Macnica Robotics Solutions

Sensing, Compute and Connectivity for Robotics and Physical AI

Key Robotics Challenges

Robotics platforms must continuously acquire and interpret sensor data, execute AI inference and control workloads with deterministic latency, and operate within strict power, thermal, and motion constraints. At the same time, reliable connectivity, functional safety, cybersecurity, and regulatory requirements must be addressed across the system architecture. These requirements are tightly coupled, making component selection and system-level tradeoffs critical to overall performance, uptime, and deployment reliability.

Real-time AI within compute and control limits

Robots need low-latency, deterministic inference and control at the edge while meeting demanding safety requirements.

Reliable perception in variable environments

Lighting changes, vibration, dust, motion, and scene complexity can reduce sensor accuracy and limit AI performance.

Connected operation and fleet visibility

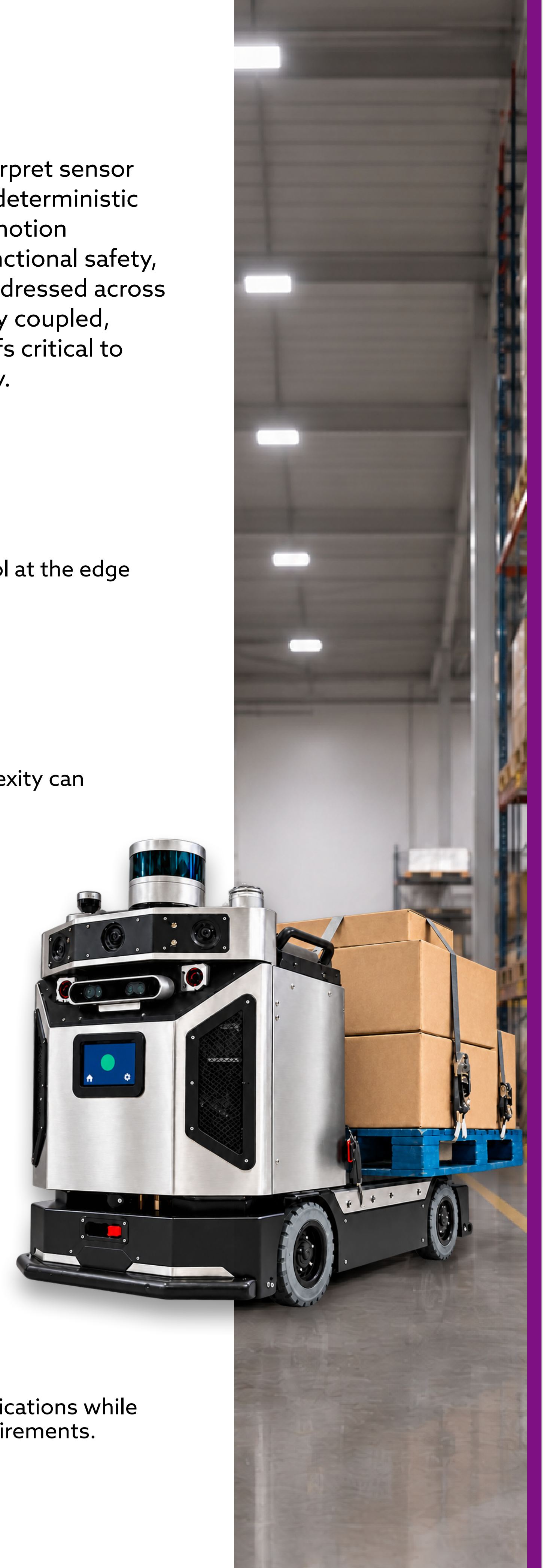
Reliable communications are essential for telemetry, diagnostics, coordination, updates, and long-term system uptime.

Power, thermal, and motion tradeoffs

Higher compute loads increase power draw and heat, affecting battery runtime, system size, and motion efficiency.

Security and compliance across the system

Connected robots must protect devices, data, and communications while supporting evolving safety, cybersecurity, and industry requirements.



Macnica Helps Turn Robotics Requirements Into System Architecture

Robotics design brings together sensing, AI, control, power, connectivity, safety, and security in one tightly connected system. Macnica helps engineering teams address these challenges by bringing together technologies from leading suppliers across the robotics stack and helping identify the right building blocks for the application.

The **Capture. Process. Communicate.** framework organizes those technologies around the three fundamental functions of a robotic system - understand the environment, make intelligent decisions, and connect those decisions across the machine and beyond.

	CAPTURE	PROCESS	COMMUNICATE
	Give the robot a reliable view of the physical world.	Turn real-world data into intelligent, deterministic robotic action.	Move data reliably across the robot, fleet, and connected environment.
Core functions	• Image and video acquisition • Depth, distance, and proximity sensing • Object and defect detection inputs • Localization and navigation inputs • Motion and position feedback • Environmental and system monitoring • Multi-sensor synchronization	• Computer vision and perception • AI inference • Sensor fusion • Localization and mapping • Path and motion planning • Real-time motor and actuator control • Safety monitoring and decision logic	• Sensor and subsystem connectivity • High-speed data transport • Robot-to-robot communication • Fleet coordination • Telemetry and remote diagnostics • Software and firmware updates • Cloud and edge connectivity
Key design requirements	• Image quality, resolution, frame rate • Dynamic range • Sensor fusion • Latency • Interface bandwidth	• AI performance • Deterministic latency • Compute density • Memory bandwidth • Power efficiency • Thermal design • Functional safety	• Bandwidth • Latency • Deterministic networking • Interoperability • Wireless performance • Cybersecurity • Reliability

Macnica helps robotics teams evaluate these functions together so technology choices across the architecture support the performance, safety, security, and reliability requirements of the complete system.

CAPTURE

Give the Robot a Reliable View of the Physical World

Robotic decisions start with the quality of the data being captured. Cameras, depth sensors, motion feedback and physical sensing allow the system to identify objects, measure position, understand its environment and monitor interaction with people or equipment.

The right sensing architecture depends on what the robot needs to detect or measure, as well as operating conditions such as motion, lighting, vibration, range and mounting constraints. Sensor synchronization and calibration become especially important when multiple inputs must work together for perception, navigation or control.

Architecture Priorities

- **Match sensing to the task:** Select imaging, depth, radar or physical sensing based on what must be detected or measured.
- **Design for operating conditions:** Account for motion, vibration, glare, dust and changing light.
- **Synchronize inputs:** Align timing and coordinate frames across sensors.
- **Plan the data path:** Resolution, frame rate and sensor count drive bandwidth and compute needs.
- **Optimize placement:** Field of view, optics, distance and mounting affect perception quality.

Macnica Solutions for Capture

FUNCTIONS	SUPPLIERS	TECHNOLOGIES
Imaging & Machine Vision	SONY, Canon	CMOS image sensors for inspection, recognition, navigation and high-speed image acquisition.
3D & Spatial Sensing	Infineon, Analog Devices, Namuga Vision Connectivity	Time-of-flight, LiDAR and radar technologies for depth measurement, obstacle detection and environmental awareness.
Force & Strain Sensing	STREAL	Embedded microstrain sensing for tension, compression, bending, torque and shear measurement.
Embedded Vision	iENSO	Camera modules, embedded vision platforms and imaging design support for application-specific sensing architectures.

The right optics are critical to reliable image capture. Macnica works with 10+ leading lens manufacturers worldwide to match lens performance to each application, from wide-angle industrial vision to precision medical imaging.

PROCESS

Turn Sensor Data Into Intelligent Robotic Action

Once sensor data is captured, the robot must interpret it and respond within the timing constraints of the application. Processing architectures support computer vision, AI inference, sensor fusion, localization, planning, motor control and safety functions.

Different workloads place different demands on the compute architecture. AI inference may prioritize performance per watt, while sensor interfaces and control loops require predictable latency. The challenge is matching each workload to the right processing technology while staying within power, thermal and form-factor limits.

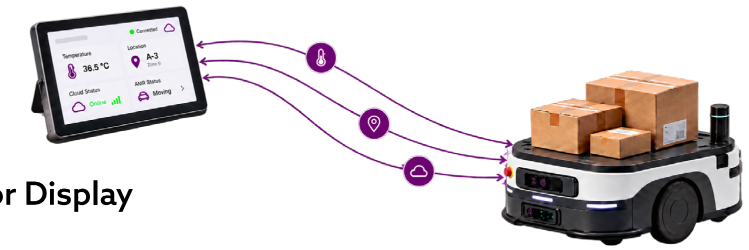
Architecture Priorities

- **Partition by timing:** Assign AI, vision, control and safety functions based on latency needs.
- **Match compute to workload:** Balance CPU, FPGA, NPU, GPU and MCU resources.
- **Manage data movement:** Sensor bandwidth and memory access can create bottlenecks.
- **Stay within power limits:** Compute must fit thermal, battery and enclosure constraints.
- **Keep control predictable:** Safety and motion functions require deterministic response.

Macnica Solutions for Process

FUNCTIONS	SUPPLIERS	TECHNOLOGIES
Edge AI Acceleration	DEEPX	Power-efficient NPUs for local object detection, classification, pose estimation and other AI inference workloads.
FPGA & Real-Time Processing	altera, terasIC	FPGAs and SoC FPGAs for sensor interfaces, image preprocessing, acceleration and deterministic processing.
Vision AI	Ambarella, iENSO	Power-efficient vision SoCs and embedded AI platforms for multi-camera perception and intelligent vision.
Rugged Robotics Compute	Connect Tech, iEi, iBASE, TQ	Rugged edge platforms for AI, 3D perception, ROS 2 and higher-level robotics workloads.
Control, Power & Safety	Infineon	MCUs, motor control, power and functional-safety technologies for real-time robotic systems.

COMMUNICATE



Connect the Robot to the Machine, Fleet, Factory or Display

Robots must exchange information across sensors, processors and controllers while also connecting to operators, other robots and factory systems. Communication enables coordination, telemetry, diagnostics, software updates and fleet-level visibility.

Fixed systems may require deterministic wired interfaces for machine control, while AMRs depend on reliable wireless connectivity as they move through a facility. The architecture must support the required bandwidth and latency while maintaining interoperability, security and reliable operation.

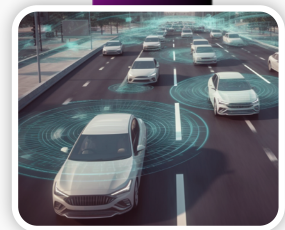
Architecture Priorities

- **Match network to data:** Control, sensor, telemetry and update traffic have different requirements.
- **Choose wired vs. wireless:** Fixed systems favor determinism; mobile robots require reliable roaming.
- **Bridge legacy systems:** Support protocol conversion between installed and modern equipment.
- **Design for resilience:** Plan for interference, packet loss and network outages.
- **Build in security:** Protect identity, access, communications and update paths.

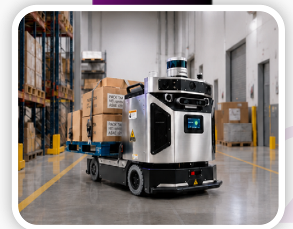
Macnica Solutions for Communicate

FUNCTIONS	SUPPLIERS	TECHNOLOGIES
Wireless Connectivity	silex technology, Infineon	Wi-Fi and Bluetooth technologies for AMRs, robotic platforms, service access and connected devices.
Wired Connectivity	altera An Intel Company, Infineon	Ethernet, low-latency networking, CAN and interface technologies for robot subsystems, controls and factory networks.
Timing & Synchronization	SiTime	Precision oscillators, clocks and synchronization technologies for coordinated sensing, processing and networking.
Security	Infineon	Device authentication, protected communications and secure system connectivity.
HMI/Displays	MACNICA, INNOLUX INNOLUX CORPORATION	Industrial displays and touch interfaces for robot status, alarms, diagnostics and operator interaction.

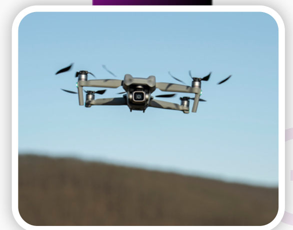
Macnica Robotics Solutions



1 AUTOMOTIVE AND MOBILITY



2 AUTONOMOUS MOBILE ROBOTS (AMRS)/ AUTOMATED GUIDED VEHICLES (AGVS)



3 DRONES AND UNMANNED AERIAL VEHICLES (UAVS)

4 VISUAL INSPECTION ROBOTS

5 HEALTHCARE ROBOTICS

Perception and Edge Intelligence for Safer, Autonomous Movement

Automotive and mobility systems combine multi-modal sensing, real-time AI and deterministic control to understand complex environments and respond safely. Reliable perception, low-latency processing, functional safety and secure connectivity are critical as vehicles take on more assisted and autonomous functions.

Design Considerations

- **Sensor fusion:** Synchronize camera, radar, LiDAR and motion data with accurate timing.
- **Real-time latency:** Keep perception, planning and control within defined response windows.
- **Environmental robustness:** Maintain sensing across lighting, weather, vibration and temperature extremes.
- **Functional safety:** Design redundancy, diagnostics and fail-safe behavior into critical functions.
- **Power and thermal:** Balance AI compute performance against vehicle power and thermal limits.
- **Cybersecurity:** Protect vehicle networks, external connections and software update paths.

CAPTURE

Perception: HDR/RGB cameras, stereo vision, LiDAR, radar, ultrasonic sensing, thermal imaging

Positioning: GNSS, IMU, wheel odometry, vehicle speed and steering data

PROCESS

Compute:

- **Sensor fusion:** Camera + radar + LiDAR + IMU for environmental perception and localization
- **AI inference:** Vehicle, pedestrian, lane, obstacle and free-space detection
- **Localization & planning:** Position estimation, trajectory planning, path prediction, and collision avoidance
- **Real-time control:** Steering, braking, acceleration, and actuator coordination

Safety & power: Functional-safety monitoring, redundant processing, power and thermal management

COMMUNICATE

Data links: Automotive Ethernet, CAN/CAN-FD, LIN, MIPI CSI-2, PCIe

Wireless: 4G/5G, Wi-Fi, Bluetooth, GNSS, V2X

Interfaces: Vehicle controllers, telematics, diagnostics, cloud services, fleet, and mobility platforms

Application Use Cases

ADAS · AUTONOMOUS DRIVING · AUTONOMOUS SHUTTLES · LAST-MILE DELIVERY · INDUSTRIAL MOBILITY · IN-CABIN INTELLIGENCE · PARKING / SURROUND VIEW

Representative Components

FUNCTION	COMPONENT	SUPPLIER
Vision Sensors	STARVIS 2™ HDR automotive CMOS	SONY
Sensor Fusion	Agilex 5 / 7 SoC FPGA	altera An Intel Company
Vision AI	CV72S SoC — multi-camera	Ambarella
Safety MCU	AURIX TC4x (ASIL-D)	infineon
Fleet Telemetry	Intdash data platform	MACNICA

AMRs Make Automation Part of the Operating Fabric

AMRs move materials, work-in-process, tools, and inspection payloads through dynamic spaces. Unlike fixed conveyors or older guided vehicles, they can localize, map, reroute and coordinate around changing production conditions.

Design Considerations

- **Latency budget:** 50–100 ms from obstacle detection to motor response. Real-time control handles servo loops; sensor fusion and AI run on parallel compute.
- **Sensor redundancy:** LiDAR for mapping, radar for dust/fog/low-light reliability, vision for object classification.
- **Power envelope:** Target 8–12 hours continuous operation. Efficient Power Management across compute, motors, and comms is critical.
- **Functional safety:** SIL-2+ for collaborative environments. Safety watchdog must run independently with dedicated kill-switch logic.
- **Fleet scalability:** Must support dozens to hundreds of robots without network congestion. Wi-Fi and 5G provide the bandwidth for real-time coordination.

CAPTURE

Perception: Radar (long and short range), LiDAR, vision (cameras), thermal imager

Navigation: IMU (accel / gyro / compass), Speedometer

PROCESS

Compute:

- **Sensor fusion:** Multi-sensor data correlation, radar + LiDAR + vision alignment, occupancy grid generation, object tracking
- **AI inference:** Object detection/classification, pedestrian recognition, semantic segmentation, anomaly detection
- **Real-time control:** Motor control loops, sensor preprocessing, camera ISP pipeline, safety, I/O bridging
- **Navigation & orchestration:** SLAM + mapping, path planning, fleet communication, task orchestration

Power & actuation: Motor drivers, power management, and battery management

COMMUNICATE

Wireless: Wi-Fi, 5G/LTE, Bluetooth/BLE

Interfaces: HMI/display, CAN/EtherCAT, Ethernet/USB

Application Use Cases

WAREHOUSE FULFILLMENT · MANUFACTURING INTRALOGISTICS · HOSPITAL LOGISTICS · COLD STORAGE / HAZARDOUS · GOODS-TO-PERSON PICKING · LINE-SIDE MATERIAL DELIVERY

Representative Components

FUNCTION	COMPONENT	SUPPLIER
Depth Sensing	3D ToF camera module	NAMUGA VISION CONNECTIVITY
Sensor Fusion	Agilex 5 SoC FPGA	altera An Intel Company
AI Perception	DX-H1 PCIe NPU card	DEEPX
Motor + Safety	AURIX TC3xx MCU + gate drivers	infineon
Connectivity	SX-SDMAX Wi-Fi module	silex technology

Drones Extend Robotic Autonomy Into Remote and Hazardous Spaces

Industrial drones bring sensing, inspection and data capture into vertical, remote and hazardous environments. Their value comes from autonomous navigation paired with onboard perception and edge AI.

Design Considerations

- **Weight vs. compute:** Every gram cuts payload or flight time. Edge AI must deliver accuracy within 5–15 W.
- **GPS-denied navigation:** Indoor, urban canyon, and under-canopy ops require visual-inertial odometry and optical flow when GPS is degraded.
- **Communication range:** BVLOS demands 4G/5G for command, telemetry, and video. Link-loss failsafe (return-to-home, loiter, land) must be deterministic.
- **Vibration isolation:** Motor vibration couples into IMU and camera data. Mechanical isolation and digital filtering are essential for stable flight and clean imaging.
- **Regulatory compliance:** Remote ID, geofencing, and altitude limits must be enforced at the real-time control level, not in overridable software. NDAA compliance.

Application Use Cases

- INFRASTRUCTURE INSPECTION
- PRECISION AGRICULTURE
- SEARCH AND RESCUE
- LAST-MILE DELIVERY
- MAPPING / SURVEYING
- SECURITY / PERIMETER

CAPTURE

Perception: Vision (stereo/RGB), LiDAR, radar, thermal imager, ultrasonic (proximity)

Navigation: GPS/GNSS, IMU (accel/gyro/mag), barometric altimeter, optical flow

PROCESS

Compute:

- **Sensor fusion:** GPS + IMU + baro blending, visual-inertial odometry, altitude estimation, wind/drift compensation
- **AI inference:** Object detection/tracking, terrain classification, landing zone detection, follow-me/gesture recognition
- **Real-time flight control:** PID stabilization loops, ESC signal generation, gimbal stabilization, failsafe/return-to-home, sensor preprocessing
- **Mission and navigation:** Waypoint navigation, path planning/obstacle avoidance, geofencing, swarm coordination, mission logging

Power & actuation: Motor drivers, power management, and battery management

COMMUNICATE

Data links: RC control link, HD video downlink, telemetry link

Wireless: Wi-Fi, 4G/5G for Beyond Visual Line of Sight (BVLOS)

Interfaces: Ground station, payload/gimbal, companion computer

Representative Components

FUNCTION	COMPONENT	SUPPLIER
Vision Sensor	STARVIS 2™ low-light CMOS	SONY
Vision AI SoC	CV72S — multi-camera perception	Ambarella
Edge AI	DX-M1 NPU — M.2 form factor	DEEPX
Flight FPGA	Agilex 3 — low-power, small package	altera An Intel Company
Power + Safety	AURIX MCU + MOSFET gate drivers	infineon

Inspection Becomes Faster, More Repeatable and More Data-Rich

Visual inspection robots bring high-resolution imaging, AI-based defect detection and repeatable inspection into manufacturing and industrial environments. Their value comes from reliable image capture, deterministic motion and edge AI working together to find defects that are difficult, inconsistent, or costly to detect manually.

Design Considerations

- **Image quality vs. speed:** Balance resolution, frame rate and exposure to maintain defect visibility at production throughput.
- **Lighting consistency:** Control illumination, glare and shadows to improve feature contrast and repeatability.
- **Inference latency:** Keep preprocessing and AI inference within the inspection cycle time.
- **Motion synchronization:** Synchronize camera triggers with robot pose, encoder or conveyor position.
- **Defect variability:** Maintain accuracy across changing materials, finishes, geometries, and defect classes.
- **Factory connectivity:** Support deterministic data exchange with PLCs, MES, and quality systems.

Application Use Cases

- SURFACE DEFECT INSPECTION
- ASSEMBLY VERIFICATION
- DIMENSIONAL INSPECTION
- ELECTRONICS / PCB / SOLDER
- WELD AND JOINT INSPECTION
- LABEL / MARKING / OCR-OCV

CAPTURE

Perception: High-resolution area/line-scan cameras, stereo/RGB, SWIR/NIR, thermal imaging, 3D/depth sensing, structured light, laser profiling
Positioning: Encoders, proximity sensors, force/torque sensing, fiducials, robot pose/position feedback

PROCESS

Compute:

- **Image conditioning:** Demosaicing, HDR, color correction, distortion correction, denoising, illumination normalization, image stitching
- **Sensor fusion:** Combining 2D/3D, thermal, spectral and positional data to improve defect detection and localization
- **AI inference:** Defect detection/classification, anomaly detection, segmentation, OCR/OCV, dimensional inspection, surface-quality analysis
- **Motion and inspection control:** Camera/robot synchronization, trigger control, scan-path execution, adaptive positioning, pass/fail handling

Power & actuation: Motor drives, precision motion control, illumination control

COMMUNICATE

Data links: GigE Vision, USB3 Vision, Camera Link, CoaXPress, MIPI CSI-2, industrial Ethernet
Wireless: Wi-Fi/5G for mobile inspection platforms, remote monitoring, and system updates
Interfaces: PLC/robot controller, MES, SCADA, quality-management system, factory network, cloud/edge server

Representative Components

FUNCTION	COMPONENT	SUPPLIER
Image Sensor	Pregius S™ global shutter CMOS	SONY
High-Res Imaging	120MP / 250MP CMOS sensors	Canon
ISP + Acceleration	Agilex 5 FPGA w/ AI tensor blocks	altera An Intel Company
AI Inference	DX-M1 NPU — 25 TOPS @ 5 W	DEEPX
HMI Display	Blanview-G industrial LCD	MACNICA

Intelligent Automation for High-Consequence Clinical Environments

Healthcare robots combine service automation, sensing and edge intelligence to support staff, patients and clinical workflows. Reliable mobility, human-aware interaction, secure connectivity, and dependable edge decision-making are critical in busy, cluttered healthcare settings.

Design Considerations

- **Functional safety:** Combine redundant sensing, collision detection and controlled motion around patients and staff.
- **Dependable mobility:** Maintain localization and obstacle avoidance through crowded, changing indoor environments.
- **Security:** Protect robot, clinical and patient data across hospital networks and wireless links.
- **Human-machine interaction:** Support predictable, intuitive interaction with staff and patients.
- **Perception in clutter:** Maintain detection accuracy despite occlusion, tight spaces, and changing surroundings.

Application Use Cases

- PHARMACY / SUPPLY DELIVERY
- CLINICAL SPECIMEN TRANSPORT
- PATIENT MOBILITY ASSIST
- SURGICAL IMAGING SUPPORT
- REHABILITATION ASSISTANCE
- SANITATION / DISINFECTION

CAPTURE

Perception: RGB/stereo cameras, depth/3D sensing, LiDAR, ultrasonic/proximity sensors, microphones
Positioning: Encoders, IMU, UWB/beacons, visual markers, indoor localization

PROCESS

Compute:
- **Sensor fusion:** Camera + LiDAR + IMU for localization, mapping, and obstacle awareness
- **AI inference:** Person detection/tracking, pose estimation, object recognition, activity recognition, voice processing
- **Navigation and orchestration:** SLAM, path planning, obstacle avoidance, dynamic rerouting, room/zone navigation
- **Assistive workflows:** Imaging support, object/instrument handling, triage assistance, repetitive-task automation
- **Safety & motion control:** Speed limiting, collision avoidance, emergency stop, motor and manipulation control

Power & actuation: Motor drives, battery management, charging/docking, power management

COMMUNICATE

Data links: Ethernet, USB, CAN, MIPI CSI-2 and device interfaces
Wireless: Wi-Fi, private 5G/cellular, Bluetooth, UWB
Interfaces: Hospital network, fleet management, clinical systems, nurse-call systems, edge/cloud platforms

Representative Components

FUNCTION	COMPONENT	SUPPLIER
Surgical Imaging	CMOS sensor + OLED microdisplay	SONY
Vitals Sensing	XENSIV™ PAS CO_2 + pressure	infineon
Video Pipeline	Agilex 7 FPGA — 4K surgical ISP	altera
Edge AI	DX-M1 NPU — low-power inference	DEEPX
Medical Compute	Panel PC (IEC 60601 certified)	iEi

CAPTURE.
PROCESS.
COMMUNICATE.

Bring the Right Technologies Together for Robotics

Macnica connects robotics engineering teams with leading technologies across sensing, AI and embedded compute, control, connectivity, power, safety, and security.

Whether the design challenge is perception accuracy, edge inference, deterministic control, power efficiency, or reliable communications, Macnica can help identify the technology building blocks that fit the application and system requirements.

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