Building submaps

For precise (±2cm) Indoor “GPS”

Hints and advice

Marvelmind
robotics

Contents

Marvelmind robotics

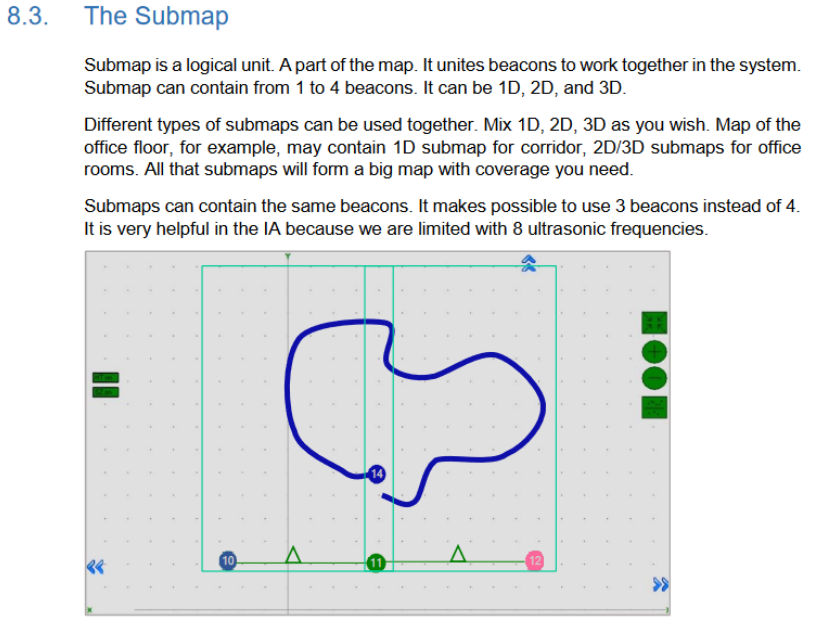
Why submaps are needed

1. Range of beacons
2. Non-line of sight (walls)
3. Non-line of sight (mobile obstructions)

Intro

- Other materials are already available:
  - Help: submaps, service zones, handover zones
  - Help video: using submaps to build large maps
  - Submap feature demo
- Operating Manual
- Placement Manual
- Step-by-Step guide on building maps

Study them beforehand



8.3. The Submap

Submap is a logical unit. A part of the map. It unites beacons to work together in the system. Submap can contain from 1 to 4 beacons. It can be 1D, 2D, and 3D.

Different types of submaps can be used together. Mix 1D, 2D, 3D as you wish. Map of the office floor, for example, may contain 1D submap for corridor, 2D/3D submaps for office rooms. All that submaps will form a big map with coverage you need.

Submaps can contain the same beacons. It makes possible to use 3 beacons instead of 4. It is very helpful in the IA because we are limited with 8 ultrasonic frequencies.

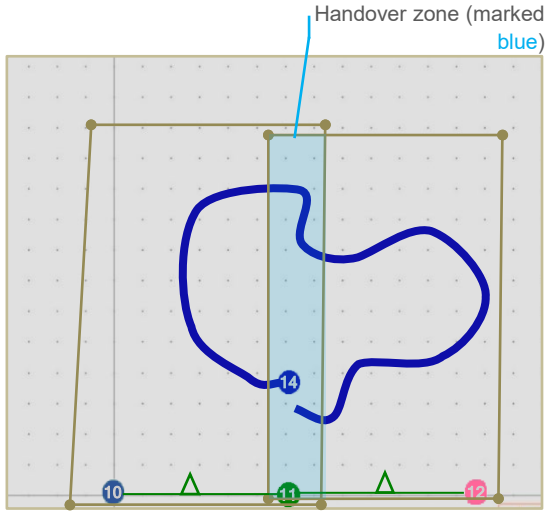
Marvelmind robotics

Terminology

- Map and Super-map
- Submap
- Table of distances
- Service zone
- Handover zone
- IA vs. NIA vs. MF NIA
- Ultrasound frequencies

Map

- 1 to 250 submaps – up to 250,000m²
- 1 to 250 beacons (stationary + mobile combined)
- One modem per map
- Freezing map

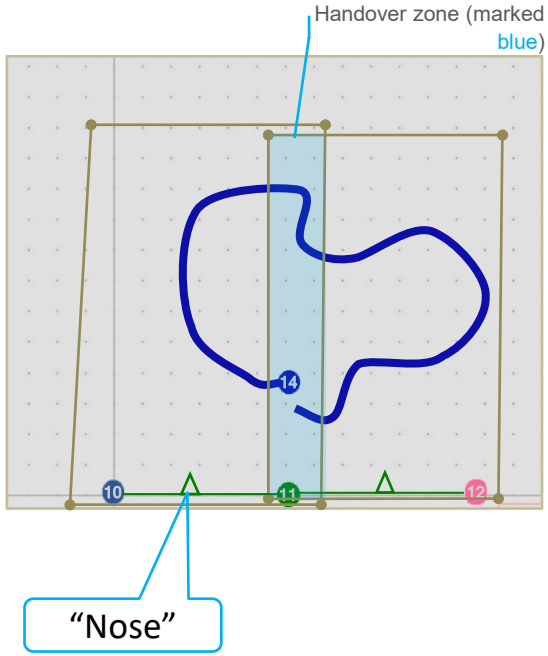


Super-map (future item):

- Multi-Modem Architecture
- Super-Super-Modem
- Map of maps – thousands of beacons
- Looks like a regular map for end-users

Submap

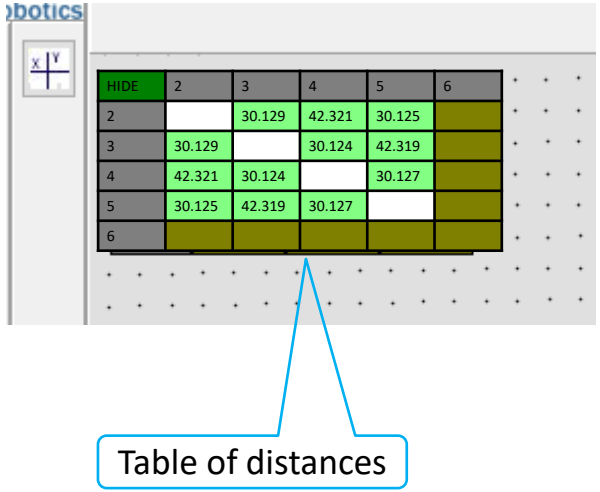
- One or more per map
- Each submap – up to 1,000m²
- 1D, 2D, 3D – 1, 2, 3-4 beacons
- Fully overlapping submap and 3+1 redundancy
- Not crossing line in 2D
- Always have service zones (limitation of distance)
- Heights of beacons – a must
- Self-building submaps with Super-Beacons
- Freezing submap



Marvelmind robotics

Table of distances

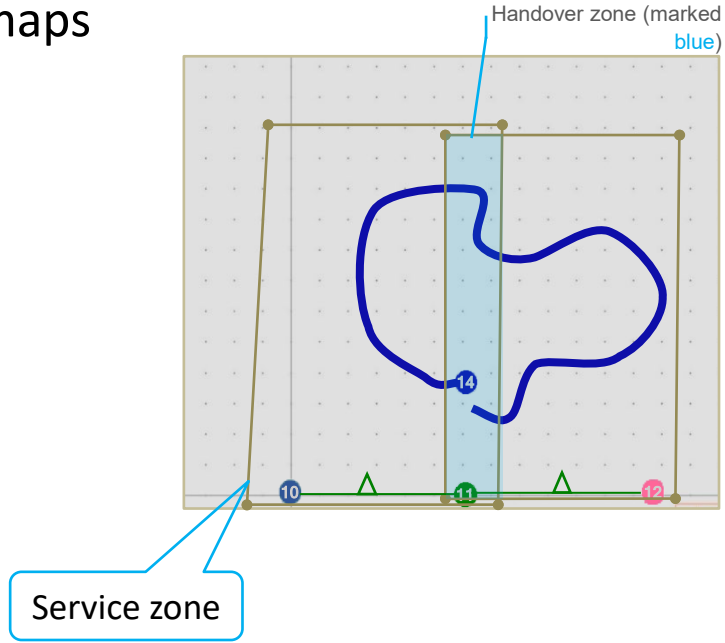
- Automatically built with Super-Beacons
- Can be populated manually (Mini-RX, etc.)
- Make sure white before freezing submap



Marvelmind robotics

Service zone

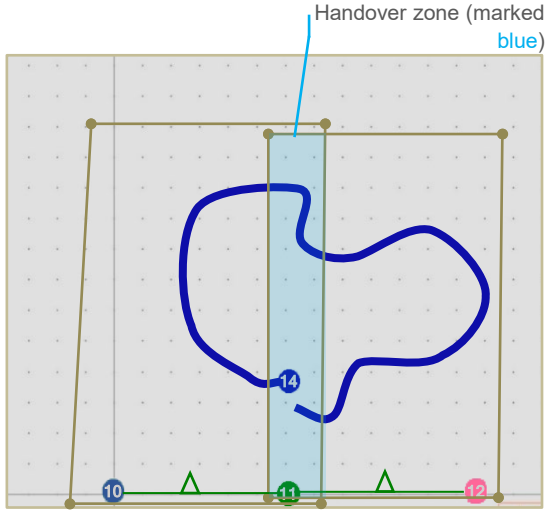
- Recommended to have in single submap
- A must to have for maps with multiple submaps
- Can be 1D, 2D, 3D
- Service zone vs. limitation of distance
- Size vs. location update rate
- Maximum 8 points per service zone (today)



Marvelmind robotics

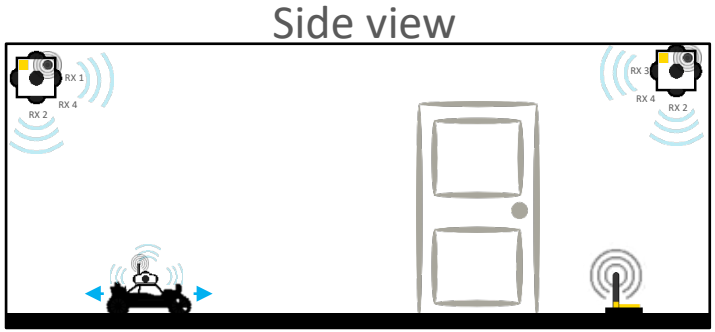
Handover zone

- Recommended width - 2-5 location updates
- Soft handover
- Hard handover



Marvelmind robotics

How to place beacons



- Line of sight. Line of sight. Line of sight.
- Least number of beacons to cover largest area
- Least chances of obstruction
- Smallest submaps => higher update rate

Marvelmind
robotics

Hints – part 1

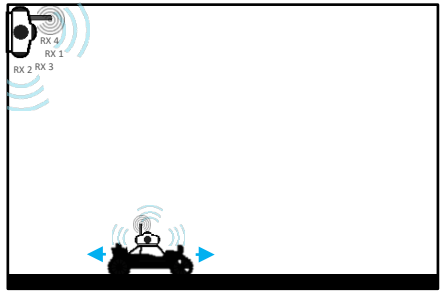
- Always enter heights for stationary beacons
- Always enter heights for mobile beacons for 2D/1D
- Enable only necessary ultrasound transducers
- Rotate beacons to the center of service zone
- Modem can be placed anywhere. Study radio

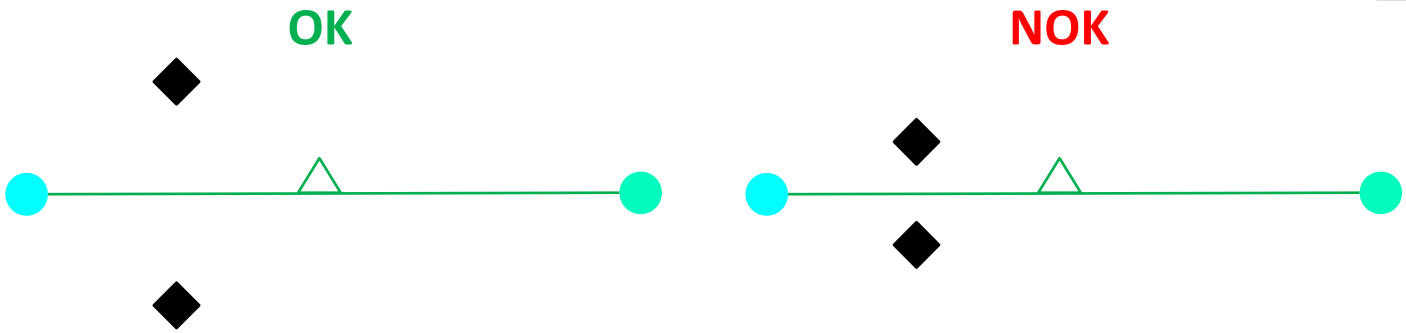
Marvelmind robotics

Hints – part 2

- Too wide and too narrow submaps – videos
- Precise Z: video 1 and video 2
- Place beacons on ceiling – easier for drones in 3D
- Never fly above ceiling
- Never cross and don’t come too close in 2D

Side view



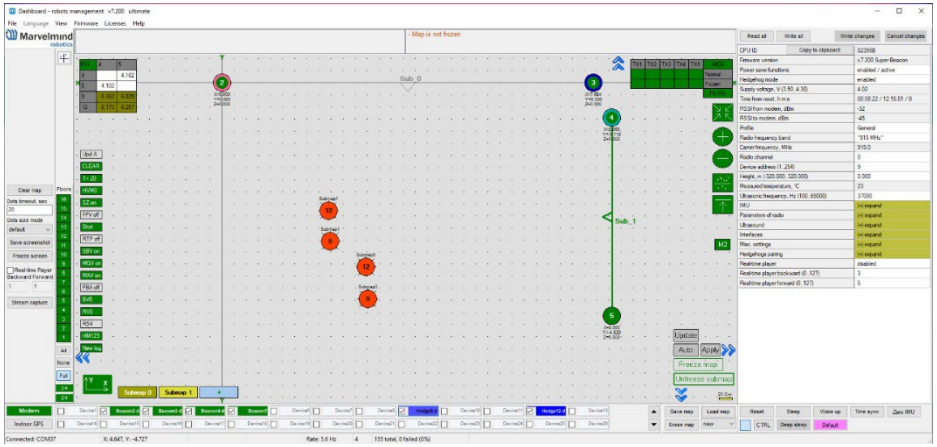


Marvelmind robotics

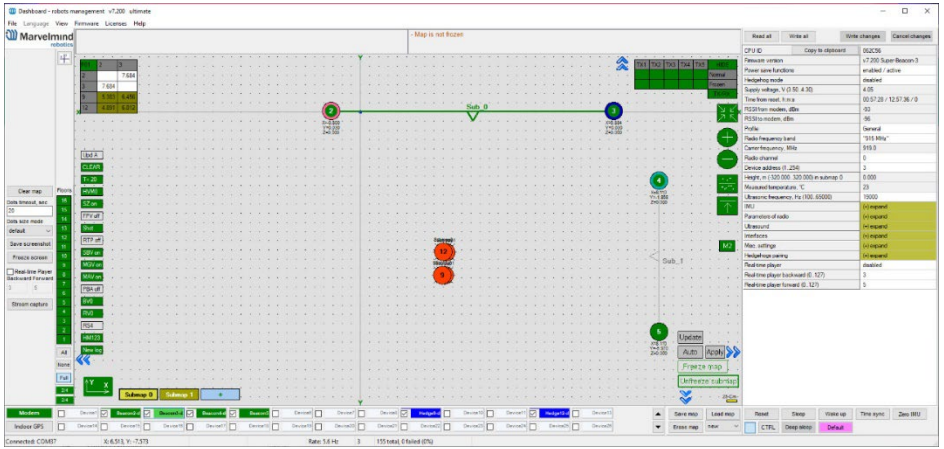
Aligning submaps

- Use “oranges” - M1/M2 - to align submaps

Not aligned submaps



Aligned submaps



Marvelmind robotics

NIA

Stationary Super-Beacon 1
Any frequency

Stationary beacons:

- Mounted high on walls or ceilings
- Have any ultrasonic frequency, if Super-Beacon. The same ultrasound frequency if Beacons HW v4.9
- Measures distances to neighboring beacons and builds submaps automatically
- Communicate with the router wirelessly in an ISM band

Stationary Super-Beacon 2
Any frequency

Key requirement for the system to work well: **unobstructed line of sight** by a mobile beacon of 2 (2D) and 3 (3D) or more stationary beacons within 30 meters – very similar to visibility of GPS satellites

Mobile Super-Beacon
Any frequency but the same for all mobile beacons

Mobile beacon:

- Installed on robot/drone/forklift and interacts with it via UART or SPI or I2C or USB (virtual UART)
- Receives location updates from the router up to f=25 Hz
- Location update rate per mobile beacon depends on the number of mobile beacons (n) as f/n
- All mobile beacons work on the same ultrasound frequency, for example, 31kHz or 45kHz
- Usually contains IMU (3D accelerometer+3D gyroscope)

Router/modem:

- Central controller of the system
- Calculates position of mobile beacons up to **25 Hz**
- Communicates via USB/virtual UART with Dashboard or robot
- Supports up to 250 beacons and up to 250 submaps

Submaps:

- Advanced feature that allows building independent submaps/clusters/cells of beacons in separate rooms or zones and thus building maps consisting of multiple submaps and covering large buildings (with area of thousands of m2) like the cellular network coverage

Indoor Navigation System in NIA consists of:

- 2 or more Stationary Beacons (receiving ultrasound) of any ultrasound frequency
- 1 or more Mobile Beacons (transmitting ultrasound on the same ultrasonic frequency)
- 1 central Router

Stationary Super-Beacon N
Any frequency

Distance between beacons-neighbors is up to **30 meters**.

Stationary Super-Beacon 3
Any frequency

Marvelmind robotics

IA

Stationary Super-Beacon 1 19kHz

Stationary beacons:

- Mounted on walls or ceilings
- In IA, stationary beacons belonging to the same submap must have different ultrasound frequencies (19 & 25kHz or 25 & 31 kHz, for example)
- Measures distances to neighboring beacons and builds submaps automatically
- Communicate with the router wirelessly in an ISM band

Stationary Super-Beacon 2 25kHz

Key requirement for the system to work well: **unobstructed line of sight** by a mobile beacon of 2 (2D) and 3 (3D) or more stationary beacons within 30 meters – very similar to visibility of GPS satellites

Mobile Super-Beacon Any frequency

Mobile beacon:

- Installed on robot/person/forklift and interacts with them via UART or SPI or I2C or USB (virtual UART)
- Calculates location updates onboard up to 25 Hz
- Location update rate per beacon doesn't directly depend on the number of mobile beacons
- Contains IMU (3D accelerometer+3D gyroscope)

Router/modem:

- Central controller of the system
- Synchronizes the beacons up to **25 Hz**
- Communicates via USB/virtual UART with Dashboard or robot
- Supports up to 250 beacons and up to 250 submaps

Submaps:

- Advanced feature that allows building independent submaps/clusters/cells of beacons in separate rooms or zones and thus building maps consisting of multiple submaps and covering large buildings (with area of thousands of m2) like the cellular network coverage

Indoor Navigation System in IA consists of:

- 2 or more Stationary Beacons (transmitting ultrasound on different ultrasonic frequencies)
- 1 or more Mobile Beacons (receiving ultrasound on different ultrasonic frequencies at the same time)
- 1 central Router

Stationary Super-Beacon N 37kHz

Distance between beacons-neighbors is up to **30 meters**.

Stationary Super-Beacon 3 31kHz

Marvelmind robotics

MF NIA

Stationary Super-Beacon 1
Any frequency

Mobile Super-Beacon
19/22/25/28/31/34/37/45kHz

Stationary Super-Beacon N
Any frequency

Stationary beacons:

- Mounted on walls or ceilings
- Have any ultrasonic frequency for Super-Beacon. MF NIA is not supported by Beacons HW v4.9
- Measures distances to neighboring beacons and builds submaps automatically
- Communicate with the router wirelessly in an ISM band

Mobile beacon:

- Installed on robot/person/forklift and interacts with them via UART or SPI or I2C or USB (virtual UART)
- Receives location updates from the router up to 25 Hz
- Location update rate per beacon up to 8 mobile beacons is like in IA. Then – like in NIA, but up to 8 times higher update rate
- Contains IMU (3D accelerometer+3D gyroscope)

Submaps:

- Advanced feature that allows building independent submaps/clusters/cells of beacons in separate rooms or zones and thus building maps consisting of multiple submaps and covering large buildings (with area of thousands of m2) like the cellular network coverage

Distance between beacons-neighbors is up to **30 meters**.

Indoor Navigation System in MF NIA :

- 2 or more Stationary Beacons (receiving ultrasound)
- 1 or more Mobile Beacons (transmitting ultrasound on the different ultrasonic frequencies)
- 1 central Router

Stationary Super-Beacon 2
Any frequency

Key requirement for the system to work well: **unobstructed line of sight** by a mobile beacon of 2 (2D) and 3 (3D) or more stationary beacons within 30 meters – very similar to visibility of GPS satellites

Router/modem:

- Central controller of the system
- Calculates position of mobile beacons up to **25 Hz**
- Communicates via USB/virtual UART with Dashboard or robot
- Supports up to 250 beacons and up to 250 submaps

Stationary Super-Beacon 3
Any frequency

Marvelmind robotics

IA vs. NIA vs. MF NIA

- **NIA**: any frequency for stationary Super-Beacons
- **MF NIA**: very similar to NIA
- **IA**: not the same frequency in the same submap
- **IA**: not the same frequency in neighboring submaps
- **IA**: dynamic range of distances, etc.

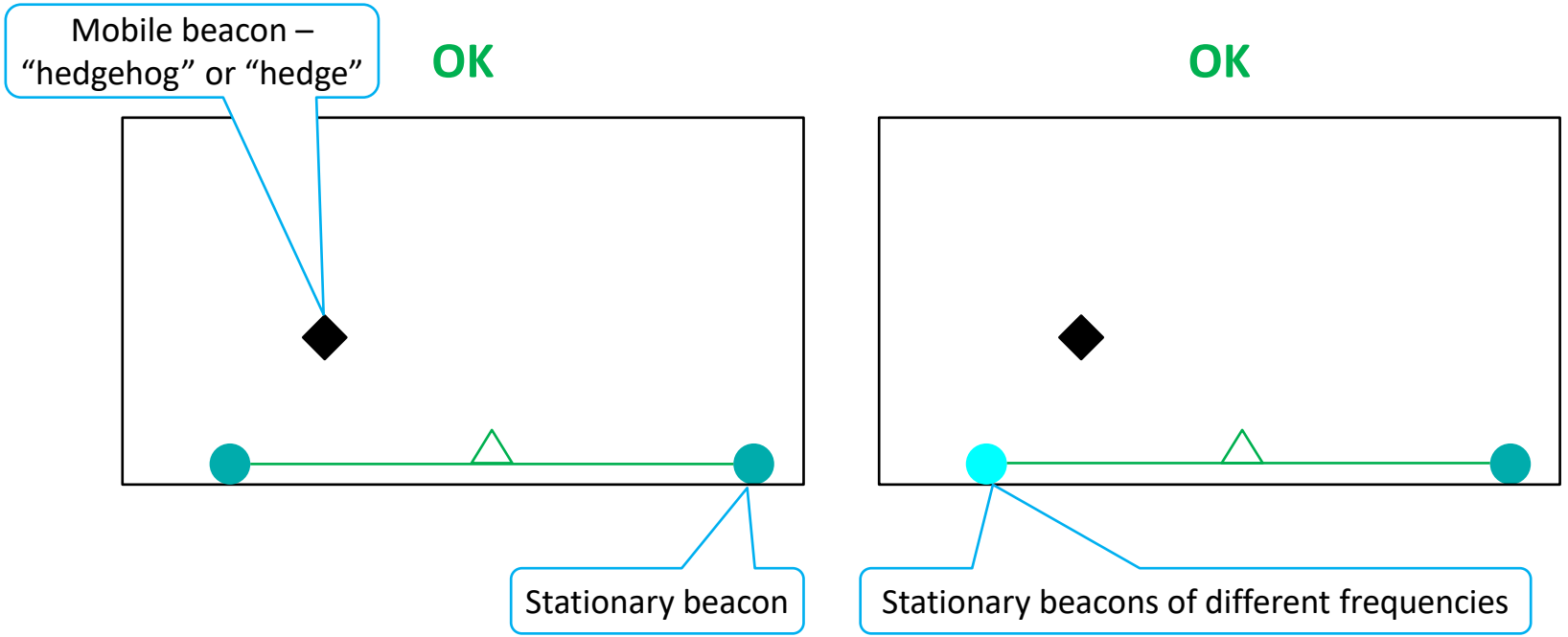
For basic maps complexity IA ≈ NIA
For complex maps complexity IA ≈ 10xNIA

We offer Full Network Planning and Full Remote Network Deployment as a service

Always start with basic NIA 2D
Watch Step-by-step guide

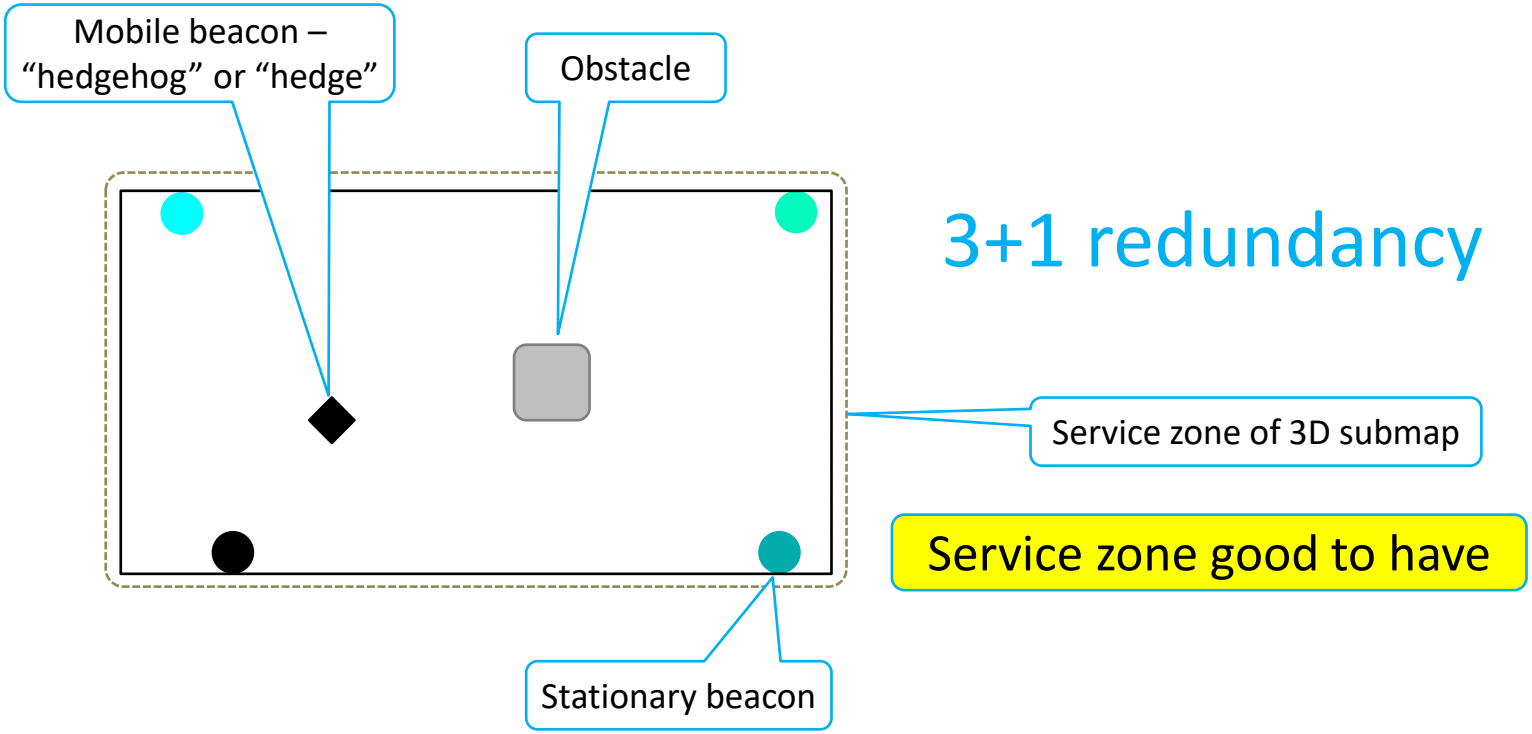
Marvelmind robotics

Single 2D NIA submap



Marvelmind robotics

Single 3D NIA submap

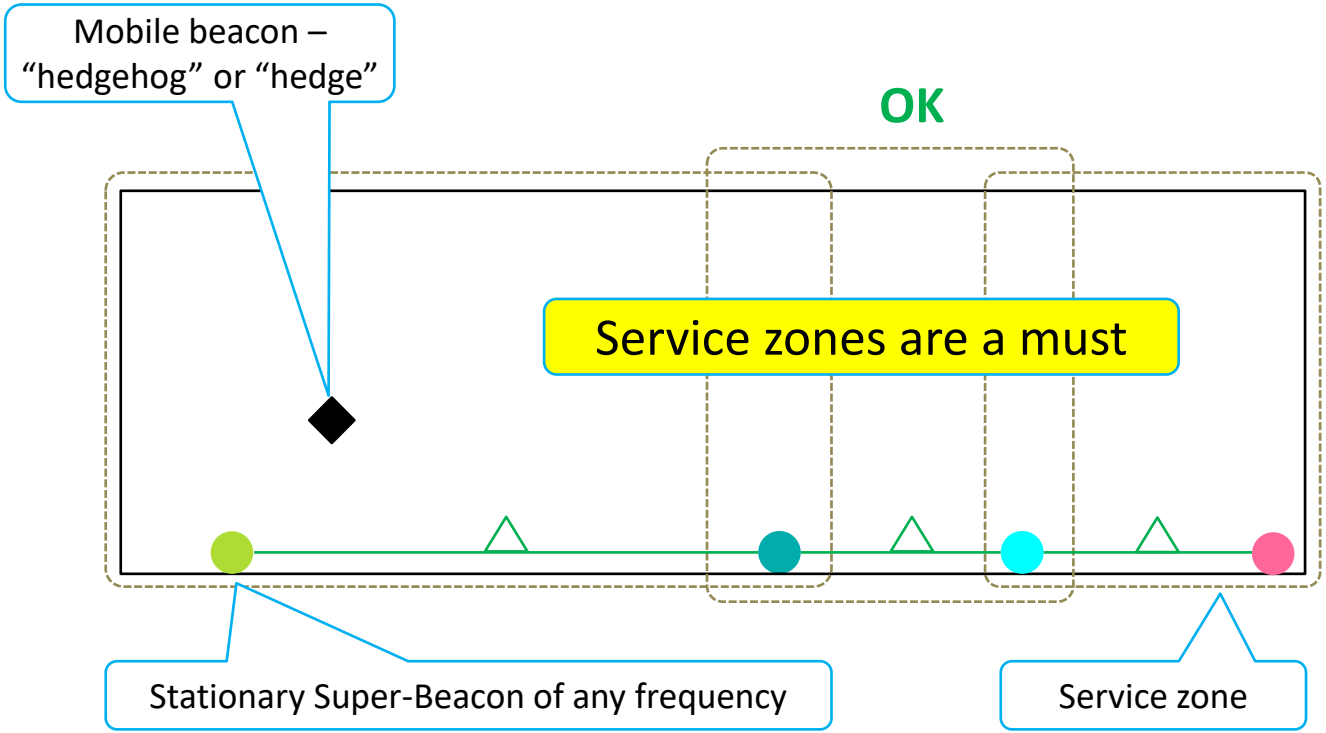


3+1 redundancy

Service zone good to have

Marvelmind robotics

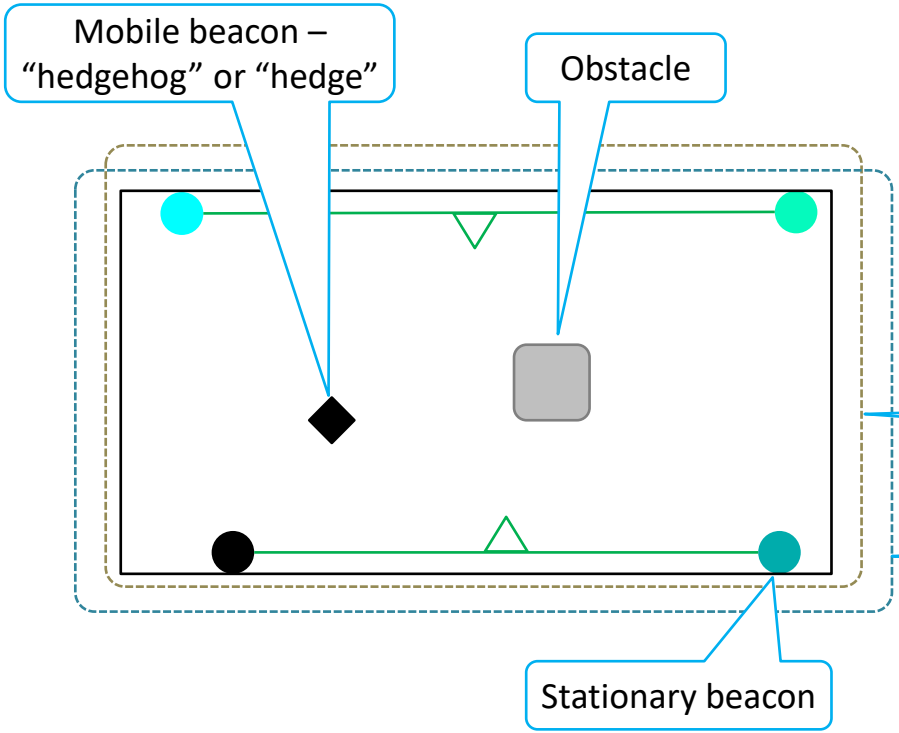
Three 2D NIA submaps



- 19 kHz beacon
- 22 kHz beacon
- 25 kHz beacon
- 28 kHz beacon
- 31 kHz beacon
- 34 kHz beacon
- 37 kHz beacon
- 45 kHz beacon

Marvelmind robotics

Redundancy 2N

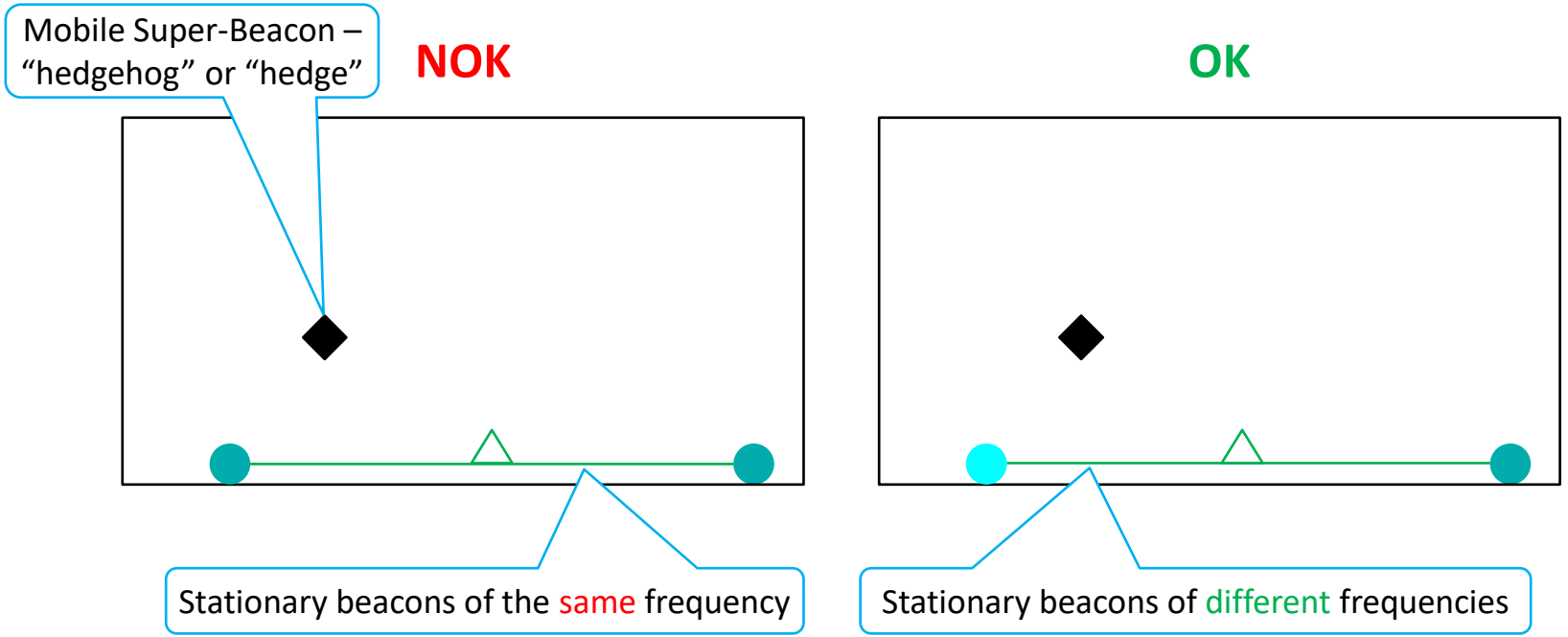


Fully overlapping submap

Video

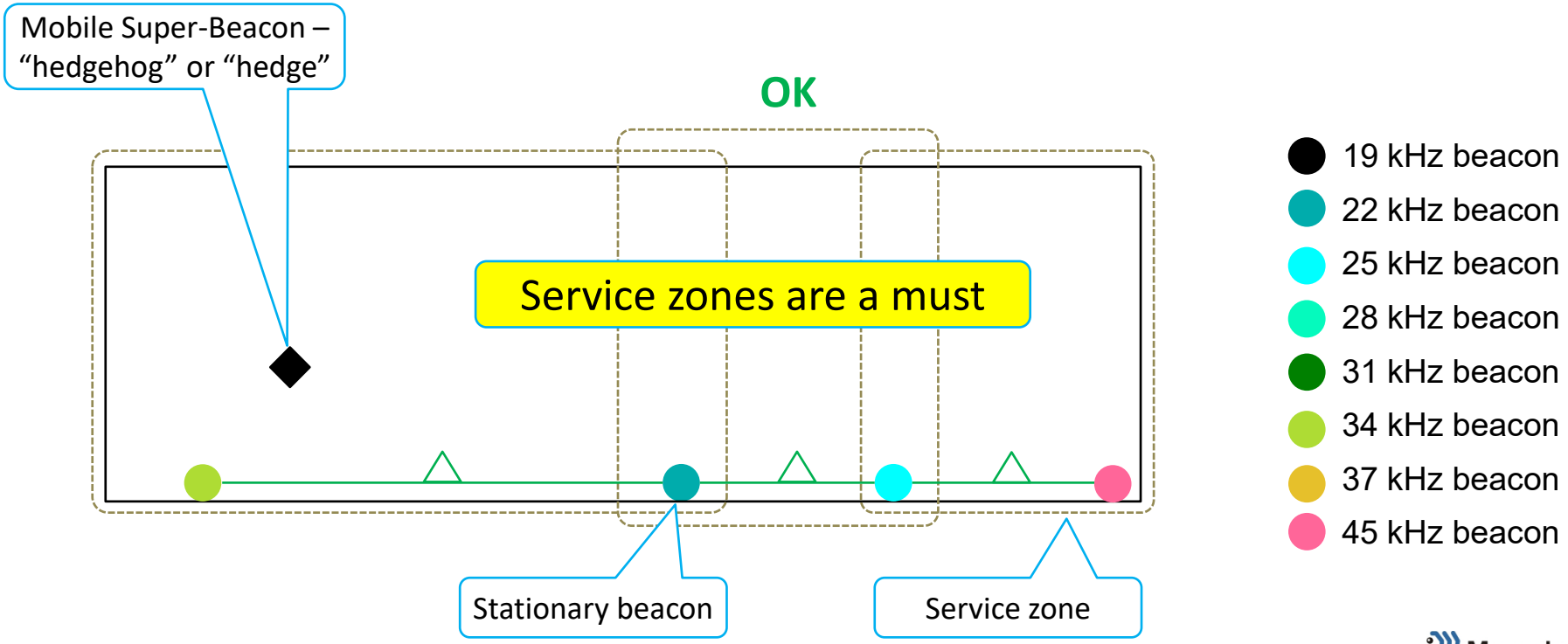
Marvelmind robotics

Single 2D IA submap



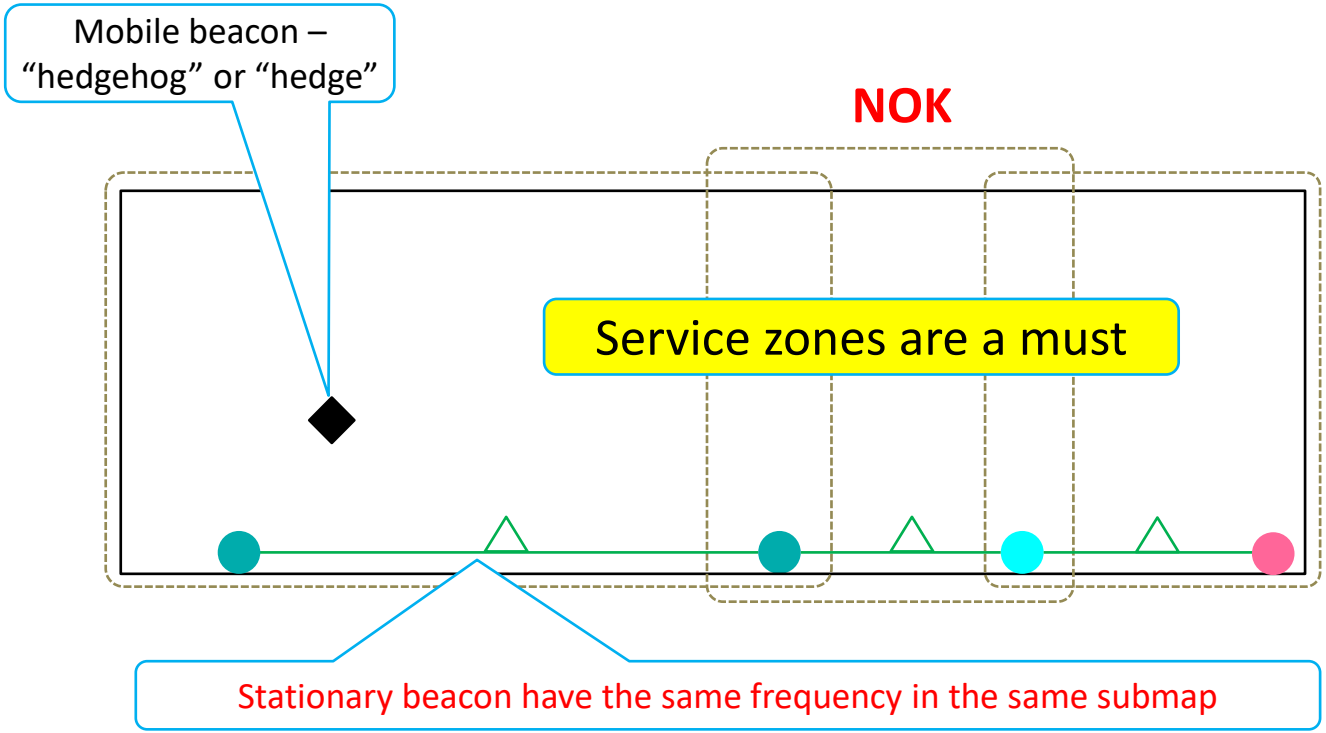
Marvelmind robotics

Three 2D IA submaps



Marvelmind robotics

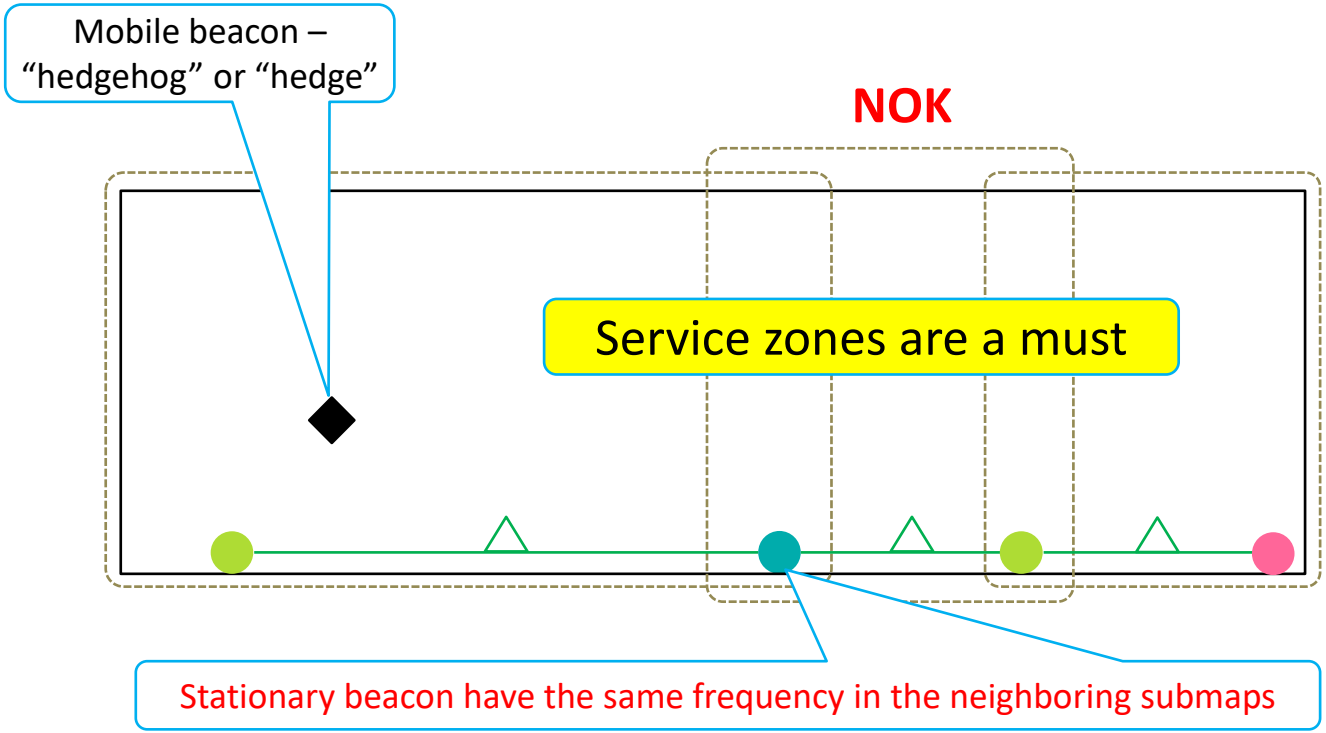
Three 2D IA submaps



- 19 kHz beacon
- 22 kHz beacon
- 25 kHz beacon
- 28 kHz beacon
- 31 kHz beacon
- 34 kHz beacon
- 37 kHz beacon
- 45 kHz beacon

Marvelmind robotics

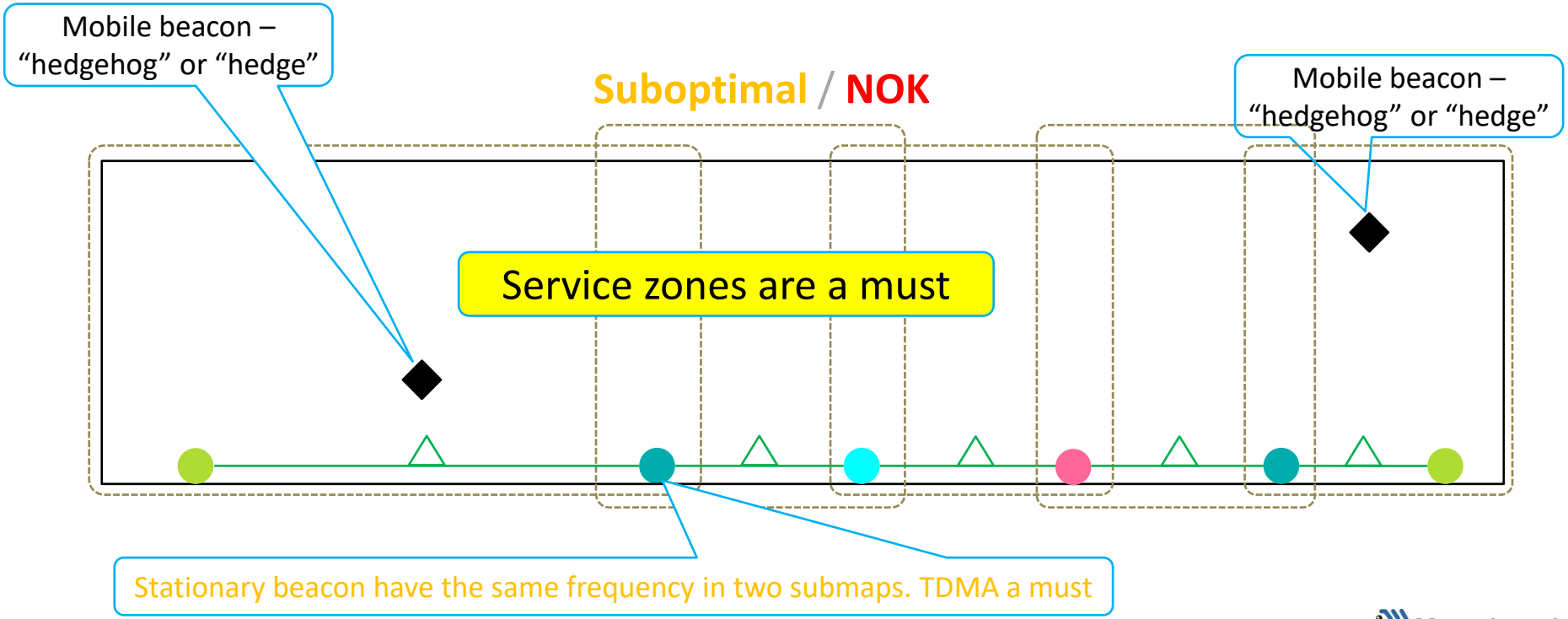
Three 2D IA submaps



- 19 kHz beacon
- 22 kHz beacon
- 25 kHz beacon
- 28 kHz beacon
- 31 kHz beacon
- 34 kHz beacon
- 37 kHz beacon
- 45 kHz beacon

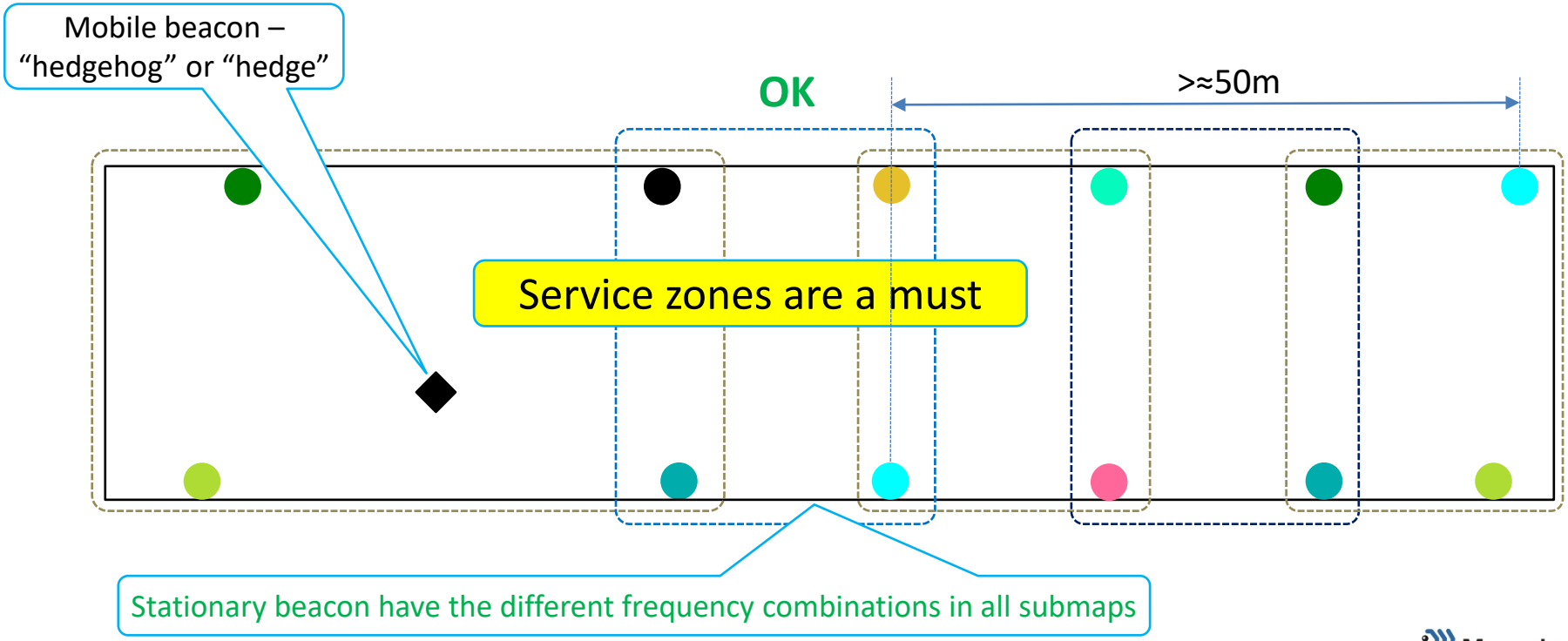
Marvelmind robotics

Three 2D IA submaps



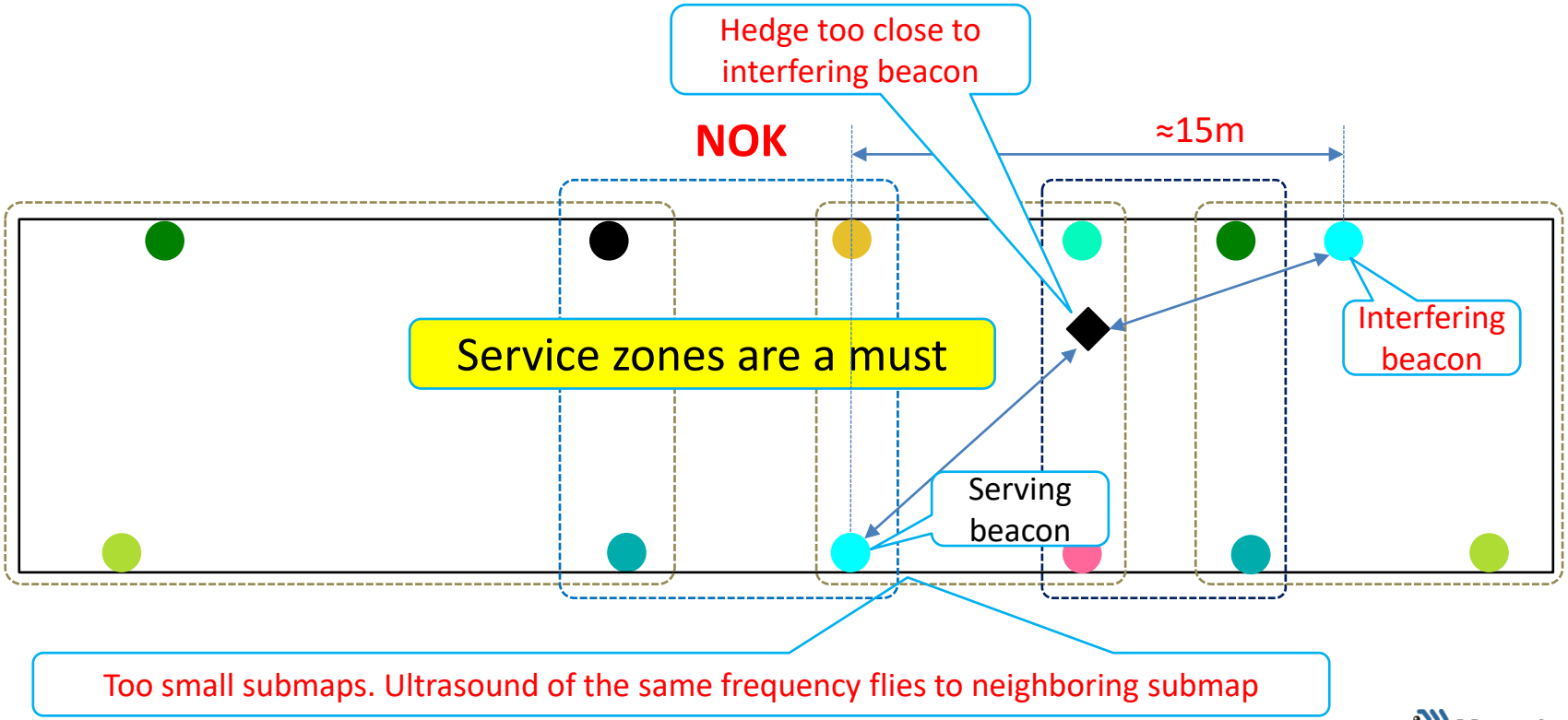
Marvelmind robotics

Three 3D IA submaps



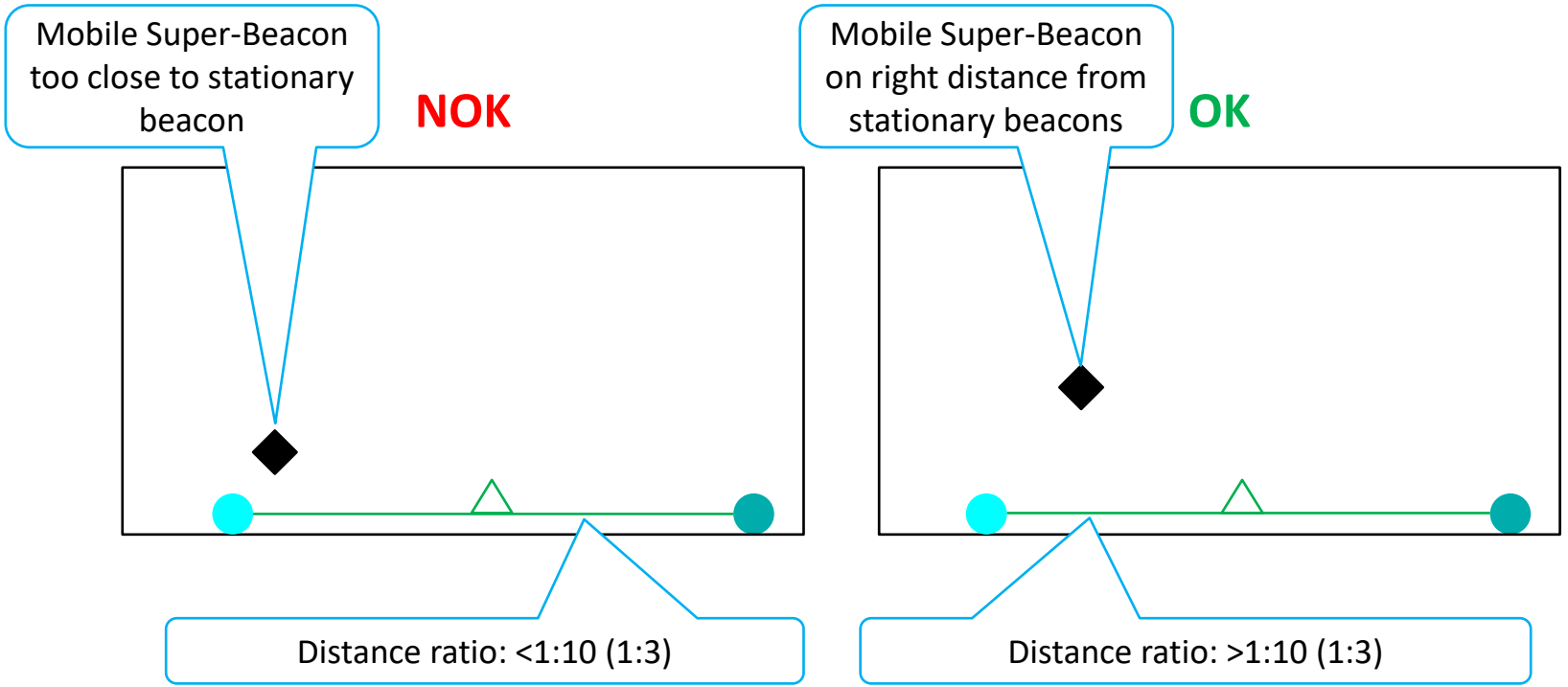
Marvelmind robotics

Three 3D IA submaps



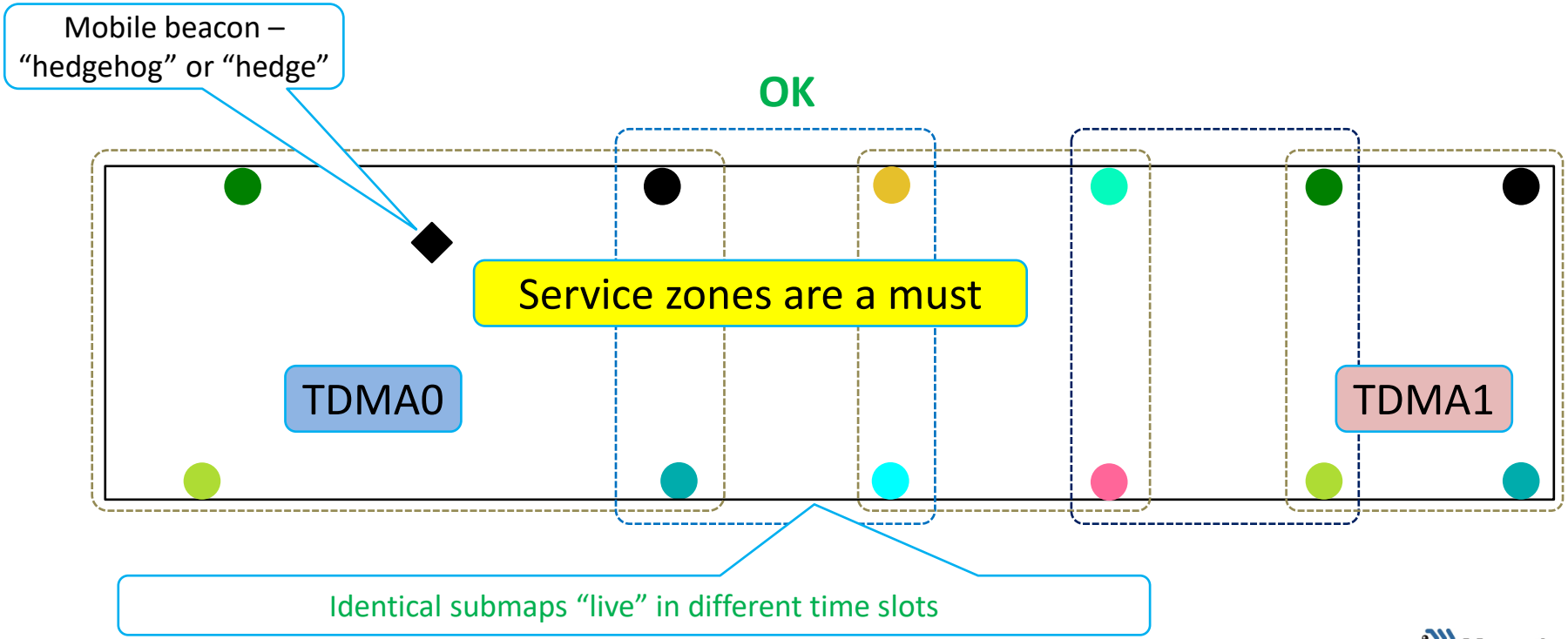
Marvelmind robotics

Dynamic range of distances



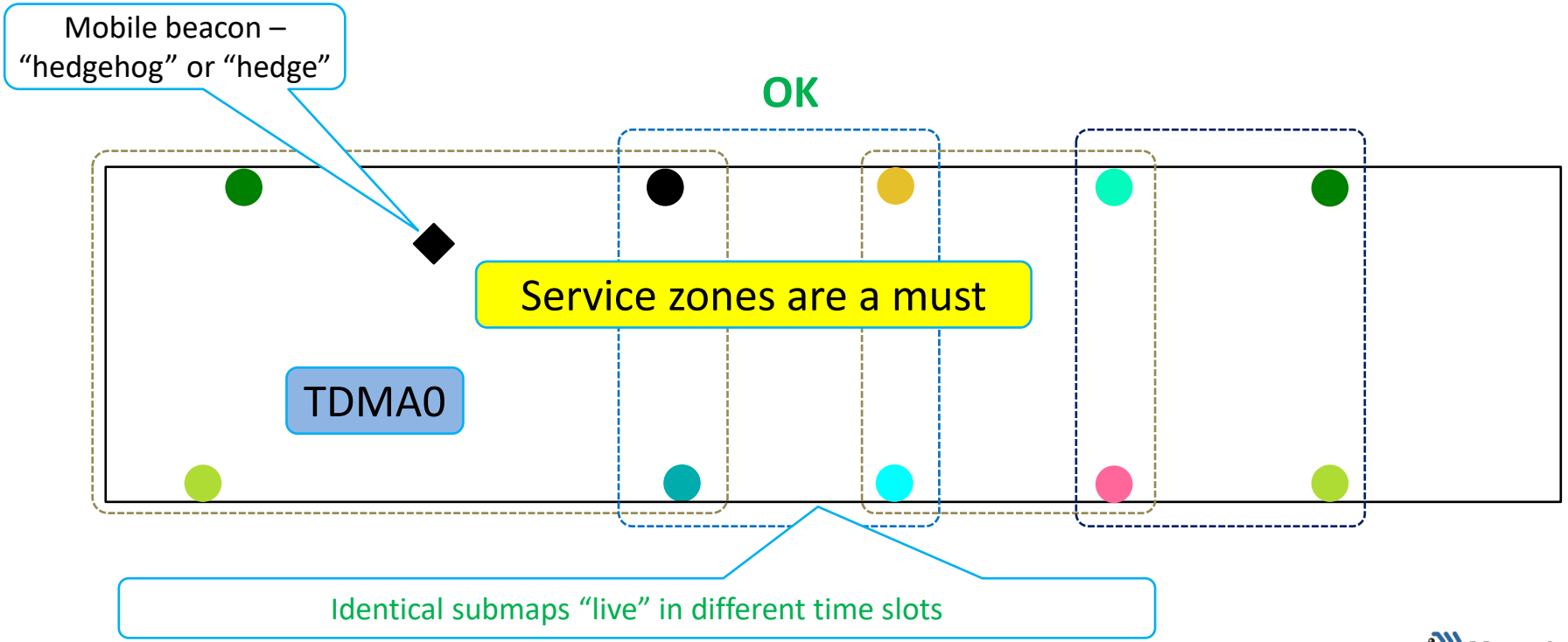
Marvelmind robotics

TDMA



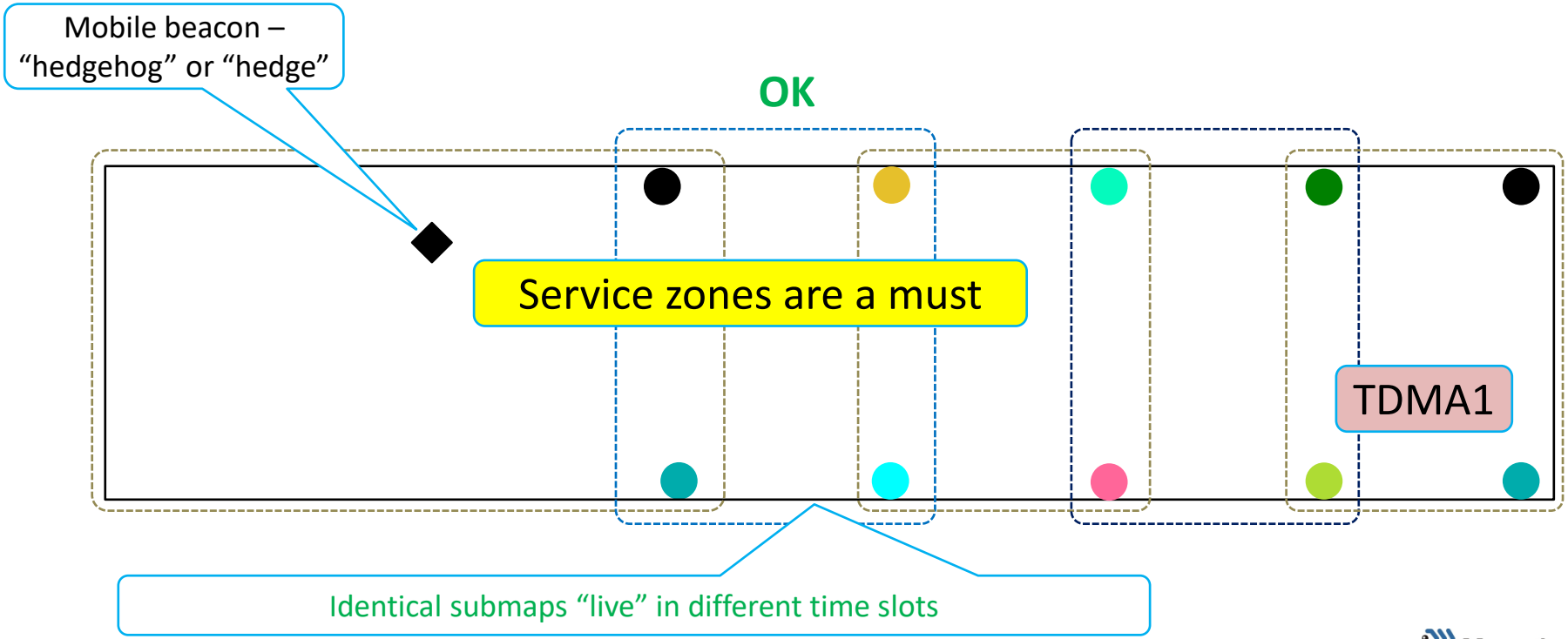
Marvelmind robotics

TDMA0



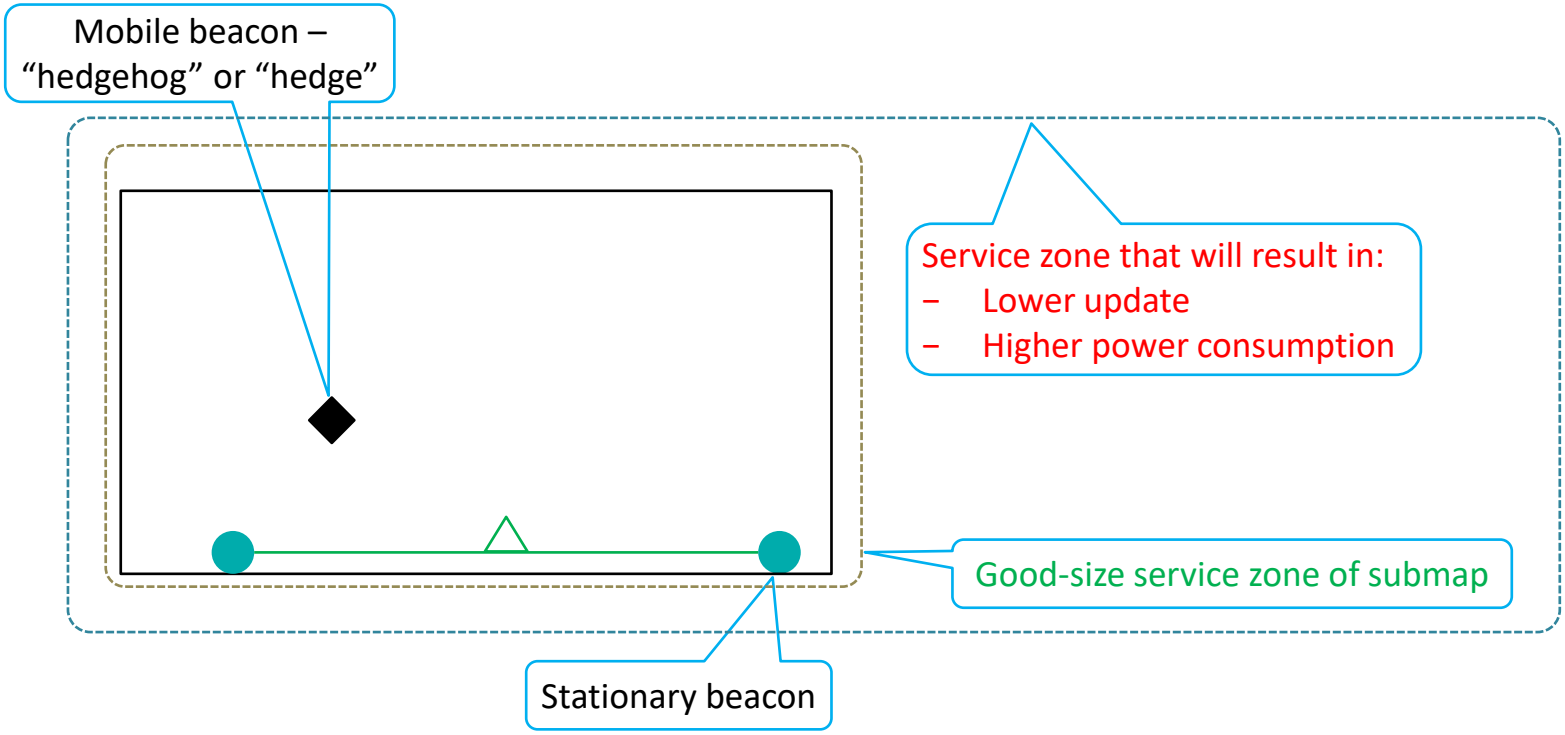
Marvelmind robotics

TDMA1



Marvelmind robotics

Size does matter



Marvelmind robotics

Special cases

- 1D submaps
- Vertical 2D
- 1D + 2D + 3D + vertical 2D in the same map
- Precise Z – see in the Placement Manual
- Example: Assembly factory, 2D, IA, for robots, people, forklifts
- Example: Indoor positioning for personnel on precast concrete plant

Remember

1. Start with basic NIA and move to more complex maps
2. Large IA maps are complex, but in steps – still easy
3. Maps can be virtually any size and any complexity
4. If anything is unclear => Help page

Thank you