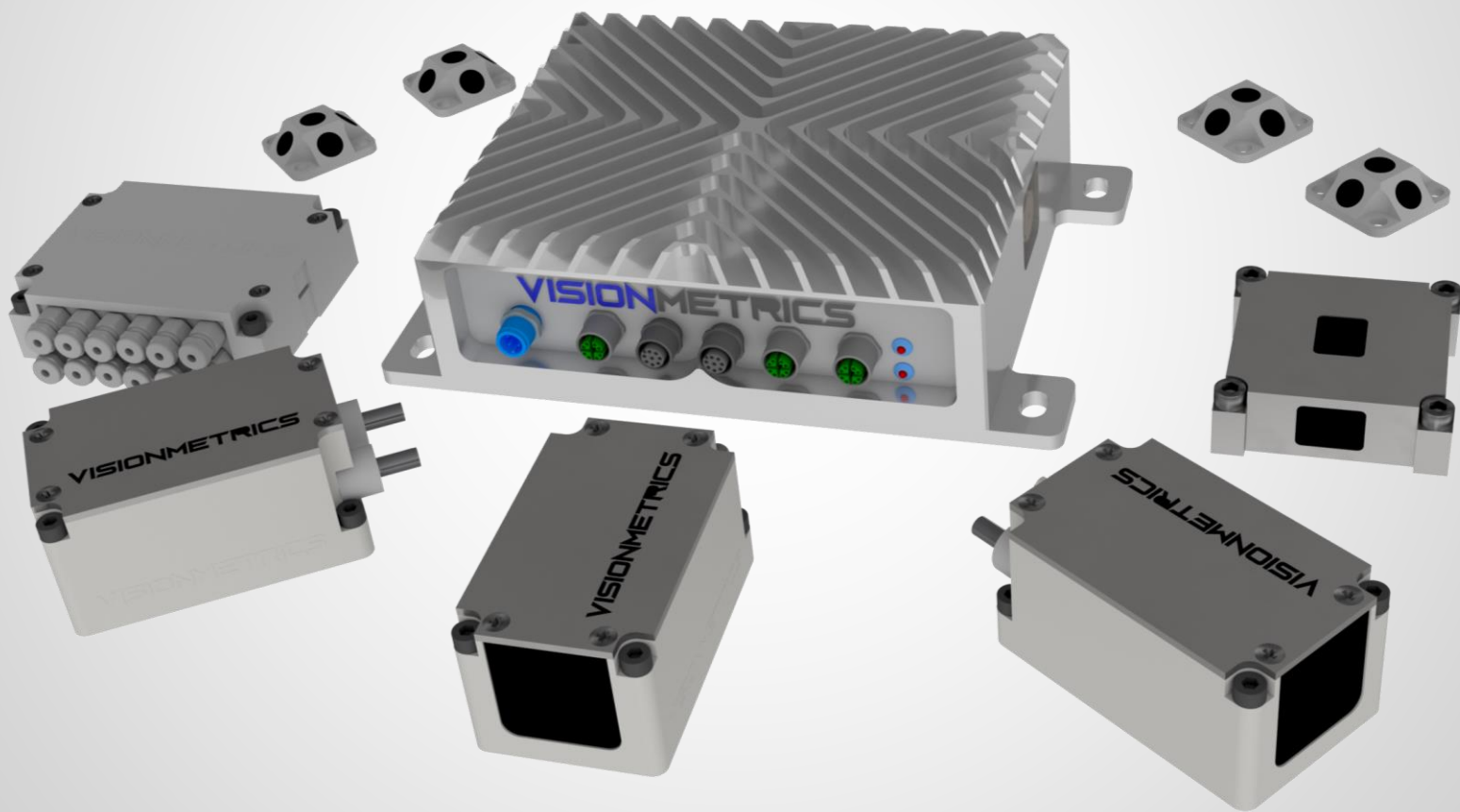


# **Next Generation automated 3D Measurement and Control System**



## **Typical Applications:**

- High demanding construction machinery systems
- Factory automation
- Indoor vehicle control automation
- Robotic control systems
- High accuracy and high-speed 3D measurement systems



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## Introduction

The VisionMetrics 3DMS is an artificial intelligence based metrology system, built to provide the most flexibility to the highest demanding measurement and control applications. Reliability and robustness to external influencing factors while maintaining a high accuracy are the most challenging design aspects for 3D metrology. Starting from a mechanically rugged and IP67-proof design, the VisionMetrics software-framework extensively continues this path of reliability and builds on years of research in AI-based error correction for hybrid-optical systems. A german patent is filed for the underlying technological approach.

All together this yields the VisionMetrics 3DMS to be the the most advanced and most flexible 3D-Measurement system for high demanding application on the market.

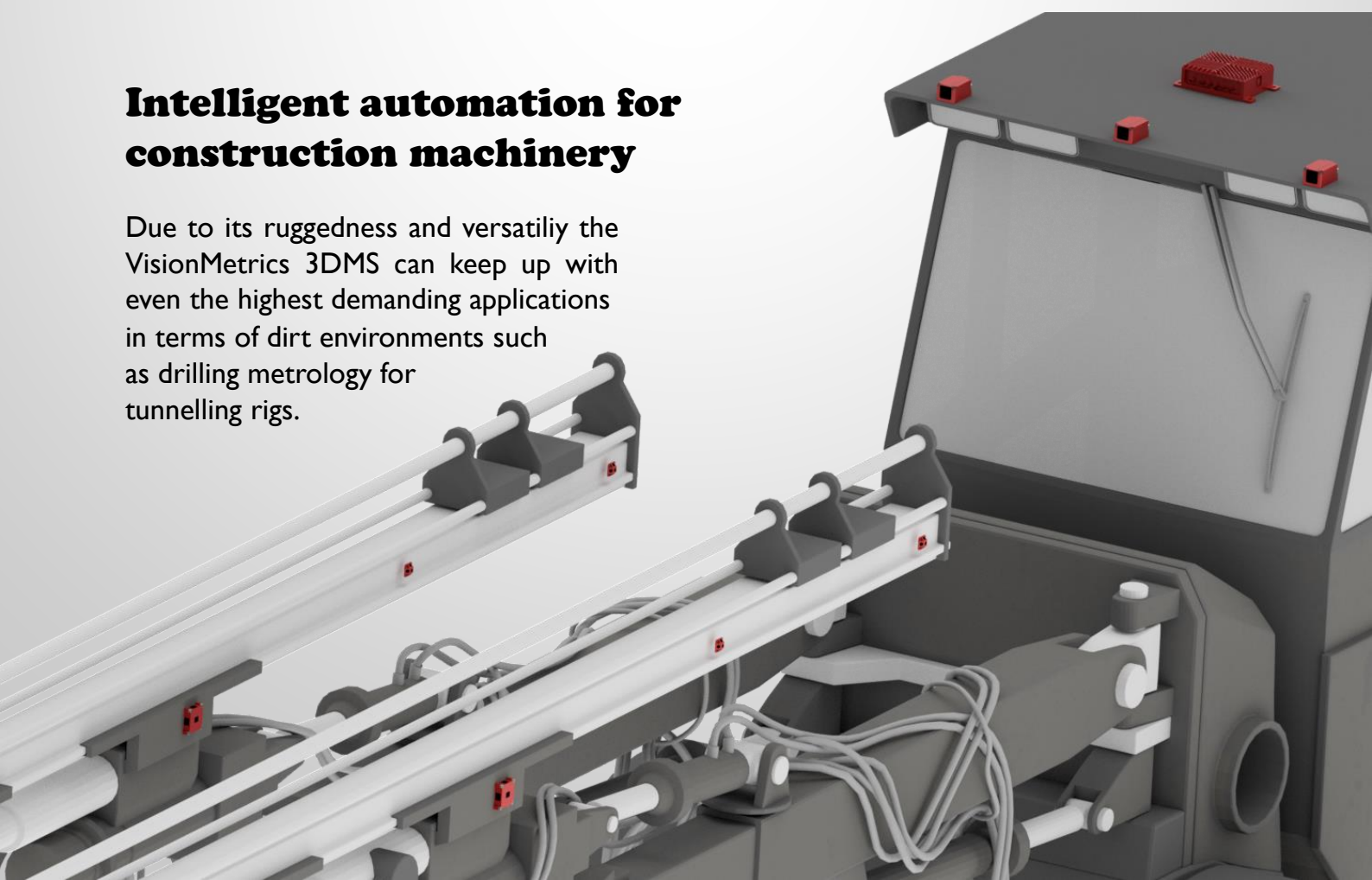
Typical applications like positioning systems on construction machinery and robotic control systems, having multiple axes and multiple degrees of freedom, mostly equipped with mechanical encoders and angular transformers suffer from inaccuracies and high maintenance-costs, especially when deployed in rough environmental conditions.

The VisionMetrics 3DMS system provides a solution for a seamless integration for contactless measurement and control, while achieving a high accuracy (exact accuracy level see below), boosting productivity and lowering the maintainance cost for the metrology system near to zero.

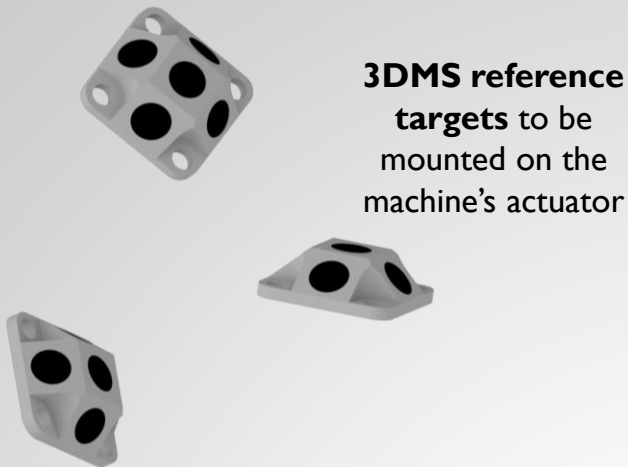
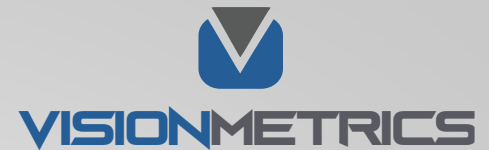
The 3DMS is built to provide a modular and extendable hardware and software toolbox for every kind of machinery.

## Intelligent automation for construction machinery

Due to its ruggedness and versatiliy the VisionMetrics 3DMS can keep up with even the highest demanding applications in terms of dirt environments such as drilling metrology for tunnelling rigs.



## Modular Concept



**3DMS reference targets** to be mounted on the machine's actuator

**3DMS sensors / SmartCameras** mounted on the machine's fixed part



The VisionMetrics 3DMS platform is built to be versatile and can be used on any type of machine due to its modular concept. Depending on the complexity of the machine, a variable amount of sensors can be mounted and configured on the machine. The sensors integrate a high precision optical measurement system, a real-time AI computing system and real-time communication interface into a construction-proof design and at industry-leading compact dimensions of less than 100x60x50 millimeters for space-limited applications.



Robust stainless steel reference targets, fixed on the moving parts of the machine are designed to be mounted in several versions, depending on the machine's geometry. A modular set of active reference targets guarantees a seamless integration into any kind of actuator at a negligible consumption of space and/or influence on the actuator's operation (a diameter of just 10mm for each reference target is required). Some types of reference targets can be countersunk into a machine's surface to lower the risk of mechanical damage even more. An easy mounting method allows screwing and welding options onto critical actuators.





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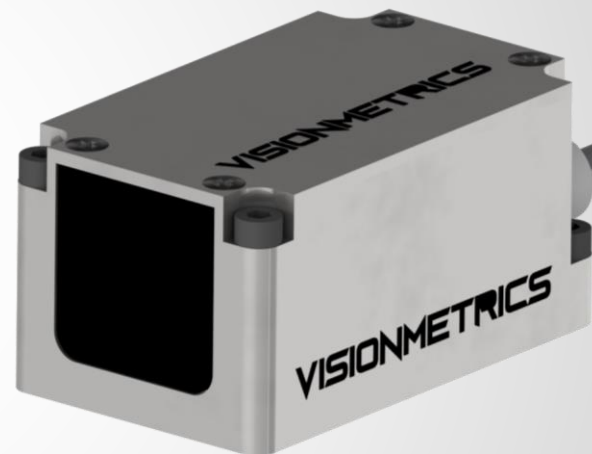
## **Designed to maximize the performance of autonomous systems**

The VisionMetrics 3DMS platform can be equipped with several other hardware- and software modules in order to seamlessly extend to a fully autonomous system.

Starting from a robust and reliable measurement system for positioning and movement control, application-specific software-modules for autonomous control-strategies can be added on an additional layer along with application-specific sensor-processing.

Depending on the design-requirements of the measurement and control system for an autonomous machine, the platform can be extended with several technologies which will seamlessly integrate into the real-time framework. The support for integrated application-specific sensing technologies is continuously extended and currently includes support for:

- Radar/Lidar sensing for collision detection
- Depth sensing using time-of-flight cameras
- Depth sensing using projected laser matrices and cameras
- Human/Animal presence and movement detection (Visible + Night Vision + thermal imaging)
- Model based collision prediction (Visible + Night Vision)
- High accuracy and high dynamics rugged tilt and rotation sensing to deploy in high demanding environments
- Automated precision convergence metering
- Real-time machine-to-machine wireless communication
- Machine-to-Cloud monitoring gateways using Long-Range Wireless and 3G / 4G







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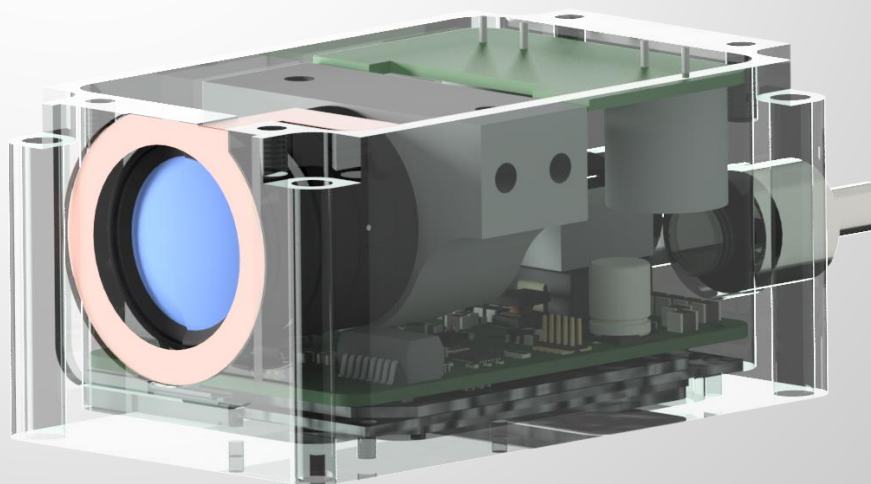
## VisionMetrics hardware module description - Part 1

### VisionMetrics SmartCamera

The VisionMetrics SmartCamera is the industry's first ruggedized and configurable camera system for precision-metering and safety-applications which includes a **real-time communication interface** based on EtherCAT and a **high-power graphics processor unit** to directly perform on-camera-measurements and run powerful artificial intelligence algorithms. The ruggedized optical system is designed to meet tight tolerances for high-performance metrology. Having a powerful AI-processor directly attached to the system enables the applications to operate at much higher data-rates, as the high bandwidth datastream from the camera can be processed directly and does not need to be transported to a processing computer through a semi-reliable high-speed transport-layer.

This special structure enables the use of high-resolution and high-framerate sensors. Combining with the intelligent on-system real-time communication interface, multiple SmartCameras can be easily expanded to an intelligent, distributed and synchronized camera-system for metrology and safety-applications, deployable in any environment.

An integrated synchronized high power infrared flashlight and an integrated tilt- and movement sensing module enable an even wider range of applications, including night-vision systems, passive retroreflective targets for high-accuracy applications and on-system stability monitoring.





## **VisionMetrics hardware module description - Part 2**

### **VisionMetrics active and passive targets**

In order to measure machine's coordinates, special marker points are mounted on the machine. The usable markers are highly customizable according to the space- and position limitations on the machine. Precision markers are named targets in the terminology of the VisionMetrics 3DMS platform.

Depending on the requirements of the application either active or passive targets can be used for accurately measure actuators and machine's coordinates.

**Active targets** are actively emitting ultra-short light pulses in a desired wavelength spectrum to be detected by the camera sensors. These active targets require a driver control unit, which operates synchronously to the sensing camera-network.

The biggest advantage of active targets is their robustness to pollution and dusty environments, as the signal-to-noise ratio can be kept on a high level due to their light-emitting property.

Another big advantage is their ability to place markers within almost any restricted space, as this type of target can be customized and integrated on a very small footprint. Even special targets which are fully-countersunk into the machine's surface are available, for a maximum level of ruggedness against mechanical stress.

Active targets are mainly used within higher-speed autonomous applications.

**Passive targets** are built using a special retroreflective material in combination with an application-dependent mounting structure. This type of target is built to operate without any cable connection and it is mostly used for precision measurements.

An infrared flashlight source is used to beam light towards the passive retroreflector targets.

By sensing the returned light from the passive targets, their position and orientation can be calculated similarly to active targets.

Passive targets are mainly used for higher-accuracy systems and for mobile vehicle sensing applications at moderate speed requirements.





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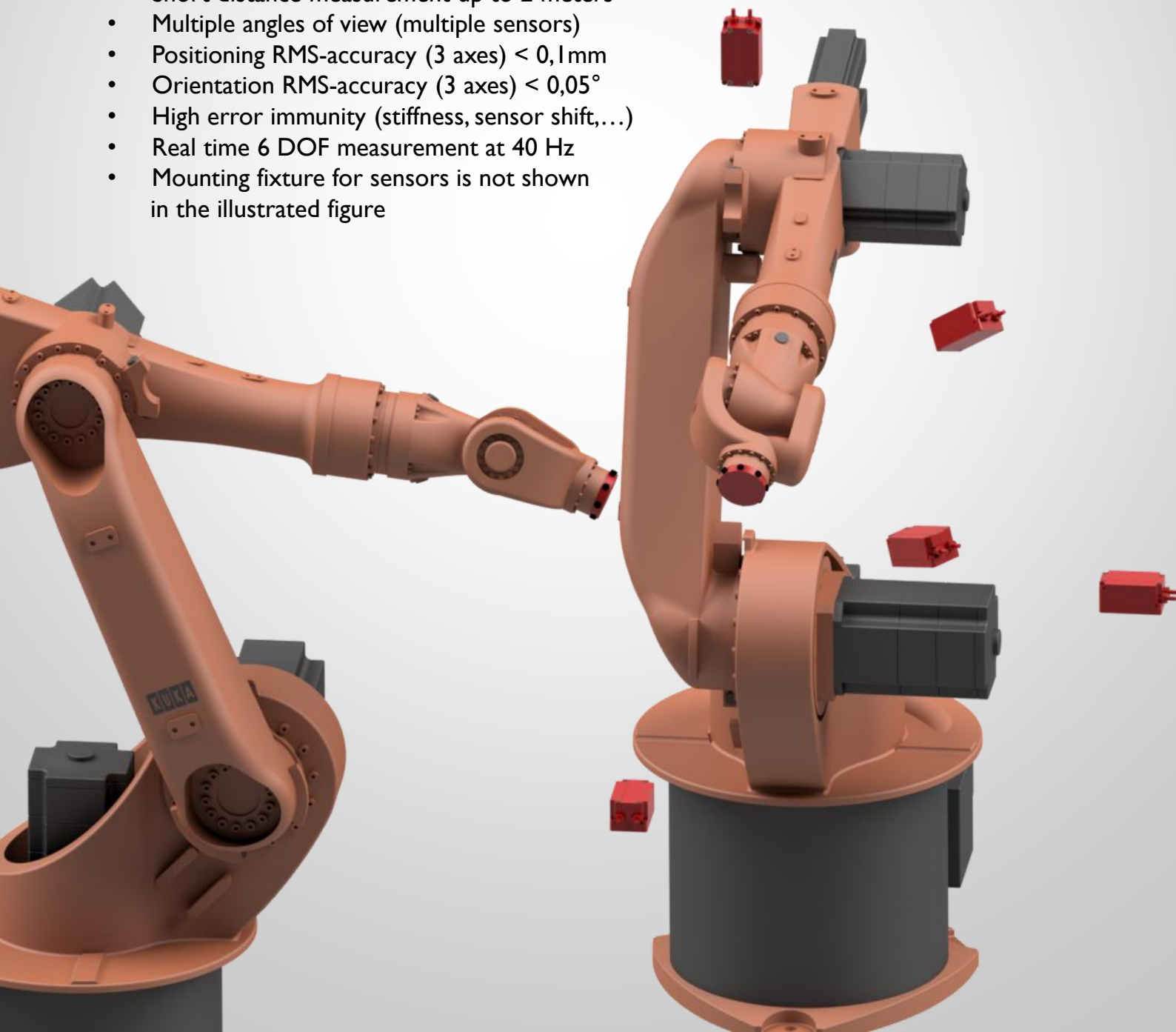
## Performance in six Degrees of Freedom

The VisionMetrics 3DMS platform is a measurement system able to measure six degrees of freedom of any given part. This includes 3-axis position sensing and 3-axis orientation sensing, referred to any fixed coordinate system.

The definition of accuracy is highly linked with the application-specific geometry of the machine to be equipped with contactless measurement technology. In the particular case of the VisionMetrics 3DMS, the achievable accuracy highly depends on the variety of viewing angles onto the moving parts/machines/vehicles.

### Example 1 : Collaborating robots with contactless control

- Real-time measurement of multiple robot actuators in the same coordinate system
- Short distance measurement up to 2 meters
- Multiple angles of view (multiple sensors)
- Positioning RMS-accuracy (3 axes)  $< 0,1\text{mm}$
- Orientation RMS-accuracy (3 axes)  $< 0,05^\circ$
- High error immunity (stiffness, sensor shift,...)
- Real time 6 DOF measurement at 40 Hz
- Mounting fixture for sensors is not shown in the illustrated figure



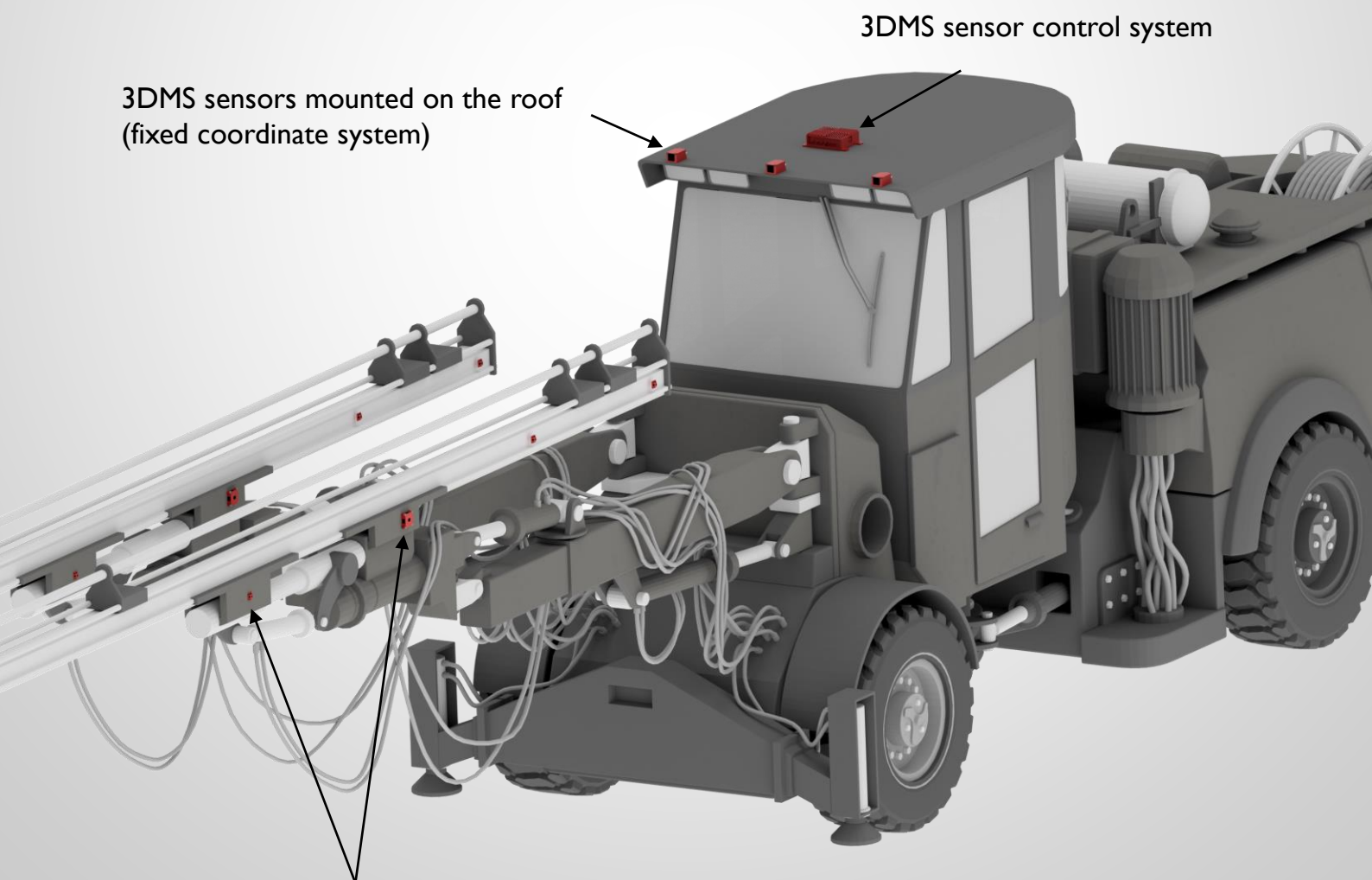


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## Performance in six Degrees of Freedom

### Example 2 : Underground Construction drill rig

- Multiple moving and rotating carriages equipped with drill hammers
- Limited viewing angles due to limited mounting possibility
- Seamless reference target integration into the surface of the carriages
- Accurate drill positioning of 1cm at a drill face distance of 10m
- Very impact-resistant and robust to concrete pollution and dust
- Concrete-coverage warning system for the targets and for the whole carriage
- Easy to install and to maintain
- Real time 6 DOF measurement of multiple carriages at 40 Hz
- 360° human and collision detection interface for safety
- Carriage-to-carriage collision detection system



3DMS sensor control system

3DMS sensors mounted on the roof  
(fixed coordinate system)

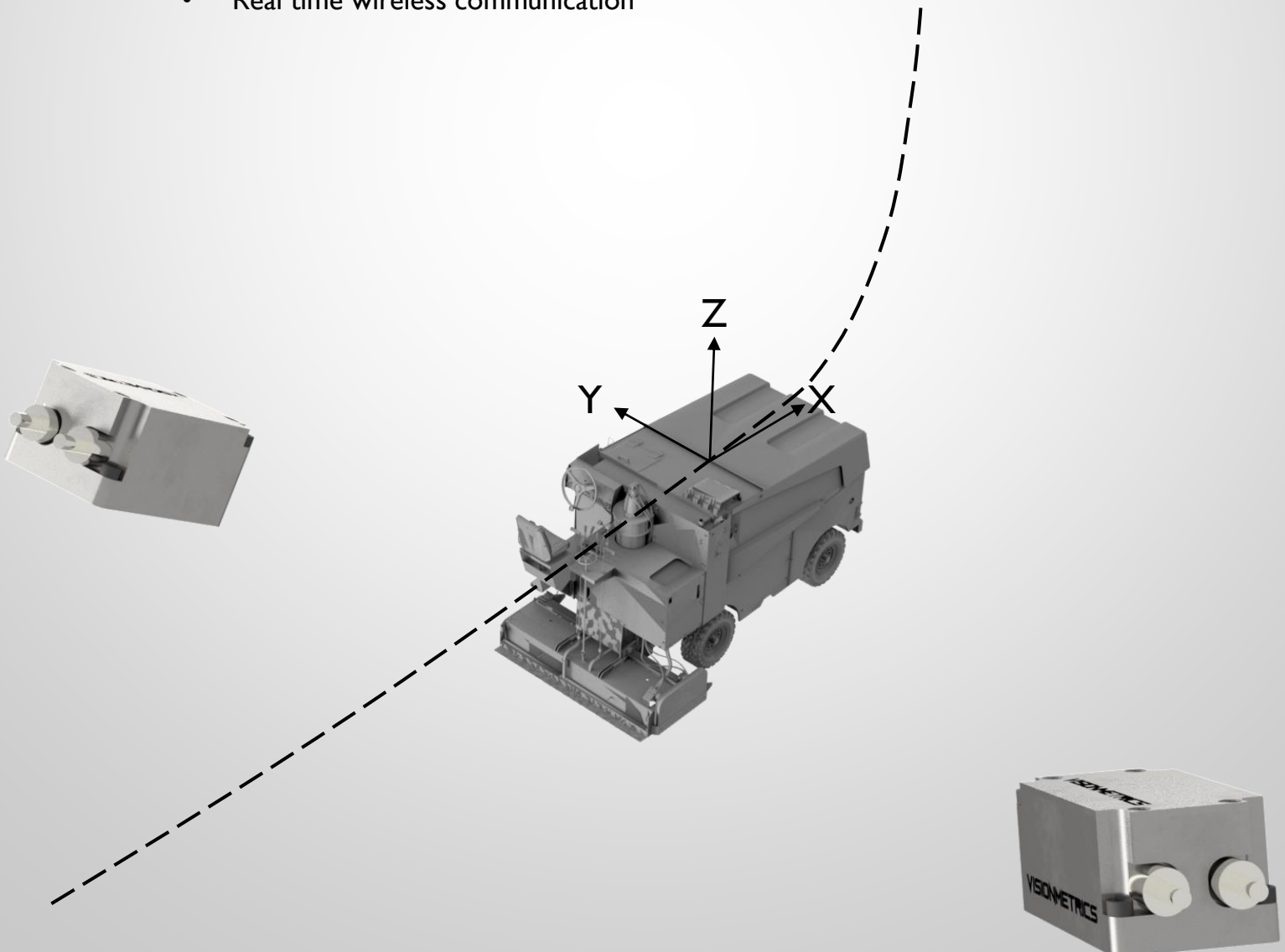
3DMS targets on multiple steered  
carriages equipped with drill hammers



# Performance in six Degrees of Freedom

## Example 3 : Driverless machine position and trajectory control

- Machinery equipped with reference targets for accurate position and trajectory control
- This example shows an autonomous ice filling machine within an ice arena
- Multiple sensors mounted on the walls inside of the ice arena
- Absolute positioning accuracy of 1 cm over an area of 2000m<sup>2</sup>
- Absolute orientation accuracy of 0,2° over an area of 2000m<sup>2</sup>
- Extra features:
  - Trajectory controlled autonomous driving
  - Equipped with additional sensing features such as Radar/Lidar-collision sensing, Time-Of-Flight sensing and human/animal detection interfaces
  - Real time wireless communication





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## **Artificial Intelligence driven Robustness and Accuracy**

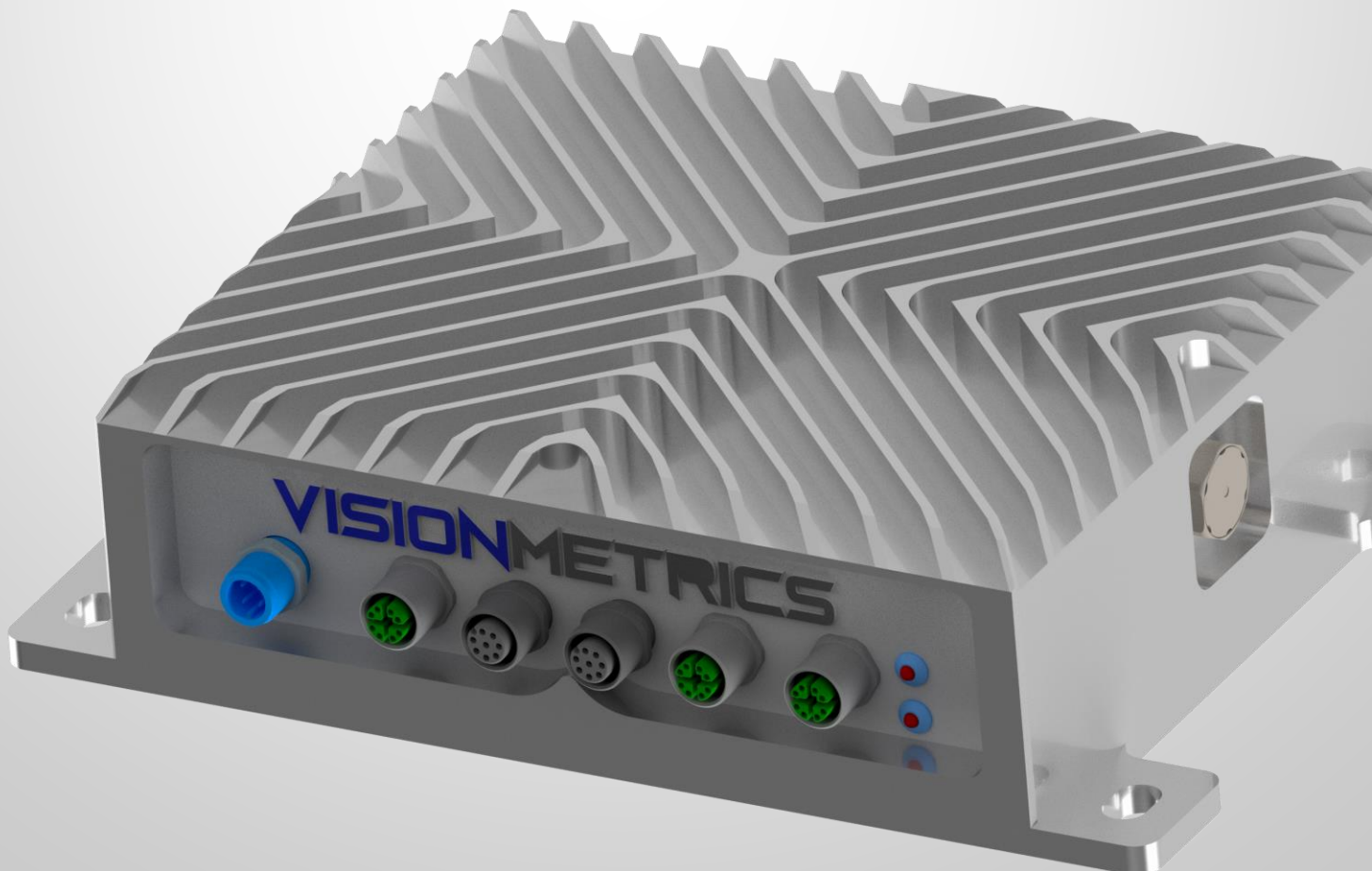
The built-in error correction and self-calibration mechanisms lead to an Industry-leading measurement stability under very demanding environmental conditions. Thanks to artificial intelligence and years of research in this field, contactless autonomous optical measurement systems are able to compete within a high demanding field.

## **Future proof technology and flexibility**

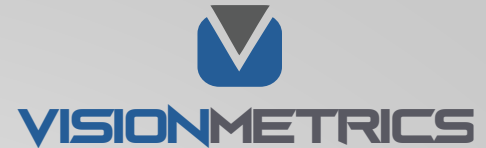
VisionMetric's Smart Sensor Technology platform enables On-Sensor calculation for the most demanding optical measurement operation. The underlying innovative real-time sensor network connects multiple sensors and allows an infinite flexibility in terms of extending the field of view to achieve a great overall-performance.

Sensor networks can be built from one single sensor in combination with one single reference target. Its highly scalable structure allows the combination of up to 1000 collaborating sensors, e.g. for factory automation of a whole manufacturing shop-floor.

This makes the VisionMetrics 3DMS the most flexible measurement system on the market, available at a very competitive price.



## **Adjustable and flexible metrology**



The VisionMetrics 3DMS sensors, as well as the reference targets can be adjusted to the geometry of the machinery in an easy and fast manner.

Typical variations due to geometry changes are:

- Viewing angle of the sensors
- Protection features of the components
- Mounting options of the reference targets
- Safety-Sensor integration onto the machine

The sensor network can be easily expanded with additional sensors such as collision detection radar systems or human/animal detection interfaces. The integration of additional sensors works seamlessly.

To realize an integration into a superordinate control system the VisionMetrics 3DMS is equipped with the following interfacing standards:

- CAN 2.0b
- EtherCAT
- Modbus (TCP)
- RS232
- RS422

VisionMetrics provides a customizable visualizing solution to be connected to the VisionMetrics 3DMS platform to generate a direct output over some standardized output terminal (e.g. computer screen, tablet,...)

For any additional information, pricing, feature integration and inquiry regarding applications of the VisionMetrics 3DMS platform please contact:

[info@vision-metrics.de](mailto:info@vision-metrics.de)