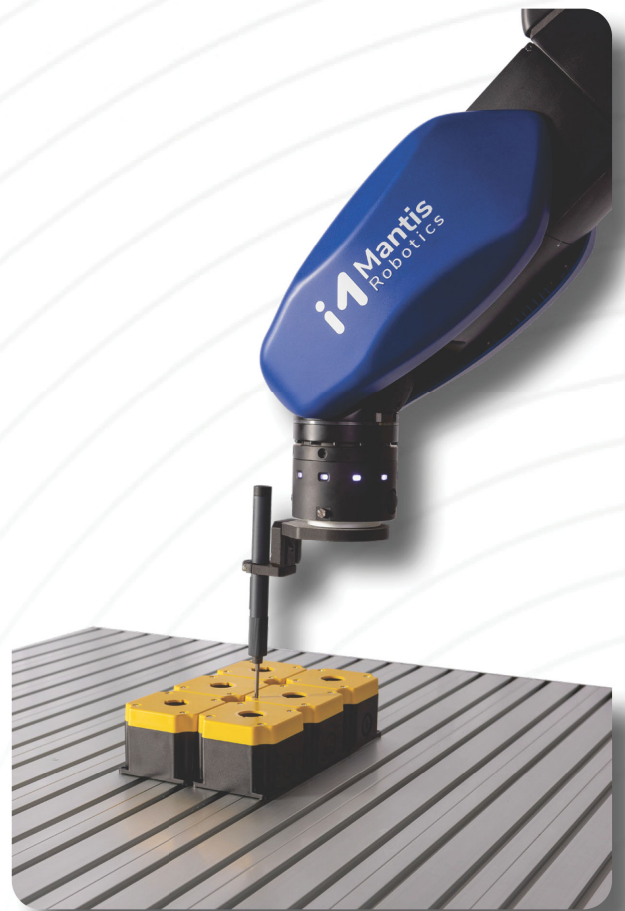




WHITE PAPER:

# ROBOTIC SCREWDRIVING

Achieving ROI in High-Mix, Low-Volume Production





## Overview

As industries worldwide push toward greater efficiency, precision, and adaptability, robotic screwdriving has emerged as a cornerstone of modern automated assembly. What was once confined to high-volume, low-variation environments, screwdriving automation is now starting to penetrate the high-mix, low volume production thanks to advances in robotics, sensors, and collaborative systems.

## Market Analysis

The robotic screwdriving market is set to grow significantly from 2025-2035. According to recent forecasts, the global robotic screwdriver market is expected to grow from **USD \$9.69 billion in 2024 to USD \$24.12 billion by 2033**, registering a robust compound annual growth rate (CAGR) of **10.96%** (DataHorizon Research, 2024).

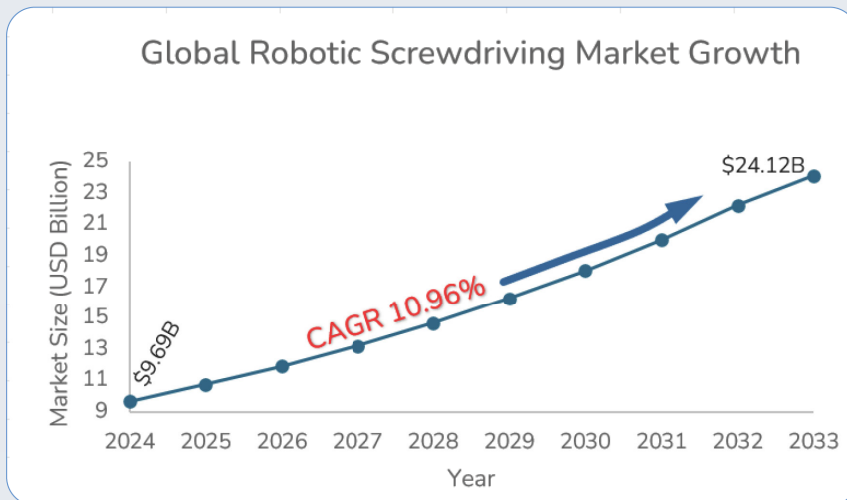


Figure 1. Global Robotic Screwdriver Market Growth (2024–2033)  
Source: DataHorizon Research, 2024 (Forecast)

This white paper explores the market dynamics driving this transformation, key applications that benefit most, and challenges that persist. It also highlights how human-robot collaboration is reshaping modern production and how Mantis Robotics is responding with a solution tailored to these emerging needs.

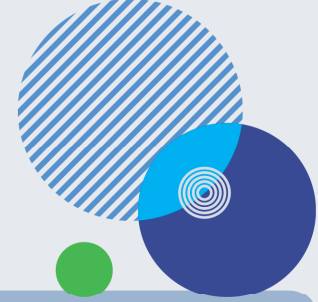


Part of the growth in robotic screwdriving is driven by high-volume production environments. Industries such as automotive, electronics, aerospace and consumer goods require highly precise and efficient assembly operations to maintain product quality and meet stringent standards. At the same time, manufacturers are under pressure to reduce labor costs and minimize human error. Compounding this challenge is the growing difficulty of attracting workers for repetitive, non-ergonomic screwdriving tasks, which are often perceived as dull or physically taxing.

Furthermore, the global shift towards **Industry 4.0** emphasizes automation and data exchange in manufacturing technologies. **This shift encourages manufacturers to adopt advanced robotic solutions to remain competitive in a fast-evolving market.**

While fully automated systems dominate high-volume environments—capturing 52% of new installations in 2024 (Verified Market Reports, 2025)—semi-automated and collaborative systems are seeing increasing traction, particularly among mid-sized firms and dynamic manufacturing operations. Semi-automated solutions grew by 14% in 2024 alone, highlighting the need for flexible, reconfigurable systems that support frequent product changeovers and limited production runs.

**This shift underscores a major growth opportunity in collaborative screwdriving applications.** As manufacturers seek more adaptable solutions for high-mix, low-volume production, robots capable of working safely alongside human operators are gaining traction. These collaborative systems are particularly valuable on mixed-model assembly lines, where frequent product changeovers and variable workflows make full automation impractical. By combining human oversight with robotic precision, they offer **a compelling balance of flexibility, safety, and efficiency**—reducing worker fatigue while maintaining high quality standards.



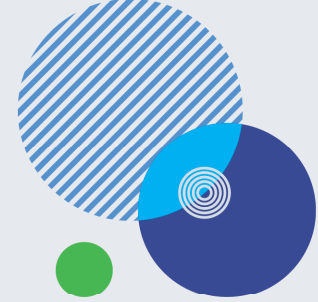
## Challenges

Despite clear advantages, the adoption of robotic screwdriving systems is not without barriers. High initial investment remains a significant deterrent, especially for small and medium-sized enterprises. Advanced systems often require substantial upfront capital, and the return on investment—though measurable—may take several years in lower-volume contexts.

Another challenge lies in integration. Aligning robotic screwdriving systems with existing production lines can be complex, requiring custom tooling, controls synchronization, and careful workflow planning. Moreover, companies must invest in training personnel and rethinking quality assurance protocols to fully benefit from automation.

Finally, there are social and organizational challenges. As automation replaces manual labor in repetitive tasks, there is growing concern over job displacement. While robotic screwdriving can alleviate the burden of tedious work and improve overall safety, it also necessitates workforce reskilling and thoughtful change management to gain organizational buy-in. IFR (International Federation of Robotics) members have estimated that up to 50% of robot operators will have to work with robots, including programming simple applications, monitoring robot performance and working collaboratively with the robot.





While cobots (collaborative robots) are popular for their ease of use, many screw-driving applications require traditional industrial robots (like SCARA or 6-axis) because of **physics and throughput**. The decision usually comes down to whether the application is limited by cycle time, torque physics, and ease of integration. The comparison is shown below.

Industrial Robot vs. Collaborative Robot		
Feature / Robot	Industrial Robot (SCARA/6-Axis)	Collaborative Robot (Cobot)
Max Speed	Up to <b>10 m/s</b> (Blink-and-miss speed)	Usually limited to <b>1 m/s</b> or less
Repeatability	<b>0.01 mm</b> (High Precision)	<b>0.05 - 0.1 mm</b>
Rigidity	High (Handles high torque reaction)	Low (Joint sensors may "trip" on torque)
Safety	Required Fencing / Caging	"Safe" by design (Force-limited)

### High Torque Reaction & Rigidity

Screwdriving creates an equal and opposite **reaction force**. When the screwdriver reaches its target torque (e.g., tightening a bolt on an engine block), that force is pushed back into the robot arm.

- **The Cobot Problem:** Cobots use sensitive joint sensors to detect collisions with humans. In high-torque applications, the robot often mistakes the **tightening reaction** for a **human collision**, causing the robot to "e-stop" or lose its position.
- **The Industrial Solution:** Industrial robots are built with high mechanical rigidity and stiff gearboxes. They can absorb high torque (**above 15–20 Nm**) without shifting or triggering safety sensors.

### High-Volume Cycle Times

In industries like electronics (smartphones/laptops), screws are driven every **1.5 to 2 seconds**.

- **Speed Gap:** An industrial robot can move between screw points almost instantly. Cobots are legally mandated to move slowly (often under **250 mm/s** when humans are nearby) to prevent injury.
- **Throughput:** If your line requires more than **10 screws per minute**, a cobot will likely become a bottleneck, making the faster industrial robot the only viable choice for ROI.

## Mantis Solution

To address the challenges brought on by the evolving landscape of robotic screw-driving, Mantis Robotics has developed the MR-1, the world's first high-speed, fenceless industrial robot. Equipped with advanced integrated safety sensors, the MR-1 can continuously scan and interpret its surroundings. **This allows it to detect the presence of nearby humans, slow down accordingly, and stop completely if someone comes too close.**

By embedding safety features directly into the robot, the MR-1 eliminates the need for traditional fencing and external safeguarding hardware. This not only reduces the cost

and complexity of installation, it also frees up valuable factory floor space. **As a result, the overall cost of a robotic screwdriving system can be reduced by up to 75%.**

The MR-1 also features a user-friendly, code-free setup interface, enabling rapid reprogramming without any need for coding skills. Its flexibility makes it particularly well-suited for adapting to frequent product changes and new tasks — **an ideal fit for high-mix, low-volume production environments where full automation isn't feasible.**



Figure 2. Code-free interface

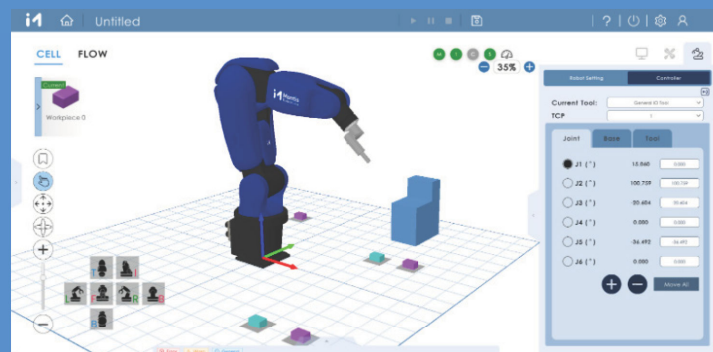


Figure 3. 3D Simulator and Layout



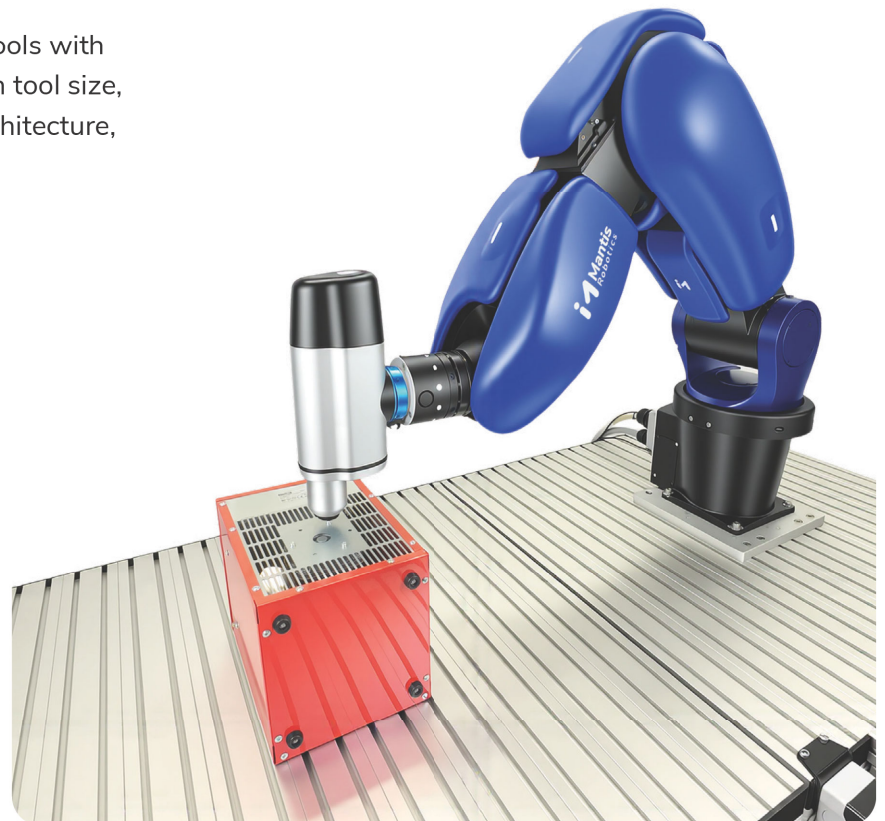
**D**esigned as a true industrial-grade robot, the MR-1 overcomes the limitations commonly associated with collaborative robots (cobots). While traditional cobots are generally restricted to lightweight tasks — such as driving small screws (M1 to M3, under 20 mm in length) — and must operate at reduced speeds for safety, the MR-1 can handle high-force applications without sacrificing speed or reliability.

During a screwdriving application, there will be a reaction force to the robot, when the driver reaches its target torque. A traditional cobot relies on its precision joint sensor to detect the collision, but in a high-torque scenario, cobots often mistakenly detect the reaction force to human body collision, causing E-STOP or position offset. **The MR-1 features a true industrial structure with strong mechanisms and gearing design to let it stand with 15-20 Nm torques without triggering the safety sensor and/or position offset.** This ensures that when doing heavy-duty applications, MR-1 can provide industry stability with the advantage of fenceless operation.

Moreover, integrating screwdriving tools with cobots often requires compromises in tool size, mounting orientation, and control architecture,

which can impact system performance and consistency. The MR-1 avoids these issues while still offering the same advantages as cobots in terms of quick deployment and safe human collaboration — but without the typical trade-offs.

Ultimately, the MR-1 bridges the gap between manual labor and full automation, offering manufacturers a powerful, flexible, and cost-effective solution tailored to modern production demands — especially for mid-sized operations and frequent product iterations. You don't have to sacrifice 50% of your cycle time just to stay safe.



## Feasibility Scorecard

To see which robot type works best for your automation application, complete the scorecard below. Review each category in the left column (Cycle Time, Torque, etc), and enter the relevant number for each row in the Your Score column. When you're done, add up all the numbers in that column, and you will have your Total Score. Review the text below the chart to see which robot category (Cobot, Mantis MR-1 or Traditional Industrial) is best based on your scorecard responses.

Category	Requirement	1 point	2 points	3 points	Your Score
Cycle Time	Screws per minute	Slow (<6 ppm)	Fast (>15 ppm)		
Torque (T)	Tightening force	Low (T<5 Nm)	High (T>15 Nm)		
Precision (R)	Repeatability	R±0.1 mm	R±0.02 mm		
Preferred Safety	Human Proximity	Collaborative	Fenceless / Coexistence	Caged / Fenced Off	
Payload	Weight of the tool	<5 kg	5-15 kg	>15 kg	
Floor Space	Total Footprint	Restricted to retrofit current manual station	Limited but have some space	No Limitation	
Tooling Type	Bit Speed / Feed	Blunt / Manual		High-speed / Auto	

**TOTAL SCORE**

### Score: 7 – 10 (The Cobot Zone)

- Best Fit: Universal Robots, Fanuc CRX.
- Application: Light-duty assembly, plastic housing, low-torque electronics. You prioritize ease of programming over raw speed.

### Score: 10 – 14 (The MR-1 “Sweet Spot”)

- Best Fit: Mantis MR-1 (Fenceless Industrial).
- The Advantage: You have Industrial requirements (High Torque, High Speed, Precision) but cobot constraints (No room for a cage, need to work near humans, or want “Smart Spending” on infrastructure).
- Why it wins: It eliminates the “Performance Penalty” usually paid when choosing a fenceless robot.

### Score: >15 (Traditional Industrial Zone)

- Best Fit: Fanuc, ABB, or KUKA SCARA/6-Axis in a full cell.
- Application: Heavy automotive sub-assembly or ultra-hazardous environments where humans are strictly prohibited from the zone regardless of robot safety features.

## Conclusions



As manufacturing evolves toward more dynamic, product-diverse environments, robotic screwdriving must keep pace with the demand for flexibility, scalability, and ease of use. High-mix, low-volume production no longer precludes automation—in fact, it demands smarter, more adaptive solutions. You should stick with an **Industrial Robot** if:

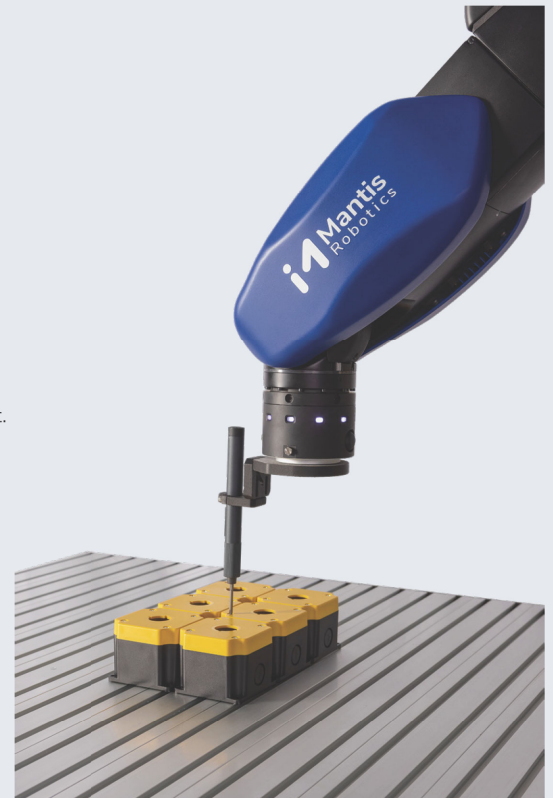
- **Torque is high:** You are tightening bolts above **10–12 Nm**.
- **Precision is critical:** You are driving tiny M1–M2 screws where **0.02 mm** accuracy is needed.
- **Speed is King:** You need to drive a screw every few seconds.

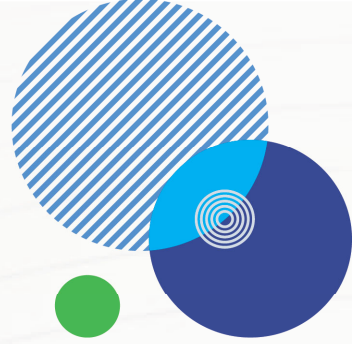
By removing the barriers of high cost, complex integration, and limited flexibility, the **Mantis MR-1 empowers manufacturers to realize ROI faster and future-proof their operations**. Whether you're aiming to reduce ergonomic strain on workers, maintain consistent quality across varied product lines, or simply make better use of factory space, the MR-1 offers a compelling path forward.

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The Mantis MR-1 answers the call for automated screwdriving by combining industrial-grade performance with collaborative safety and a user-friendly setup, enabling rapid deployment without the compromises typical of conventional systems.





Ready to transform your screwdriving operations?

To learn more about the Mantis MR-1 robot for screwdriving or other industrial applications, email [sales@mantisbots.com](mailto:sales@mantisbots.com).



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