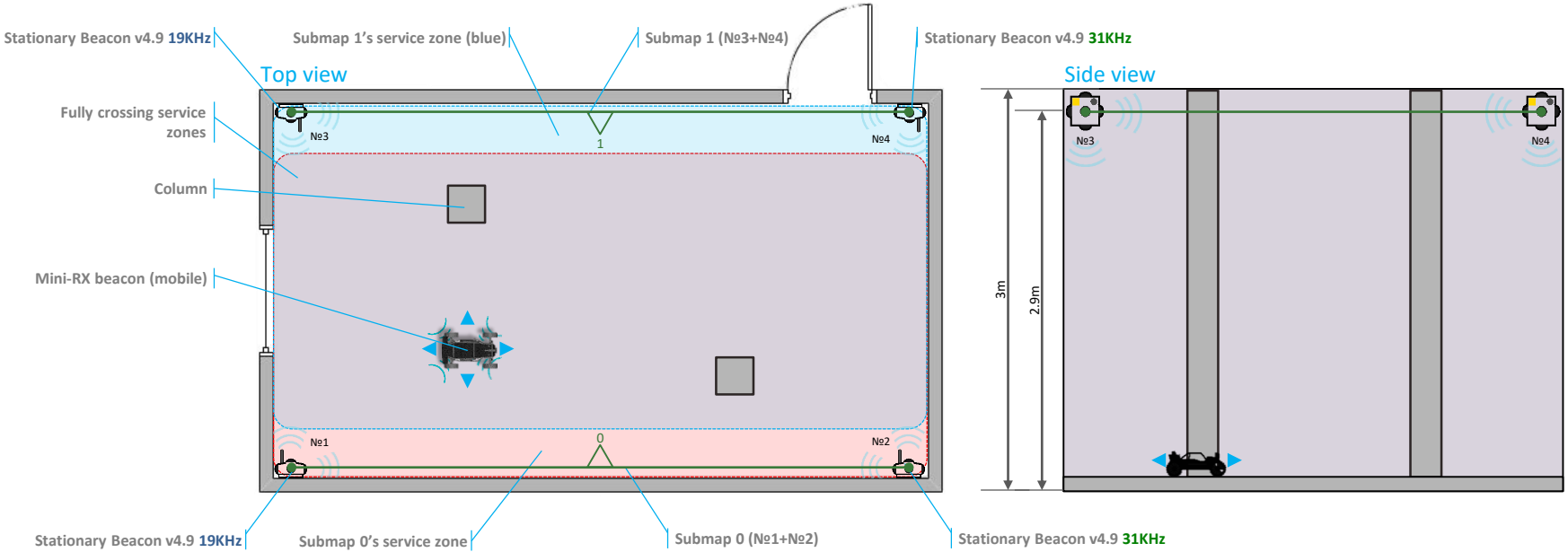
# 12: Full overlapping submaps (IA, 2D, TDMA)




## Configuration:

- Inverse Architecture (IA) with TDMA:
  - 2 x HW v4.9 Beacon 19KHz
  - 2 x HW v4.9 Beacon 31KHz
  - 1 x Mini-RX as a mobile beacon (or more Mini-RXs for more mobile objects)
  - 1 x Modem

## Notes:

- TDMA feature, which helps to improve the tracking quality in complex situations
- If one submap obstructed, another submap will provide solid tracking
- Check Operating Manual for more details about TDMA (Chapter 6.2)
- Check Track of Marvelmind Jacket indoor video
- Check our YouTube channel – Marvelmind Robotics

## TDMA settings:

- TDMA sequence length = 2
- TDMA position in sequence:
  - Submap 0 = 0
  - Submap 1 = 1

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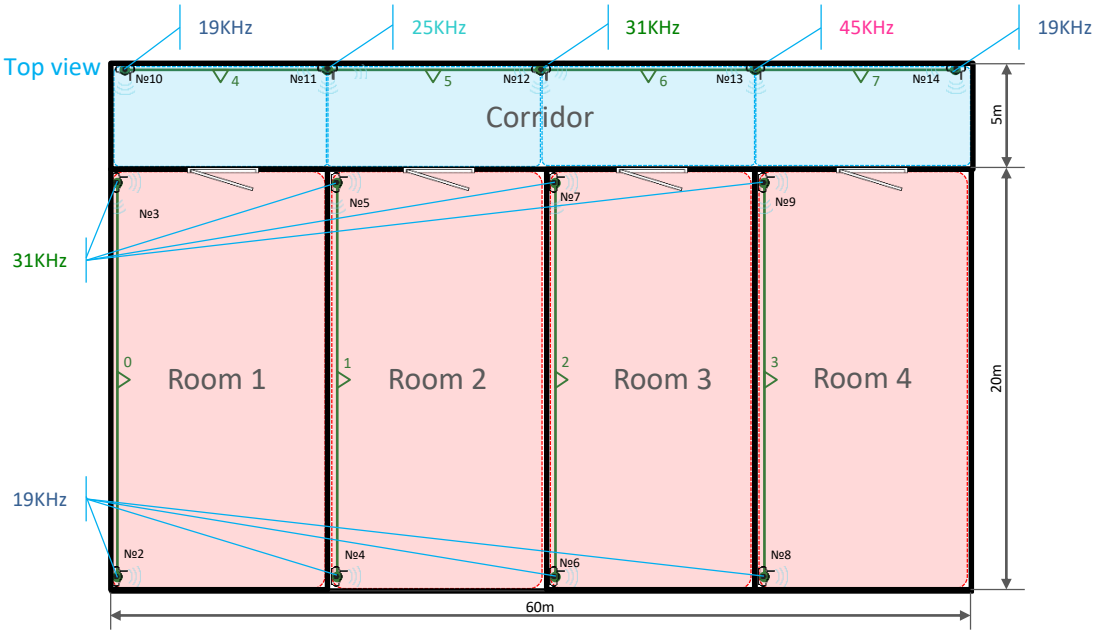
# 13: Rooms + corridor (IA, 2D, TDMA)




**TDMA case description:**

- xxxxxxxxx

**Configuration:**

- Inverse Architecture (IA) with TDMA:
  - 6 x HW v4.9 Beacon 19KHz
  - 1 x HW v4.9 Beacon 25KHz
  - 5 x HW v4.9 Beacon 31KHz
  - 1 x HW v4.9 Beacon 45KHz
  - 1 x Mini-RX as a mobile beacon (or more Mini-RXs for more mobile objects)
  - 1 x HW v4.9 Modem

**Notes:**

- Designed for tracking people or robot In the office
- This particular configuration supports 2D
- Check Operating Manual for more details about TDMA (Chapter 6.2)
- Check Submaps Help Video
- Check TDMA in Museum demo video
- Check Tracking 4 warehouse workers video

**TDMA settings:**

- TDMA sequence length = 2
- TDMA position in sequence:
  - Submap 0-3 = 0
  - Submap 4-7 = 1

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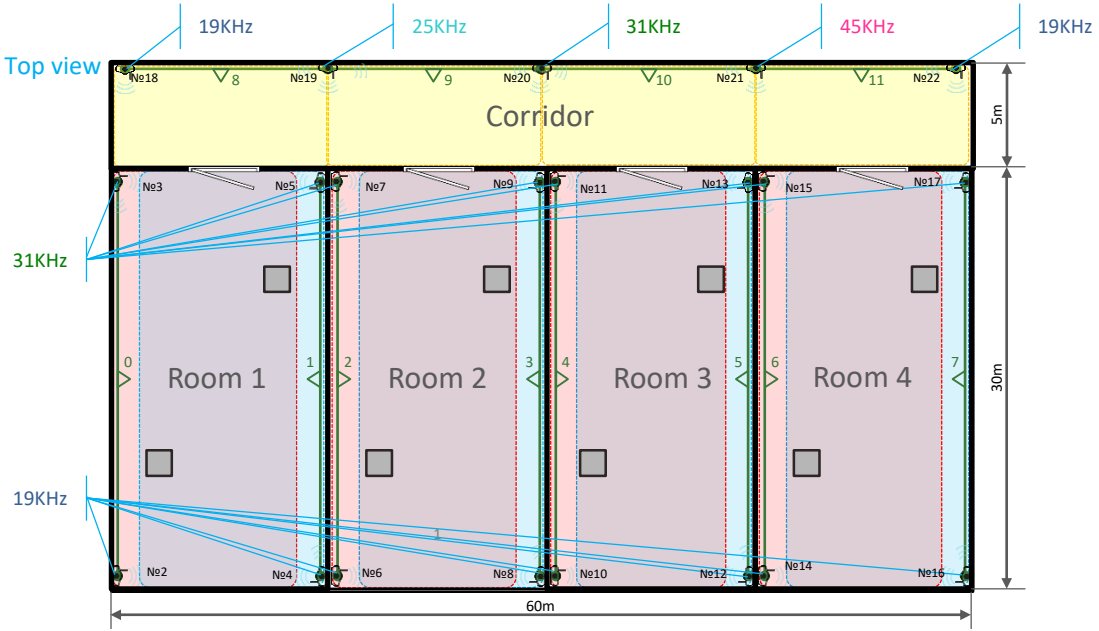
# 14: Rooms with columns + corridor (IA, 2D, TDMA)




**TDMA case description:**

- xxxxxxxxx

**Configuration:**

- Inverse Architecture (IA) with TDMA:
  - 10 x HW v4.9 Beacon 19KHz
  - 1 x HW v4.9 Beacon 25KHz
  - 9 x HW v4.9 Beacon 31KHz
  - 1 x HW v4.9 Beacon 45KHz
  - 1 x Mini-RX as a mobile beacon (or more Mini-RXs for more mobile objects)
  - 1 x HW v4.9 Modem

**Notes:**

- Designed for tracking people or robot In the office
- This particular configuration supports 2D
- Check Operating Manual for more details about TDMA (Chapter 6.2)
- Check Submaps Help Video
- Check TDMA in Museum demo video
- Check Tracking 4 warehouse workers video

**TDMA settings:**

- TDMA sequence length = 3
- TDMA position in sequence:
  - Submap 0, 2, 4, 6 = 0
  - Submap 1, 3, 5, 7 = 1
  - Submap 8, 9, 10, 11 = 2

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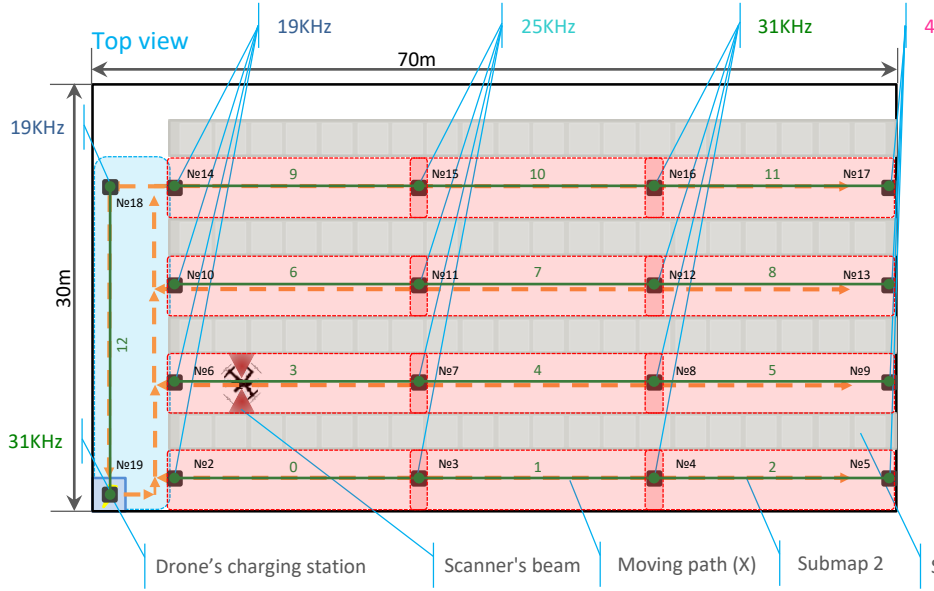
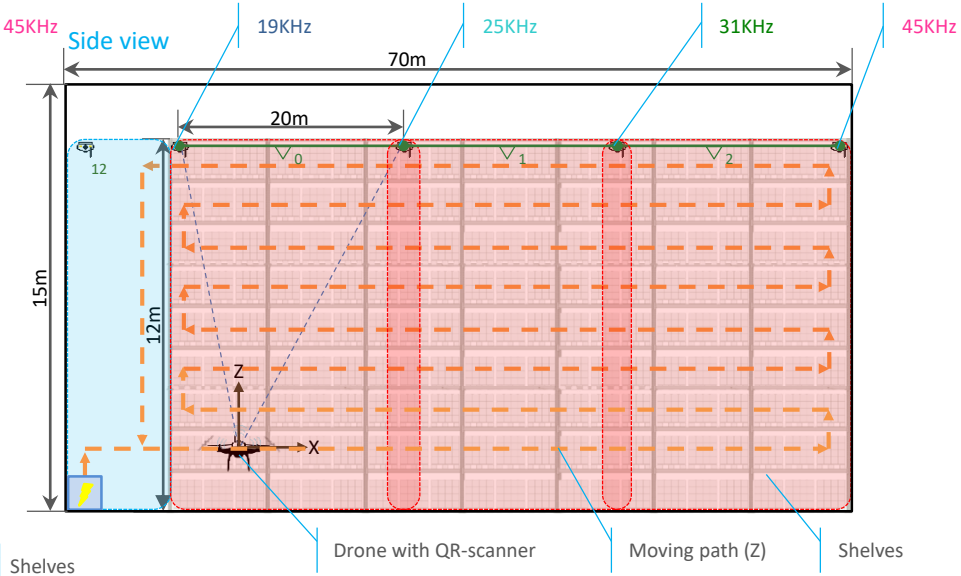
# 15: Autonomous inspection drone (IA, 2D, TDMA, Vertical-XZ)




## Configuration:

- Inverse Architecture (IA) with TDMA:
  - 5 x HW v4.9 Beacon 19KHz
  - 4 x HW v4.9 Beacon 25KHz
  - 5 x HW v4.9 Beacon 31KHz
  - 4 x HW v4.9 Beacon 45KHz
  - 1 x Mini-RX as a mobile beacon (or more Mini-RXs for more mobile objects)
  - 1 x HW v4.9 Modem

## Notes:

- Designed for autonomous warehouse inspection
- This particular configuration supports 2D Vertical tracking with X and Z axis. X axis displays horizontal movement, Z axis displays vertical movement. Y is not available.
- Check Operating Manual for more details (TDMA chapter)
- Check Submaps Help Video
- Check TDMA in Museum demo video
- Check Tracking 4 warehouse workers video

## TDMA settings:

- TDMA sequence length = 2
- TDMA position in sequence:
  - Submap 0-11 = 0
  - Submap 12 = 1

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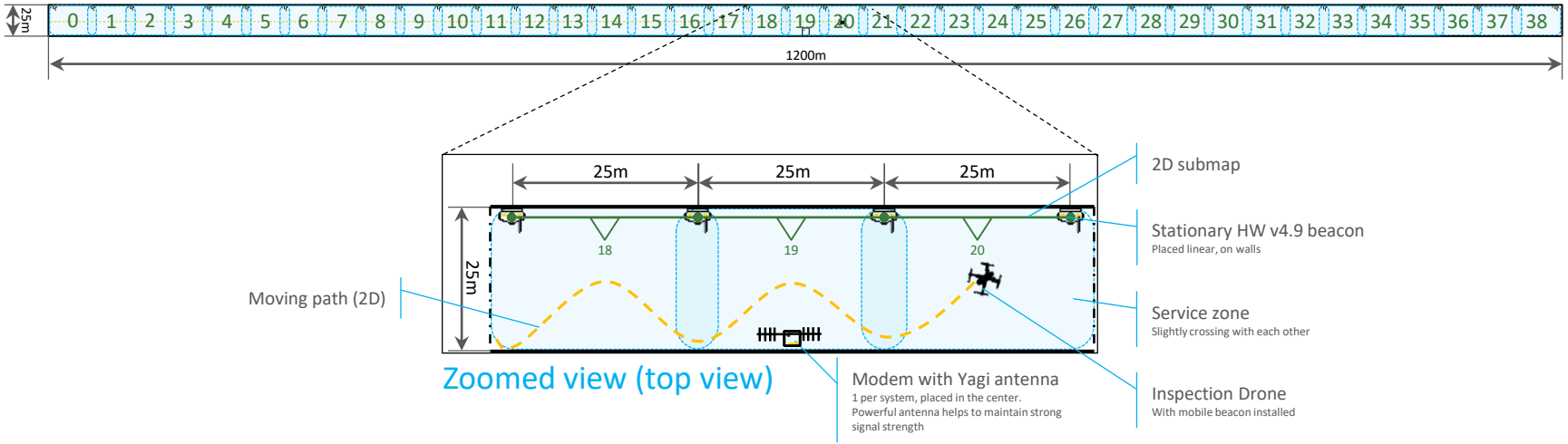
# 16: Tunnel 1200x25m, autonomous inspection (NIA, 2D)

## General view (top view)




## Zoomed view (top view)

**Configuration:**

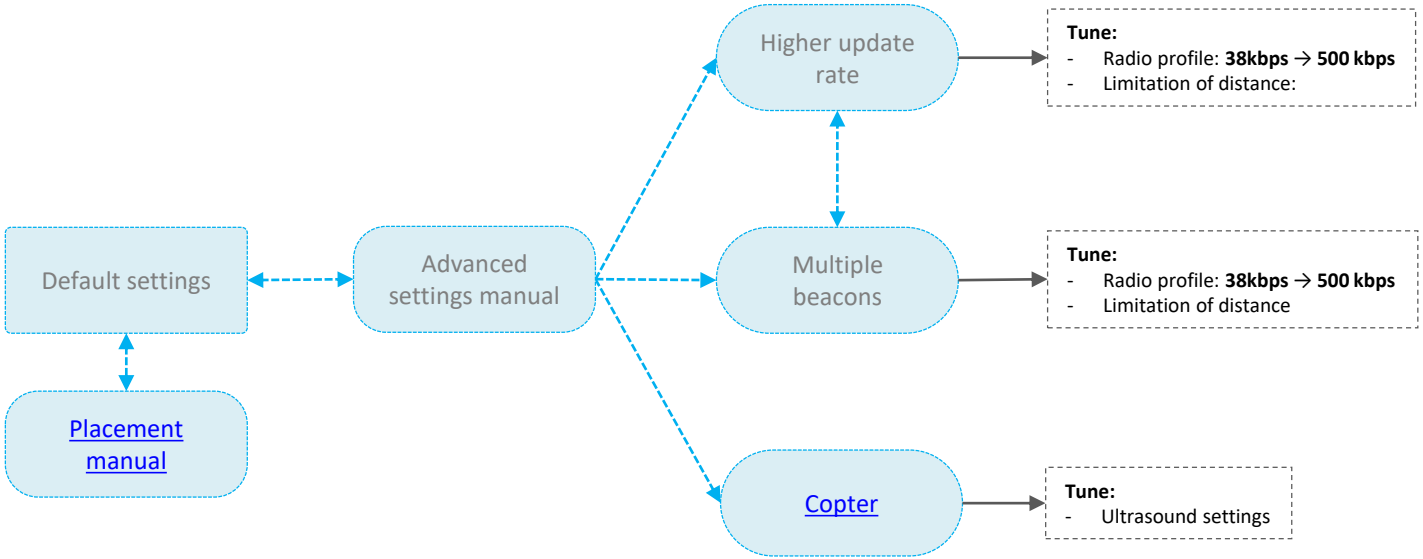
- Non-Inverse Architecture (NIA):
  - 40 x Beacon HW v4.9
  - 1 x Modem HW v4.9
  - N x Beacon HW v.4.9 as a mobile beacon

**Notes:**

- Designed for autonomous tunnel inspection
- Check Operating Manual for more details (TDMA chapter)
- Check Submaps Help Video

# 17: Steps beyond default settings

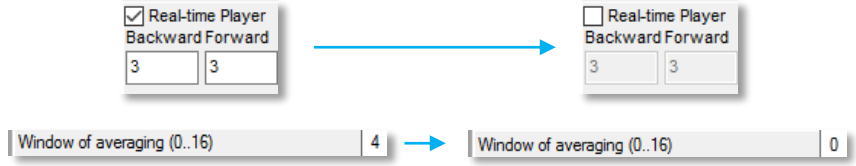
After default settings, you have an opportunity to go to advanced settings and installations. Check the info bellow.



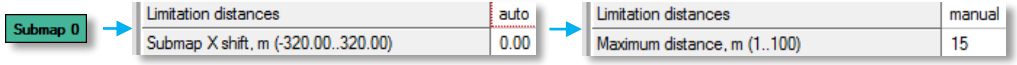
# 18: Real-time tracking: reducing the delay

Use this instruction if you need the smallest delay possible

1. Turn off the Real-time player
   - Real-time player is a feature, which makes the tracking path smoother. As far as it looks backward and forward, it has some small delay. Turn it off if you need less delay
     Real-time player set to 0/0 or disable
     Real-time Averaging window in Modem settings set to 0 instead of default 4




2. Move radio profile to higher speed => 500kbps instead of default 38kbps
3. Change the limitation of distances
   - Go to submap settings and change it from Auto to Manual and set it to the largest distance between the mobile beacon and stationary beacons in the submap - 10-15m - whatever you have.
     Latency will be 1.2..1.5/Update rate, i.e. for 16Hz ultrasonic update rate, you have ~100ms latency




4. Use IMU + ultrasonic fusion.
   - As soon as you have location update rate 4-8Hz or more, the sensor fusion works well and you will have 100Hz resulting update rate and latency around 12-15ms

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# Additional help

- https://marvelmind.com/
- Marvelmind YouTube channel
- FAQ
- For additional support, send your questions to info@marvelmind.com