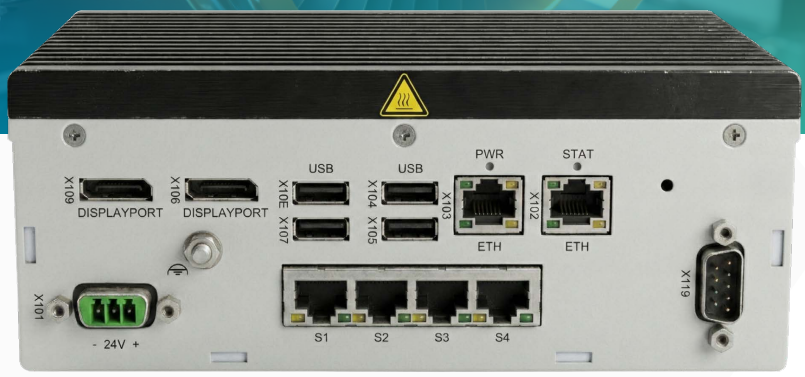
Engineering the Future of Edge AI:

The Kontron KBox A-151-EAI with SiMa.ai Modalix MLSoC



A Strategy for Multi-Modal Edge Intelligence Systems in Embedded Computing

The embedded computing landscape is shifting as AI moves from the cloud to rugged edge systems near machines and infrastructure. Edge AI accelerator revenue is expected to reach USD 7–10 billion in 2025 with strong growth, while the industrial edge market will more than double to about USD 45 billion by 2030. Traditional CPUs and GPUs face power and thermal limits, prompting a shift to specialized SoCs with significantly better performance-per-watt. The Kontron KBox A 151 EAI addresses this by combining a 13th Gen Intel Core with a SiMa.ai Modalix MLSoC, offering both flexible x86 computing and efficient AI acceleration in one industrial-grade platform. Supporting standard AI frameworks and streamlined deployment tools, it avoids proprietary lock-in. Used across industries, the KBox enables scalable AI integration with real-time perception, inference, and actionable insights, demonstrated by enhanced manufacturing and maintenance outcomes.

kontron
The Power of IoT

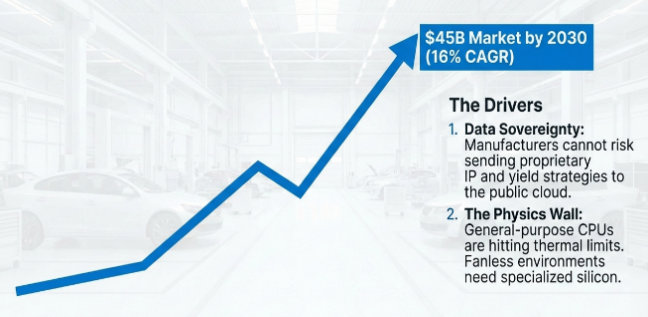
The Strategic Context:

Three Macro Trends Shaping Embedded Computing

The embedded computing landscape is undergoing a fundamental architectural shift. Decision-makers are no longer questioning whether to deploy physical AI but how to do so efficiently and reliably. Three major market trends define this new era, and the Kontron KBox A-151-EAI is designed to address them directly.

1. The Explosive Growth of Physical AI

Demand for local intelligence is surging in both consumer and commercial markets. The embedded physical AI market is projected to reach USD 7–10 billion in 2025, growing at a 25–31% CAGR through the early 2030s. This growth is fueled by innovative applications in Industry 4.0, automotive, defense, agriculture, healthcare, smart cities, drones, and robotics, where cloud latency and bandwidth costs are no longer sustainable.



2. The Need for Efficiency: The Shift to Specialized Silicon

General-purpose computing is hitting a power wall. We are witnessing a shift where ASIC-style accelerators and Machine Learning Systems on Chip (MLSoCs) are rapidly taking market share from pure CPUs and GPUs. The driver is physics: specialized architectures like the SiMa.ai Modalix deliver 4–7x gains in TOPS-per-Watt compared to traditional architectures. In fanless embedded computing environments, this efficiency is the difference between a viable deployment and a thermal failure.

Comparison Matrix: MLSoC vs. FPGA vs. GPU

Feature	MLSoC (SiMa.ai)	FPGA	GPU
Primary Strength	Best Performance-per-Watt	Deterministic Low Latency	Raw Throughput & Ecosystem
Architecture	Hardened AI Accelerators	Programmable Logic Fabric	Massively Parallel Cores
Power Efficiency	Highest (<5W to 15W)	High (Application dependent)	Moderate/Low (15W to 60W+)
Flexibility	Software-defined (fixed AI blocks)	Hardware-defined (fully custom)	Software-defined
Software Stack	Standard frameworks (PyTorch, TensorFlow, ONNX)	Vendor HDL + AI overlays	Proprietary ecosystem
Ideal Use Case	Edge vision/inference	Signal processing & I/O	Heavy model training/inference

Table 1: Comparison of edge AI acceleration architectures

3. The Industrial Edge Investment Pivot

As computing power migrates out of the data center and into ruggedized nodes close to the machine, the overall industrial edge market is expected to more than double, growing from ~USD 21 billion in 2025 to ~USD 45 billion by 2030 (~16% CAGR). Crucially, capital spending is shifting from general-purpose Industrial PCs (IPCs) to domain-specific SoCs that can handle complex edge physical AI workloads.

The industry faces a dilemma: stick with flexible but inefficient general-purpose IPCs or move to efficient but less flexible specialized compute modules.
The Kontron answer is a Unified Open Platform Architecture. The KBox A-151-EAI resolves the dilemma by combining both in a single industrial-grade box. It pairs the versatility of a 13th Gen Intel Core host with the dedicated efficiency of a domain-specific SiMa.ai MLSoC. This ensures that you are ready for the future of physical AI without sacrificing the utility of the past.

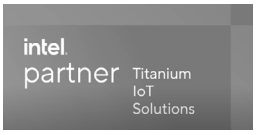
Architecture and Platform:

The KBox A-151-EAI Design

Why Kontron + SiMa.ai?

Kontron Value:

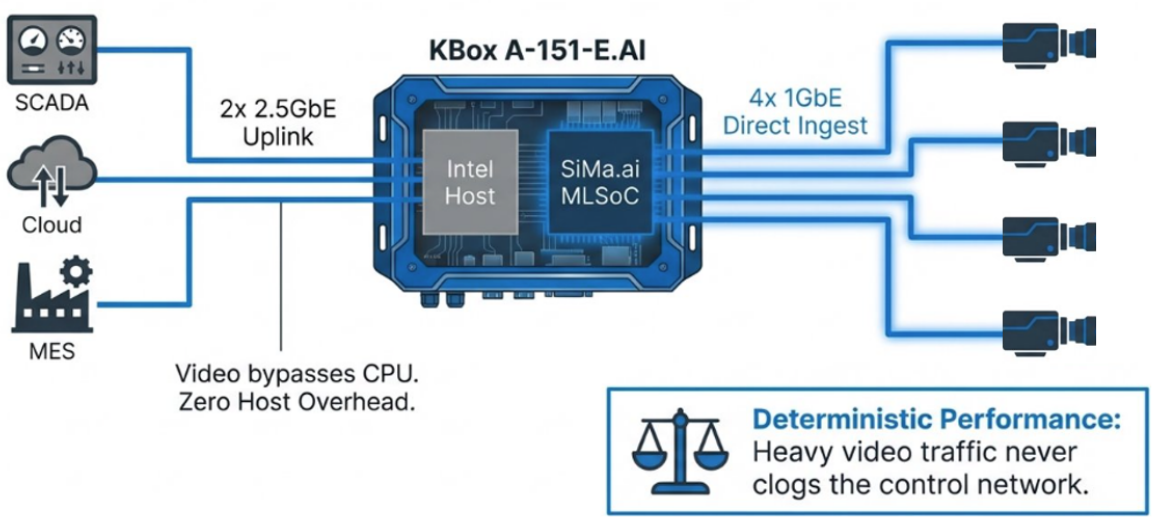
- KBox Industrial Platform: Rugged mechanical design, extended temperature range, fanless operation, vibration/shock resistance, and IP65-rated options
- Long-Term Availability: Multi-year supply guarantees and lifecycle management aligned with industry specific certification services and support
- x86 Control and Integration: Proven Intel host for HMI, PLC emulation, RTOS/Linux/Windows, ROS 2 orchestration, and connectivity to SCADA, WMS, MES, and ERP systems



- Field-Proven Ecosystem: Modular I/O expansion options, standard mounting, and compatibility with existing industry interface standards and global ecosystem
- Cybersecurity and Compliance: TPM 2.0 hardware security, IEC 62443-compliant platform design, and certified to ISO 9001, ISO 27001, AS 9100D, and regional safety standards (UL, CE, FCC) for global industrial deployments

SiMa.ai Value:

- Modalix MLSoC Performance: 50 TOPS machine learning acceleration (BF16, INT8, INT16) with integrated 8-core ARM Cortex-A65 application cores, dedicated computer vision unit (CVU), image signal processor (ISP), and low-power (<10 W) operation
- Dedicated Video Pipeline:
  Hardware encode/decode at 4K@60fps (H.264, H.265, MJPEG, AV1) with ARM Mali-C71AE ISP supporting 8–24-bit RGB/RGB-IR sensors
- Open Software Stack: Palette SDK and LLiMa framework supporting PyTorch, TensorFlow, and ONNX models without proprietary translation layers; 250–650+ precompiled models, with support for ROS 2 if needed
- Multi-Modal and GenAI Capability: Industry's first purpose-built MLSoC for Transformers, LLMs, and LMMs at the edge, enabling perception, reasoning, and natural language explanation through conversational all in a single device
- Secure Hardware: Secure boot, trusted execution environment (TEE), and internal secure NoC for defense and critical infrastructure deployments



Network Architecture: Direct Camera-to-AI Pipeline

The KBox A-151-EAI features a purpose-built dual-network architecture optimized for intensive multi-camera AI workloads:

This separation ensures that high-bandwidth video streams do not compete with control traffic, and that AI inference performance remains deterministic and isolated from host-level processing spikes. The Modalix MLSoC operates within its own optimized OS environment, processing video ingestion, ISP functions, AI inference, and video encoding/streaming independently from the x86 workload.

- 4x 1.0 GbE ports direct to Modalix MLSoC: IP cameras, machine vision sensors, and video streams connect directly to the AI accelerator, bypassing the x86 host entirely for minimum latency and maximum throughput
- 2x 2.5 GbE ports to Intel x86 host: IT/OT networks, fleet connectivity, SCADA/WMS/MES integration, and control-plane traffic

Architecture and Functional Split

Subsystem	Primary Role	Typical Workloads	Network Connectivity
Intel x86 Host	Control, orchestration, IT/OT integration	ROS 2 navigation stack, PLC/soft-PLC logic, fleet/task management, WMS/ERP/MES connectors, HMI rendering, data logging, containerized services	2x 2.5 GbE to enterprise/control networks
SiMa.ai Modalix MLSoC	Perception, sensor fusion, AI inference	Multi-camera object detection/segmentation/tracking, video encode/decode, ISP processing, LiDAR/radar fusion, anomaly detection, pose estimation, edge LLM for explanations, real-time video analytics, ROS 2 navigation stack (if needed)	4x 1.0 GbE direct from cameras/sensors

The Open Platform Advantage

In the race for AI dominance, some of the major silicon vendors have built powerful but restrictive "walled gardens." They incentivize developers to use proprietary software stacks that lock companies into a single hardware vendor's roadmap and pricing structure.

The KBox A-151-EAI represents a fundamental departure from this model: The Open Platform.

- Breaking the Vendor Lock: Decoupling the AI processor (SiMa.ai) from the Intel x86 host enables a truly open environment without needing to refactor your software when changing hardware.
- Democratizing Innovation: Kontron's open approach empowers niche industries and integrators to innovate and adapt independently, unlike proprietary vendors focused on mass-market models.
- Leveraging Frontier Models: With native support for PyTorch, TensorFlow, and ONNX, the SiMa.ai Palette SDK lets engineers deploy the latest open-source models immediately, without waiting for vendor updates.

The Innovation Leap:

Multi-Modal and GenAI at the Edge

The KBox A-151-EAI is more than a faster computer vision system—it's a gateway to multi-modal industrial AI. By combining an Intel x86 host with the SiMa.ai Modalix MLSoC, it supports classic vision, time-series analytics, and GenAI reasoning on one rugged edge platform, enabling explainable, conversational, and context-aware automation at the machine level.

From Single-Task to Multi-Model Pipelines

Unlike traditional edge AI systems that run one model per task, the KBox A-151-EAI runs coordinated chains of specialized models on a single device. For example, in a production cell, it can combine detection, segmentation, time-series analysis, and lightweight LLM models to generate clear operator recommendations, allowing flexible software-based model updates without hardware changes.

Real-World Application: Explainable AI for Operators

Its true value lies in explaining issues in operator-friendly language. Instead of generic alarms, the Modalix MLSoC performs sensor and image analysis, while an embedded LLM transforms technical data into clear, human-readable narratives for easier troubleshooting.

"Bearing 4 vibration signature indicates thermal stress. Recommend replacement within 24 hours to avoid unplanned downtime."

This turns raw AI outputs into guided, step-by-step actions, reducing diagnostic time, improving consistency between shifts, and lowering the skill barrier for operating increasingly complex equipment.

Beyond One Use Case: A Pattern You Can Reuse

This scalable physical AI architecture combines real-time perception, on-device inference, and actionable explanations to support both automated control and human-in-the-loop decisions, extending well beyond predictive maintenance. In quality inspection, it can explain rejections with specific causes and recommended actions. In safety monitoring, it moves from basic alarms to detailed alerts with suggested responses. The KBox A-151-EAI is more than an accelerator—it's a reusable platform for multi-model, explainable AI workflows that deliver both decisions and rationale at the edge, where they matter most.

Domains for Physical AI

The following section represents areas where the KBox A-151-EAI delivers measurable value today, along with emerging applications where the platform's flexibility enables rapid adaptation.

Industrial Automation and Manufacturing

The Vision: Zero-defect production and predictive asset health.

Typical Setup: Integrated into electrical enclosures near production lines, CNC cells, assembly stations, and robotic work cells. Up to four IP cameras connect directly to Modalix GbE ports for low-latency vision processing.

Applications:

- Multi-camera quality inspection (surface defects, dimensional accuracy, OCR/label verification)
- Predictive maintenance via vibration, acoustic, and thermal signature analysis
- Assembly verification and worker safety zone monitoring
- Real-time process optimization and anomaly detection

Key Benefits:

- Consolidation of multiple legacy vision PCs into a single KBox
- 20–50% improvement in maintenance planning time
- 5–10% overall equipment effectiveness (OEE) gains
- Reduced cloud bandwidth and latency for time-critical control loops
- Direct camera-to-AI connectivity eliminates x86 host bottlenecks

Robotics, AGVs, and Intralogistics

The Vision: From "blind stops" to explainable, multi-modal autonomy.

Typical Setup: Onboard controller in AGVs, AMRs, collaborative robots, and picking systems. Multiple cameras (front, rear, side, depth) connect directly to Modalix for 360-degree perception.

Applications:

- Multi-camera and LiDAR perception for obstacle avoidance, pallet detection, and worker intent prediction
- Semantic segmentation of warehouse floors, dock areas, and no-go zones
- Pick-and-place pose estimation and bin picking
- Fleet coordination and software/container integrations via x86 host

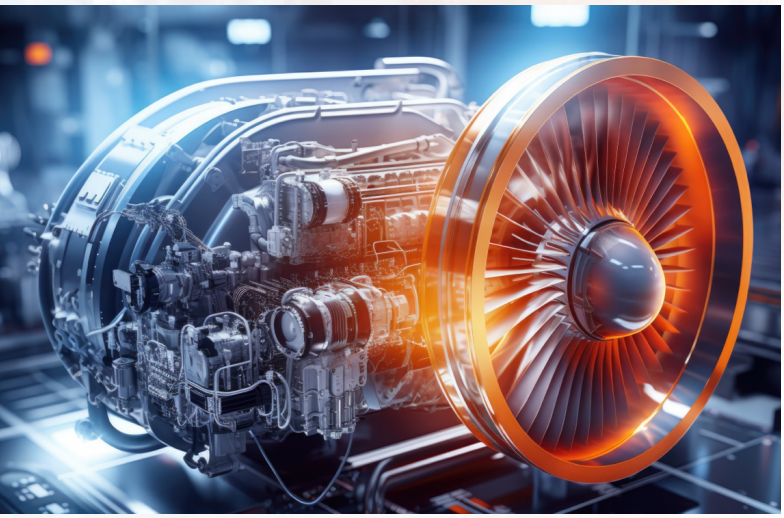
Key Benefits:

- Real-time navigation with explainable routing decisions ("AGV 5 rerouted: forklift blocking Aisle 2; using alternate path via Aisle 4; delivery delay ~1.5 minutes")
- Fanless, vibration-resistant design for mobile platforms
- ROS 2 compatibility on either x86 or Modalix, with offloaded perception to Modalix
- Reduced safety incidents through proactive worker detection and intent analysis
- Independent camera networks prevent video traffic from interfering with fleet/WMS communications

Energy and Utilities

The Vision: Intelligent monitoring and anomaly detection for distributed infrastructure.

Typical Setup: Ruggedized nodes deployed at substations, wind/solar farms, pipeline right-of-way, and water treatment facilities. Thermal cameras and PTZ surveillance cameras connect to Modalix ports.



Applications:

- Thermal and visual inspection of electrical equipment, turbines, and solar panels
- Vibration and acoustic monitoring for rotating equipment and pumps
- Perimeter security and intrusion detection at remote sites
- Automated fault classification and remote diagnostics

Key Benefits:

- Reduced truck rolls and site visits through edge-based diagnostics
- Lower bandwidth to central SCADA and cloud systems
- Multi-year availability and extended temperature operation for outdoor deployments
- Integration with legacy industrial protocols (Modbus, OPC-UA, DNP3)
- Direct thermal camera processing enables real-time hotspot detection without cloud roundtrips

Medical and Healthcare Technology

The Vision: Point-of-care diagnostics and surgical assistance.

Typical Setup: Integrated inside mobile surgical carts, endoscopic towers, and diagnostic imaging systems. Medical cameras connect directly to Modalix for real-time image analysis.

Applications:
Real-time tissue anomaly detection, sterile fanless operation, long-lifecycle support for medical device certification.

Government and Municipal (Smart Cities)

The Vision: "Smart City" AI-based inspection and monitoring.

Typical Setup: Retrofitted into municipal vehicles (waste management trucks, street sweepers, buses) with road-facing cameras connect to Modalix GbE ports and/or stationary AI-enabled cameras (16 per Modalix device) that can be stacked into KBox to scale to 80 cameras per box.

Applications: Road surface degradation detection (potholes), infrastructure damage logging, GPS-tagged maintenance data upload to city systems, security and public safety.

Autonomous Delivery and Last-Mile Logistics

The Vision: Human-centric robotic interaction.

Typical Setup: Compute core for autonomous delivery bots and last-mile drones. Navigation cameras feed Modalix directly.

Applications: Speech-to-text-to-speech interaction, package verification, privacy-preserving local processing.

Detailed Use Cases

Use Case 1: Robotics and AGV/AMR – From "Blind Stops" to Explainable, Multi-Modal Autonomy

Scenario: A logistics operator is adding AGVs into an existing warehouse with narrow aisles, mixed pedestrian and forklift traffic, and inconsistent lighting and floor markings. The AGVs must navigate around pallets, people, and forklifts while staying aligned with WMS tasks and safety rules. The KBox A-151-EAI is mounted onboard each AGV as the main industrial controller: Intel x86 handles navigation, fleet connectivity, and PLC-style I/O, while the SiMa.ai Modalix MLSoC module handles perception and AI/ML workloads, including conversational interface under 10 W.

Old Way vs. KBox Way

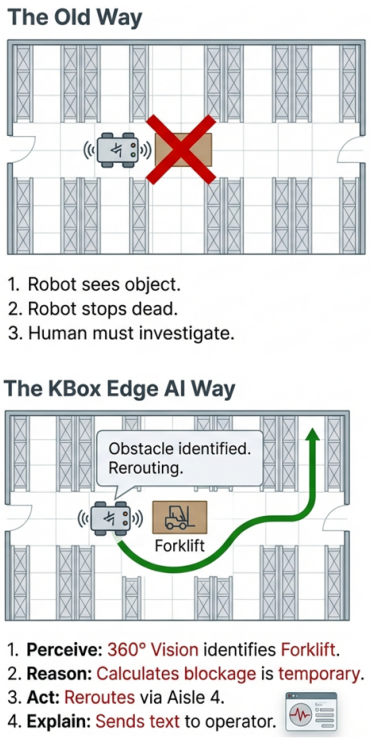
Old Way: "Blind" AGV with Simple Safety

Traditional AGVs rely on laser scanners and basic safety PLCs with static routes and limited perception. When any obstacle enters the safety field, the vehicle simply stops and raises a generic error such as "obstacle detected," forcing technicians to investigate, manually reroute, or move the obstruction. The system cannot distinguish a pedestrian from a forklift or a pallet, cannot anticipate whether the blockage is temporary, and provides little insight to WMS or supervisors beyond cryptic status codes. workloads, including conversational interface under 10 W.

KBox Way: Perception, Inference, Actionable outputs with explanation

With the KBox A-151-EAI, four IP cameras (front 180-degree, rear, left, right) connect directly to the Modalix MLSoC via dedicated 1.0 GbE ports, providing complete 360-degree situational awareness. The integrated Modalix runs high-performance YOLO-style detection and semantic segmentation across all camera streams simultaneously, tuned specifically for robotics and AGV/AMR workloads. The MLSoC differentiates pedestrians, forklifts, pallets, racks, and temporary objects, and produces high-frequency occupancy and cost maps. The Intel x86 side runs ROS 2 navigation and fleet services, consuming these maps via a high-speed internal bus to re-plan trajectories on the fly and synchronize with WMS/ERP orders over the 2.5 GbE control network. A small on-device LLM, enabled by SiMa.ai's LLiMa framework, transforms low-level AI outputs into clear, operator-friendly messages—turning "blocked" into:

"AGV 5 rerouted: forklift blocking Aisle 2; using alternate path via Aisle 4; delivery delay ~1.5 minutes."



How the KBox Is Used on the Vehicle

Rugged Controller and Dual-Network Architecture

Mounted onboard the AGV/AMR, the KBox provides the complete compute stack in a compact, fanless, industrial enclosure:

- **Vision Network:** Four IP cameras connect to the 4x 1.0 GbE Modalix ports, creating a dedicated vision pipeline with no competition from control traffic
- **Control Network:** 2x 2.5 GbE ports on the x86 host handle Wi-Fi AP uplink for fleet management, WMS/ERP connectivity, and optional wired Ethernet for charging dock communication
- **I/O & Safety:** Serial ports and digital I/O connect to safety relays, e-stops, motor controllers, and status indicators

This architecture ensures that multi-camera AI processing on Modalix runs deterministically and is completely isolated from x86 workload spikes caused by WMS updates, log writes, or HMI rendering.

Software Stack and Partitioning

On the x86 side, a Linux-based stack hosts containerized ROS 2 navigation (e.g., Nav2), fleet and diagnostics agents, PLC emulation, and WMS/ERP connectors. On Modalix, SiMa.ai's Palette SDK orchestrates pre-compiled detection, segmentation, tracking, and pose-estimation models optimized for physical AI, while LLiMa runs small LLMs and multi-modal models locally. The Modalix ISP pre-processes camera feeds (debayering, tone mapping, noise reduction) before feeding frames into the ML pipeline. Secure boot and a hardened SoC interconnect on Modalix combine with the KBox's industrial design to ensure deterministic, secure operation under vibration, dust, and temperature extremes.

Fast Deployment and High Reliability

Accelerated Integration

Modalix is a mature AI SoC technology with full software stacks and reference designs with ML pipelines, allowing OEMs and Integrators to start from proven real-world solutions rather than building perception stacks from scratch. The KBox family offers consistent mechanical form factors, mounting, and various expansion options, making it straightforward to reuse enclosures and cabling concepts across multiple platforms. IP camera integration is plug-and-play: cameras auto-negotiate with Modalix GbE ports and begin streaming H.264/H.265 or raw sensor data immediately. Together, these reduce engineering effort, shrink time-to-first-pilot, and simplify scaling from a handful of vehicles to full-fleet rollouts.

Built for Always-On Operation

Fanless, solid-state KBox designs and extended temperature support increase MTBF for mobile equipment deployed in 24/7 logistics environments. Modalix's sub-10 W power envelope enables sealed or semi-sealed enclosures with lower thermal stress and without active cooling, critical for dusty warehouses and high-vibration vehicles. By running all perception and reasoning at the edge, navigation and safety remain fully functional even under degraded or intermittent backhaul connectivity. The dual-network design means that even if the control network (Wireless to WMS) drops, the vision network continues to operate and the AGV can execute local obstacle avoidance and safe-stop behaviors.

Why Multi-Modal AI Matters for AGV/AMR

The real leap is multi-modal AI: fusing visual, depth, LiDAR, and time-series data, then attaching language and reasoning models on the same edge device. Modalix combines multiple camera feeds and optional LiDAR/ToF inputs to robustly identify humans, vehicles, pallets, and floor zones in cluttered and changing environments. The system correlates this with motion and mission context (speed, heading, task state from ROS 2) to determine whether an obstacle is transient, structural, or unsafe, and then uses an on-device LLM to convert that understanding into a narrative and a plan.

In practice, this evolves the user experience from:

- **Old way:** "AGV stopped – obstacle detected."

  to

- **KBox way:** "AGV 5 slowed: pedestrian with pallet jack entering shared zone. Rerouted via Aisle 4, ETA +90 seconds. Safety event logged for Zone West."

For operators, supervisors, and integrators, the KBox A-151-EAI with Modalix transforms AGVs/AMRs from opaque, stop-prone assets into explainable, multi-modal robotic co-workers that can see, decide, and clearly communicate why they act the way they do—entirely at the edge.

Conclusion

Multimodal edge AI is no longer a lab experiment; it is a competitive requirement for industrial automation, robotics, energy, and beyond. With the Kontron KBox A-151-EAI, you gain the agility of modern AI acceleration with the stability of a certified, industrial-grade platform. The unified architecture—x86 for control and connectivity, Modalix for perception and reasoning, and a purpose-built dual-network design for multi-camera applications—gives you the best of both worlds: efficiency without lock-in, innovation without re-engineering, and explainability through conversational interface without cloud dependencies.

It is time to stop thinking about the future of automation and start building it.

Your Contact

Kontron America Inc.

9477 Waples Street
San Diego, CA 92121, USA
Tel.: +1 888 294 4558
sales@kontron.com

SiMa Technologies Inc. Headquarters

333 W. San Carlos St.
Suite 1100 San Jose, CA 95110
USA
mlsoc@sima.ai

Global Headquarters

Kontron Europe GmbH

Gutenbergstraße 2
85737 Ismaning, Germany
Tel.: +49 821 4086-0
info@kontron.com

www.kontron.com

kontron
The Power of IoT