

## White Paper

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### Axiomtek achieves high-accuracy movement with DigiHub for AMR

According to Next Move Strategy Consulting, the global autonomous mobile robot (AMR) market is estimated to generate USD 22.15 billion by 2030. More than common applications in warehouse, hospital, or cleaning functions, Axiomtek's Autonomous Mobile Robot (AMR) builder package transcends the scope in the past to the niche market of heavy-duty vehicles and expects to bring revolutionizing transformation to the industry.

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## Helping customers take the lead in AMR development

The AMR builder package is aimed at assisting the solution provider, independent software vendor (ISV), and system integrator (SI) in developing AMR without having to start from scratch, shortening the R&D process as much as possible. Choosing an all-in-one AMR builder package from Axiomtek means customers are already making headway in development; and with the consulting service, the AMR will be ready to go soon. It saves time, reduces effort and cost, and increases efficiency for the customer, allowing more focus on technical tuning in detail and more potential business opportunities.

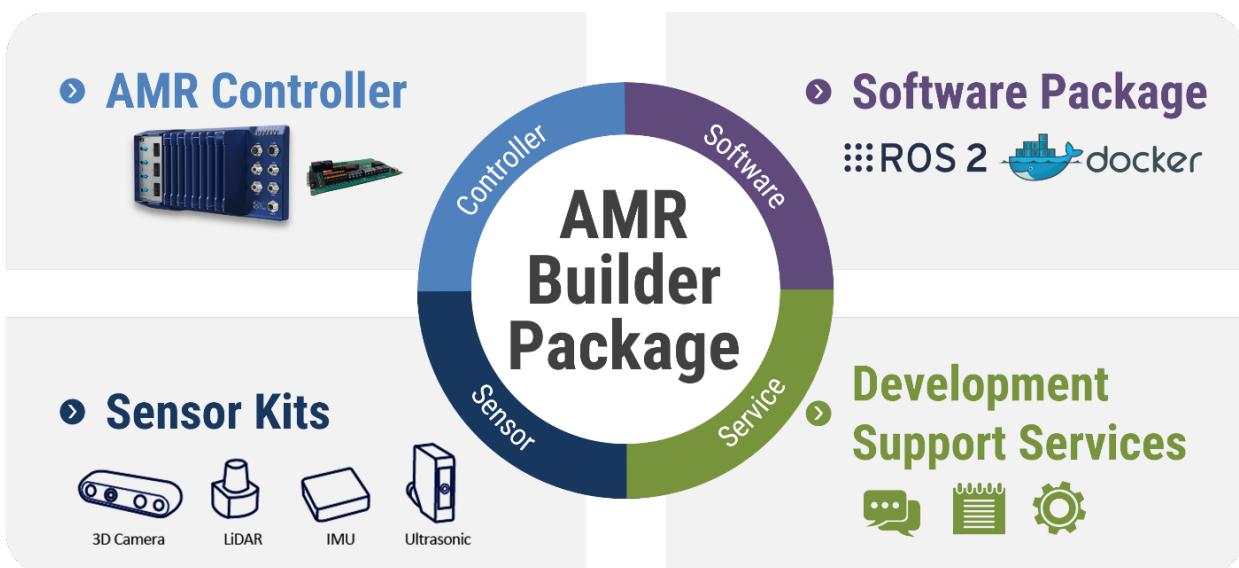


Figure 1. The AMR Builder Package architecture

The AMR builder package bundles the software and hardware altogether; moreover, the customer can obtain the reference design from Axiomtek on demand. The reference design is thoroughly tested to be deployment-ready. Therefore, developing a purpose-built AMR based on the reference design requires little tuning and will be an efficient solution. If the customer pursues their own design of the vehicle with our controller, Axiomtek also provides tailor-made development support services for technical details such as sensors' placement and accuracy tuning.

## High-accuracy AMR with Axiomtek DigiHub

Axiomtek introduces the market with its AMR builder package consisting of an AMR controller, DigiHub for AMR, sensor kits, and development support services including reference design and design guide, assisting customers in building the AMR efficiently and cost-effectively.

The DigiHub, the open-source package, is based on ROS2 nodes with Docker Images and provides:

### Basic

- ROS2 Nodes with Docker Images
    - Intel AMR SDK
    - Axiomtek nodes
    - SLAM and navigation nodes
  - GMSL Camera and Sensor Fusion
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### Advanced

- Web-based Management System
- AprilTag and Shape Detection
- Precise Positioning and Obstacle Avoidance

In other words, Axiomtek provides not only an AMR controller but also an all-in-one turnkey solution to accelerate time-to-market as much as possible through a complete program. The solution is acclaimed for its precision of motion, which enhances the efficiency of the work and safety.

By virtue of a team of elite experts with various expertise and experience, Axiomtek's reference design AMR has been tuned to provide ultra-precise motion powered by advanced simultaneous localization and mapping (SLAM) technology to enhance environmental perception ability. Cruising at a maximum speed of one meter per second, the control accuracy is 1 mm; with the

optimization of motor/LiDAR mounting design, the repeat accuracy can be 10 mm. Having the assistance of AprilTag, the position accuracy can even be within 10 mm. When the reference design passes through a narrow area, with a body of 60 cm in width, the passage only needs to be 65 cm wide.

## Who can benefit the most from choosing the Axiomtek AMR Builder Package

With both rich experiences in software and hardware from Axiomtek, the following types of customers can benefit the most from our products and services.

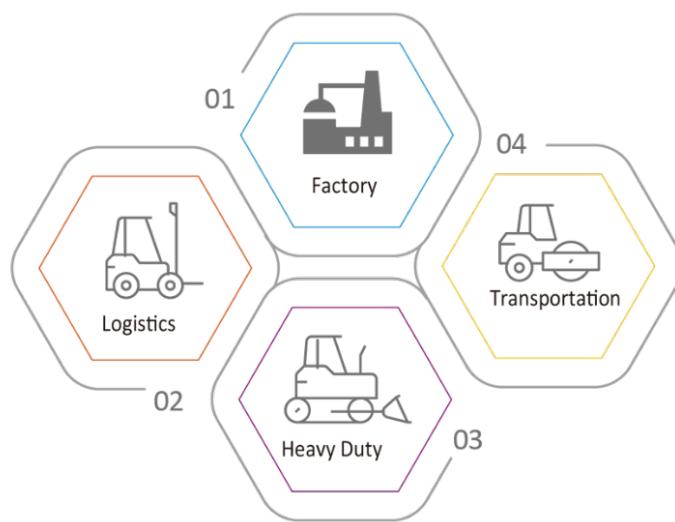


Figure 2. The key applications of the AMR

**First, the customers who have plans to upgrade from Automated Guided Vehicle (AGV) to AMR.** The biggest difference between an AGV and an AMR is the ability for spatial perception. An AMR solely relies on sensors on the vehicle to map out the space and tell how far it is from nearby objects, being able to self-navigate intelligently along the most efficient route from point to point with high accuracy. It does not need pre-programmed routes. Therefore, the applications of AMR are far more flexible and limitless. In the contrast, the AGV requires on-site guidance to inform the position and plan the routes, which means the end users need extra effort to change the facility layout for the AGV. Deploying AMR saves the cost of facility modification and magnetic stripes. The AGV developer already possesses the ability to assimilate the vehicles into the working environment; with the AMR builder package, the AMR solution can start accommodating the workloads in a shorter term.

**Secondly, the AMR developers who use ROS 1 but aspire to upgrade to ROS2 for product**

**longevity and optimization.** In the coming years, the developers will completely migrate to ROS2, which features better communication with the real-time data distribution service (DDS) protocol. With ROS2 the most crucial feature is that it provides improved communication between multi-AMR. In the upcoming future, automated work from an AMR fleet will be a trend and unmanned work will be more common to reduce labor costs. Therefore, migrating from ROS1 to ROS2 is inevitable. Also, in addition to the fleet, the AMR can even communicate with Human Machine Interface (HMI) via ROS 2. More than that, as a developer and company, migrating to ROS 2 earlier lessen the burden of transferring code in the future.

**Lastly, the system integrators who have already developed robots with lower movement accuracy** function as UVC disinfection robots and intend to develop high-accuracy robots to expand the business. With assistance from Axiomtek, customers will be taking the lead and be ready for integration for work. All in all, Axiomtek speeds up development.



Figure 3. Service flow chart of the AMR development services

## How does sensor fusion influence movement accuracy

Although Axiomtek has been recognized as a leader in the industrial computer, when it comes to software, Axiomtek gets extraordinary and progressive results in sensor fusion on ROS2 to incorporate different sensors from various manufacturers. Sensor fusion starts with collecting information from different sensors and compiling them together and turning them into useful information for movement. But the very first and most important step is to perceive the continuous consciousness of the current position for the AMR, then navigate safely and precisely. It enables the AMR to be cooperative and sensitive to the nearby 360-degree vicinity then the response to the obstruction is fast enough for a swift reaction of stop or reroute to prevent a collision. It is like the human vision that sees the surrounding objects and tells the distance while walking at the same time.

*"Axiomtek puts tremendous effort into sensor fusion to achieve the best accuracy; plus the seamless software and hardware integration, the customers get a trustworthy solution for rapid deployment."*

*Albert Huang, President & CEO of Axiomtek.*

Sensor fusion is the process of perfectly balancing the volume of data from multiple sensor sources to decide on which to rely on more in different situations; then, as the "data" collected by the sensors is turned into the "information", adequate action orders will be sent to the motor while keeping the processing but not eating up nearly all your CPU's resources to ensure fast reaction and smooth movement. For example, if we assume that there are four kinds of data from the sensors, what kind of volume combination of sensor parameters could level up the desired accuracy in the most effective way and not overload the CPU? In search of the most precise movement, Axiomtek takes the advantage of Artificial Intelligence (AI) to gradually minimize the deviation.

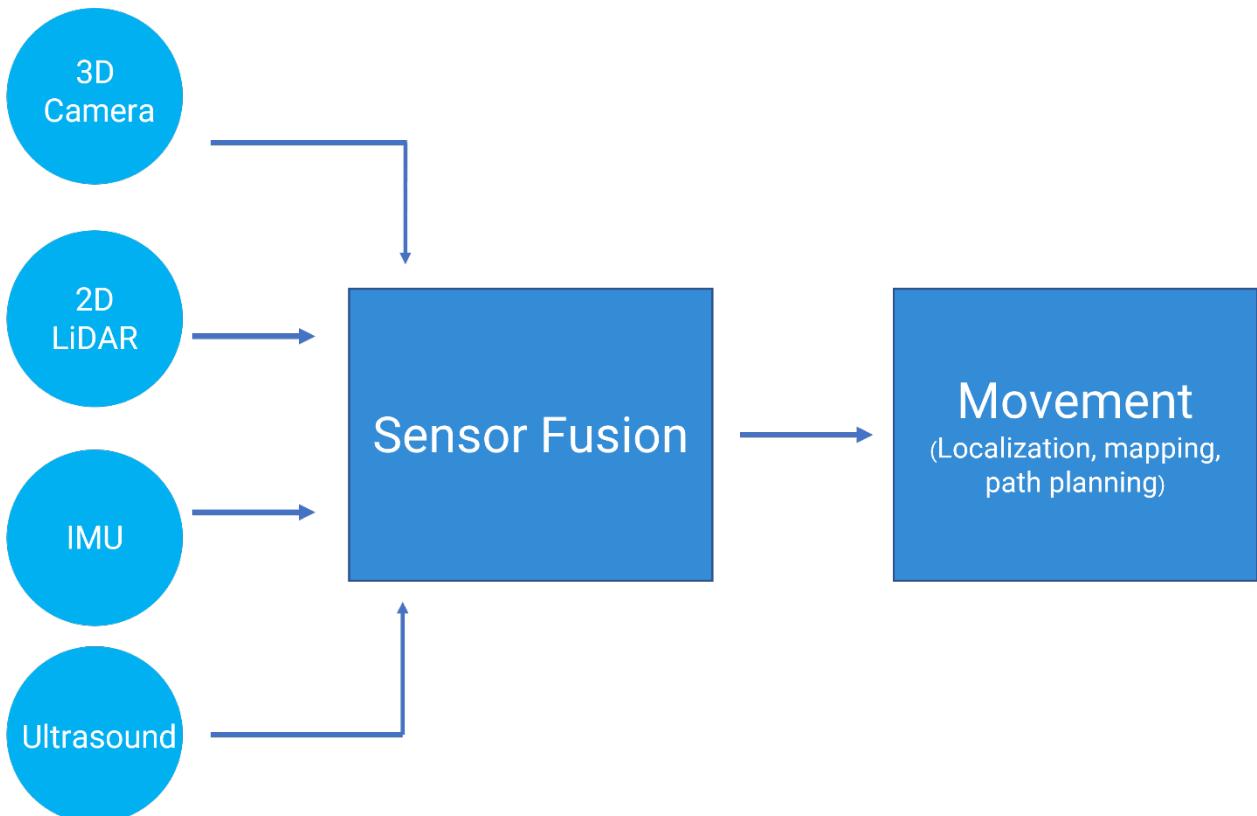


Figure 4. Concept and process of sensor fusion

In terms of the architecture type of the sensor fusion, the AMR team of Axiomtek chose to be centralized. In this architecture, the data fusion is directly processed by the control system, keeping the processing simple and efficient. Thus, the control system can function effortlessly with sensors and provide the most reliable result. In consequence, the AMR from Axiomtek has the best stability and instant reaction in movement because all the sensors collaborate and assist each other fluently.

When it comes to sensor setup, Axiomtek chooses “Cooperative Fusion Mode” to receive all the raw data from the sensors observing the same objects. Although this mode is more complicated, the system therefore can receive detailed new insights into the working environment. It demonstrates that by the virtue of our mature and reliable sensor fusion and software, all the sensors are like a champion football team where teammates get each other’s back.

## Excelling at sensor fusion to achieve high accuracy

While the AMR is cruising around for work, from the sensors’ perspective, the relative position is constantly changing every second and the processing keeps going on. However, sometimes accidental, and unexpected misjudgment can happen to sensors. For instance, the LiDAR sensors are not able to detect transparent objects and specular reflective surfaces.

Now sensor fusion enables other sensors to give a hand to provide the data for the next movement; the sensors with different features complement each other and work together and keep correcting to locate the position, and then the accuracy of spatial perception will be relatively high. In the process of development, since the volume of parameters is enormous and needs constant adjustment to carry out the most satisfying result, therefore the AI has been utilized to automatically adjust the parameters and keep track of accuracy to the most efficient setting, enhancing accuracy to the highest level possible and striking a balance between accuracy and computational burden. Likewise, the positioning deviation measuring will be provided to our customers for system integration and tuning.

To perfectly integrate the data from all the sensors, with the assistance from the software development kit, Intel® Edge Insights for AMR, the AMR will be able to offload the data processing workload to the integrated GPU, speeding up pose estimation calculation four times faster, keeping the CPU able to process other information at its best computing efficacy under the premise of not overburdening the CPU. Thanks to the offload, the density of the LiDAR beams can be multiplied. As a consequence, it avoids bumping, inaccurate cruising, or accident caused by processing delay and error.

As the customer discloses the demands for accuracy and functions, the professionals from Axiomtek will adjust the parameters according to the on-site situation or different vehicle designs.

To prevent developers' AMR from being affected by the deviation from the sensors and redoing the vehicle body, in the sensor kits, based on our experimental experience, Axiomtek provides extra purpose-built peripherals to correct the deviation including:

- LiDAR's bracket
- Chassis
- Motor mounting
- Anti-vibration connectors
- High-quality cables

With these customized peripherals, AMR developers can achieve much higher and more reliable movement accuracy and shorten the time to market.

## Conclusion: Flexible programs for AMR developers

Axiomtek does not simply provide the vehicle of AMR. Axiomtek possesses the ability of hardware and software integration that creates the most value for both parties. While every AMR developer has different progress, Axiomtek can be value-added to them, no matter if the customer needs assistance in software, hardware, or precision adjustment. If a customer builds an AMR based on ROS 2 but encounters an accuracy problem, Axiomtek is open to any kind of service and business opportunity and can help and be the final piece of the puzzle.

In conclusion, Axiomtek can facilitate the development of AMR with all-around services in less time and result in greater accuracy for multiple kinds of applications. The capability of integrating hardware and software provides developers with self-evident advantages.

## ROBOX500

ROS 2 AMR Controller for Navigation and Control Solutions

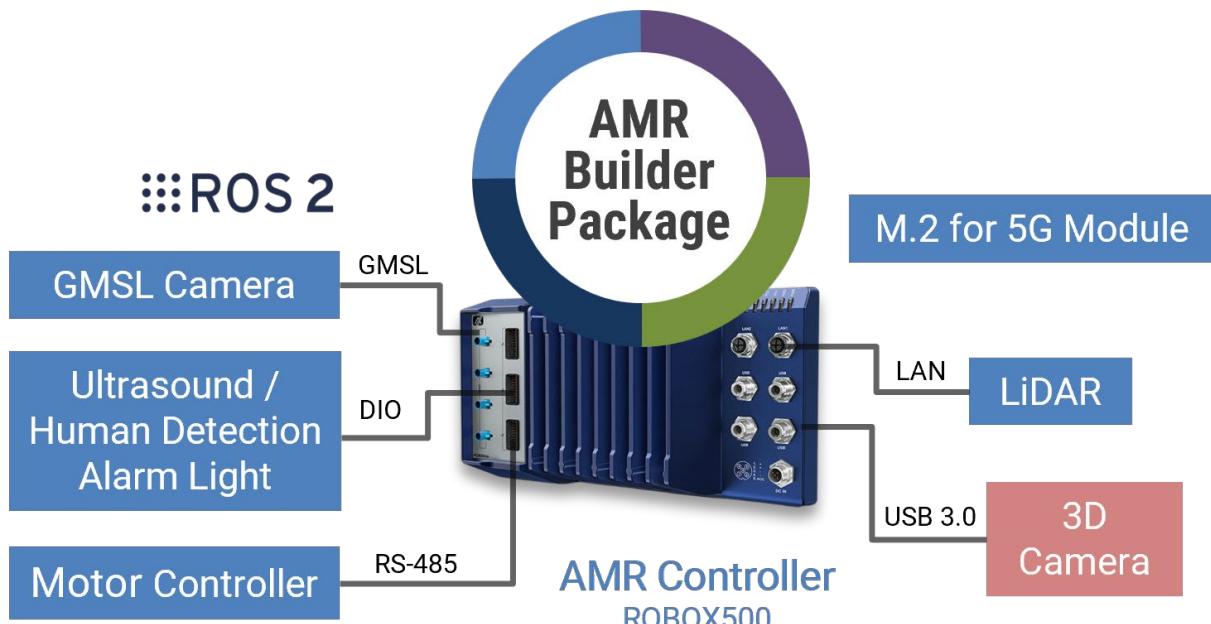


Figure 6. Features of the AMR controller, ROBOX500

The ROBOX500 is a state-of-the-art AMR controller, which is designed for heavy-duty applications like forklifts and excavators. The GMSL ensures its long-range stable and real-time vision during operation. It has excellent anti-vibration capability and wide operating temperature, making it perfect for any harsh working environment. The controller is one of the few in the market that provides the high-speed serial interface, GMSL.

- Intel® Alder Lake-P processor, 15W
- 4-channel GMSL camera
- 4 RS-422/485 and 2 CAN 2.0
- Wi-Fi/Bluetooth/5G/LTE
- Wide voltage input from 9 to 60 VDC
- M12 lockable connectors
- Supports Linux Ubuntu 20.04 LTS
- Supports Axiomtek AMR Builder Package

## Learn More

- [AMR Builder Package](#)
- [Axiomtek's AMR Builder Package - ROS 2 Based AMR Turnkey Solution](#)

## About Axiomtek

Axiomtek has experienced extraordinary growth in the past 30 years because of our people, our years of learning which resulted in our tremendous industry experience, and our desire to deliver well-rounded, easy-to-integrate solutions to our customers. These factors have influenced us to invest in a growing team of engineers including software, hardware, firmware, and application engineers. For the next few decades, our success will be determined by our ability to lead with unique technologies for AIoT and serve our key markets with innovatively-designed solution packages of hardware and software – coupled with unmatched engineering and value-added services that will help lessen the challenges faced by our systems integrator, OEM and ODM customers and prospects alike. We will continue to enlist more technology partners and increase collaborations with our growing ecosystem who are leaders in their fields. With such alliances, we will create synergy and better deliver solutions, value, and the expertise our customers need.

Axiomtek is a Member of the Intel IoT® Solutions Alliance. A global ecosystem of more than 800 industry leaders, the Alliance offers its members unique access to Intel technology, expertise, and go-to-market support—accelerating the deployment of best-in-class solutions.



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