Indoor “GPS”
(with ±2cm precision)
 Placement Manual

v2019_08_15
Version changes

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
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

01: Starter Set HW v4.9 – simple 3D installation
01a: Simple 2D Tracking – for example, RC car indoor
01b: Mini-RX Starter Set – simple 3D installation
02: Starter Set + IMU – settings and recommendation
03: Paired beacons – location + direction
04: Stable “Z” for drone – settings and recommendations
05: Tracking sidewalks, tunnels, metros, mines in 2D
06: Submaps in 2D
07: Wheeled robot in 46x5m area (2D navigation)
08a: Business center area – Tracking people in 2D
09: Multi-modem 1.5D – tracking vehicles underground
10: Tracking in 30x30m area
11: Area of 100x100m with tracking using submaps
12: Room with columns (IA, 2D, TDMA)
13: Rooms + corridor (IA, 2D, TDMA)
14: Rooms with columns + corridor (IA, 2D, TDMA)
15: Autonomous inspection drone (IA, 2D, TDMA, Vertical-XZ)
16: Tunnel 1200x25m, autonomous inspection (NIA, 2D)
17: Steps beyond default settings
18: Real-time tracking: reducing the delay

Contacts

Conventions:

Mini-RX beacon
V4.9 Mobile beacon
V4.9 Beacon
Modem
Submap/zone
01: Starter Set HW v4.9 – simple 3D installation

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

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

Mobile beacon
- Placed on a forklift/robot, person

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

**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

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

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

**Modem**
- Must be always powered, when tracking is needed
01b: Mini-RX Starter Set – simple 3D installation

**Side view**

- 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

**Top view**

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

- Room
  - Start with a midsize map of 6×4 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

**Room:**

- Start with a midsize map of 6×4 to 6-10m or so
- Maximum size of the map for Starter Set is up to 1000m²
02: Starter Set + IMU – settings and recommendation

**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

**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**
- 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
- Mobile beacon + IMU
  - Placed on a forklift/robot, person
03: Paired beacons – location + direction

**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

**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

**Top view**

**Direction of Travel**

**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

**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

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

Wall Stationary beacons:
- Needed for providing better Z positioning

Submap 1
Vertical submap for taking off and landing. Particular focus on obtaining good Z.

Submap 2
Used for flying on a height – not next to the ground. Next to the ground, X,Y will be perfect, but Z – not. This is due to basic geometry of trilateration.

Beacon 1:
- Enable RX1, RX2, RX4

Beacon 2:
- Enable RX3, RX3, RX4

Beacon 3:
- Enable RX2, RX3, RX4

Mobile beacons (paired)
- For location + direction

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 autonomous drones indoor and good Z tracking on all heights
- Supports 3D (X,Y,Z) + N redundancy
- Detailed video help: Help: Z-coordinates for copters
05: Tracking sidewalks, tunnels, metros, mines in 2D

**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

**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**

**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

**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

**Small delivery vehicle example**

- RX1
- RX2
- RX3
- RX4

**Underground railway transport example**

- RX1
- RX2
- RX3
- RX4

**Light pole**

-les 500m*

-les 500m*
06: Submaps in 2D

Top view

Stationary beacon
- Shall be placed high on the wall or ceiling – to minimize shadows in ultrasonic
- Enable only required sensors – to improve sensitivity and external noise immunity

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
Option 1: Optimal conservative, 2D

Option 2: Stretching, 2D

Submap/service zones overlapping for smooth handover between submaps

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 3: Optimal conservative, 3D

Option 4: Conservative, 2D

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

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.

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

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.

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

*All the distances are given in meters*
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)
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.
10: Tracking in 30x30m area - zones

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

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

**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

See the instructions on the next slides
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...

Beacon 2
| RX4 only |
Beacon 3
| RX4 only |
Beacon 4
| 30m |
Beacon 5

Frozen distance

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</table>
10.1a: How to freeze distance for pair

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</table>

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

2

Click Freeze distance for pair

Now it's frozen
**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...

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</tbody>
</table>
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...

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</tbody>
</table>
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...

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</tbody>
</table>
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…

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)

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.

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…

The table below shows the distances measured:

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</tbody>
</table>
10.6a: Manual distance input

1. Right mouse button click on the distance tab

2. Click Enter distance for pair

3. Enter the distance
   - Enter distance (meters)
   - 21.300
   - OK
   - Cancel
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.
10.8: Step 7(b): The final configuration (2D tracking)

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.

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

Here is an example of tracking in open-spaced warehouse. Stationary beacons mounted on the ceiling 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
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.
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 shelves.

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
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
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
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
**11.8: 3D stretched**

Notes:
Configuration “3D stretched” is actually the same as “3D optimal”, but works with longer distances. That gives an advantage in price, but tracking can be interrupted 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 shelves.

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

Total: $1 242 per 100x100m precise (±2cm) and (X,Y,Z) tracking
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
12: Room with columns (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
- 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

**Top view**
- Stationary Beacon v4.9 **19KHz**
- Submap 1’s service zone (blue)
- Submap 1 (№3+№4)
- Column
- Mini-RX beacon (mobile)
- Fully crossing service zones

**Side view**
- Stationary Beacon v4.9 **31KHz**
- Submap 0’s service zone
- Submap 0 (№1+№2)
- Stationary Beacon v4.9 **19KHz**
- Submap 0 (№1+№2)
13: Rooms + corridor (IA, 2D, TDMA)

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

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

Top view

Room 1
Room 2
Room 3
Room 4

Room 1
Room 2
Room 3
Room 4

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

**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

**TDMA case description:**
- xxxxxxxxx
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
16: Tunnel 1200x25m, autonomous inspection (NIA, 2D)

General view (top view)

Zoomed view (top view)

Configuration:
- **Non-Inverse Architecture (NIA):**
  - 40 x Beacon HW v.4.9
  - 1 x Modem HW v.4.9
  - 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
After default settings, you have an opportunity to go to advanced settings and installations. Check the info below.

- **High update rate**
  - Radio profile: 38kbps → 500 kbps
  - Limitation of distance:

- **Multiple beacons**
  - Tuning:

- **Copter**
  - Tuning:
    - Ultrasound settings

**Default settings**

**Advanced settings manual**

**Placement manual**
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
Additional help

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