

Moisture-Sense

Inline moisture analysis

INLINE MOISTURE MONITORING

Why inline moisture measurements?

Moisture content is a key quality parameter for numerous products in the food, pharmaceutical, and chemical industry. Moisture testing ranges from checking the incoming raw materials and in-process intermediate products, to finished products which need to comply with the legal requirements. Moreover, flowability, stability of various products as well as microbiological contamination strongly depend on the moisture content. When not well regulated, the material cannot longer be used or sold.

As the production process is very complex and can be influenced by various process parameters and raw material variability, it is not possible to have a constant moisture content with fixed production settings. The current quality control requires trained personnel and takes 20-30 minutes before the results are known. This approach makes it impossible to adjust the production process in real time. Therefore, an inline moisture sensor providing split-second real-time feedback makes a big difference.

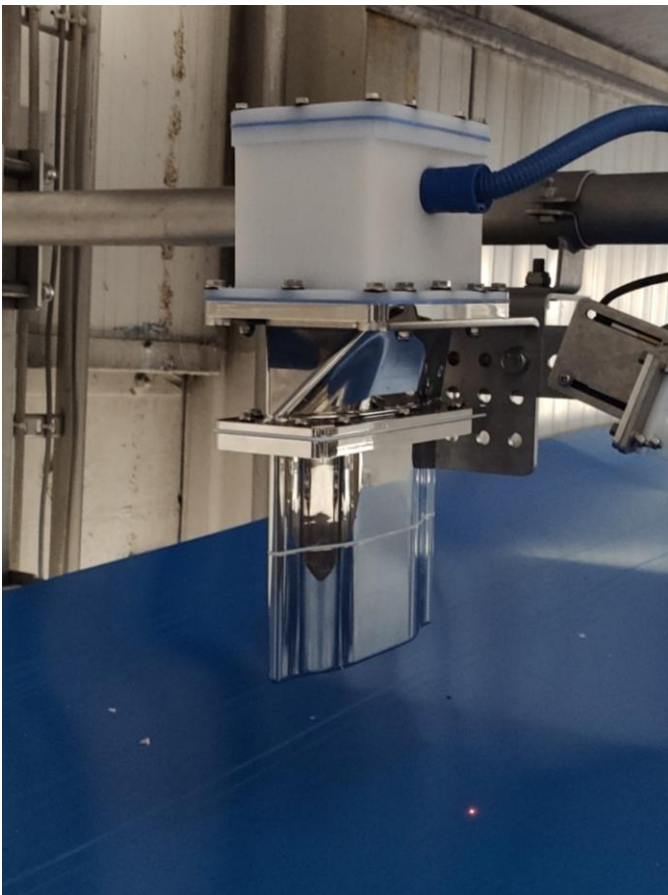


Figure 1: Installed Moisture-Sense sensor for industrial food applications.

Moisture-Sense

Aquantis offers an inline moisture solution - **Moisture-Sense** - based on microwave technology to track the moisture levels for various products and production processes in real time.

The Moisture-Sense sensor emits very low-power microwaves. These electromagnetic waves can easily travel through various materials and are not affected by opacity and color. As the waves penetrate through the product, the water absorbs a part of the energy. The energy loss as a result of the moisture content is further processed to determine the moisture content of the product. Newly developed algorithms ensure high accuracy over a large moisture range.

The Moisture-Sense conducts bulk measurements which allows it to handle heterogeneous products. Furthermore, surface treatments or coatings do not affect the measurements. The Moisture-Sense comes in various versions and can be customized depending on the type of application or process.

Applicable to various products



Food & Nutrition

- French fries & potato-related products
- Chips
- Tacos
- Dried fruit & vegetables
- Alternative proteins
- Coffee
- Grains
- Rice
- Seeds
- Spices



Pharmaceuticals

- Tablets
- Capsules
- Granules
- Lyophilized products



Chemicals

- Detergents
- Cellulose
- Recycled paper & pulp
- Plastic pellets,
- Biofuels

BENEFITS OF INLINE VS. LAB QUALITY CONTROL

The limitation of loss on drying methods

Thermogravimetric measurements are frequently used for moisture content analysis. These methods are based on change of weight by heating the sample via either halogen/infrared lamp or oven method. The sample weight before and after the water removal gives a fair estimation on moisture content determination. The main limitations include:

1. The time it takes for such a measurement usually exceeds 20 minutes which makes it impossible to adjust the process parameters in real time.
2. A typical production line usually produces a few hundred kgs to many tons per hour. It is close to impossible to have a sample of a few grams which is sufficiently representative to such large volume. Variations in small samples can overpower the accuracy of all the analytical techniques.
3. Manual handling of the samples can introduce additional errors. Differences between operators can affect consistent quality control.

Moisture-Sense: inline moisture

By continuously monitoring the moisture levels, it is possible to follow up this product parameter in **real-time**. The moisture content continuously changes with different production steps and used materials. Installing inline moisture sensors in the production facility provides real-time feedback to the industrial equipment. Any deviations in the process can be immediately corrected preventing product waste or even loss of the entire batch.

Inline measurements no longer require sampling and sample preparation of the product. Removing this intermediate step results in saving time, costs and eliminating manual errors. The Moisture-Sense sensors provide a massive amount of data which allows to optimize the processes for every specific product.

The Moisture-Sense drives further digitalization of industrial production of the food, pharma and chemical industry. Process variations are minimized and corrected if necessary. This system allows automated and data-driven allocation and optimization of your resources reducing errors, time and costs. **Industry 4.0 flat out.**

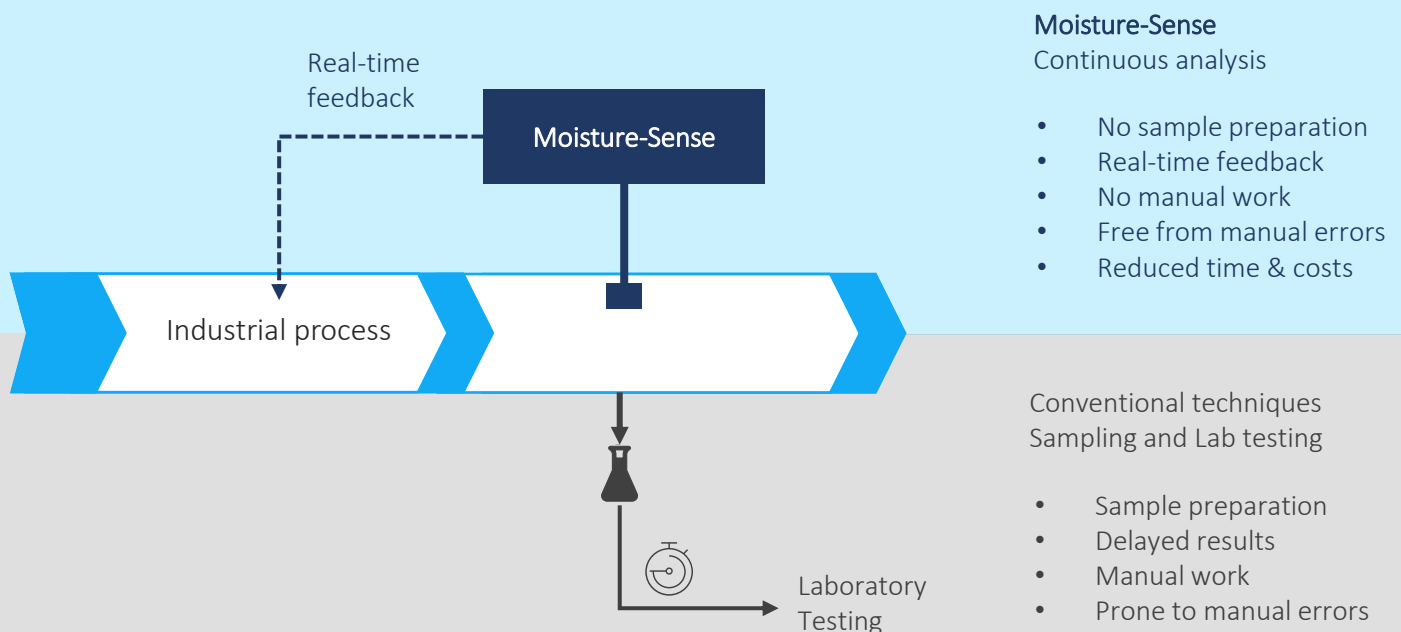


Figure 2: Benefits of the Aquantis sensors over the conventional techniques to monitor moisture – dry matter.

BENEFITS OF BULK OVER SURFACE MEASUREMENTS

NIR spectroscopy: surface measurements

Near infrared (NIR) spectroscopy is a very versatile technology that is suitable for the moisture detection of thin and small products. However, the penetration depth of such measurements is limited (0.1 – 0.2 mm). This is problematic for larger particles with a more heterogeneous moisture distribution (Figure 3). Consequently, it is physically impossible to measure a representative moisture content with this type of technologies

One example is moisture measurements during drying processes by which the outside of the products dries more than the core. Studies indicated obtaining a homogeneous water distribution within certain products can take several weeks up to a few months. In case the water distribution in the products is always the same, NIR measurements could be used to some extent. But this is mostly not the case.

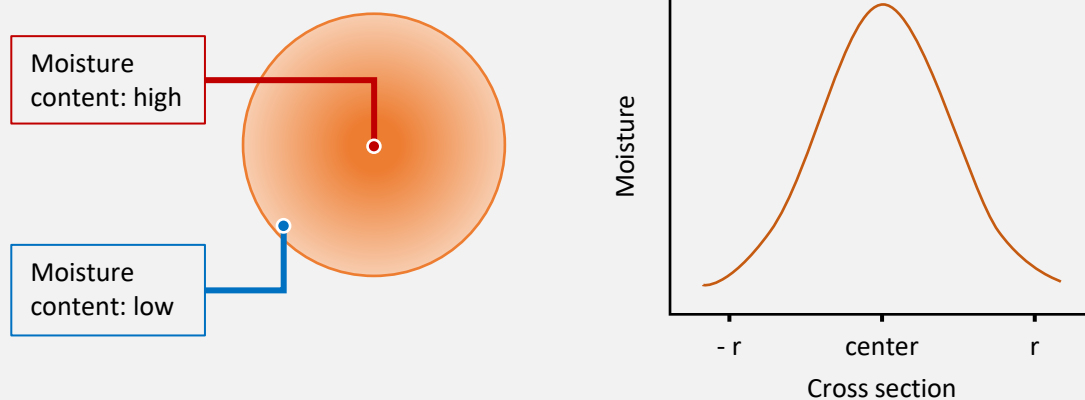


Figure 3: Cross section of a particle with a radius r indicating the heterogeneous moisture distribution.

Moisture-Sense: bulk measurements

In contrast to NIR technology which is limited to surface measurements, the Moisture-Sense measures a volume of the bulk material. The low-power microwaves travel from the transmitter (Tx) to the receiver (Rx) measuring the moisture over a large volume.

By measuring over a large volume, variations in moisture distribution are averaged out and don't affect the moisture measurements. Consequently, microwave-based sensors allow to measure over larger and more heterogeneous products accurately.

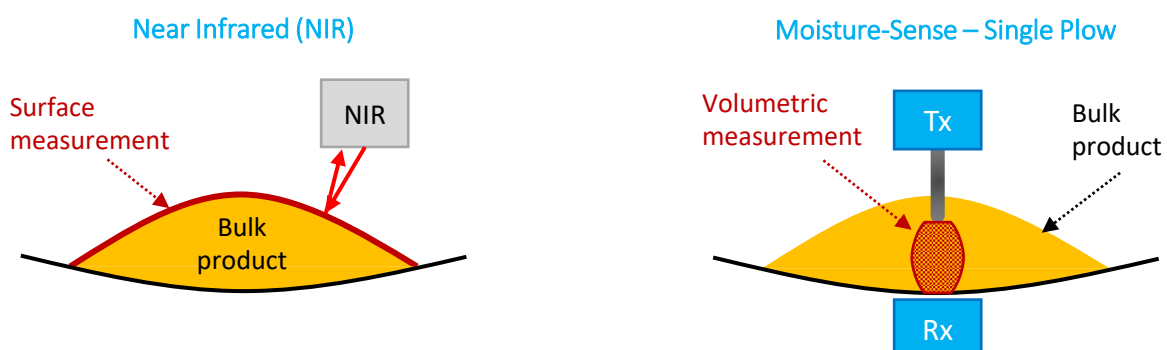


Figure 4: Cross section of bulk products on a conveyor belt for NIR and Moisture-Sense measurements.

OPTIMIZING DRYING PROCESSES

Avoiding excess drying

Without inline monitoring of the moisture content, it is likely that drying processes are ran much longer than needed. The delay with sampling and lab analysis results in loosing valuable time and resources. Moreover, the characteristics of the products might be affected impacting the overall quality.

Continuous moisture measurements during drying allows to finish the process when the targets are reached. This way, excessive drying can be avoided which further helps to allocate time and resources more effectively.

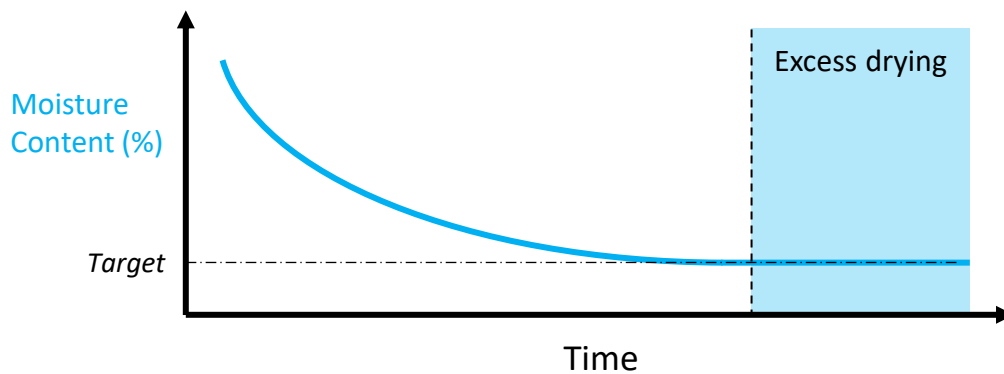


Figure 5: Change in moisture content during drying processes.

Case study: Dry matter in French fries

The Moisture-Sense has been used for inline moisture or dry matter monitoring of French fries. During the production, the dry matter contents were compared to the thermogravimetric method. The results show large variations between the samples up to 2%. This indicates that samples are not representative for bulk of the material.

The bulk measurements of the Moisture-Sense provide more stable data. Figure 6 shows a clear upward trend until the target is reached. This real-time information allows the operator to immediately alter the dryer settings to achieve consistent moisture levels throughout the production.

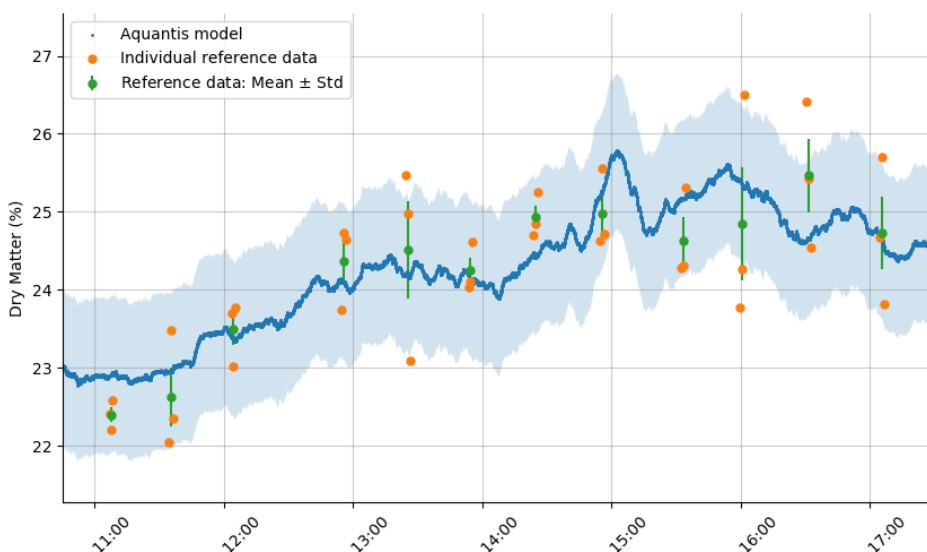


Figure 6: Dry matter measurements using the Moisture-Sense (blue curve \pm 1% blue shadow) and reference measurements using thermogravimetric method (Halogen lamp). The orange dots represent the individual thermogravimetric measurements, and the green dots are the corresponding means \pm standard deviation.

WEB INTERFACE AND NETWORK COMMUNICATION

The web interface is used to visualize the processed data and manage the device settings for the different type of products.

The software supports Modbus TCP/IP communication to integrate the data in the used SCADA systems. Other communication protocols can be foreseen.

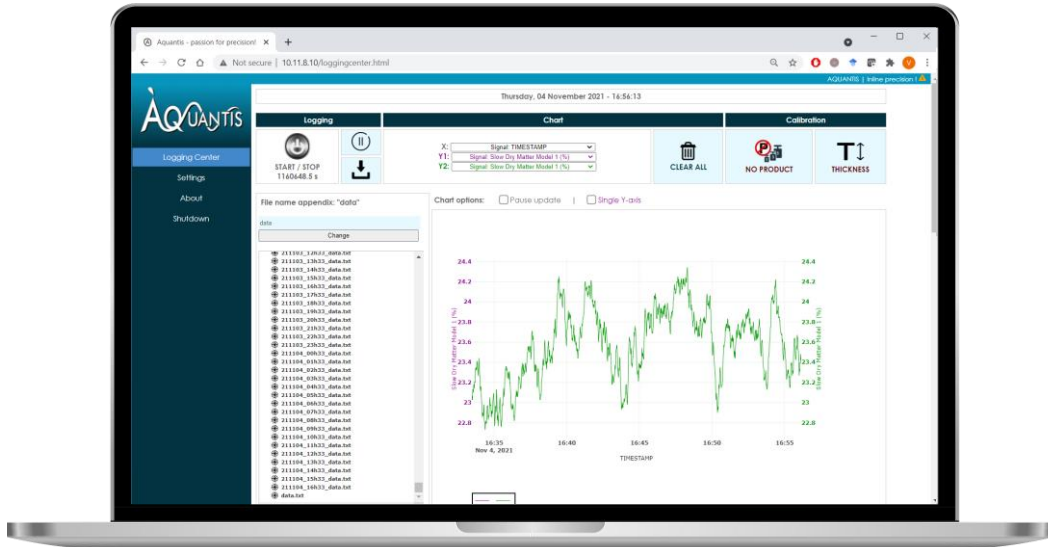


Figure 7: The web interface of the Moisture-Sense.

INTEGRATED PROCESS CONTROL

The Moisture-Sense is a part of the Aquantis inline sensor series for various industries. While the Moisture-Sense provides the moisture level, the MICROFREEZE® monitors how much of the water is frozen indicating the quality of the freezing process.

The collected data after every production step can be consulted via the Aquantis web interface or a SCADA system. Combining multiple inline sensors after various processes provides a powerful tool to steer and coordinate the different production steps to maximize efficiency.

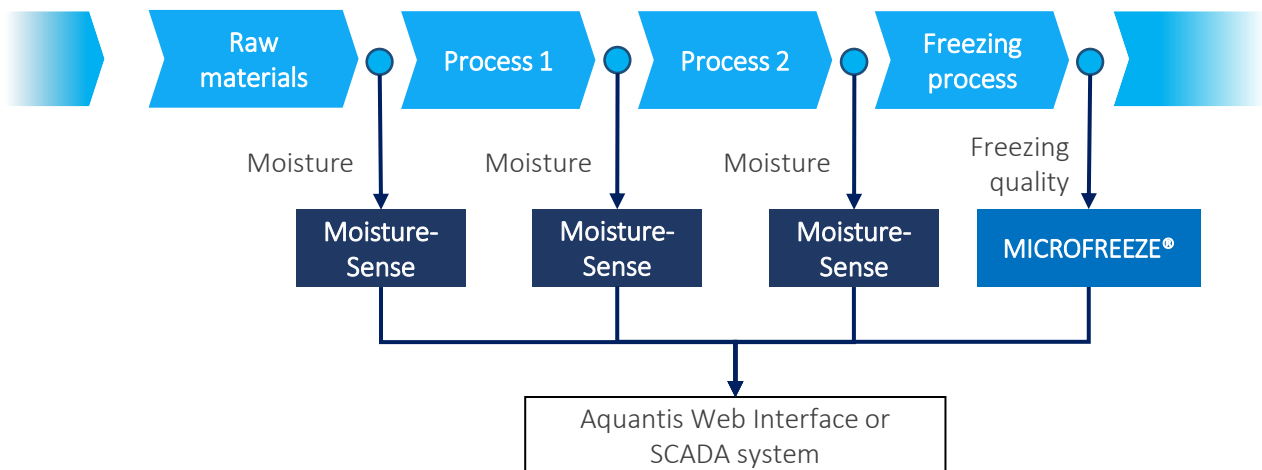


Figure 8: Aquantis inline sensors at different production steps of French Fries.

MAIN FEATURES

Our inline technology has various benefits compared to conventional methods:

- **High penetration:** The microwaves emitted by the Moisture-Sense penetrates the entire product layer. This guarantees that both the surface and the core of the products are measured
- **Non-stop dry matter readout:** The Moisture-Sense performs 500 measurements/sec on a 24/7 basis. This gives non-stop, real time measurement results on the moisture content.
- **Representative measurement:** The volumetric measurements averages variations of individual products within the layer providing representative measurements. Based on received signal the moisture level is calculated.
- **Non-destructive measurements:** The power of the used electromagnetic waves are very low and consequently do not affect measured product in any matter.

TECHNICAL SPECIFICATIONS

Item	Moisture-Sense
Sensing Technology	Microwave technology
Measuring range moisture	0 - 100% *
Sampling rate	500 Hz
Field frequency	ISM frequency bands
Transmitted power	~1 dBm (~1.25 mW)
Housing	Stainless steel AISI 304 - Hygienic design
IP class	IP66
Dimensions transmitter unit (W x H x D)	210mm x 350 mm x 130 mm **
Dimensions receiver unit (W x H x D)	177 mm x 187 mm x 178 mm **
Dimensions computing unit (W x H x D)	390 mm x 794 mm x 268 mm **
Operational temperature range	-40 °C to 50 °C
Data connection	Ethernet RJ45 plug
Industrial interface	Modbus TCP/IP server
User interface	Web-based user interface

Table 2: Technical specifications of the Moisture-sense.

* Less than 1 % is also possible depending on product and measurement conditions.

** Dimensions can change depending on the application.

FURTHER CUSTOMIZATION IS ALSO POSSIBLE

Aquantis also provides **customized sensor solutions** tailored to the individual needs of a customer. Further customizations of Moisture-sense are possible to fit the application(s)-dependent needs. Each of your requirements will be evaluated by conducting different study to ensure our technological solutions fulfill your needs.

If the outcome is satisfactory, the technical specifications for the inline solution will be determined in collaboration with the customer. On-site validation will be conducted to prove technological benefits. The final step includes the delivery of the inline customized solution which is integrated in the production process.

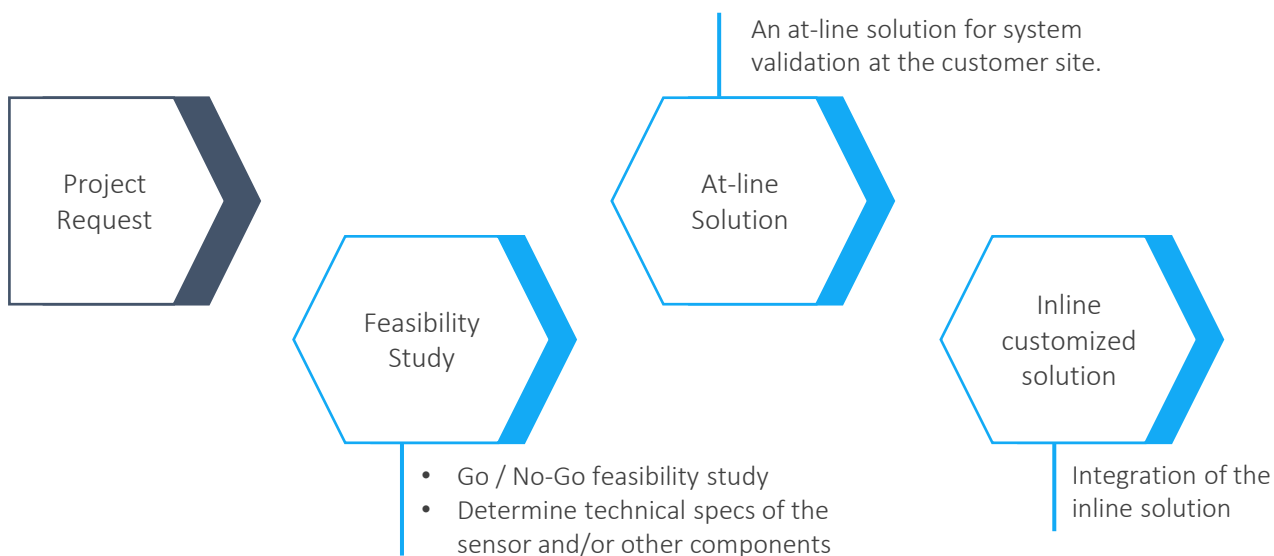


Figure 9: Project-based approach for inline customized solutions.

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