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The rise of humanoid robots in warehouses

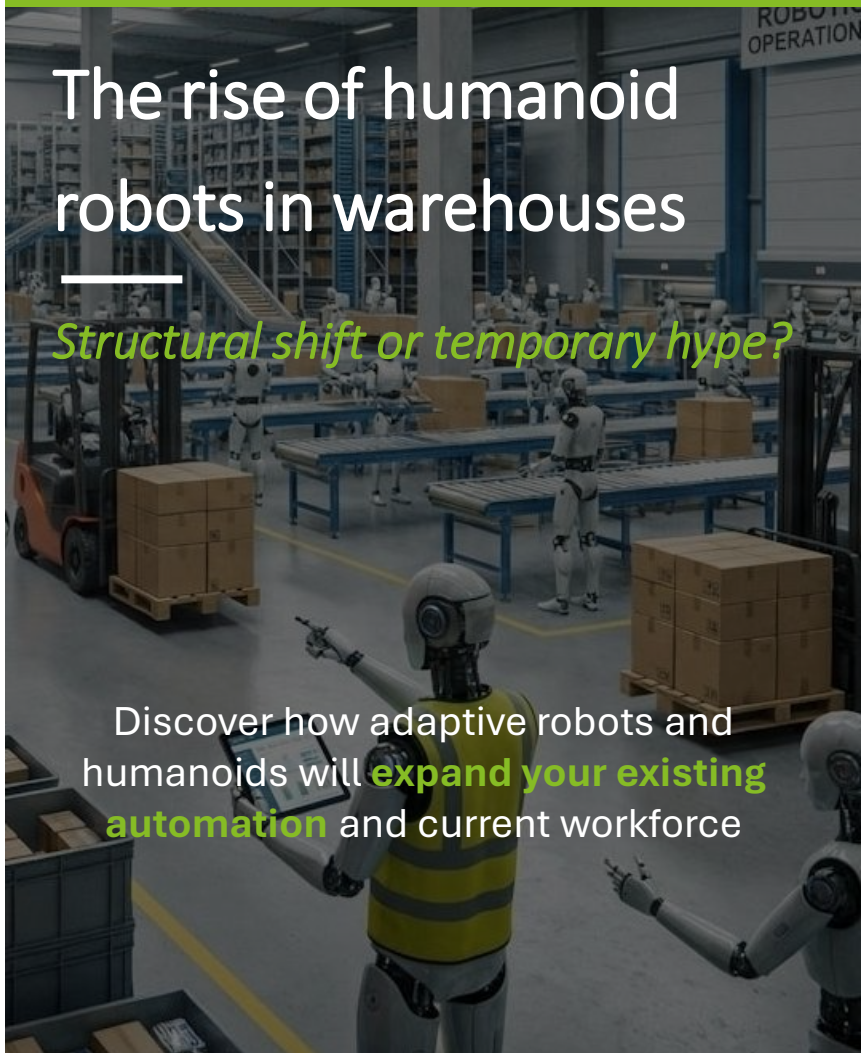
Structural shift or temporary hype?



A Deloitte humanoid robotics series

We will guide you through the world of humanoids in three booklets

Focus of this booklet



The rise of humanoid robots in warehouses

Structural shift or temporary hype?

Discover how adaptive robots and humanoids will **expand your existing automation** and current workforce



Economics of humanoid robotics

Value for money or bottomless pit?

Discover how adaptive robotics fundamentally reshape automation economics and investment rationale by delivering **faster payback** through **multi-task deployment**



Capabilities to lead a humanoid workforce

New way of working or all the same?

You want to lead the way? Understand what are the next steps in implementing adaptive robotics in your warehouse. Covering **technical integrations**, a **pilot approach** and the **human role.**

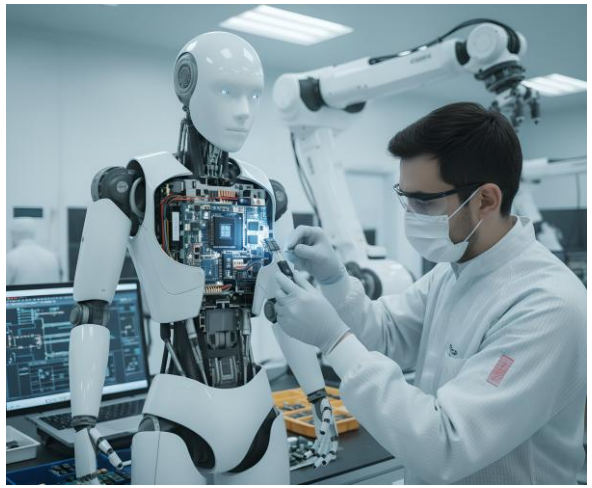
There is a lot of trending content on humanoid robots in all areas of society



Eye-catching martial arts performance at China gala

The Guardian[1]

February 16, 2026



Nvidia strikes humanoid robot partnerships with European chipmakers

Reuters[2]

March 16, 2026



Elon Musk says humans could eventually download their brains into robots

CNBC[3]

April 8, 2022



G1 robot makes Shanghai Fashion Week debut

China Daily[4]

March 26, 2025

So, will humanoid robots take over your warehouse?

Humanoid robots are no longer science fiction. In recent years development has moved from lab concepts to pilots on warehouse shopfloors, and humanoid models are being tested for tasks such as picking totes and moving boxes. Their arrival marks a new phase in warehouse automation.

Automation has traditionally been defined as mechanized equipment to perform specific warehouse tasks, such as storing, picking, packing or shipping. Common examples are conveyors, sorters and Automated Storage and Retrieval Systems (AS/RS). These solutions are highly efficient but optimized for fixed tasks and ways of working. When processes change the systems remain usable, but their effectiveness drops because they cannot be put to different tasks without significant reconfiguration: a conveyor and palletizing line built to create full case pallets cannot efficiently handle large volumes of single item orders.

Humans have filled this flexibility gap by moving between tasks and manage the exceptions. For example, pickers are redeployed from replenishment to piece-picking or processing returns during peak hours.

However, with new technological advancements like AI-driven task orchestration capabilities and autonomous movement, a new workforce enters your shopfloor: **Humanoid robots combine flexibility of humans with efficiency of automation.**

We believe five structural pressures in warehousing further drive the potential of the breakthrough of humanoid robots:

Structural labor volatility | Unpredictable workforce supply and no-show make staffing forecasts unreliable

Space & regulatory constraints | Limited land and strict regulations prevent greenfield expansion, forcing optimization of existing sites

SKU assortment growth & e-commerce complexity | Growing product variety and more complex order profiles raise handling and picking complexity

Throughput unpredictability | Volatile order volumes and tighter SLAs reduce the ability to reschedule work, making peaks harder to absorb

Fixed automation limits | Single-task systems deliver low utilization under changing economic pressures, tying up capital and forcing costly reconfiguration or replacement

These pressures demand a new kind of innovation, exactly at the core strength of humanoid robotics: **adaptive efficiency**.



Humanoids are entering the warehouse, and the question for supply chain leaders is no longer if they will be part of the workforce, but where and when

Static automation evolved to mobile manipulators and humanoid robots

Warehouse automation started with static, mechanized systems built to move goods or perform a single-task efficiently. Over time, both forms of automation evolved to become more mobile and more adaptive. **These developments are now converging into robots that can both move and perform multiple tasks, increasing adaptability in warehouse operations.** In the future, warehouse automation will become a mix of fixed and standardized handling systems, combined with more complex and mobile assets like humanoids

Development	*Fixed infrastructure*	*Fixed path navigation*	*Autonomous navigation*	*Handling & movement*	*Human-like adaptability*
Movement Automation *Evolution of how goods are transported*	**Conveyor systems** Conveyors move goods through **embedded fixed routes** in the warehouse layout	**AGVs** Automated Guided Vehicles move goods along **predefined paths** using markers or guiding systems	**AMRs** Autonomous Mobile Robots **navigate dynamically** and transport goods freely	**Mobile manipulators** Adaptive **multi-task robotics** can move through the warehouse and **switch between tasks** such as picking, replenishment and transport based on demand	**Humanoid Robotics** Humanoid robots combine **human-like mobility**, allowing them to perform many different warehouse tasks and **adapt to existing processes** and environments
Task Automation *Evolution of how goods are handled*	**Fixed automation** Systems such as AS/RS and pallet robots automate a **specific task for highly standardized goods** (e.g., pallets, totes, cases)	**Early picking robots** Robots **begin to pick individual items**, but typically only items with predictable shapes or packaging	**AI-enabled manipulation** Advances in vision and grippers allow robots to **handle a wide variety of items** with different shapes, packaging and orientation		
Development	*Standardized handling*	*Limited item picking*	*Mixed item handling*	*Handling & movement*	*Human-like adaptability*

Humanoids give true flexibility with pilots ongoing, but they are not yet mature

Humanoid robots represent a fundamental breakthrough in warehouse automation through **human-like mobility and dual-hand capability**: two hands operating in synchronized coordination, enabling simultaneous retrieval and precision picking operations that current robotic systems cannot replicate. This physical dexterity, combined with **adaptive intelligence** including **task learning, autonomous decision-making, and real-time environmental adaptation**, fundamentally expands automation potential and redefines operational efficiency. **Warehouses are the optimal environment with typically standardized processes** and transparent workflows, which do need to be executed within **complex layouts**. This creates the **ideal conditions for AI orchestrated, human-like machines**. This while the need to manage demand peaks, repetitive task execution, and heavy load handling demand precisely the capabilities that humanoids deliver.

Although humanoid robotics are **not yet ready for widespread deployment**, **developments are going at a rapid pace**. Safety integration with human workers and operational runtime limitations remain critical barriers. However, it was also only ~10 years ago that electric car batteries were limited to approximately 150 km[5]. Hence the trajectory is clear with costs declining and capability accelerating. **Widespread adoption in warehouses can be expected in the next decade**. Operational pilots in logistics at Amazon[6] and GXO Logistics, alongside European deployments from NEURA Robotics, validate that **humanoid robotics represent not hype, but a structural addition** to the automation portfolio that will reshape warehouse automation in the years ahead.





Case Example: GXO testing humanoid robots[7]

GXO is already deploying humanoid robots in live warehouses, testing humanoids for heavy tote lifting, Apptronik's Apollo (four-hour battery, 25 kg payload) and Reflex units for **box transport**. Since October 2024 **robots operate in supportive roles—lifting, transporting and positioning—alongside staff**, providing **real-time feedback** through an operational incubator. **Small pilots** (e.g., two humanoids) **aim to expand**; GXO sees scalable, multi-task humanoids as a **near-term logistical advance.**

Mobile manipulators are current state, available, and more mature solutions



Although humanoid robotics represent the ultimate vision of truly adaptive automation, there are still a few years for transitioning. **Mobile manipulators act as the strategic bridge between traditional static automation, rigid systems optimized for specific tasks, and the humanoid versatility of the future**. Multi-task robots combine mobility without fixed infrastructure constraints with real-time task switching capability, enabling immediate adaptation to operational changes.

Real-world applications

Robots like the MC600 from Mobile Industrial Robots, the Geek+ Gino1, and Boston Dynamics' Stretch robot excel at modernizing existing warehouses by **combining handling and movement in a single robot**. These examples of **increased flexibility maximize utilization and create predictable ROI in volatile environments**. The ability to dynamically redeploy robots between different tasks and locations without requiring infrastructure modifications makes them particularly valuable during demand fluctuations, where traditional fixed automation would remain underutilized.

Understanding the limitations

However, these systems have clear limits: multi-task robots excel in repetitive operations of medium complexity in structured and predictable environments, but **struggle with highly unstructured environments or unplanned scenarios**. Their true strategic value lies in being the **catalyst toward the next frontier: humanoid systems that combine adaptability without predefined limits**. However, that does not mean that investing in mobile manipulators is a waste of resources. With **reduced payback periods** they can **still have positive ROI before humanoids are deployed**. They serve as the operational proving ground, allowing organizations to build expertise in robotic integration, develop workforce collaboration models, and establish the foundational infrastructure for more advanced autonomous systems.

Humanoids show most value where efficiency and adaptability needs merge



When **fixed automation** is best**: hyper efficiency**

- High-volume, repetitive operations with consistent, predictable workflows
- Environments requiring extreme accuracy and speed with minimal task variation
- Near-continuous operations in controlled environments where human presence is problematic
- Scenarios where capital investment is justified by stable, long-term demand patterns





Where **humans** outperform: **full adaptability**

- Unpredictable exceptions that fall outside standard procedures and require judgment
- Supervision and coordination in complex scenarios
- Quality assessments require subjective evaluation, aesthetic judgment, or contextual understanding
- Regulatory compliance and accountability must be documented and verified in safety-critical environments
- New situations or emergencies arise that require creativity and strategic adaptation

Where **humanoids** shine: **merging efficiency and adaptivity**

Operational Flexibility

- Product mix, layouts, or requirements change frequently without physical system redesign
- Multiple different tasks performed sequentially without reprogramming or reconfiguration requirements
- Diverse product types requiring different handling techniques within the same operation
- Dynamic, unstructured environments with obstacles, moving equipment, and human workers

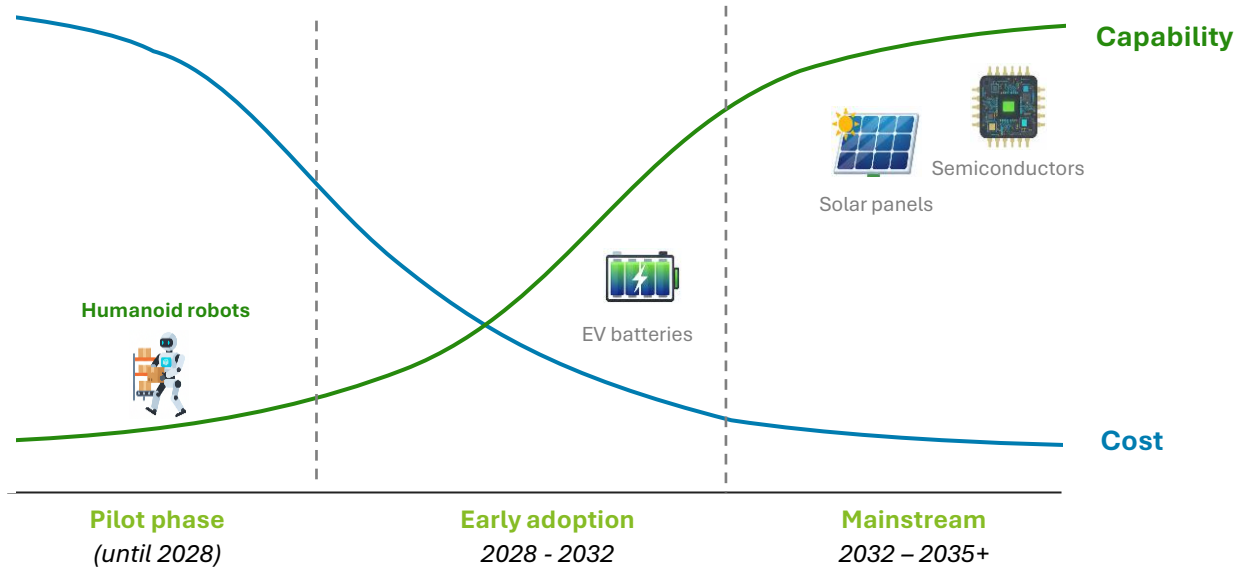
Operational Reasoning

- Quality issues during operations that must be identified and routed without halting workflow
- Conditions change mid-operation (congestion, equipment issues) requiring approach adjustment
- Deviations from expected patterns occur and must be flagged for human review without stopping operations
- Competing operational demands (speed vs. safety, throughput vs. accuracy) without explicit instruction

Operational Endurance

- Round-the-clock operations without fatigue-related performance degradation
- Tasks are physically demanding and repetitive, causing ergonomic strain or injury in human workers
- Environments are harsh (extreme temperatures, humidity) where human performance and health suffers
- Materials are hazardous or unpleasant, reducing human health and performance

Capability of humanoid robots will increase and cost decrease exponentially



Deep Dive: Simplified Return on Investment

- **€75k per operator** based on high income countries
- **4 FTE for 24/7 operations** based on 40 hours per FTE
- **3-5 robots = 1 FTE** for efficiency loss, charging, and maintenance
- **5 years** maximum payback period

Positive ROI if 5-year TCO per robot is below €300K - €500K

Booklet 2: Economics of humanoid robotics will further elaborate on the business case and return on investment

CAPABILITY DEVELOPMENT

Humanoids face **three critical barriers**. **Energy efficiency is limited**, with current robots operating only two to four hours per charge. **Productivity remains constrained** because humanoids move slower than people for balance and safety reasons. **Capacity & precision are limited**, with low payload capacity and poor hand dexterity limiting heavy lifting and fine manipulation.

However, history shows rapid improvement is possible. Looking at reference innovations we see **semiconductor transistor density rose** roughly tenfold every six years[8], and **EV battery energy density jumped** from about 55 Wh/L in 2008 to 450 Wh/L by 2020[9] — an eightfold gain in 12 years.

We expect humanoid capabilities to follow a similar growth path. Rapid advances in AI, simulation-based learning and computer vision are closing the gap toward human-level performance. The **Bank of America Institute projects mass adoption of general-purpose humanoids from around 2035**[10], a timeline consistent with the exponential gains seen in semiconductors and batteries.

COST DEVELOPMENT

Cost reduction in humanoid robotics follows a proven pattern: as manufacturing scales, costs decline exponentially. This mirrors what we have seen with solar panels, of which costs dropped 99.8% since 1975[11], and EV batteries. **Manufacturing scale, component competition, and global investments** from Tesla, Boston Dynamics, NVIDIA, and Amazon drive costs down. More investment means faster production, lower prices, wider adoption and even more investments. The evidence is clear: Goldman Sachs reports **humanoid manufacturing costs dropped 40% between 2023 and 2024**[12].

The Bank of America Institute projects that **material costs** of a humanoid robot **will fall from $35,000 to just $13,000-$17,000 by the next decade**[13]. At the same time, **human labor costs continue to rise** due to wage inflation and personnel shortages. This widening gap between declining prices and rising human labor costs improves the business case for humanoid adoption. As this gap expands, humanoid robots become the smarter investment choice. **This solidifies the 2032-2035 prediction** of widespread adoption.

The next booklet will zoom in on the humanoid business case and ROI

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Get in touch

With our experience and expertise, we are committed to helping you navigate the future with confidence



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With thanks to Pieter-Bas Vlaandere, Dephna Albor Mejia, and Luuk Jansen for their contribution in realizing this booklet

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