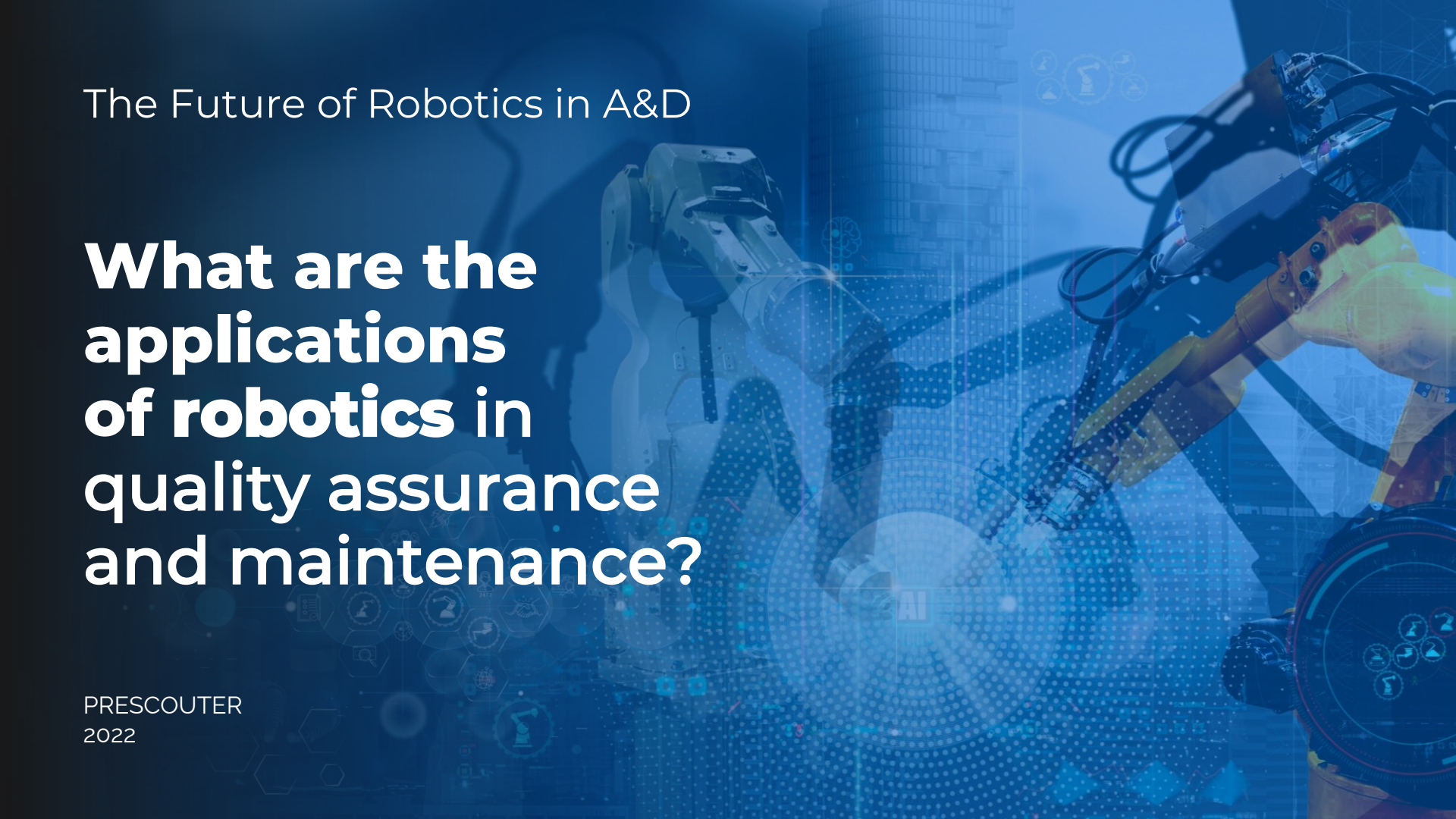
The Future of Robotics in A&D

What are the applications of robotics in quality assurance and maintenance?



PRESCOUTER
2022

Robotic technologies can be leveraged by aerospace & defense companies to streamline the stringent maintenance and quality assurance needs from these industries.

Aircraft maintenance encompasses about 20% of total operating costs. The manual inspection of aircraft and various components is also a time-consuming procedure, subject to human error. Automated inspections systems are emerging as an attractive alternative to augment (if not eventually replace) human efforts.

This Intelligence Brief highlights new approaches being enabled by the use of novel sensors (such as LIDAR, machine vision, etc.…) and advanced artificial intelligence to help streamline operational processes for the aerospace & defense sectors.

TECHNOLOGIES COVERED

COMMERCIAL AVIATION

- A*Star
- Hexagon
- CREAFORM

DEFENSE INDUSTRY

- Vention
- Integro Technologies
- Kitov.ai

AEROSPACE INDUSTRY

- Blue Origin
- Omnirobotic

1 COMMERCIAL AVIATION

- A*Star
- Hexagon
- CREAFORM

A*Star

Smart Automated Aircraft Visual Inspection System (SAAVIS)

The Singapore-based Agency for Science, Technology, and Research (A*STAR) develops R&D strategies in four key areas: artificial intelligence, analytics and informatics, health and medical technologies, and agritech and aquaculture.

Two of its units, Infocomm Research (I2R) and High-Performance Computing (IHPC) have developed SAAVIS that combines robotics, computer vision, and AI technologies automating the aircraft inspection process.

Website:	https://www.a-star.edu.sg	**Company size:**	5,895 employees
Contact:	+65 6826 6111/+65 6478 9048	**Founded:**	2002
HQ:	20-10 Connexis North, Singapore, 138632, SG	**Revenue:**	1B USD (in 2021)

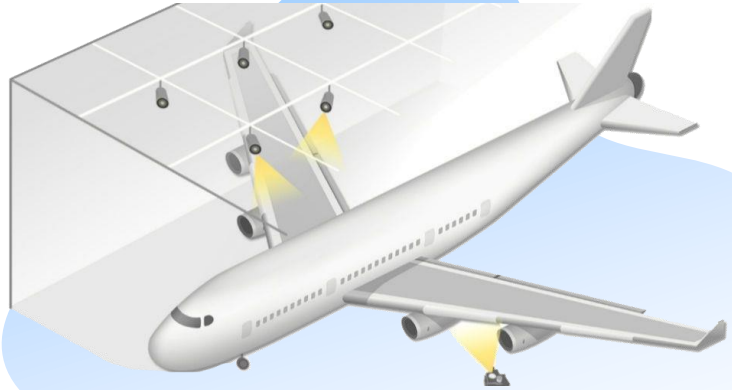


Illustration of cameras installed in the hangar to capture images of the plane, where the image data is processed by using AI technology for defect detection. Source: A*Star.

A*Star

Smart Automated Aircraft Visual Inspection System (SAAVIS)

The software uses computer vision and path planning algorithms to help determine the optimal path for the robots considering aircraft geometry and environment.

Type of robot used and its hardware functionalities

Autonomous low and high-reaching ground robots are equipped with 3D lidar obstacle detection, accurate aircraft localization, and path planning capabilities.

Robots can detect aircraft defects by scanning various engine components and profiles.

Type of maintenance work

- Recurring defects
- Predicting component failures in aircraft

Type of vehicle or component of the maintenance work

Commercial aircraft and aircraft components including:

- GPS
- LIDAR sensors
- Sonar sensors
- Wings
- Aerodesign
- Undercarriage
- Dedicated ECUs
- Motor and engine actuators

A*Star

Smart Automated Aircraft Visual Inspection System (SAAVIS)

Technology Details & Capabilities:

SAAVIS encompasses:

- Image collection acquired through high-resolution cameras placed in the hangar and autonomous ground robots equipped with 3D lidar obstacle detection and path planning capabilities.
- Robots equipped with path planning algorithms can scan below the airframe and engine (i.e., low-reaching robots) as well as above the engine and the sides of the aircraft (i.e., high-low-reaching robots).
- An AI technology that can detect over 20 different types of airplane defects using image data processing.

Use Case

A*STAR's current project, "AI for Airline Operations," is targeting the improvement of airline operations by predicting quality assurance and safety of commercial aircraft in collaboration with Singapore Airlines (SIA) and SIA Engineering Company (SIAEC). SIA and SIAEC have seen improvements in their operational efficiency by optimizing their maintenance interval, workflow sequence, manpower and resource allocation.

Relevant IP
SG 11201909082T A (pending)
SG 11201908974X A (pending)
SG 11201909042Q A (pending)
A search of A*STAR IP here.

Hexagon

HxGN Robotic Automation Software

Hexagon AB specializes in hardware and software digital reality and their Hexagon Manufacturing Intelligence division produces and develops sensors, autonomous technology applications, software, and actuators.

HxGN Robotic Automation is a robotic programming and control software that enables industrial robots to perform fully automated quality inspections.

Website:	http://www.HexagonMI.com	**Company size:**	20,000+
Contact:	+46 8 601 26 20	**Founded:**	1992
HQ:	Stockholm, Sweden	**Revenue:**	4.1B USD (in 2021)

Image: HxGN Robotic Automation software.

Hexagon

HxGN Robotic Automation Software

The software uses simple UX principles that programs and controls robotic cells. The software can perform automated inspection cells off-line, near-line or inline.

Type of robot used and its hardware functionalities

Supports Hexagon laser trackers, Leica T-Scan and AS1 scanners and directly interfaces with FANUC and KUKA robots.

Built-in postprocessors enable the robot controller to work with a wide range of third-party robots.

Type of maintenance work

- Inline metrology
- Real- time data acquisition from manufacturing line
- Self-correcting manufacturing
- Automatically repairing maintenance

Type of vehicle or component of the maintenance work

- Commercial aircraft
- Aircraft mechanical components
- Motor engine and other actuators
- Aerodesign
- Wings

Hexagon

HxGN Robotic Automation Software

Technology Details & Capabilities:

HxGN performs fully autonomous quality inspection assurance and maintenance to commercial aviation crafts. The software can be installed in autonomous optical inspection cell platforms or adapted to all types of fabrication integrating different variety of sensors and actuators.

The technology also enables machine modelling. Users can build or edit any kinematic or static device as part of a robotic solution. The program contains cell modelling and layout tools to design solutions for any particular application requiring robot automation.

HxGN performs real-time collision detection and avoidance ensuring safe robot path generation, and counts with offline and online robot program executions allowing fast online implementation. It can be integrated with Hexagon metrology software (e.g., PC-DMIS and Inspire), which helps extending the capabilities for analysis of data capture.

Use Case

ŠKODA AUTO company is using HxGN Robotic Automation software to take full advantage of offline programming.

Skoda reports it has significantly reduced the time required for the offline programming of robotic measurement and the debugging of measurement programs.

Relevant IP
Proprietary technology
(>10 patents)

CREAFORM

CUBE-R

Creaform develops, manufactures and sells 3D portable measurement and analysis technologies for the manufacturing industry.

Cube-R is a stationary 3D scanner that harnesses the power of optical 3D measurement and industrial automation. It optimizes the production cycle and throughput resulting in better product quality.

Website:	creaform3d.com/en	**Company size:**	724 employees
Contact:	1.855.933.4446 | Email	**Founded:**	2002
HQ:	5825 Rue Saint-Georges Levis, QC G6V 4L2 Canada	**Revenue:**	$172 Million*

*Date not specified. Source

Image of the Creaform Cube-R technology. Source: Creaform.

CREAFORM

CUBE-R

The software uses simple UX principles that programs and controls robotic cells. The software can perform automated inspection cells off-line, near-line or inline.

Type of robot used and its hardware functionalities

Robot-mounted optical 3D scanner CMM

Type of maintenance work

Scanning of castings during multiple steps before they are shipped out to customers.

Type of vehicle or component of the maintenance work

- Designed for the aerospace industry.
- Inspect geometrically complex aerospace components
- Inspect sub-assemblies which require high precision measurements.

CREAFORM

CUBE-R

Technology Details & Capabilities:

The Creaform CUBE-R is a turnkey 3D scanning CMM that consists of a robot-mounted optical 3D scanner and an enclosure, and combines real-time visualization capabilities with real-time performance indicators and a 3D scanning experience.

The Creaform CUBE-R

The turnkey solution can process up to 3,000,000 measurements/sec regardless of geometric features and offers a high-density scanning area.

It can also be installed directly into the manufacturing process, compatible with industrial and collaborative robots and with metrology software.

The Creaform CUBE-R

The turnkey solution can process up to 3,000,000 measurements/sec regardless of geometric features and offers a high-density scanning area.

It can also be installed directly into the manufacturing process, compatible with industrial and collaborative robots and with metrology software.

Another product that can perform similar tasks as the CUBE-R is the **MetraSCAN 3D-R**. It has the capability to generate 3D scans on shiny surfaces and objects of varying reflectivity and surface geometries.

Relevant IP
Proprietary technology with 93 patents.

2 DEFENSE INDUSTRY

- Vention
- Integro Technologies
- Kitov.ai

Vention

WALT autonomous CNC machine

Headquartered in Montreal, and with subsidiaries in Boston and Berlin, Vention is a digital manufacturing automation platform (MAP) that provides industrial automation solutions with products including autonomous surface vessels and robotic systems.

In its robotic division, Vention has developed and manufactured the **WALT Machine**.

WALT specializes in CNC machining for the defense industry and can deploy robots and automated equipment on the manufacturing floor.

Website:	https://vention.io/	**Company size:**	218 employees
Contact:	+49-30-56795545	**Founded:**	2016
HQ:	Montreal, Canada	**Revenue:**	220 M USD (in 2021)

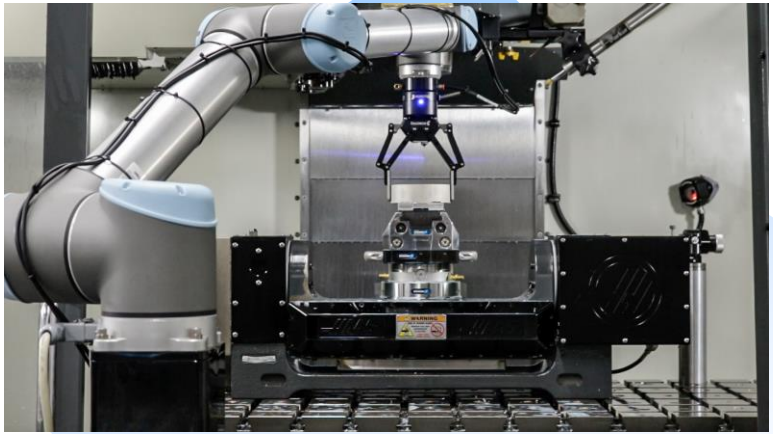


Image of the autonomous CNC WALT Manufacturing Machine for defense industry. Source: Vention.

Vention

WALT autonomous CNC machine

The software is called the Vention URCap Software for Linear Motion and allows users to also make use of MachineLogic, a code-free programming software.

Type of robot used and its hardware functionalities

Automated Computerized Numerical Control (CNC) machining with an industrial arm robot, a gripper equipped with camera sensors, latches, and a post-machining gauging system.

Type of maintenance work

- Land and aircraft combat vehicles
- Naval ship components and missiles
- Inspection post-machining of any vehicle/weapons components
- Ensuring predictive maintenance and QA

Relevant IP

Proprietary technology is in pending status but no patent appears to have been registered.

Vention

WALT autonomous CNC machine

Technology Details & Capabilities:

Vention's WALT automated robot cells can be used to assemble and manufacture in-line defensive components such as:

- Weapons
- Cruise missiles with long foot distances
- Land and aircraft combat vehicles
- Naval ship components

First, at the beginning of the manufacturing operations, the **URCap for Linear Motion** operating software runs simulations **leveraging ML/AI** pre-trained data sets enabling **predictive maintenance** and **quality assurance**.

The CNC is equipped with three Haas CNC lathes (where the material or part is clamped and rotated by the main spindle).

WALT is also equipped with a **Universal UR10 Robot**, and it allows a 2-output option and reverses synchronization and extendable layout for 7 axes, up to 40 feet long. The height is 87 inches robot base flange to the ground.

At the end of the process, **the inspection is done by the arm robot**, which has a Robotiq 2F-85 Gripper with a **wrist camera** and a **Renishaw Equator 500** for measuring larger parts.

In general, CNC approaches offer compatibility with various materials, making them ideal for manufacturing defense components.

Multi-axis CNCs, like the ones produced by Vention, can fabricate 20-foot-long cruise missiles.

References
1. https://www.china-machining.com/blog/cnc-defense/
2. https://craft.co/vention
3. https://www.dnb.com/business-directory/company-profiles.vention_inc.5ff66862a02affa704913ff5064d588d.html

Integro Technologies

The Raptor

Integro Technologies develops machine vision for QA and logistics productivity technologies using deep learning, hyperspectral imaging, robotics, and artificial intelligence (AI). Integro Technologies' most recent development is the Raptor, a single solution for precision 2D and 3D measuring with broad industrial applications industries such as:

- Aerospace
- Automotive
- Military
- Medical
- Plastics
- Electronics

This 2D and 3D vision inspection system uses proprietary software, and optical, and ultra-high resolution image formation technology.

Website:	integro-tech.com/	**Company size:**	80 employees
Contact:	(704) 636-9666	**Founded:**	2000
HQ:	North Carolina, USA	**Revenue:**	11 M USD (in 2021)

The Raptor 2D and 3D measuring system. Source: Integro Technologies.

Integro Technologies

The Raptor

The software uses simple UX principles that programs and controls robotic cells. The software can perform automated inspection cells off-line, near-line or inline.

Type of robot used and its hardware functionalities

2D/3D inspection machines that use sensor fusion to scan the components and identify defects based on AI/ML techniques.

Type of maintenance work

- 3D metrology
- Automated QA and surface inspection
- Fracture and imperfection detection
- Object conformity in defense industry components

Type of vehicle or component of the maintenance work

Defense industry components such as:

- Bullets
- Guns
- Heavy machinery
- Grenades
- Anti-missiles

Integro Technologies

The Raptor

Technology Details:

This is a fully automatic 2D/3D inspection that applies pre-data image training from ML and AI into computer vision applications.

The system is based on sensor fusion techniques from high resolution optical, illumination, and camera systems to capture the images of grenade and bullet casing surfaces with high precision (up to 0.004mm).

It performs predictive maintenance through algorithm inspection, detecting any wear marks or damage to military defense equipment.

The technology is inline capable and can work with a single target calibration procedure.

It produces a graphical representation of key product metrics, with interfaces available for SPC/SQL packages.

The system also provides service in defense with the QA inspection of vehicles' engine heads.

It is equipped with two Cognex DS (displacement sensor) camera 3D units in conjunction with a Yamaha single-axis linear servo that carries the two DS units across the scanning plane.

The inspection system gathers information from the upper assembled head of the engine at different angles, inspecting 4 parts per minute.

Relevant IP
Proprietary technology
US-9110032-B2
US-20140270466-A1

References

1. https://earlymetrics.com/key-use-cases-of-computer-vision-in-the-defence-industry/
2. integro-tech.com/2d-and-3d-precision-measuring-system/
3. integro-tech.com/manual-linescan-station/

Kitov.ai

Kitov-CorePlus

Kitov.ai's main business concept revolves around the development of fully automated visual inspection systems for Industry 4.0.

Kitov.ai, a spin-off of RTC Vision, has commercial regional centers opened in Israel, Germany, and China. It makes use of 3D Computer Vision Algorithms and AI to help detect and classify physical defects without human intervention.

A robotic arm and a rotating table are features of its Kitov-CorePlus which is outfitted with CAD2SCAN software and allows for the acquisition of several photos of the product being examined from various locations, angles, and lighting settings.

Website:	https://kitov.ai/	**Company size:**	34 employees
Contact:	+972-3-373-1355	**Founded:**	2014
HQ:	Petach-Tikva, Israel	**Revenue:**	4.5 M USD

CorePlus showing the robotic are and rotating table. Arm robot equipped with camera can scan all the angles and heights. Source: kitov.ai.

Kitov.ai

Kitov-CorePlus

The proprietary software "CorePlus" controls the vision systems by combining deep learning, 2D/3D imaging, novel algorithms or Semantic Detectors, and intelligent robotic planning technologies.

Type of robot used and its hardware functionalities

A fully automated industrial robot arm equipped with optical heads takes images of the part from all angles in both offline and in-line configurations.

Type of maintenance work

Inspection QA

Type of vehicle or component of the maintenance work

- Aerospace vehicles
- Turbines
- Inspection of geometric shapes and sizes
- Missing or disconnected components
- Screw issues
- Labels
- Connector pins

Kitov.ai

Kitov-CorePlus

Technology Details & Capabilities:

The **Coreplus** has three main components: A robotic arm resting on a rotating table, the optical head and the Kitov-CorePlus software (that includes CAD2SCAN, the Kitov Smart Planner and the Kitov Review Station)

The **robotic arm** is equipped with a camera with a 25/50 mm lens with a minimum detection property of 50 um.

The **Kitov-CorePlus** software dictates the camera position, robot arm movement, and rotating table for inspection.

The **Kitov Smart Planner** then enables the preparation of new inspection plans offline and, together with CAD2SCAN, automatically extracts geometric information for each inspection requirement.

The **Kitov Review Station** supports the flow of faulty products and provides a remote inspection review tool from a central location.

Automatic CAD-based inspection planning or CAD2SCAN was developed to improve the inspection of single-material parts with complex 3D geometric shapes (e.g. turbine engines, blades, wheels, and metal molding including CNC parts).

CAD2SCAN is a plugin for common CAD software systems (currently available for SolidWorks and Creo). In addition, it supports the "evolving" QIF (quality information framework).

Relevant IP
Proprietary technology:
3 patents

3 AEROSPACE INDUSTRY

- Blue Origin
- Omnirobotic

AEROSPACE INDUSTRY

Blue Origin

Autonomous high-precision metrology sensor system

Blue Origin is a private sub-orbital spaceflight company. It is also categorized as a defense and space manufacturing company that is immersed in developing an autonomous robot spacecraft.

Website:	http://www.blueorigin.com	**Company size:**	4,972 - 6000
Contact:	1(253) 872-0411	**Founded:**	2002
HQ:	HQ: Blue Origin, Kent, WA 98032, US	**Revenue:**	42.8 M USD in 2021

Autonomous New Shepard Aerospace Craft. Source: Blueorigin.

Blue Origin

Autonomous high-precision metrology sensor system

Blue Origin's flight software embedded system utilizes an autonomous high-precision metrology sensor approach, AI, ML, QA, and predictive maintenance.

Type of robot used and its hardware functionalities

Industrial robot arms use point-to-point touch and 3D axis optical sensors applied in metrology autonomously.

Type of maintenance work

Aerospace craft components, which includes QA and maintenance of:

- Ring and wedge fins
- Drag brakes
- Engine propellers
- Autonomous steerable aft fins

Type of vehicle or component of the maintenance work

High metrology accuracy using touchpoint-to-end sensors for maximum quality assurance, measuring components, and looking for defects or cracks.

Blue Origin

Autonomous high-precision metrology sensor system

Technology Details & Capabilities:

Industrial robot arms perform **autonomous quality assurance** in mechanical parts of the New Shepard aerospace aircraft by using precise o**mni-directional touchpoint-to-end mechanical and optical sensors**, using AL and ML to automate the performance.

The machines perform specific tasks such as **identifying anomalies and errors** on the surface of mechanical parts as well as **matching and collecting data** between design, manufacturing simulation, and in-line production.

The sensors obtain 2D and 3D measurements and can contour the mechanical assemblies looking for cracks, defects, aero design anomalies, or any other errors that could cause the aircraft to fail.

The inspection of the separate components of New Shepard happens in controlled temperature metrology rooms, including humidity and dust control, for better precision, scalability, and accuracy.

Then, real tests with different testing parameters are performed on Earth and in space. In the event a defect is spotted, the quality assurance engineer has to find a specific OEM partner to solve the issue.

Before putting New Shepard into operation, autonomous inspection is carried out during a number of automated tests on the flight test program, ensuring verification and confirming the validity of both mechanical and electrical parts.

Fault tolerance tree analysis and failure system backups determine the functionality of the:

- Capsule
- Re-entry parachute deployment
- Pad
- In-flight and transonic escapes on the capsule
- Propulsion module boost
- Consequent re-entry

References

1. nypost.com/watch
2. www.space.com/
3. www.blueorigin.com/new-shepard/
4. linkedin.com/company/
5. www.easyleadz.com/company/
6. www.youtube.com watch 1; watch 2; watch 3; watch 4; watch 5

AEROSPACE INDUSTRY

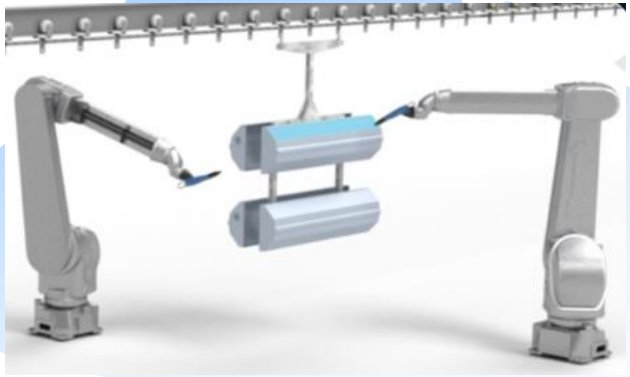
Omnirobotic

AutonomyOS

Omnirobotic develops autonomous QA inspection processes utilizing industrial arm robots and AI/ML with Industry 4.0 technologies to provide quality assurance and predictive maintenance.

Omnirobotic's latest development is the AutonomyOS, an operating system capable of generating motion plans based on a 3D perception that can be installed on any industrial robot.

Website:	https://omnirobotic.com/	**Company size:**	24 employees
Contact:	(450) 231-1077	**Founded:**	2016
HQ:	Laval, Quebec, Canada	**Revenue:**	5 M USD in 2021



Omnirobotic's autonomous industrial arm and 3D perception and AI motion planning system. Source: Omnirobotic.

Omnirobotic

AutonomyOS

The software uses OmniBrain and Omnirobotic's Shape-To-Motion technologies, AI/ML, and embedded autonomous systems. It can perform autonomous QA and predictive maintenance based on DL.

Type of robot used and its hardware functionalities

AutonomyOS™ can control multiple 3D cameras and robot controllers, with additional adaptive capabilities for other hardware.

It uses 3D perception, infrared structured lighting, and robotic industrial arms.

Type of maintenance work

QA inspection of mechanical parts is done with the aid of autonomously generating robot programming in real-time.

Type of vehicle or component of the maintenance work

- Aerospace craft components
- Full-up aircraft
- Large-piece aircraft
- Parts
- Aircraft inlets
- Missiles
- Ground vehicles
- Unmanned aerial vehicles

Omnirobotic

AutonomyOS

Technology Details & Capabilities:

Omnirobotic's technology is composed of a **3D perception industrial robot arm** with **sensor fusion infrared structured lighting**, able to perform imaging processing below 1 millimeter.

The robot arm is equipped with **STL** and **STEP CAD** files that can scan the assigned parts, reconstructing them and their position in a real-time process.

While data is being collected, a number of high-end GPUs, the OminiBrain spare-based architecture, and AI enable the robot to build algorithms on its own with various motions and calculate the most efficient approach.

The robot takes action and executes the embedded solution to finish processes, parts, or paint parts without the need for developing the algorithm from scratch, fixturing, or jigging.

Manufacturing errors during an inspection are identified during simulations, and later by sensor capture, data investigation, or software failure detection in real time.

Omnirobotic's platform allows robots to interact with high-mix parts loading.

With a feature dubbed "behavior editing," the program enables clients to select equipment that will operate autonomously in an infrastructured workplace while also assisting in helping meet production requirements.

Omnirobotic also launched Autonomy Studio™, defined as a "shape-to-motion technology" that enables manufacturers and integrators to build their own autonomous systems with AutonomyOS™.

This unlocks a vast venue of robotic independence across new industries, including aerospace and commercial aviation.

Relevant IP
Only one patent found

References
1. www.qualitymag.com/articles
2. www.linkedin.com/company
3. www.zoominfo.com/c/omnirobotic/
4. www.youtube.com/watch

About the Authors

Sofiane Boukhalfa, PhD

Technical Director, PreScouter

Sofiane leads the high-tech, aerospace & defense, and automotive & logistics practices at PreScouter. For nearly a decade, he has worked with hundreds of F500 and G1000 clients across multiple industries, through which he has developed expertise in key emerging technologies (such as 5G, IoT, AI/ML, blockchain, energy storage and generation, quantum sensing, and others) and a strong understanding of the associated business ecosystem and drivers pushing these sectors forward (e.g., key players and trends, roadblocks to commercialization, etc.). Sofiane's strategic insights have ranged from technical due diligence for acquisition targets to identifying relevant markets for newly developed products based on emerging technologies and assessing market penetration strategies. Sofiane holds a Ph.D. in Materials Science and Engineering from the Georgia Institute of Technology, where his research focused on nanotechnology and energy storage.

Jorge Hurtado

Researcher

Jorge has a broad interest in sustainability and development issues that can generate positive changes in the lives of local communities. He is also involved in communicating science to specialized and general audiences, and still diverges most of his efforts to work with indigenous communities and volunteers to teach kids the importance of keeping in touch with nature.

Lucas Pissolati, MsC

Technical Writer, PreScouter

Lucas is currently finishing his Master's degree in Autonomous Vehicle Control Engineering at the Budapest University of Technology and Economics. He holds a bachelor's degree in Mechatronics Engineering, and a part of it was in an exchange program in Robotics Engineering at Algonquin College, Canada. Throughout his academic and professional life, he was able to work on different engineering projects, from the automotive industry to highly automated vehicles` V2X communication cybersecurity, from quantum applied physics to renewable energy research, from mechatronics robots to AI/ML 3D object detection in real-time projects. Furthermore, Lucas speaks 5 languages so far and is enthusiastic about acquiring knowledge from different backgrounds.

Potential Next Steps

PreScouter can conduct anonymous interviews with companies profiled to help you learn more about their technologies, processes, and partnership potential.

PreScouter can identify the intellectual property position of these players and understand patent trend evolution.

PreScouter can identify additional suppliers located in specific regions to source products and other services.

Other reports from PreScouter that you might like

Lightweighting in the Aerospace & Defense Sector

Hydrogen-Based Energy Adoption in Aviation

An Overview of Drone & EVTOL Regulations

Engage our network of experts and researchers on your topic.

CONTACT US HERE

About PreScouter

PRESCOUTER PROVIDES CUSTOMIZED RESEARCH AND ANALYSIS

PreScouter helps clients gain competitive advantage by providing customized global research. We act as an extension to your in-house research and business data teams to provide you with a holistic view of trends, technologies, and markets.

Our model leverages a network of 4,000+ advanced degree researchers, industrial experts, engineers, and analysts across the globe to tap into information from small businesses, national labs, markets, universities, patents, startups, and entrepreneurs.

CLIENTS RELY ON US FOR:

Innovation Discovery: PreScouter provides clients with a constant flow of high-value opportunities and ideas by keeping you up to date on new and emerging technologies and businesses.

Privileged Information: PreScouter interviews innovators to uncover emerging trends and non-public information.

Customized Insights: PreScouter finds and makes sense of technology and market information to help you make informed decisions.

500+ CLIENTS WORLDWIDE

5,000+ RESEARCH REPORTS CREATED

150,000+ HOURS OF RESEARCH COMPLETED FOR CLIENTS