GUIDE //

How to hire an inspection Robot

AMV botics

Why Should I Use an Inspection Robot?

Meticulous facility inspection optimizes maintenance efforts, extends equipment life, minimizes downtime, and increases operational productivity. However, inspection processes involve multiple steps that require a significant investment of human time, costs, and varying risks to workers.

Automation technology offers tremendous opportunities for efficiency gains, cost savings, and production increases. Beyond the basic coverage provided by stationary sensors, autonomous mobile inspection robots offer a scalable and effective method for continuously collecting and analyzing digital operational data. This approach has a significant impact on the effectiveness of inspections and remote operations, and improves safety by removing human workers from hazardous environments.

To take advantage of these benefits, plant operators are using autonomous robots that can navigate multi-story environments, tolerate adverse conditions and gather valuable operational insights. Autonomous robotics technology is relevant to all asset-intensive industries, including oil & gas, chemicals, mining, energy & utilities, and construction. Innovative asset owners know this and are increasingly using autonomous robots in their inspection and workforce planning.

Comparing different robotic inspection offerings can be overwhelming. It involves knowing why you require the technology, considering the suitability of an entire solution, i.e., looking beyond the physical robotic carrier platform, evaluating the solution from an end-to-end perspective, and ultimately partnering with an enterprise-level vendor.

The first step is to determine what you want to accomplish with inspection robots. Typically focused on productivity, safety, optimization and digitalization, industrial plant owners are deploying autonomous robotics technology for one or more of the following reasons:

Increase Productivity
Higher equipment uptime
Longer asset lifetime
Reduce production losses

Improve Safety & Sustainability
Reduce hazardous exposure
Mitigate workforce shortages
Attract & upskill workforce

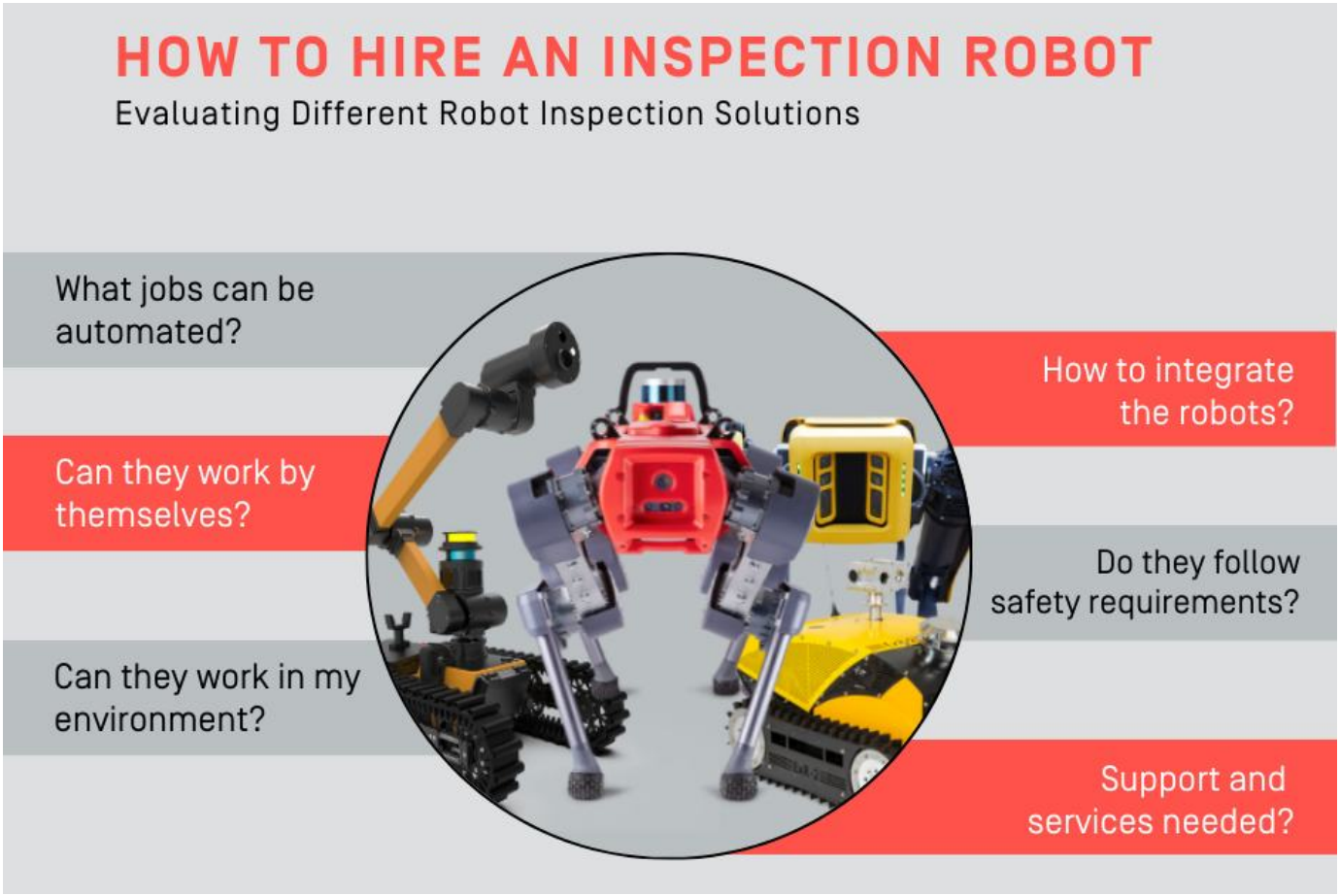
Optimize Maintenance
Increase inspection accuracy
Inspections during operation
Decrease inspection costs

Accelerate Digitalization
Maintain digital facility records
Digitalize manual processes
Enable predictive monitoring

Selecting a Fitting Robot Inspection Solution

It is critical that you determine if robotic inspection solutions meet your organization's specific needs. To do this best, you need to consider several aspects when matching inspection solution capabilities with your automation needs and operational realities.

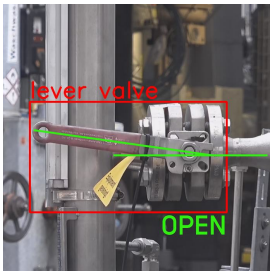
Having a good grasp of your inspection and data needs, your operational environment, and inspection robot capabilities is crucial. It is also essential that you assess safety and security compliance and understand the role, and availability, of support services provided by the vendor.



Automating Inspection – Determine the Jobs to be Done

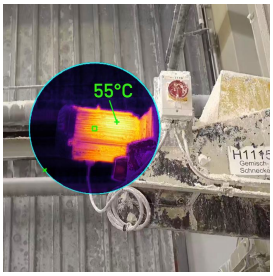
The type of inspection jobs you want to automate will determine the type of output data and insights you need. This is critical because the type and quality of data that can be delivered will vary from robot to robot. The first step in ensuring that an inspection robot solution can work effectively is to be clear about the jobs that can be automated by inspection robots.

What jobs can inspection robots automate?
Inspection robots create value by efficiently performing various essential and repetitive jobs autonomously, which allows you to collect and manage your inspection and monitoring data. Typical jobs automated by industrial-grade inspection robots include:



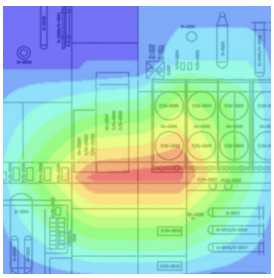
Monitor Assets in Operation
Detect equipment failures early and take preventive maintenance action to avert costly defects and downtime.

What sensor does the robot need?
Visual optical zoom camera
Directional ultrasonic microphone



Identify Thermal Anomalies
Powerful, previously undetected insights about the condition of equipment through frequent automated thermal inspection.

What sensor does the robot need?
High quality thermal camera



Detect Gas Presence
Monitor combustible and toxic gas concentration levels in real-time and enable operators to react to gas leaks early.

What sensor does the robot need?
Range of toxic and/or combustible gas sensors

Enable Reality Capture
Create and update existing 3D models on-demand, more accurately, cheaper, and quicker.

What sensor does the robot need?
360° Lidar scanner

How accurately do inspection robots monitor industrial facilities?
High-end sensors enable inspection robots to perceive beyond a human's natural perception, which allows the robots to collect very accurate, high-quality data. They cover hundreds of inspection points per mission and can consistently conduct multiple, precise tasks at any time of the day. The data quality depends on the robot's data capturing, contextualization, processing, and quality optimization capabilities.

Capturing data: The robot's ability to consistently locate and access all predefined and ad hoc inspection points and reliably capture high-quality raw sensor data from the same viewpoint.

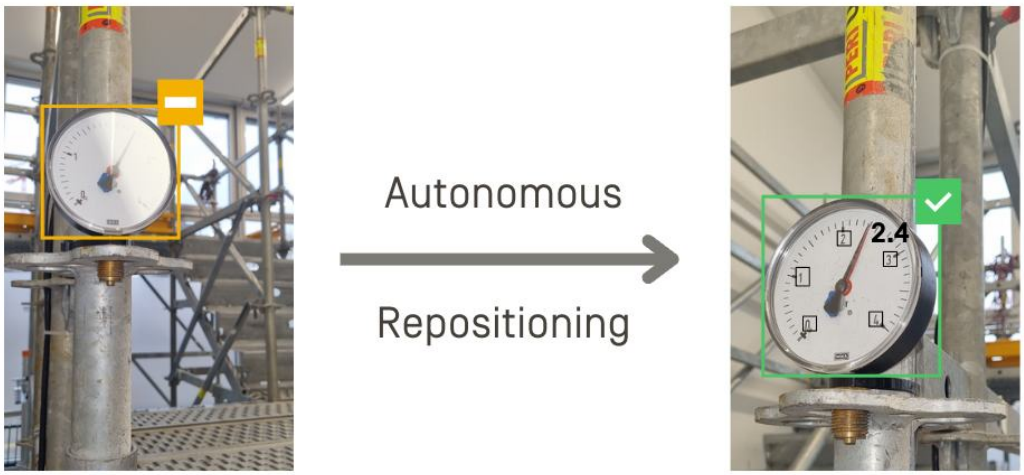
Data contextualization and fusion: The robot's ability to associate data with time, location, viewpoint and create additional insights through the fusion of extrinsically calibrated sensors (e.g., visual, thermal, and acoustic measurements, gas leak detection, and reality capture).

Inspection intelligence: The robot's ability to firstly, verify the state of instrumentation and equipment (e.g., manometers, gauges, counters, LCDs, levers, and valves) and, secondly, through AI-based inspection algorithms, detect anomalies and turn information into insights.

Quality optimization: The robot's ability to assess data through edge computing and to make adjustments for poor quality. This happens through object recognition, correctly framing equipment (even after movement), unwarping perspectives, removing background objects, and reacting to visibility issues such as occlusion or glare.

ANYMAL – AUTONOMOUS INSPECTION INTELLIGENCE

ANYmal immediately self-determines the quality of the data collected on its missions and autonomously takes corrective measures. As can be seen in the image below, ANYmal adjusts its position to avoid reflections on the gauge and retrieves the exact value on the display. The same applies to occlusion caused by people or material.



Can inspection robots work by themselves?

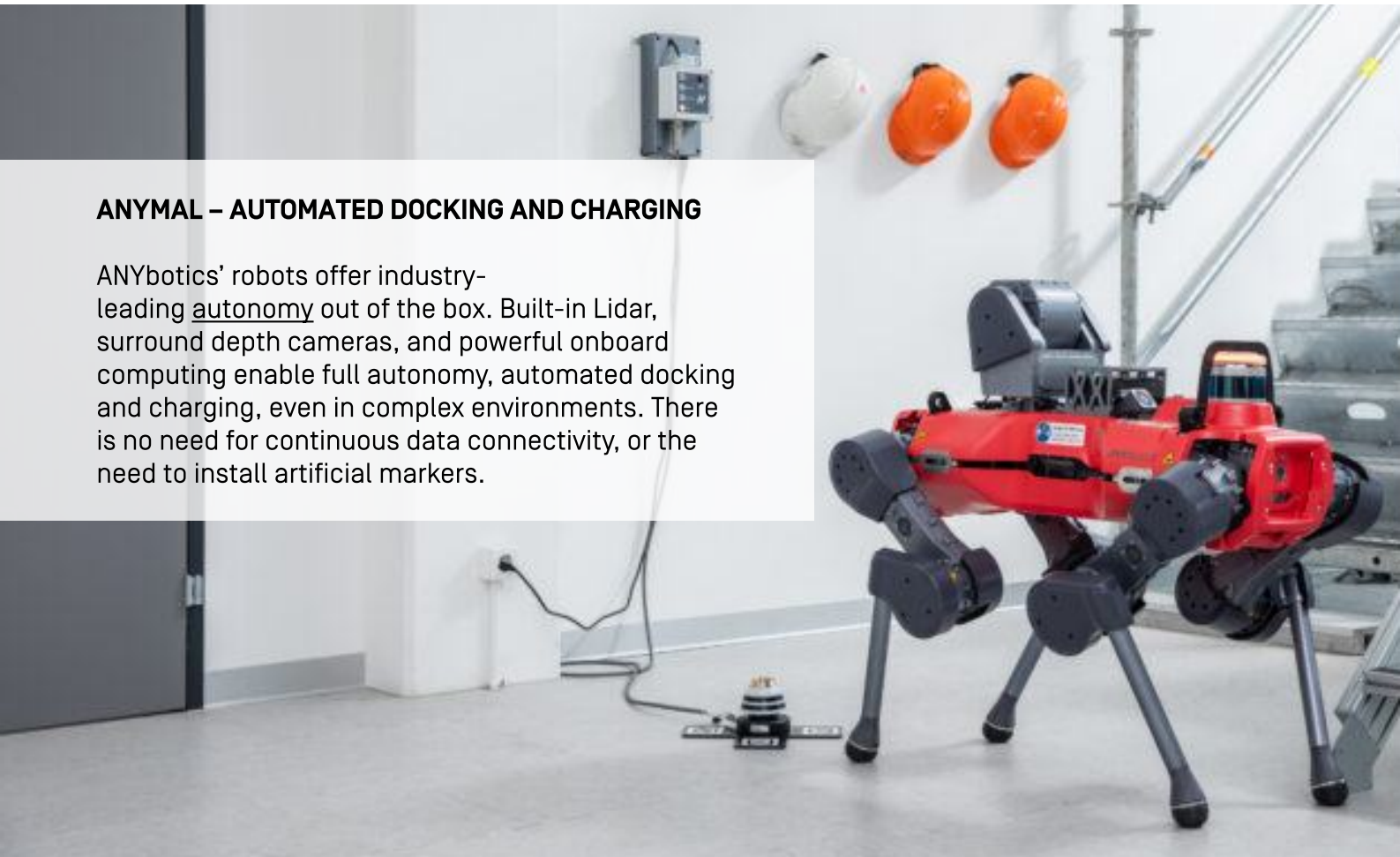
With the availability of small 3D sensors, such as depth cameras and Lidar, and powerful portable computing, established technology enables autonomous mobile robots to accomplish work by themself in complex environments. Robot control occurs on three levels:

Full autonomy: The robot can repeatedly move through industrial environments without human intervention. Once set up for the environment, the robot finds the fastest way to complete its inspection tasks while continuously checking for and avoiding obstacles.

Supervised autonomy: The robot operates independently to accomplish individual short-term tasks under human supervision. For example, the operator might ask for a specific reading, and the robot will self-navigate to the required location to deliver the result. During execution, the robot might rely on operator feedback in unexpected situations.

Teleoperation: Operators maintain complete control over the robot remotely. The user receives a real-time video stream and other environmental data and commands the robot to move in a particular direction. The robot takes care of basic mobility, stability, and obstacle avoidance, but the user can also steer the robot in previously unknown environments.

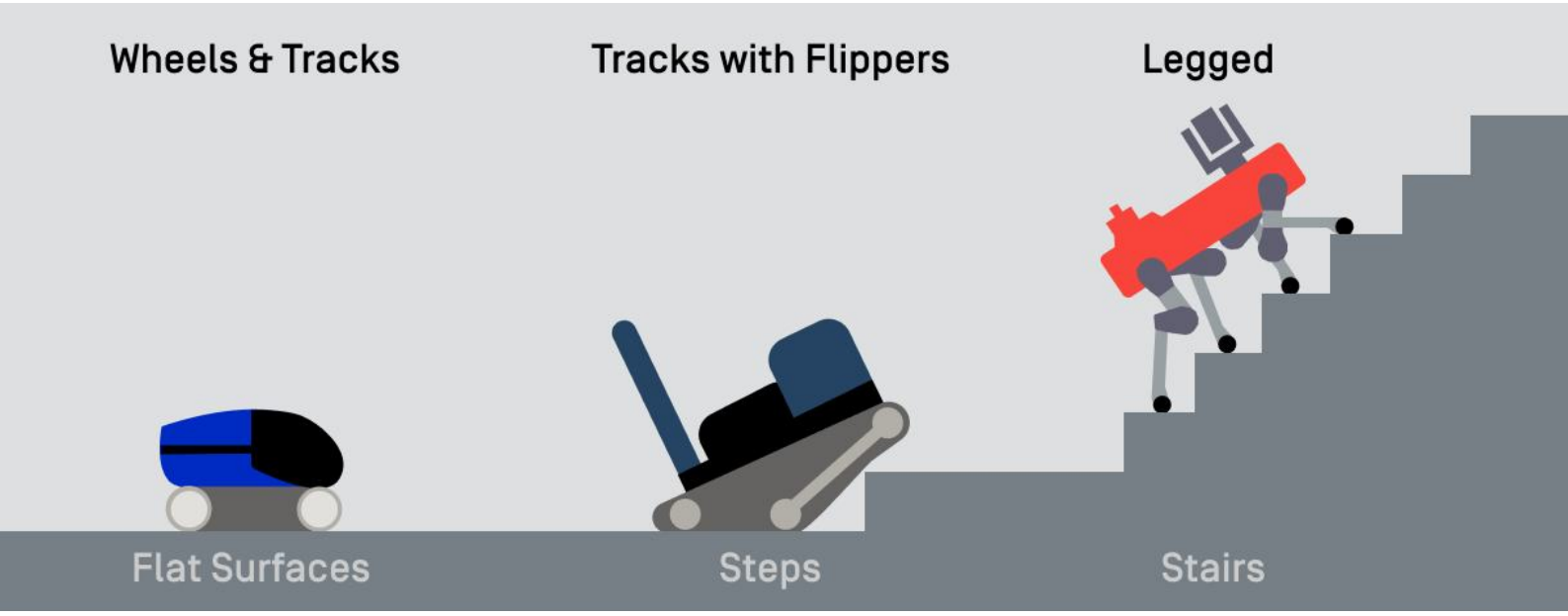
Fully autonomous robots are required to conduct effective routine inspections. They enable more frequent inspection missions around the clock, provide accurate data consistently, minimize the risk of human operator error, and don't require human resources. Most fully autonomous solutions offer robot docking stations that allow for regular recharging, which enables numerous inspection missions, as well as operating time and range extension through multiple docking stations.



ANYMAL – AUTOMATED DOCKING AND CHARGING

ANYbotics' robots offer industry-leading autonomy out of the box. Built-in Lidar, surround depth cameras, and powerful onboard computing enable full autonomy, automated docking and charging, even in complex environments. There is no need for continuous data connectivity, or the need to install artificial markers.

Will Inspection Robots Work in My Environment?



Industrial sites vary in complexity, including stairs, multiple levels, Ex-rated zones, dark areas, outdoor facilities, and adverse weather conditions. The robot's ability to autonomously navigate your facility is critical to automating inspection tasks.

Can inspection robots climb stairs?
People design industrial plants for people, and they invariably have stairs, steps, and other obstacles, such as piping. For large-scale automation of inspection tasks, robots must climb stairs and be able to overcome various obstacles on the ground. Ideally, robots have a small footprint and can move in all directions (omnidirectional) to get close to the machinery. Because passages are often very narrow, robots often provide a symmetric design to move bidirectionally, i.e., forward or backward, without turning around.

Different robotic inspection platforms are better suited to distinct types of terrains. Robots with wheels or tracks are physically limited to flat surfaces, while some systems provide so-called "flippers" that enable them to overcome moderate terrain with steps. Robots that move on legs offer maximum flexibility. These four-legged robots can climb stairs, and easily overcome steps, piping, and other obstacles, and reliably move in gravel, sand, grass, and snow.

Can inspection robots navigate complex environments?
For autonomy and safety in dynamic environments, robots need to perceive the world around them precisely. They achieve this by using Lidar, depth cameras, and sensors that cover 360 degrees around the robot.

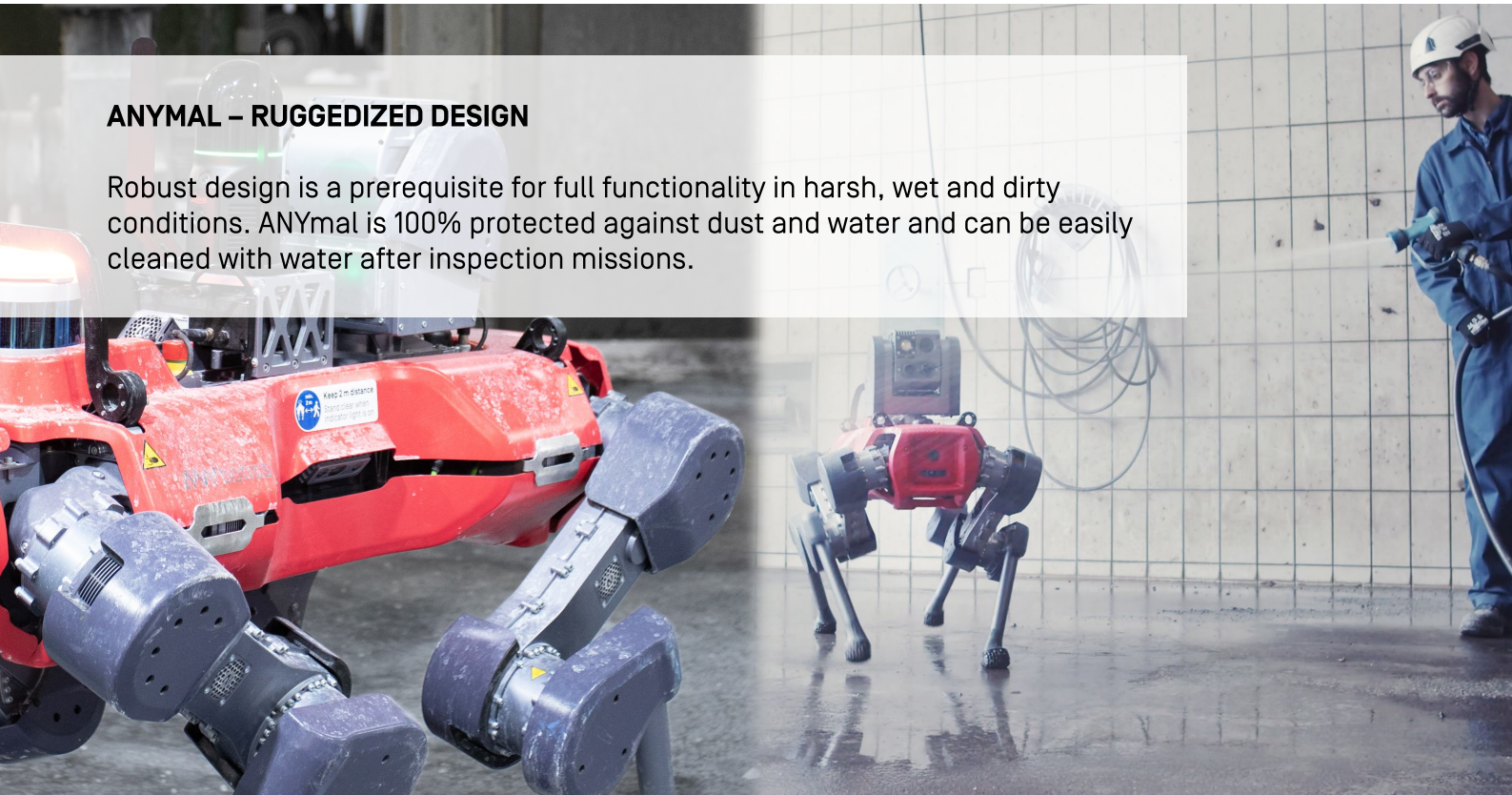
The robot's ability to locate itself and plan a new route when it encounters unforeseen obstacles is critical. Some systems can get 'lost' or confused easier than others and require additional artificial markers (AR tags) to be set up in the environment. Other systems provide advanced autonomy that robustly localizes the robot, providing reliable path optimization and navigation, even in adverse weather conditions and harsh environments such as the open sea.

Leading solutions are designed to navigate existing facilities and require no additional structural changes.

Can inspection robots work without WiFi/ cellular connectivity?
Most industrial plants can only provide partial wireless data connectivity throughout the facility. This means that the robotic solution needs to operate without a permanent data connection. Leading inspection robots carry built-in computing capabilities, have onboard data storage, and upload the data once they connect to an available network. This functionality eliminates the need for continuous network communication and allows the robot to operate effectively without WiFi or cellular connection. For example, ANYmal from ANYbotics provides full autonomy and continuous data collection independently of a stable network connection but can leverage a WiFi and 4G/LTE interface for real-time reporting and teleoperation.

Can inspection robots work in harsh environments?
Outdoor inspections present several challenges, including rain, humidity, dust, and salt water. Robotic solution providers rate their inspection robots according to the ISO Standard for Ingress Protection (IP Code), which indicates how well a device is protected against liquids and dust. An IP67 rating is the standard for outdoor inspection robots because it allows for continuous long-term use in outdoor environments without the risk of damaging the system.

Due to the nature of industrial sites, inspection robots can accumulate a variety of undesirable substances, including hydrocarbons, chemical residues, and radioactive dust. It is important that robots can be easily cleaned and decontaminated of toxic or active substances without compromising functionality. Robots with an IP67 ingress protection rating can be cleaned quickly and easily with high-pressure water.



ANYMAL – RUGGEDIZED DESIGN

Robust design is a prerequisite for full functionality in harsh, wet and dirty conditions. ANYmal is 100% protected against dust and water and can be easily cleaned with water after inspection missions.

The robot's area coverage is significant
The ability of an inspection robot to cover a given area affects its effectiveness and operational capacity. Monitoring more inspection points in larger areas makes the robot more effective. The robot's range, i.e., the distance it can cover, is determined by the complexity of the environment, the number of inspection points, the weight of the payload, the runtime allowed by battery life, and recharge time. Legged and tracked robots can cover different areas and are more suitable for different environments.

Tracked robots are relatively heavy, some weighing more than 100 kg. They can have a battery life of up to 4 hours and a range of up to 2-3 km. Because of their relatively slow speed, short range, and inability to climb industrial stairs, tracked robots are primarily suited for relatively flat environments.

Legged robots are comparatively light at around 55 kg or less. They typically have a battery life of 2 hours and a range of up to 4 km. Because of their comparatively higher speed, longer range, and ability to climb industrial stairs, legged robots provide complete coverage and are well-suited for flat and complex environments.

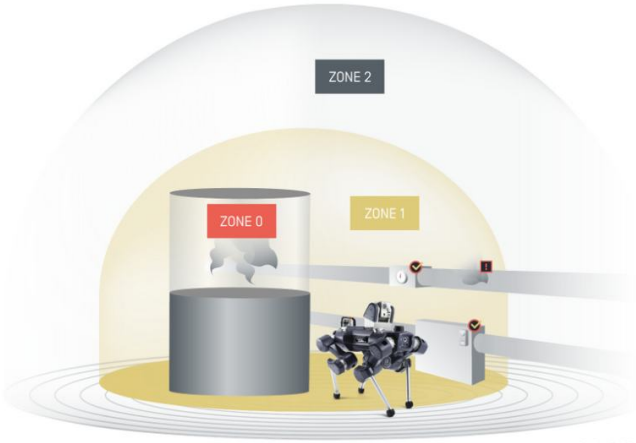
Are there Ex-proof inspection robots?
Environments where flammable or explosive gasses or liquids are handled, are Ex-rated. Most areas in Oil & Gas and Chemical facilities are Ex-rated, and operators require Ex-certified, intrinsically safe equipment in these zones (ATEX or IECEx certification, for example). Ex-rated areas are classified into zones (Zone 0, Zone 1, or Zone 2), based on the occurrence and duration of explosive atmospheres. Zone 1 certification is typically required to get inspection robots close to the equipment.

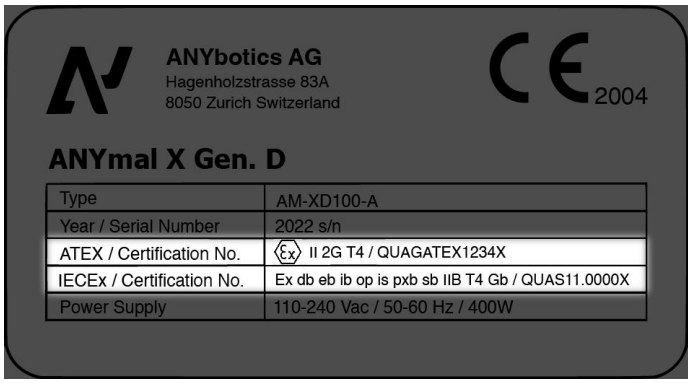
Several inspection robots such as ExRobotics' ExR-2, Taurob's Inspector, and ANYbotics' ANYmal X are Ex-certified. Certification classes differ, so it is important to check that the robot's certification is compatible with your facility. Both the ATEX and IECEx certifications align with the IEC 60079 standards and, as the marking systems are very similar, they are often combined. See the Hazardous Area Guide for a breakdown of ATEX and IECEx marking characters.

As the world's only Ex-certified, legged robotic solution, ANYmal X is Ex-certified for Zone 1 usage according to the IECEx and ATEX standards.

HAZARDOUS AREA CLASSIFICATION

Depending on the zone, the duration and likelyhood of explosive atmospheres are continuous (0), likely (1), and unlikely (2)

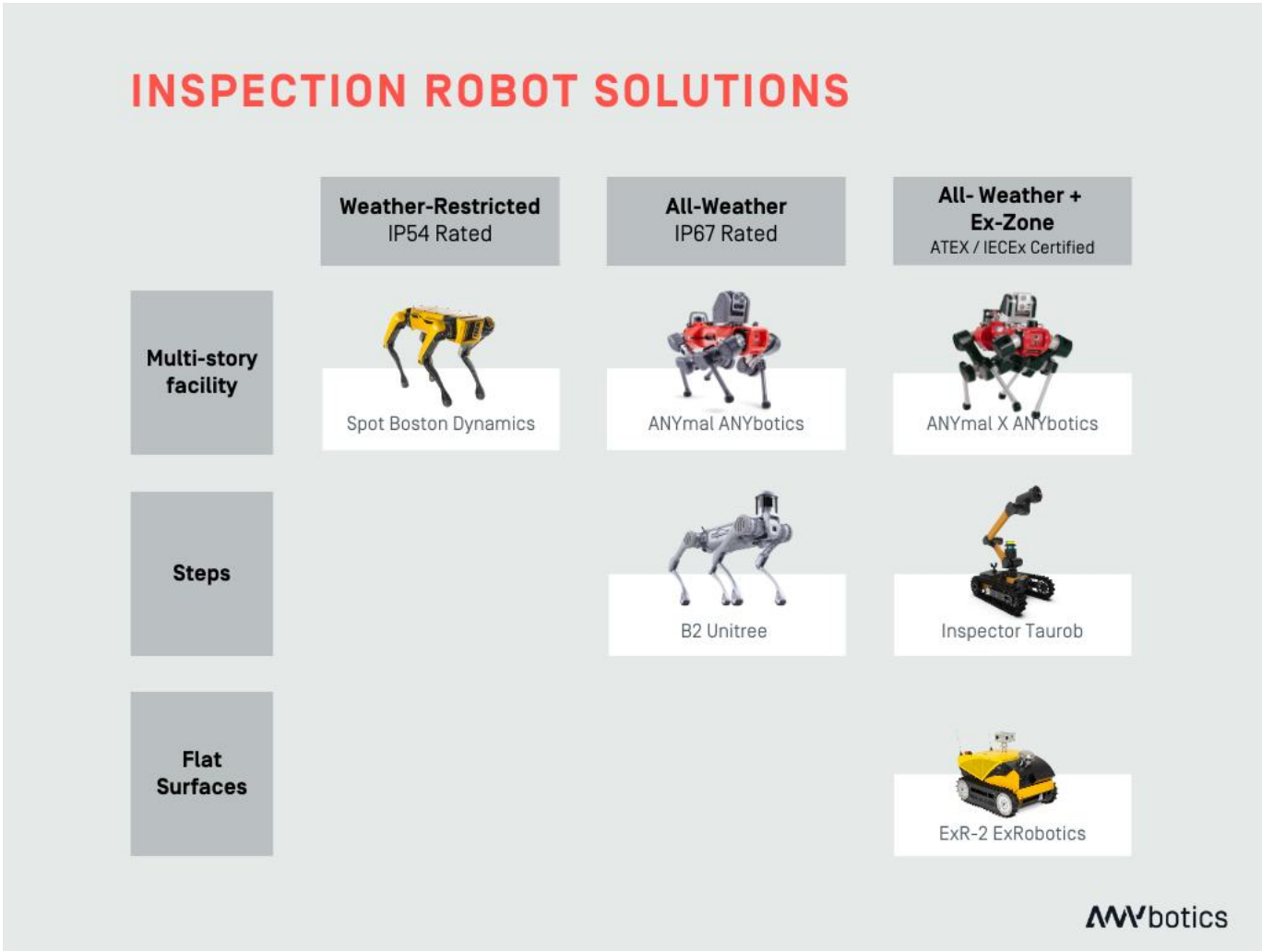




Different Inspection Robots Suit Different Environments

Robots for inspecting industrial facilities can be grouped according to environmental requirements: Boston Dynamics‘ highly mobile Spot (IP54 rating) is suitable for indoor and outdoor areas with temperate weather conditions. Both Unitree‘s B1 (IP68 rating) and ANYbotics‘ ANYmal (IP67 rating) can operate outdoors in adverse weather conditions, but only ANYmal has shown to negotiate industrial stairs autonomously.

When it comes to hazardous and potentially explosive areas, which are ubiquitous in the Oil & Gas and Chemical industries and require intrinsically safe equipment with ATEX/IECEx certification, robots currently available that meet Zone 1 certification requirements include: ExRobotics‘ tracked ExR-2, which navigates on flat surfaces; Taurob‘s Inspector, with flexible tracks, that can mount steps; and ANYbotics’ ANYmal X, which is the only legged robot that can navigate complex multi-story facilities.



Integrate the Robotic Solution in Your Operation

ANYBOTICS – ACCELERATING DEPLOYMENT THROUGH DIGITAL TWINS

ANYmal supports the digitalization of operations through scanning and documenting 3D environment data as a digital twin for mission simulations, accelerated deployment, and advanced automated condition monitoring.

Robots add maximal value when they are well integrated into existing operations. When fully integrated, robotic inspection is seamlessly connected to your plant's operations management systems and requires no manual data processing steps. It also means that the robots can be operated by non-robot experts, which requires high ease of use.

During the qualification of vendors, it's important to understand the scope of the offered solution and ease of integration. While some solutions are turnkey and can be deployed quickly, others require the overhead of working with third-party payload or software providers.

Can I use my existing digital twin to install an inspection robot?
Digital twin models are a crucial element for the digitalization of industrial plant maintenance. They enable virtual setup and validation of missions remotely before robots are deployed on-site, speeding up the installation of inspection robotics technology. In addition, real-time robot data fed into the digital twin enables operators to intervene quickly and preemptively. The most sophisticated robots can leverage existing digital twins, and update and create new ones.

What data formats and interfaces do inspection robots provide?
Inspection robot solutions collect large amounts of data. Evaluating the ideal data interface for your operations is essential to leveraging the best insights from the collected information. Typical robotic inspection solutions provide one or multiple of the following data interfaces:

User interface (UI): Direct access and interaction with the inspection results through the UI of the robotic inspection solution. This interface can monitor the progress and results of inspection missions in real-time (provided connectivity with the robot) and study the time series from a sequence of inspection runs.

File exports: Inspection sensor data taken for points of interest includes, for example, images and video sequences for visual and thermal inspection, raw audio files for acoustic recordings, and point clouds for 3D asset scans. Access to raw data is ideal for further analysis and training of predictive models.

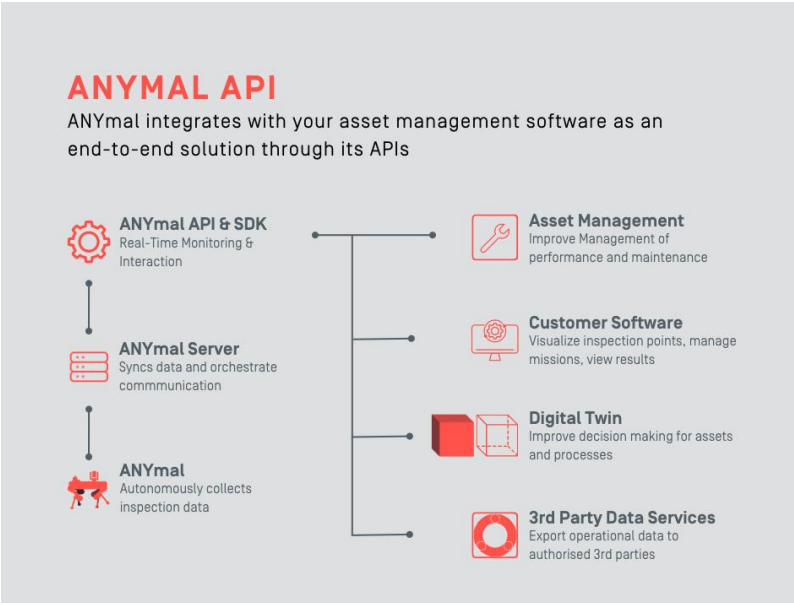
Inspection reports: Structured results from complete inspection runs, including information around the inspection analysis (e.g., the values that are read out), identifier, time, position, and other meta information. Inspection reports are often provided as PDF reports for direct consumption and as XML for import into other software.

Can I integrate an inspection robot with my Maintenance Management System?
The inspection data must be integrated into your management systems for inspection robots to function as proper end-to-end solutions. Integration with your maintenance management system, for example, allows you to set up alerts, react to detected anomalies early, and automate end-to-end workflows and preventive maintenance by triggering intervention actions. Integration further enables you to flexibly schedule routine and relevance-based monitoring, including on-demand, conditional, and spot inspections.

Effectively integrating inspection data is most commonly achieved through application programming interfaces (APIs).

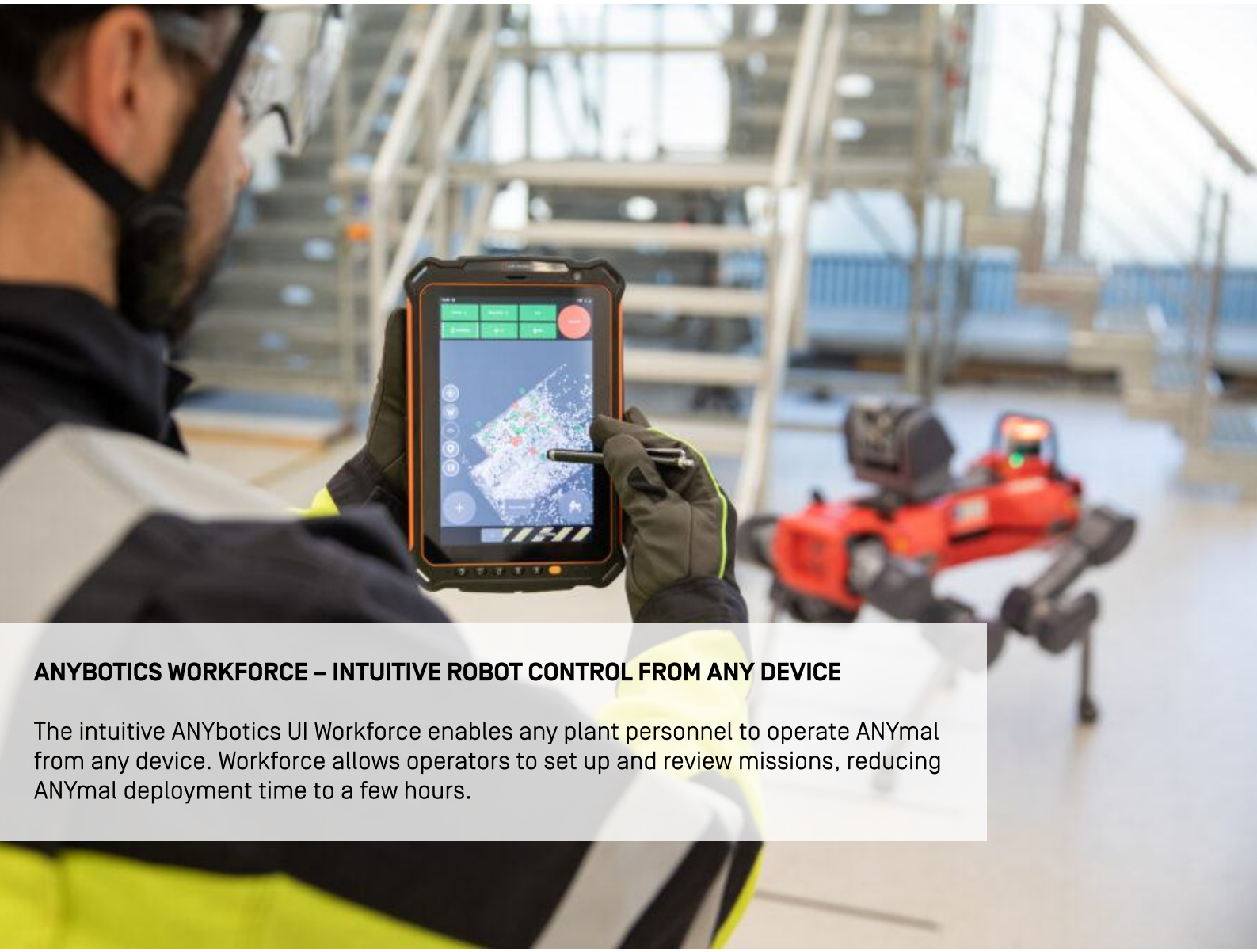
Software integration via APIs enables deep integration of robotic inspections into existing maintenance management systems. In addition to transferring inspection reports and original files, many APIs also offer the possibility of transferring sensor data in real-time. Inspection robot APIs are typically based on the open source, standardized gRPC API and supported by a software development kit (SDK) in commonly used programming languages, e.g., C++ or Python. The connection to the robot from operator systems can be direct or managed via a robot data server for increased security and reliability. That server can be located on-site at the end user's facility, in the operator's cloud infrastructure, or optionally in the solution provider's cloud infrastructure.

Integrating your inspection data via APIs facilitates consistent inspection data and analysis reports, as well as up-to-date information about the condition of your equipment and infrastructure.



What device do I need to operate the robot?
High usability of inspection robots for non-experts is essential so that operators can set up, manage, and customize inspection jobs without calling in an integrator. Robot control devices and interfaces should fit into your daily work, meaning they should be rugged, waterproof, and able to be operated while wearing gloves. Most robotic solutions offer a standard control device, but the software is ideally device-independent and can be used from existing tablets and computers.

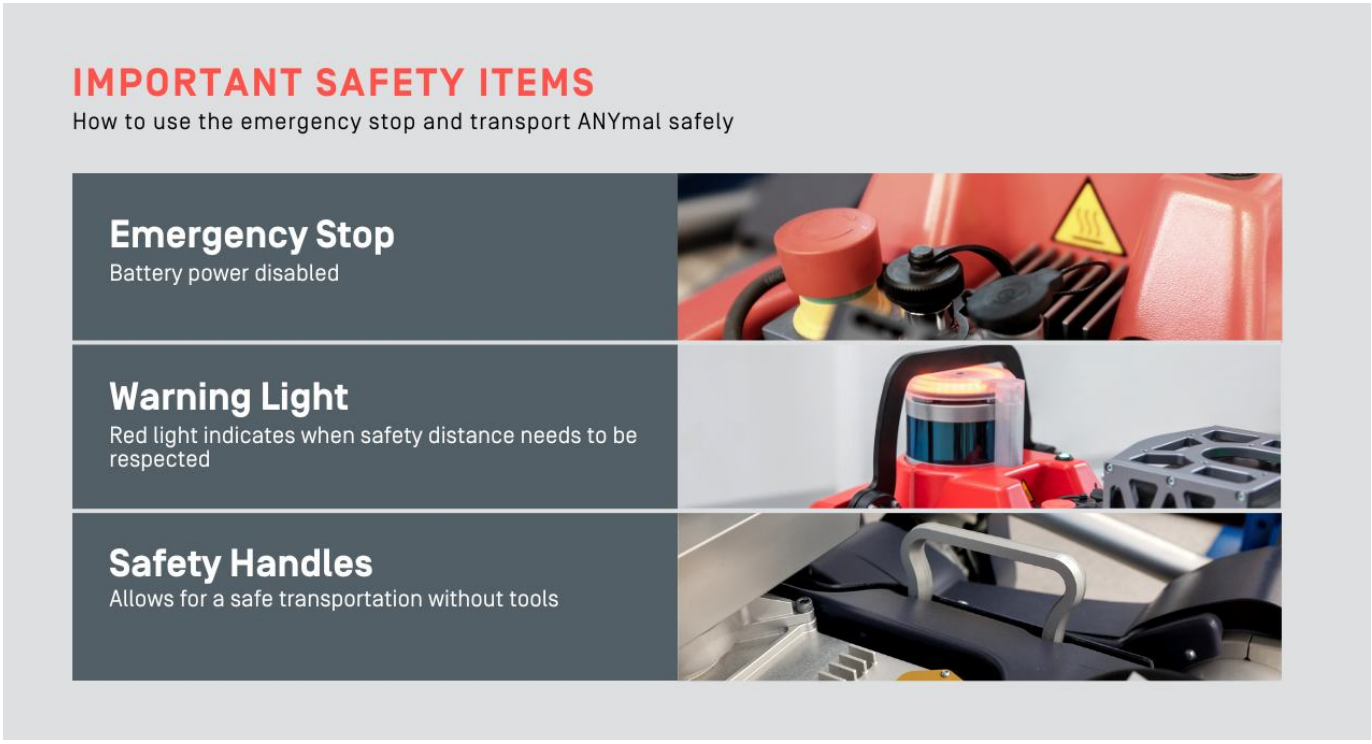
Leading robotic solutions provide a device-independent, intuitive user interface (UI) that allows a single operator to quickly and safely set up, review, and schedule autonomous or manual inspection missions and control the robot. This reduces robot deployment time to less than a day and is highly recommended when scaling inspection robots for broad applications.



ANYBOTICS WORKFORCE – INTUITIVE ROBOT CONTROL FROM ANY DEVICE

The intuitive ANYbotics UI Workforce enables any plant personnel to operate ANYmal from any device. Workforce allows operators to set up and review missions, reducing ANYmal deployment time to a few hours.

Don’t Compromise on Safety



Autonomous inspection robotics is a powerful, multidisciplinary technology. During the evaluation process, ensure that the solution meets your safety requirements by paying attention to these three aspects.

Marks and Certification: The CE mark for products that meet EU health, safety, and environmental requirements and FCC certification for electronic components in the U.S. represent basic safety for people and the environment.

IECEx (international) and ATEX (EU) are special certifications for equipment used in hazardous environments and potentially explosive atmospheres.

Operational Safety: Mobile inspection robots move between plant equipment and physical objects, occasionally encountering workers. Full autonomy and extreme mobility are critical, meaning the robot can ‘see’, identify and safely navigate your plant’s infrastructure. Leading inspection robots feature 360° vision, near-depth perception, and obstacle avoidance technology. In addition, these robots visibly communicate their operational status to the environment, e.g., through a red-green warning light system. They are equipped with multiple levels of accessible, certified emergency stop functionality and safety transport handles. Ensure operators do not need special equipment to physically or remotely shut down or move the robot.

To comprehensively address safety, best-in-class solution providers conduct on-site risk assessments in collaboration with end users.

User Training: Reputable robotic solution providers offer comprehensive online and on-site training to familiarize operators with key operating hazards, safety instructions, and emergency shutdown procedures. It is beneficial if they also have an online Learning Management System for retraining new joiners and a Master Operator module that allows your operators to train additional users in your organization independently.

Secure Your Data

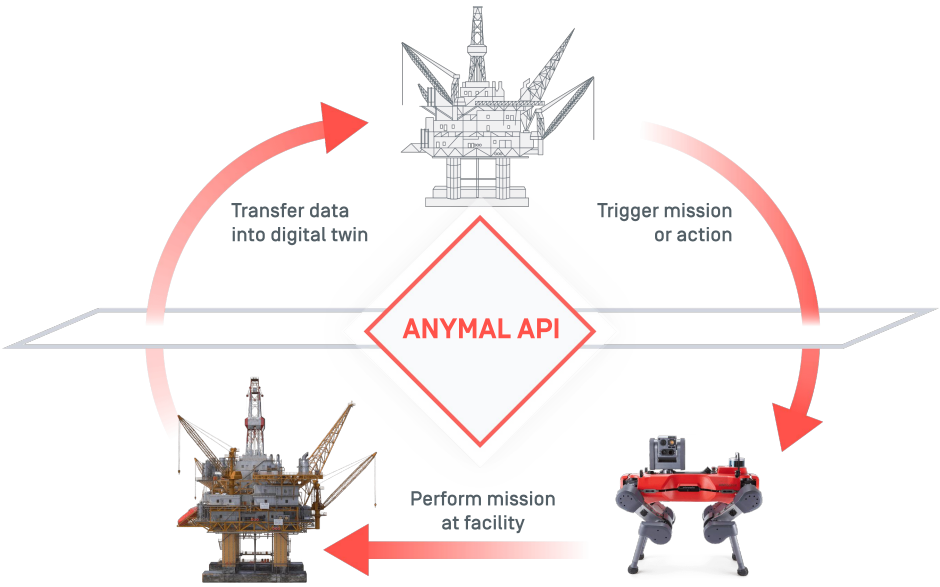
An inspection robot generates and collects various data about itself, its operational environment, its missions, and the inspection points on its routes. This data is typically classified into one of two categories, which affects where the data is sent and processed.

Environmental and Inspection data: Includes both data gathered in real-time from its onboard sensors used to understand and navigate its world (e.g., depth camera feeds and Lidar scans) as well as information used by the robot to perform its missions and the gathered inspection data, e.g., mission settings, 3D maps, navigation paths, and inspection results. While most data is discarded immediately, mission and inspection data can be processed and stored on the robot and forwarded to the operator's computer or end-user systems via the robot API. This means that the inspection output data should only be transmitted to the systems that you as the customer define.

Robot log data: Information about the robot's activities and its hardware and software performance (e.g., steps taken, battery cycles, software logs, inspection performance). This data is transmitted to the data server and the provider's systems, where it is stored and processed. The solution provider usually uses this data to further develop the robot solution, improve its services, and also to better fulfill customer support requests.

Integrating data from mobile robotics solutions with your management system via APIs means that the data must be secure and meet your standards for data handling. To avoid data security risks and business disruption due to data loss, integrity, authorization (e.g., GDPR in the EU), or intrusion (i.e., third-party hacking), the robotic platform and solution provider must have effective data security measures in place.

Ensure that the robotics solution provider complies with international information security management standards and implements security programs that ensure risk assessment and security controls. Also, ensure that the vendor communicates with its customers about incidents and threats, handles intermittent and unreliable connections without causing data breaches, and implements regular software and firmware updates to minimize security risks.



What Support Services will I need?

The core robotic solution is important, but equally important are the support services around the solution that assist you in running the solution smoothly and with high availability. Vendor or reseller support is critical for effective deployment and optimal robotic inspection performance. Leading vendors typically provide comprehensive support through collaboration, on-site consulting, and ongoing solution development. Watch out for resellers who may not have the technical knowledge and resources to provide adequate support. In these cases, working directly with a solution provider is better.

Important support service aspects you should look for when evaluating vendors and resellers include:

Technical expertise: Does the reseller have the necessary technical competence?

Resources: Does the reseller have the resources to provide adequate support at your facility?

Custom engineering: Does the vendor offer hardware and software adaptations to meet your facility's specific inspection needs better?

Operator training: Will vendor trainers work with your team on operational and maintenance aspects, from onboarding to ongoing deployment support?

Setting-up inspection missions: Can the vendor prepare inspection missions by importing your existing CAD/BIM facility models before the robot arrives?
Post-deployment support: Does the vendor provide a single direct point of communication for on-call troubleshooting and quick response times?

Replacement programs: Does the vendor offer robot or parts replacement programs for defects or robots that need extended repair?

Updates and upgrades: Does the vendor provide software updates and hardware upgrades regularly and, if necessary, remotely?

In-house servicing and repairs: What level of in-house maintenance and repair are you allowed or expected to perform?

Maintenance: What are the maintenance protocols and costs of the robotic solution?

How Should I Acquire the Inspection Robot Solution?

Industrial inspection robotics solutions can be purchased outright or acquired on a subscription basis through Robot-as-a-Service (RaaS). The outright purchase traditionally included the hardware, i.e., the robot, payload, and accessories, as well as the software. To ensure regular software updates, leading vendors now offer the option of purchasing the hardware with licensed Software-as-a-Service (SaaS) or offering the entire system (hardware and software) as RaaS. Each of these options licenses the software, and the licensing fees vary depending on the system's capabilities. Some organizations still purchase the hardware, but the trend is clearly to acquire the entire system as RaaS.

Outright purchasing is suitable for early innovation projects, such as demonstration systems, and is usually funded from CAPEX budgets, while SaaS software is acquired through OPEX budgets. The inability to lock in future costs (e.g., for customer service) and long approval cycles make this model more suited to pilot projects and initial testing.

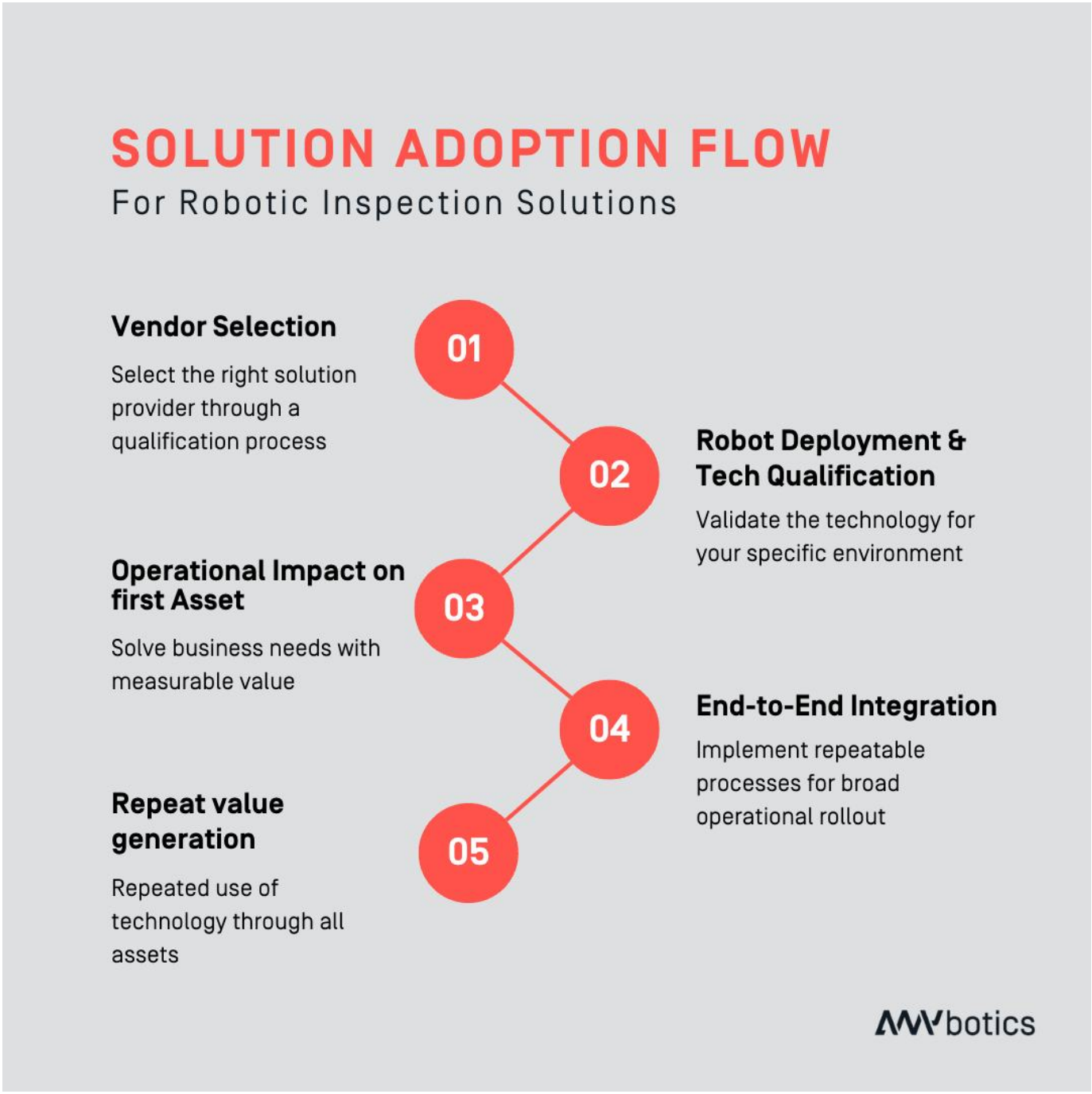
RaaS is well suited for operators moving from a pilot phase to full operational deployment. This more modern approach suits organizations with an asset-light strategy that prefer to manage inspection robots through their OPEX budget. Benefits of RaaS include long-term budget clarity, faster approval cycles, quicker access to hardware and software upgrades, and after-sales services.

Which option is the best? The short answer is: it depends. Financial considerations, your company's digitization strategy, and your inspection automation plan will inform whether it's best to own or rent robots to perform your needed tasks.

ANYBOTICS – FLEXIBLE ROBOTIC INSPECTION SOLUTIONS

Flexibility and customer success are at the heart of the options ANYbotics offers for purchasing robotic inspection systems. These options allow CAPEX and OPEX alternatives and are among the most advanced in the industry. They include providing the robotic and inspection software as SaaS and either purchasing ANYmal or ANYmal X directly (CAPEX) or renting the complete solution through the RaaS model (OPEX).

Getting Started



Implementing robotic inspection solutions should be a deliberate, step-by-step process. Consider vendor evaluation, deployment aspects, impact on your business, integration with your systems, and broad-scale adoption. By taking a systematic approach, you can maximize the benefits of using inspection robots while avoiding disappointment and setbacks.