

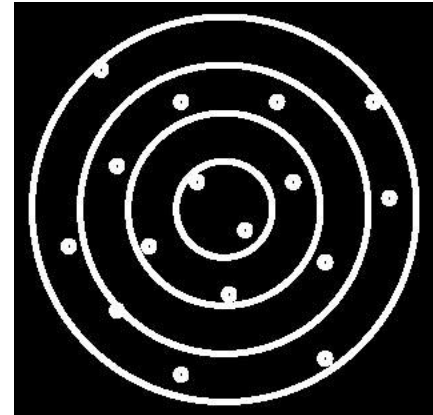
# Indoor “GPS”

(with  $\pm 2\text{cm}$  precision)

For autonomous vehicles, robots, drones, forklifts and humans



# Problem to solve



# Problem

- **GPS does not work indoor:**
  1. no direct view to satellites
  2. location precision is measured in meters rather than in centimeters (required indoor)
- Other indoor navigation systems - UWB, Bluetooth beacons, odometry, magnetometers, WiFi RSSI, laser triangulation, optical, etc. - have their **own serious limitations** – usually, either precision, or price, or size
- Without precise and timely knowledge of location, autonomous navigation is impossible

# Solution



- **Off-the-shelf ready-to-use indoor navigation system** based on stationary **ultrasonic beacons** united by radio interface in license-free ISM band
- Location of a mobile beacon installed on a robot (vehicle, copter, human) is calculated based on the propagation delay of ultrasonic signal to a set of stationary ultrasonic beacons using **trilateration**

# Indoor “GPS” ( $\pm 2\text{cm}$ )

- Starter Set configuration:
  - 1 mobile beacon – USD 69
  - 4 stationary beacons – USD 4x69
  - 1 router – USD 69
  - All required SW included



Ready to use 3D (x, y, z) system for USD 399

Can cover up to 1000m<sup>2</sup>

Customers in 40+ countries

# Selected customers



# Autonomous robots, drones, VR



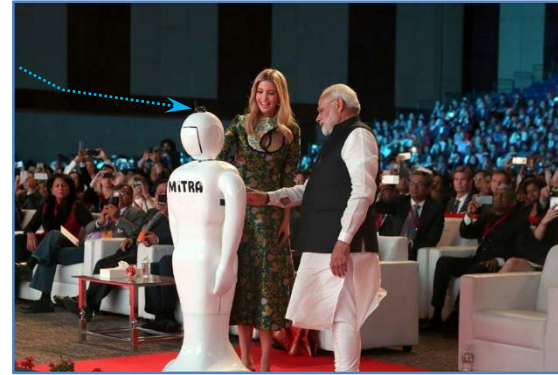
Virtual reality for  
BIM, quests, training  
and gaming

Marvelmind beacon

Automatic  
delivery inside  
large buildings



Autonomous drones indoor  
for inventory management,  
video/photo, security



PM of India  
Modi and  
Ivanka Trump



Advertising robots with high-  
tech charm - shows, shopping  
malls, conferences, museums

# Use cases: mobile assets tracking

## Use case:

- Tracking vehicles, buggies, trolleys, forklifts and other mobile assets in tunnels, passenger and cargo areas of airports and warehouses

## Problems solved:

- Speeding
- Accidents
- Broken equipment and goods
- Lost or underutilized mobile assets

## Benefits:

- Precise knowledge of who is doing what and where => productivity increase
- Real-time data about speed, acceleration, position of the mobile assets => productivity increase
- Preventing accidents and decreasing insurance and other avoidable costs

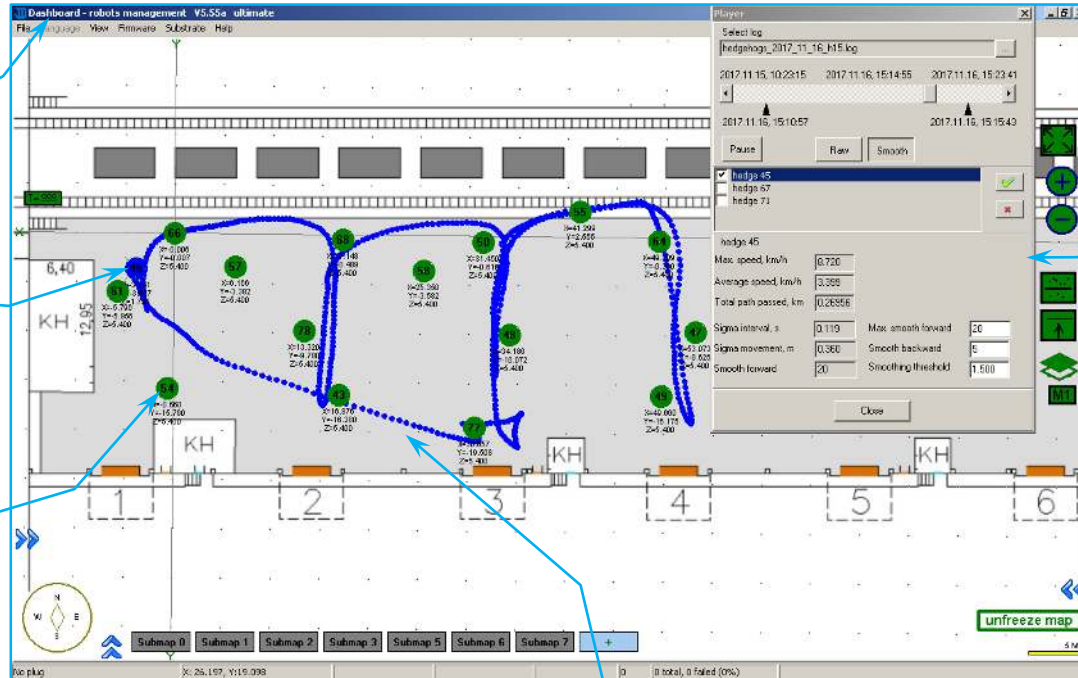


# Use cases: mobile assets tracking

Marvelmind Dashboard for system setup and monitoring:  
<https://marvelmind.com/download/>

Path of a forklift or human in real time with up to 4-8Hz update rate

Stationary beacons placed every 10-30m on ceiling (depends on warehouse, shelves, etc.)



Analytics module – Marvelmind Player:

- Forklift track at any given recorded time
- Peak speed
- Average speed
- Alarms of different sort
- Many more options for analytics based on request

Map of a warehouse as a substrate and multiple zones for alarms and triggers:

- Geo-fencing; no driving; driving; no speeding, etc.

# Use cases: safety & productivity

Tracking workers' location underground,  
in metro or tunnels, on construction sites  
or railways stations or under bridges

## Use case:

- Underground / mining / metro
- Construction sites
- Large manufacturing factories
- Dangerous manufacturing
- Oil refineries and gas companies



- Increasing productivity
- Improving safety

# Use cases: safety & productivity

## System capabilities:

- Tracking of workers/vehicles indoor, underground or outdoor with up to  $\pm 2\text{cm}$  precision
- Optional various triggers and alarms, for example:
  - Geo-fencing – automatic alarm, when mobile beacon/helmet/worker/vehicle exits a permitted zone or enters a restricted zone
  - Possibility to set time for trigger activation or violation distance
  - Alarms based on position of a mobile beacon/helmet – no activity, strange position, too high acceleration, free fall, etc.
- Embedded Player with a possibility to play recorded measured location track of any mobile beacon at any given date and time
- Many different optional analytics and statistics: average speed, maximum speed, running time, no activity time, etc.
- Two-directional radio channel in ISM band (433MHz or 915MHz) – from mobile beacon to modem and from modem to mobile beacon – for alarms, sensors, emergency button, route/task settings, etc.
- Different implementation options: helmet, shoulder tracker, etc.
- Possibility to have a combined Indoor “GPS” + regular GPS + Bluetooth

Helmet with installed  
mobile beacon



- Increasing productivity  
- Improving safety

# Tracking inside warehouse - video



Helmet with precise tracking.

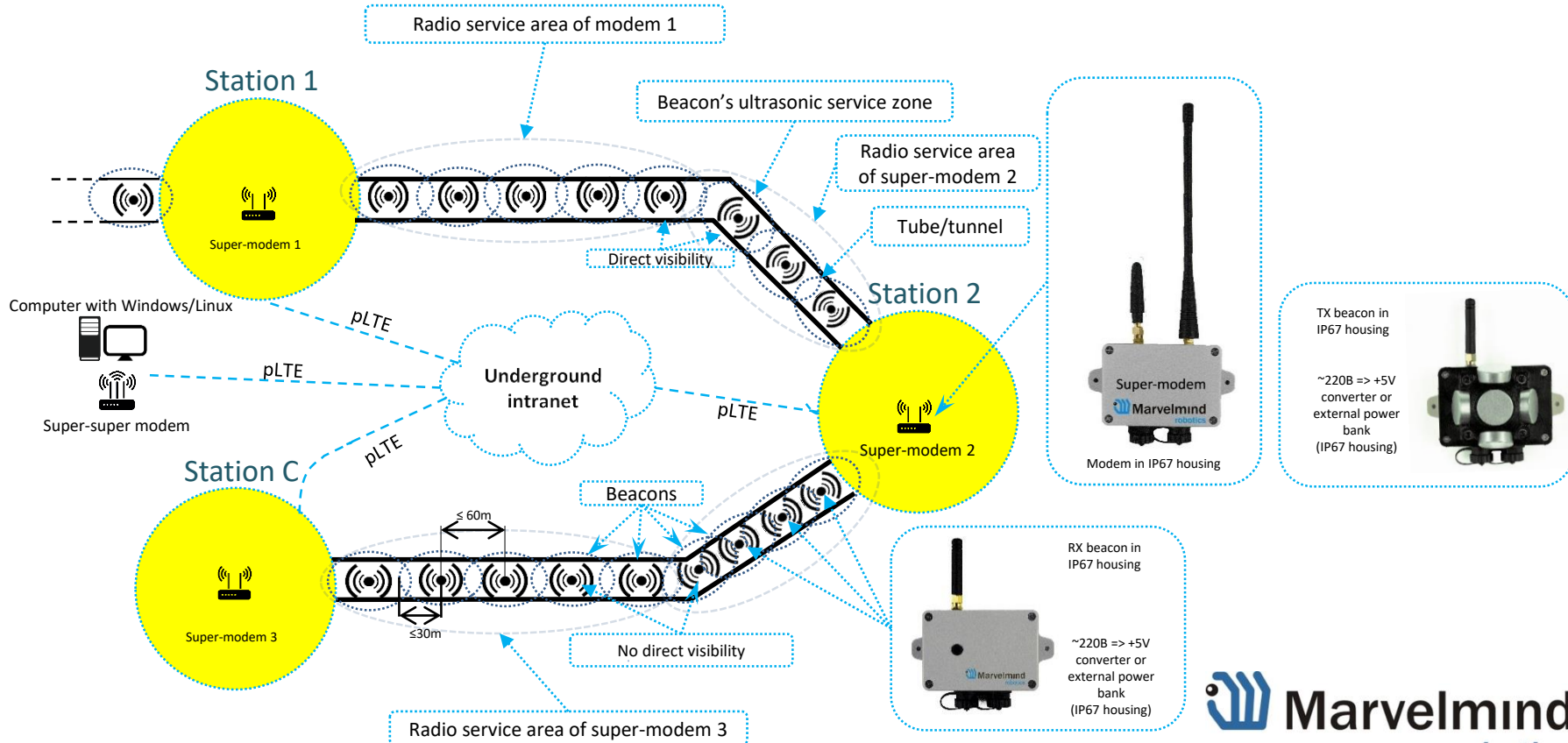
Other types of helmets and customer's branding are available.



<https://www.youtube.com/watch?v=I53mEx7lQ-0>

# Marvelmind Robotics for underground

1.5D positioning for vehicles and people with  $\pm 2\text{cm}$  precision



# Beacons comparison



	DSP RX v5.05/DSP RX v5.05 Outdoor	Mini-beacon TX v5.07/Mini-beacon TX v5.07 Outdoor	Mini-beacon TX v5.07 batteryless	Beacon HW v4.9/Beacon HW v4.9 Outdoor	Beacon-TX-915-IP67/Beacon-TX-915-EX	Beacon-RX-915-IP67/Beacon-TX-915-EX
<b>Specialty and main use</b>	Universal, multi-frequency and high-sensitivity RX-only beacon	Small TX only beacon	The lightest TX only beacon	Universal dual-use beacon. Support of 433- or 915/868MHz bands	Heavy-duty outdoor/Explosion dangerous environment; RS485 or CAN	Heavy-duty outdoor/Explosion dangerous environment; RS485 or CAN
<b>Mode of operation</b>	RX only	TX only		Dual-use (RX and TX)	TX only	RX only
<b>Range</b>	- Up to 50m <sup>3</sup>	- Up to 30m with DSP RX v5.05 - Up to 20m with Beacon v4.9		- Up to 50m with DSP RX v5.05 <sup>3</sup> - Up to 30m with Beacon v4.9 <sup>3</sup>	- Up to 30m with Beacon-RX-915-XX	- Up to 30m with Beacon-TX-915-XX
<b>Ultrasonic frequencies</b>	- 19/25/31/37/45/56kHz - Several at the same time	- 31/37/45/56kHz - Only one HW defined frequency at the time		- 19/25/31/45kHz - Only one frequency at the time	- 19/25/31/45kHz	- 19/25/31/37/45/56kHz - Several at the same time
<b>Radio band</b>	915/868MHz	915/868MHz		915/868MHz or 433MHz	915/868MHz or 433MHz	915/868MHz or 433MHz
<b>Power/LiPol battery</b>	USB/750mAh	USB/250mAh	USB/No embedded battery	USB/1000mAh	+5V or 12V or IP67 converter/Optional	+5V or 12V or IP67 converter/Optional
<b>Environmental conditions</b>	- Indoor/Outdoor up to IP67 - t=0..40C <sup>6</sup>	- Indoor/Outdoor <sup>2</sup> - t=0..40C <sup>6</sup>	- Indoor - t=0..40C <sup>6</sup>	- Indoor/Outdoor <sup>2</sup> - t=0..40C <sup>6</sup>	- Outdoor <sup>2</sup> /Intrinsically Safe <sup>5</sup> - t=-20..40C <sup>6</sup>	- Outdoor <sup>2</sup> /Intrinsically Safe <sup>5</sup> - t=-20..40C <sup>6</sup>
<b>Size and weight</b>	47x42x15mm & 25g	35x35x26mm & 19g	35x35x20mm & 12g <sup>9</sup>	55x55x33(64 <sup>7</sup> )mm & 62/75g	83x58x65mm <sup>8</sup> & 250g	83x58x33mm <sup>8</sup> & 200g
<b>IMU (3D gyro+acc+mag)</b>	Yes (6D)	Yes (6D)	Yes (6D)	No/Yes 9D (for the version with IMU)	Yes (6D)	Yes (6D)

- 1) Withstand submersion to water on 1m up to 30m (IPX7 requirements)
- 2) Mild outdoor: occasional rain, dust doesn't kill the device. Performance during this time is no guaranteed
- 3) 1D mode: RX4 to RX4 sensors; other sensors are disabled
- 4) Other power options available upon request
- 5) Exact type of certification shall be discussed separately

- 6) Temperature range down to -40C is available with external power supply only and upon request
- 7) With antenna
- 8) Sizes without mounting holes
- 9) 6.3g without housing

# Marvelmind Watch Outdoor



## Marvelmind Watch

- Very small tracker: 44x40x13mm – 4 times smaller volume than regular beacon. Designed for shoulder strap use (recommended) or for wrist strap use (possible) or as a versatile stationary beacon
- Long battery lifetime: 12h-1month – depending on usage. USB charging – 1-2h
- Outdoor and indoor usage. Embedded antenna. Very robust

# Marvelmind Watch: shoulder usage



Marvelmind Watch  
mounted on the uniform  
(shoulder strap mounting)

## Description:

- Designed for outdoor use cases with mild protection requirements. Fog, dew, occasional rain or dust do not harm equipment, but tracking performance during these events is not quarantined
- Very light = comfort
- Solid structure = hit resistive
- Small size = does not hold down moves

## Protection\*:

- Board and electronics: fully compound-sealed water and dust protection
- Temperature: 0...+40C (-10C..+40C without charging)

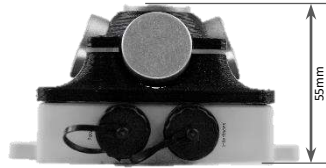
## Parameters:

- 44x40x13mm
- Weight: 28g

\* Tested by submerging to 1m for 30min without any degradation of performance

Jacket + Marvelmind Watch

# Beacon-TX-25-IMU-IP67-RS485



Ultrasonic transducer (25KHz)

Housing  
IP67 protection

Connector 4-pin  
(included)

Connector 7-pin  
(included)

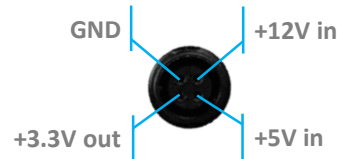


## Specification

Mode	TX-only beacon – can transmit ultrasonic, but can't receive it
Protection	IP67
Ultrasonic frequencies	Special IP67-protected 25-kHz transducers
Connectors	Two IP67 external connectors
Ultrasonic range	Up to 30m with <a href="#">Beacon-DSP-RX-IMU-IP67-RS485</a>
Power	External battery (15Wh for 2y & 1/5Hz)

Power connector

Interface connector



UART TX 3.3V

USB RX

USB TX

UART RX 3.3V

RS485B

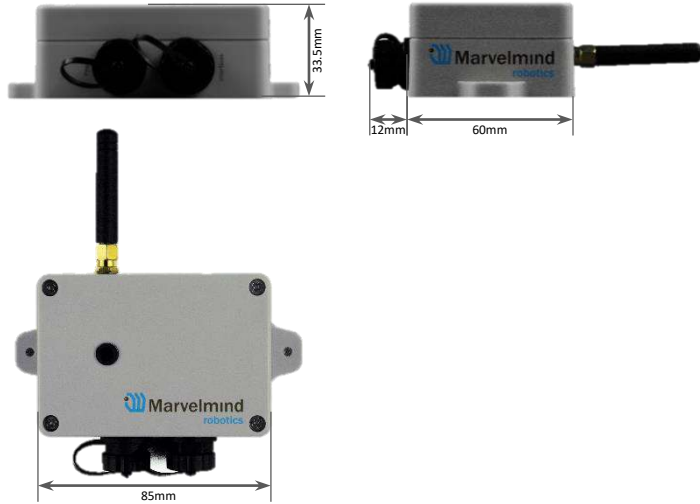
GND

RS485A



**Marvelmind**  
robotics

# Beacon-DSP-RX-IMU-IP67-RS485



Microphone protected by  
IP67 membrane

Housing  
IP67 protection

Connector 4-pin  
(included)

Connector 7-pin  
(included)

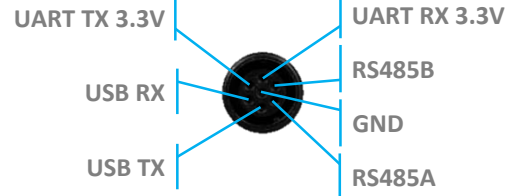
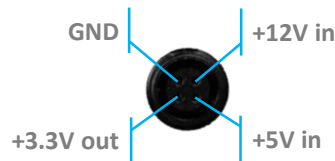


## Specification

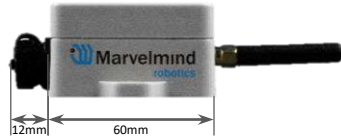
Mode	RX-only beacon – can receive ultrasonic, but can't transmit it
Protection	IP67
Ultrasonic frequencies	Can receive 19/25/31/37/45/56 KHz; DSP filters
Connectors	Two IP67 external connectors
Ultrasonic range	Up to 30m with <a href="#">Beacon-TX-25-IMU-IP67-RS485</a>
Power	External battery (38Wh for 2y & 1/5Hz)

Power connector

Interface connector



# Super-Modem-IP67-RS485



Wi-Fi antenna

Antenna

Housing  
IP67 protection

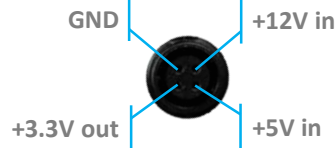
Connector 4-pin  
(included)

Connector 7-pin  
(included)

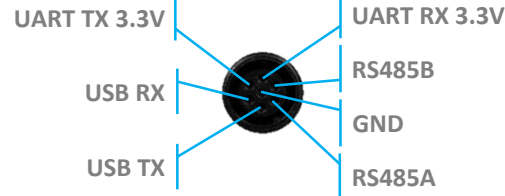
## Specification

Mode	Controller of the system
Protection	IP67 (+EX optional)
Connectivity	Two IP67 external connectors: 1) Power: +5V in, +12V in, +3.3V out 2) RS485 or CAN, UART, USB (+PLC) Wifi + BT (+optional 2G/3G/LTE) License-free radio (915MHz or 433MHz)
Capacity	Up to 255 beacons
Power	External 1W

Power connector



Interface connector



# Thank you!

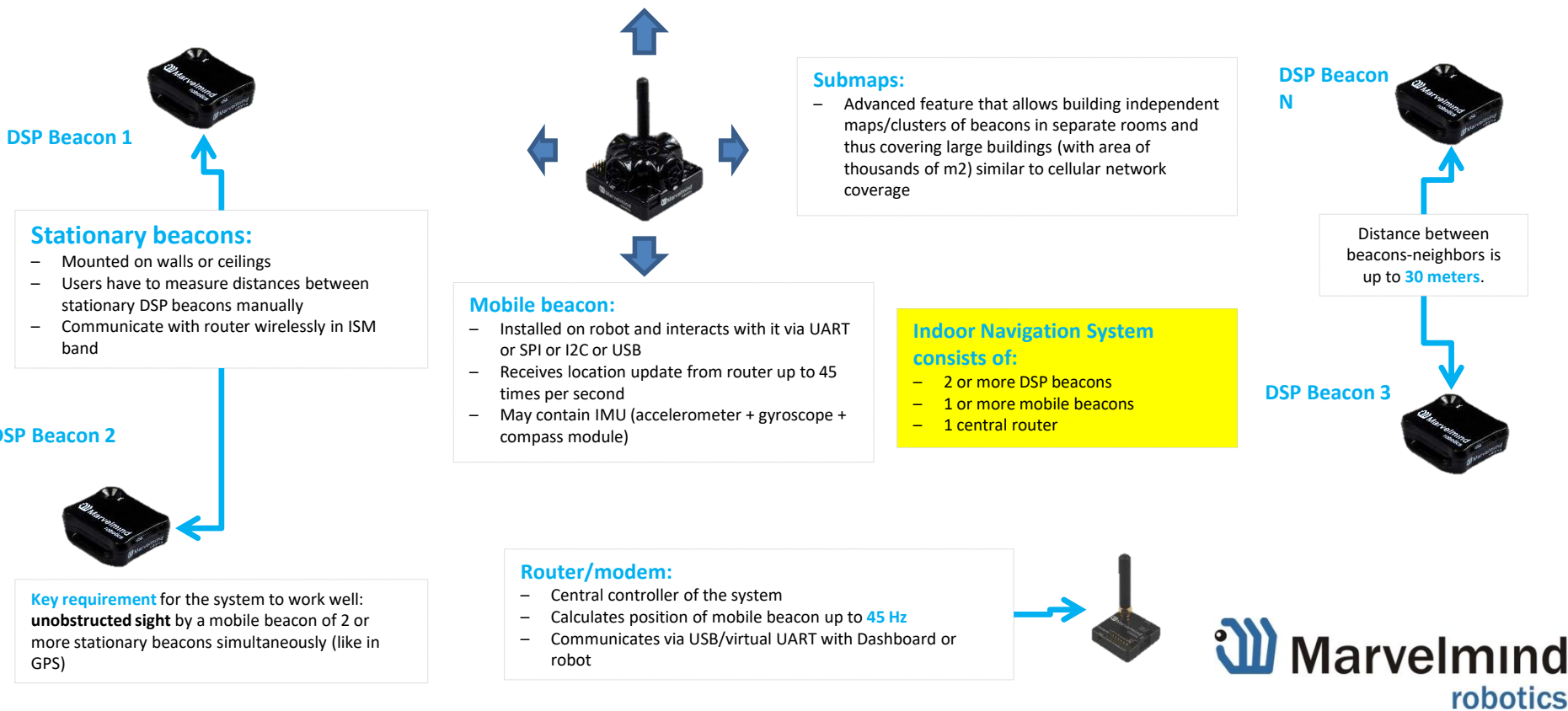
## Marvelmind Robotics

1111 W El Camino Real #109-365  
Sunnyvale CA 94087 USA

- <https://marvelmind.com>
- [info@marvelmind.com](mailto:info@marvelmind.com)
- [YouTube video channel with demo and help videos](#)
- [Operating Manual](#)

# Additional

# Non-Inverse Architecture (NIA)



# Inverse Architecture (IA)



## Stationary beacons:

- Mounted on walls or ceilings
- In inverse system beacons belonging to the same submap should have different ultrasound frequencies (19 & 25kHz or 25 & 31 kHz, for example)
- Communicate with router wirelessly in ISM band

Beacon 2  
(25KHz)



**Key requirement** for the system to work:  
**unobstructed line of hearing/sight** by a mobile beacon to 2 or more stationary beacons simultaneously (like in GPS)



## Mobile DSP beacon(s):

- Installed on robot (human) and interacts with it via virtual UART over USB
- Contains 3D IMU (accelerometer+gyroscope)
- Beacon's update rate doesn't directly depend on the number of mobile beacons unlike in Non-Inverse Architecture
- Calculates its location by itself – not by modem
- Recommended distance from mobile beacon to stationary ones up to 30m

## Router/modem:

- Central controller of the system
- Communicates via USB/virtual UART with Dashboard or robot
- Get location data from Mobile DSP beacons
- Supports up to 250 beacons

## Submaps:

- Advanced feature that allows building independent maps/clusters of beacons in separate rooms and thus covering large buildings (with area of thousands of m2) similar to cellular network coverage
- In Inverse Architecture every submap must have beacons with non-repeating ultrasound frequency
- Available frequencies: 19, 25, 31, 37, 45, 56 KHz

## Indoor Navigation System consists of:

- 2 or more stationary beacons
- 1 or more DSP beacons
- 1 central router

Beacon N  
(19, 25, 31,  
37, 45, 56  
KHz)



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

Beacon 3  
(31KHz)

