Indoor “GPS”

(with ±2cm precision)

For autonomous vehicles, robots, drones, forklifts and humans

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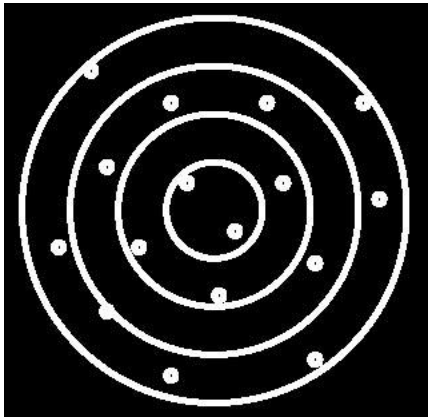
Problem to solve



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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, magnitometers, 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

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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**

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Indoor “GPS” (±2cm)

- 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 1000m²

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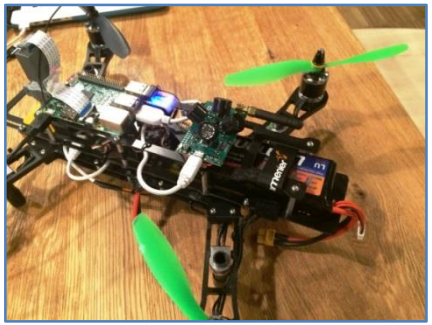
Selected customers

Customers in 40+ countries

Autonomous robots, drones, VR

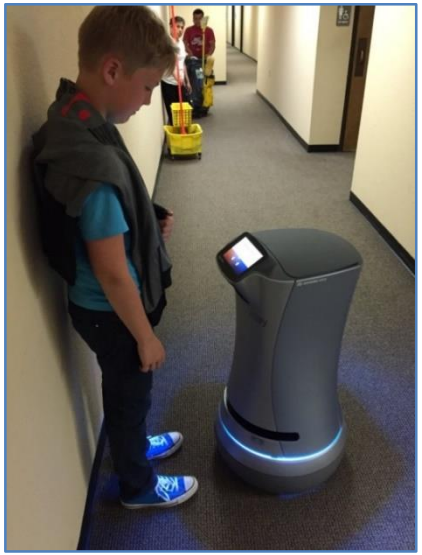
Virtual reality for BIM, quests, training and gaming

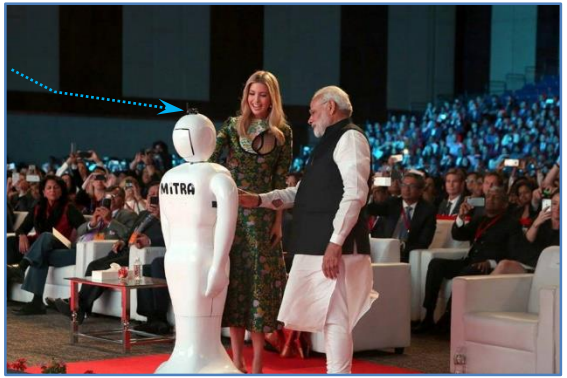


Autonomous drones indoor for inventory management, video/photo, security

Marvelmind beacon

Automatic delivery inside large buildings





PM of India Modi and Ivanka Trump

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

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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

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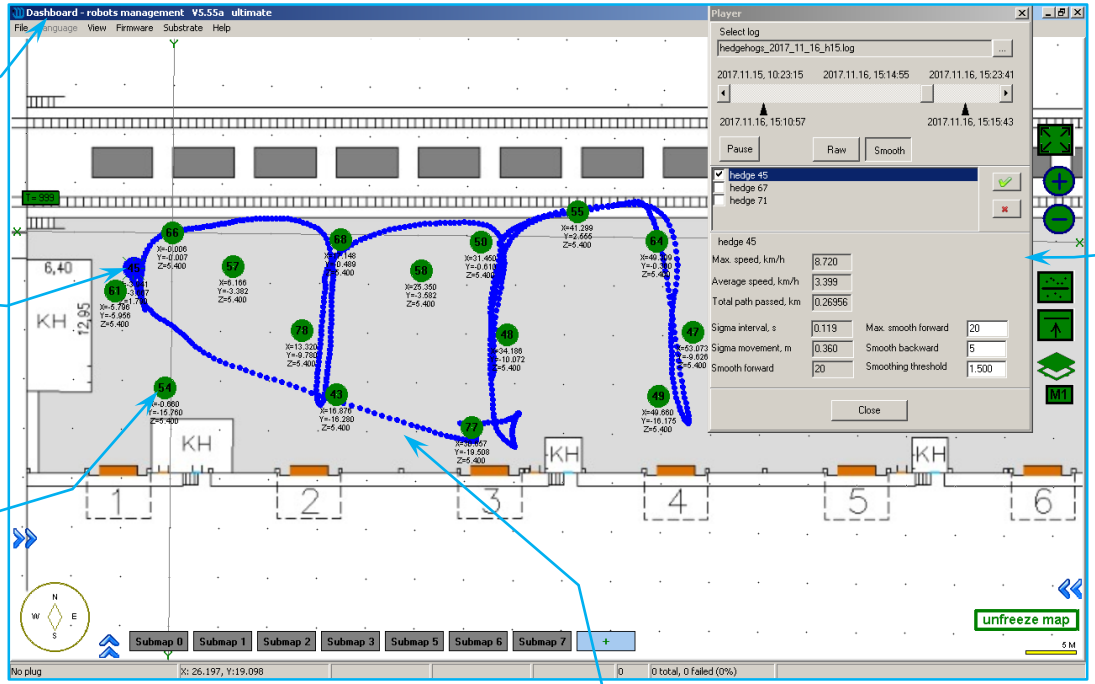
Use cases: mobile assets tracking

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.

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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

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Use cases: safety & productivity

System capabilities:

- Tracking of workers/vehicles indoor, underground or outdoor with up to ±2cm 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

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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

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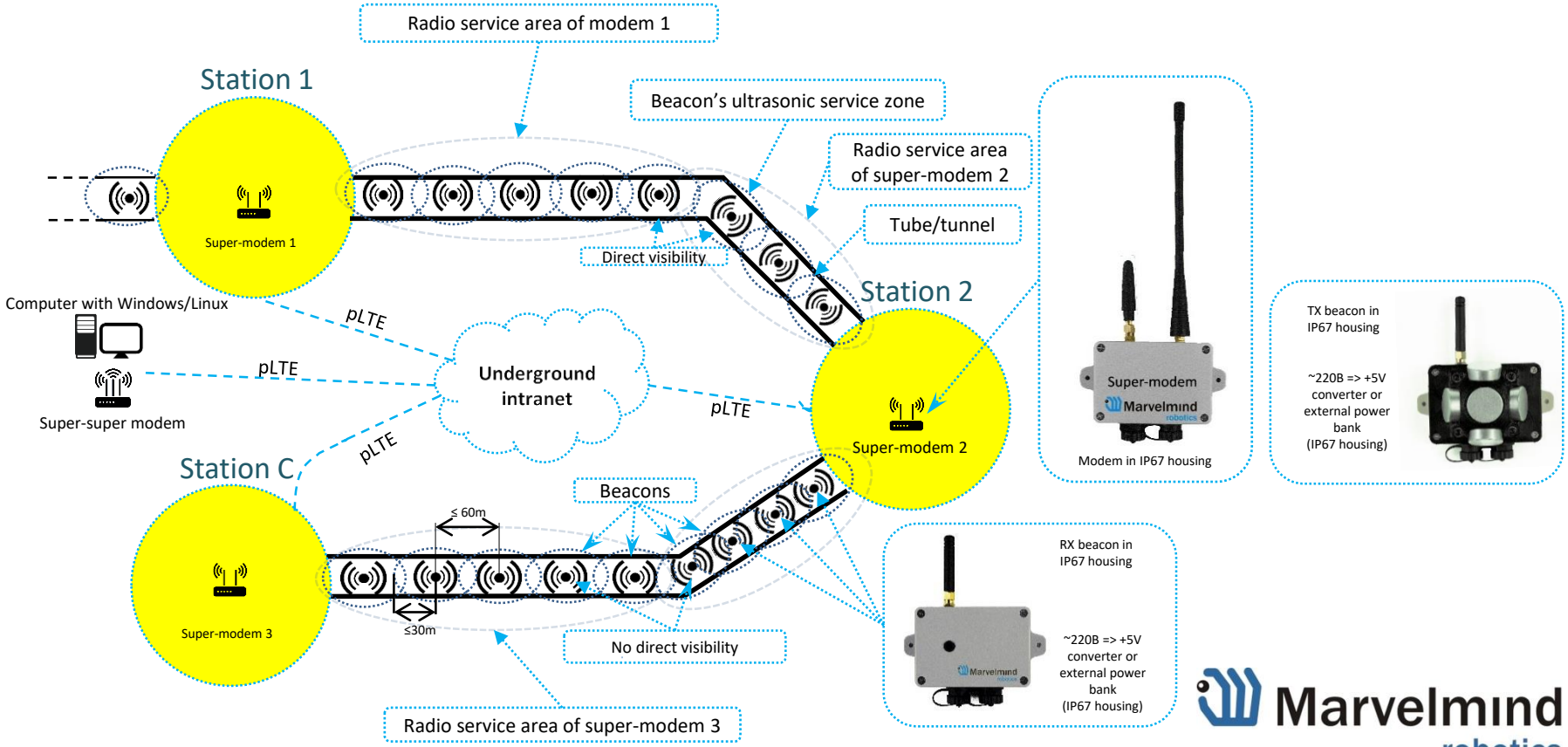
Marvelmind Robotics for underground

1.5D positioning for vehicles and people with ±2cm precision



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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
Specialty and main use	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
Mode of operation	RX only	TX only		Dual-use (RX and TX)	TX only	RX only
Range	- Up to 50m[3]	- Up to 30m with DSP RX v5.05 - Up to 20m with Beacon v4.9		- Up to 50m with DSP RX v5.05[3] - Up to 30m with Beacon v4.9[3]	- Up to 30m with Beacon-RX-915-XX	- Up to 30m with Beacon-TX-915-XX
Ultrasonic frequencies	- 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
Radio band	915/868MHz	915/868MHz		915/868MHz or 433MHz	915/868MHz or 433MHz	915/868MHz or 433MHz
Power/LiPol battery	USB/750mAh	USB/250mAh	USB/No embedded battery	USB/1000mAh	+5V or 12V or IP67 converter/Optional	+5V or 12V or IP67 converter/Optional
Environmental conditions	- Indoor/Outdoor up to IP67 - t=0..40C[6]	- Indoor/Outdoor[2] - t=0..40C[6]	- Indoor - t=0..40C[6]	- Indoor/Outdoor[2] - t=0..40C[6]	- Outdoor[2]/Intrinsically Safe[5] - t=-20..40C[6]	- Outdoor[2]/Intrinsically Safe[5] - t=-20..40C[6]
Size and weight	47x42x15mm & 25g	35x35x26mm & 19g	35x35x20mm & 12g[9]	55x55x33(64[7])mm & 62/75g	83x58x65mm[8] & 250g	83x58x33mm[8] & 200g
IMU (3D gyro+acc+mag)	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

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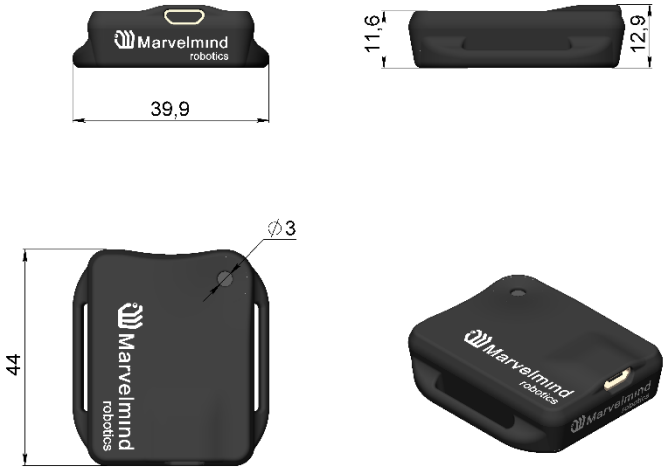
Marvelmind Watch Outdoor



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

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Marvelmind Watch: shoulder usage

Jacket + Marvelmind Watch

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

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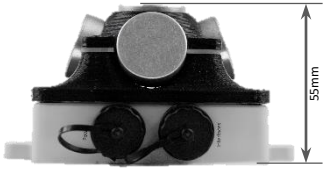
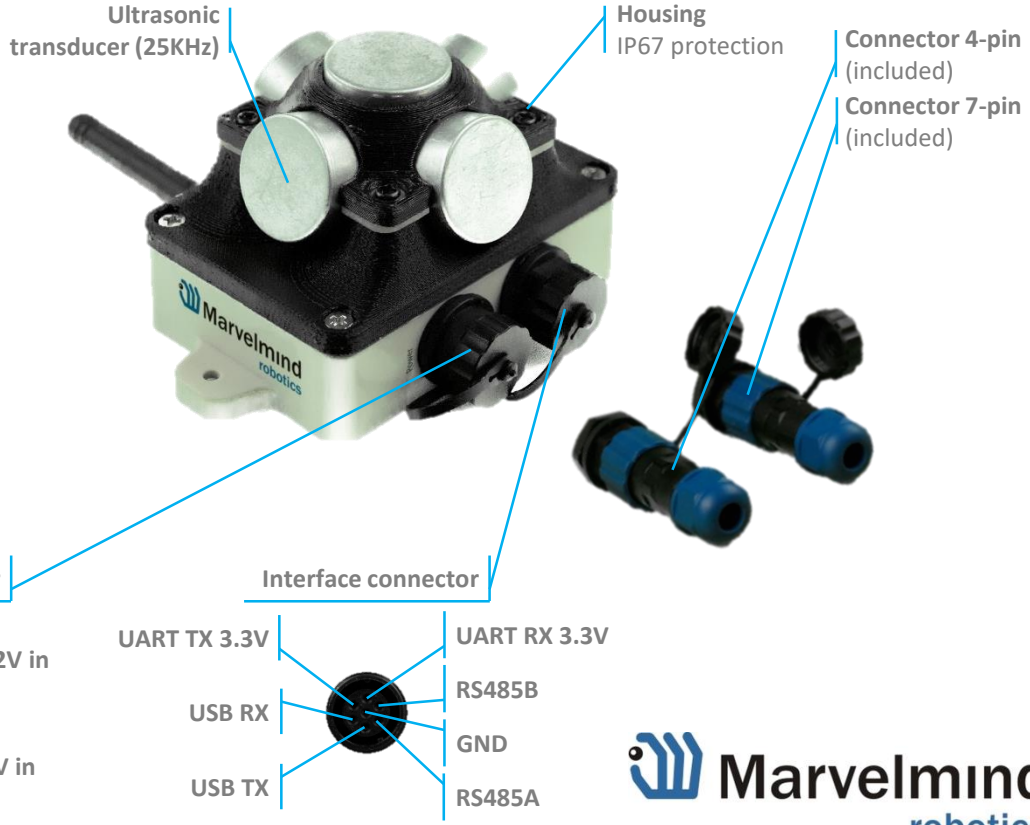
Beacon-TX-25-IMU-IP67-RS485



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 Beacon-DSP-RX-IMU-IP67-RS485
Power	External battery (15Wh for 2y & 1/5Hz)



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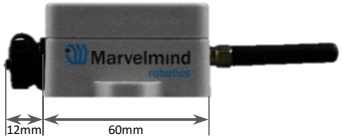
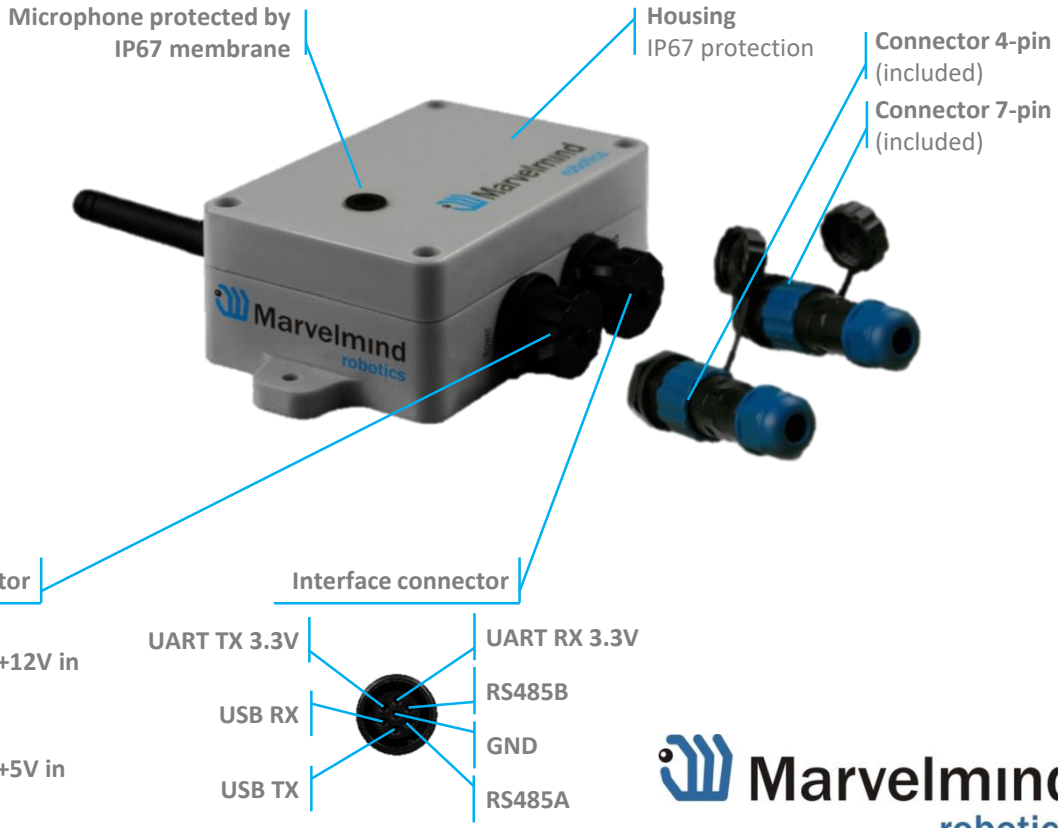
Beacon-DSP-RX-IMU-IP67-RS485



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 Beacon-TX-25-IMU-IP67-RS485
Power	External battery (38Wh for 2y & 1/5Hz)



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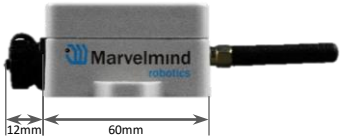
Super-Modem-IP67-RS485



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

Thank you!

Marvelmind Robotics

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Sunnyvale CA 94087 USA

- https://marvelmind.com
- info@marvelmind.com
- YouTube video channel with demo and help videos
- Operating Manual

Additional

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Non-Inverse Architecture (NIA)

DSP Beacon 1

Stationary beacons:
- Mounted on walls or ceilings
- Users have to measure distances between stationary DSP beacons manually
- Communicate with router wirelessly in ISM band

DSP Beacon 2

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

Mobile beacon:
- Installed on robot and interacts with it via UART or SPI or I2C or USB
- Receives location update from router up to 45 times per second
- May contain IMU (accelerometer + gyroscope + compass module)

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

Indoor Navigation System consists of:
- 2 or more DSP beacons
- 1 or more mobile beacons
- 1 central router

DSP Beacon N

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

DSP Beacon 3

Router/modem:
- Central controller of the system
- Calculates position of mobile beacon up to **45 Hz**
- Communicates via USB/virtual UART with Dashboard or robot

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Inverse Architecture (IA)

Beacon 1 (19KHz)

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

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)

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

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