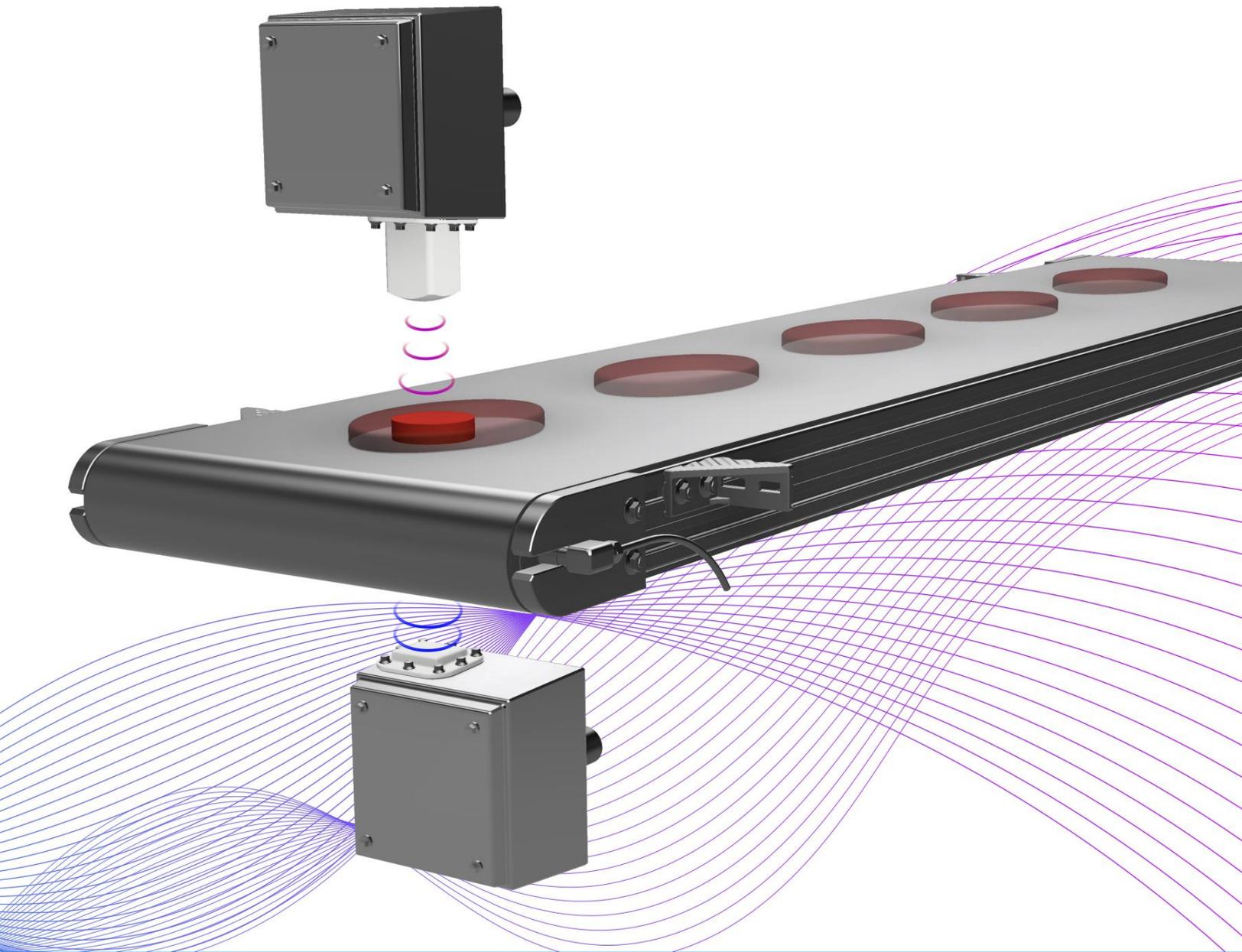


AQUANTIS

Inline Measurement Solutions



CALLIFREEZE®

Inline freezing monitoring

INLINE FREEZING MONITORING

Why the need for inline freezing sensors?

Food safety, minimal operating costs and sustainability are key challenges for industrial food processors. Increasing energy costs associated with freezing processes challenge the processors to keep offering competitive product prices. However, there is a lot of room to improve the efficiency of these freezing processes. The CALLIFREEZE® offers a sustainable solution to reduce these energy costs while meeting the food safety and quality standards.

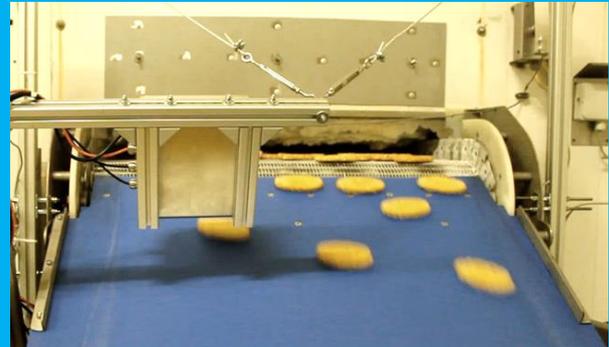


Figure 1: The CALLIFREEZE® monitoring frozen röstis.

CALLIFREEZE®

The CALLIFREEZE® is the first inline freezing sensor to monitor and optimize freezing and defrosting processes in **real time**. The sensor measures the fraction of water within **individual** products which is crystallized into ice. This measurement is expressed as the level-of-frozenness (LOF). By measuring through the product and non-metallic packaging material, the sensor provides insights about the core of the product. This information can be used to provide real-time feedback to the freezing units.

The installation of the CALLIFREEZE® translates to an **increased production capacity** and **reduced energy costs** without affecting the freezing quality. The sensor is specifically designed to measure the LOF of individual products such as

- röstis,
- meat,
- fish,
- vegetables, and
- other products.



Figure 2: CALLIFREEZE® with emitter, receiver and computing unit.

BENEFITS OF INLINE MEASURING

Conventional measurements: offline

Evaluating freezing processes is typically achieved by at-line or offline temperature measurements. A quality control manager collects samples from the production line and places a temperature probe in or between products. It takes 15-30 minutes before the equilibrium temperature is reached. Based on the obtained readings, the freezer settings are adjusted. This quality control approach is time consuming, prone to manual errors, and energy inefficient.

CALLIFREEZE®: inline freezing monitoring

By continuously monitoring the freezing state of the food products, you can follow up the freezing processes in **real-time**. Inline measurements no longer require sampling and sample preparation of the processed food products. Removing this intermediate step saves time, energy costs and eliminates manual errors. This system allows to minimize process variations and immediately adjust the freezer's settings. This significantly increases the efficiency of the freezer.

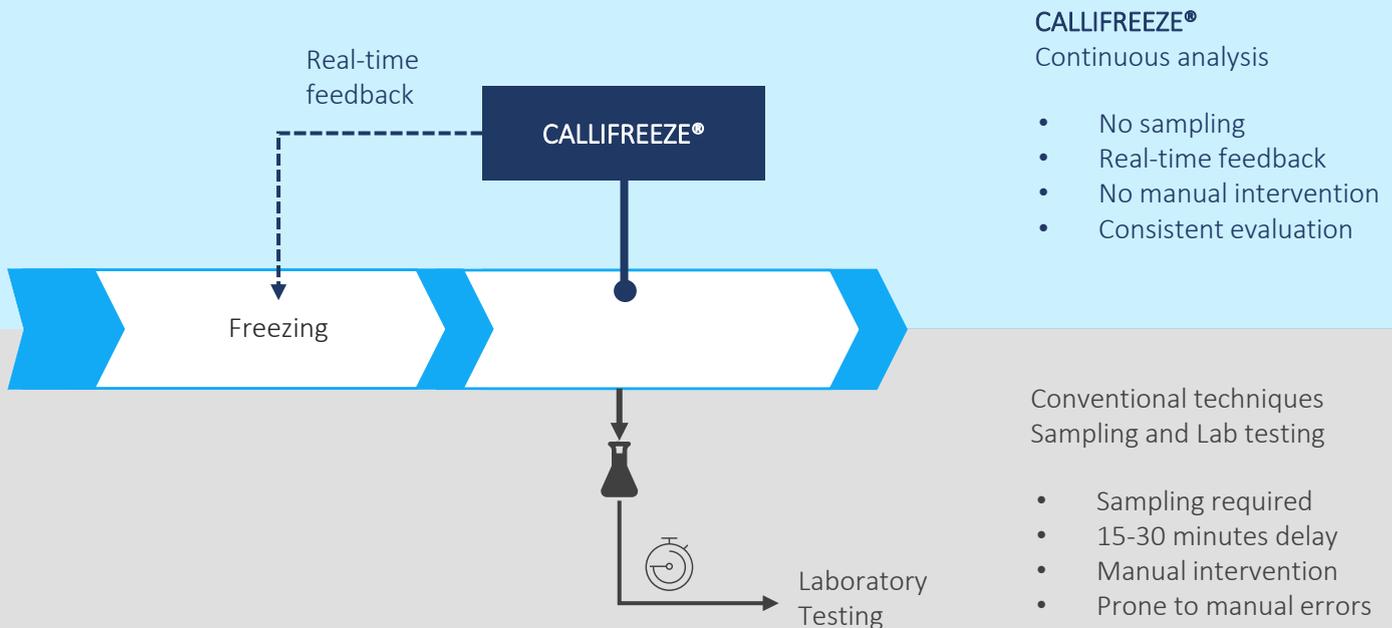
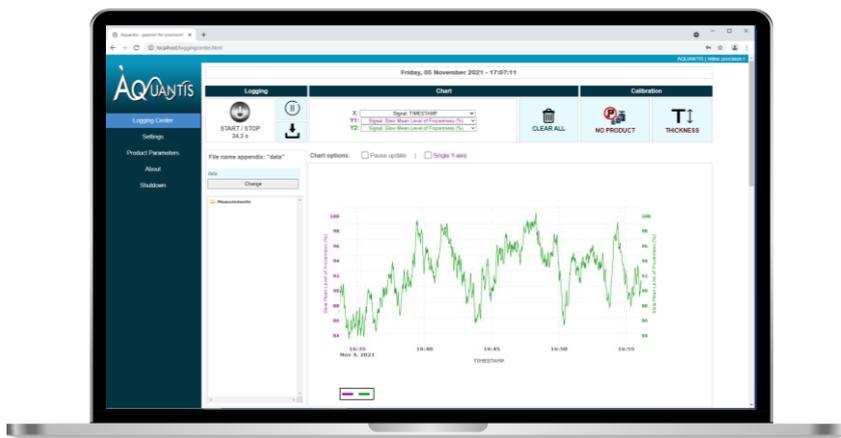


Figure 3: Benefits of the Aquantis sensors over the conventional techniques to monitor LOF.



Web interface and network connection

The web interface is used to visualize the processed data and manage the device settings for different products. The software supports Modbus TCP/IP direct communication with PLC units for automatic process control.

Figure 4: The web interface of the CALLIFREEZE®.

BENEFITS OVER CONVENTIONAL METHODS

Temperature vs. Level-of-Frozenness

Temperature is an unreliable indicator to evaluate if a product is frozen. Once the temperature drops below the freezing point, the water starts to crystallize. During this crystallization process, the ice fraction grows over time, while the temperature remains rather constant (latent heat region).

Aquantis introduced the use of level-of-frozenness (LOF) instead of temperature in order to determine to which extent a product is frozen. The CALLIFREEZE® clearly distinguishes the liquid from crystallized water fractions in food products. This makes it more reliable to determine if your product is properly frozen.

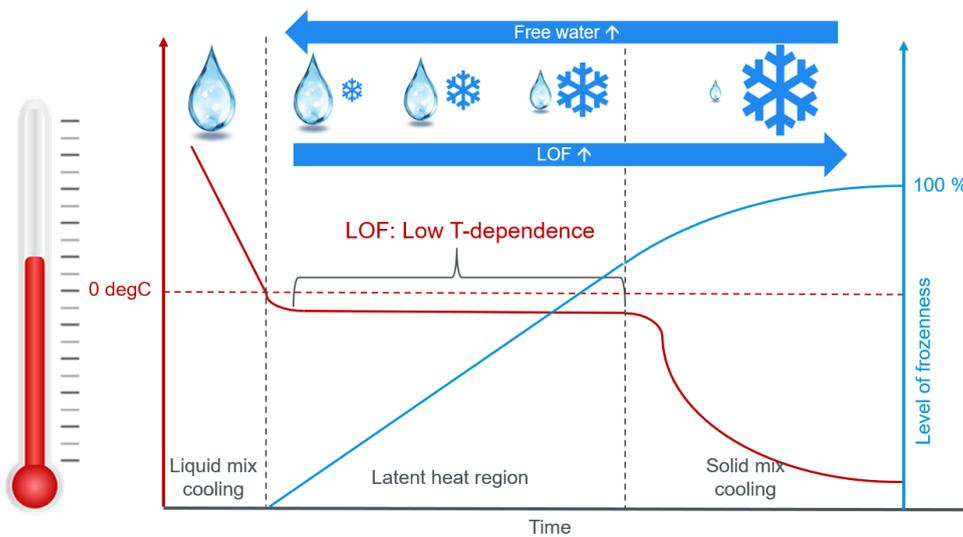


Figure 5: Comparison between temperature and Level-of-Frozenness (LOF) measurements. The water droplet and ice crystals represent the ratio of fresh over frozen water. The red and blue line represent the temperature and LOF, respectively.

CALLIFREEZE®: Core measurements

The CALLIFREEZE® is based on millimeter wave technology allowing to measure the **core of individual products**. The millimeter waves travel from the transmitter (Tx) to the receiver (Rx) **through** the product.

Based on received signal the level-of-frozenness (LOF) is calculated. This provides more information to which extent both the **surface and the core** of the product are frozen.

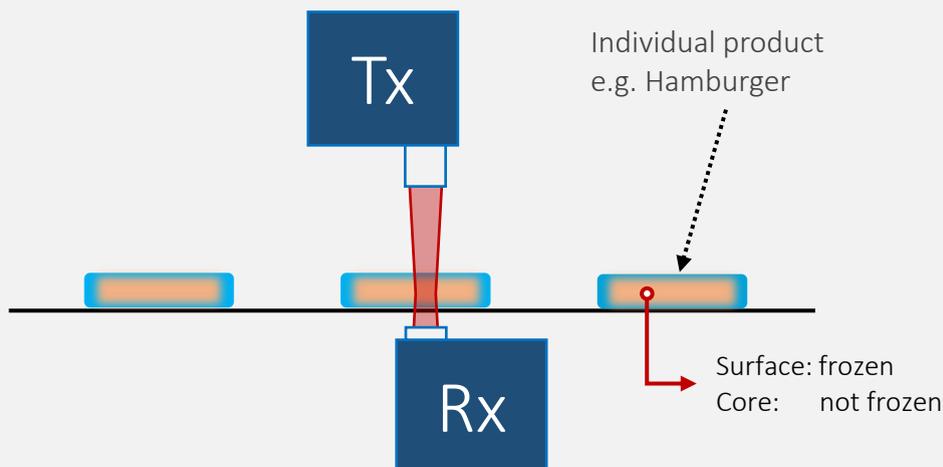


Figure 6: Cross section of individual hamburgers on a conveyor belt scanned by the CALLIFREEZE®.

FINANCIAL GAIN OF THE CALLIFREEZE®

Energy as the main cost of the freezer

When considering an investment in an industrial freezer with a 20 - 30-year lifespan, only 25% of the total costs represent the capital investment. The maintenance costs are estimated to be around 20%. However, more than half of the total costs are energy related. Reducing energy costs becomes essential to stay competitive and to meet the safety and quality standards. This reduction in energy costs can be realized using the CALLIFREEZE®.

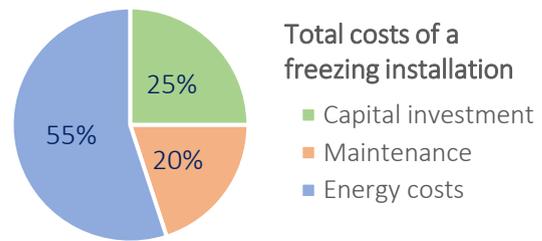


Figure 7: Cost distribution of an industrial freezing installation.

Excess freezing

The installation of the CALLIFREEZE® on various industrial freezers has shown that most systems excessively freeze the products. Products tend to be frozen to -23°C to -25°C which is beyond the required -18°C. In several case studies, the CALLIFREEZE® measurements indicated no difference in crystallization of the product between products frozen to -23°C or -18°C. In both cases the products are properly frozen but at different energy costs. The CALLIFREEZE® can reduce these costs with an **average of 10-20%**.

The potential savings depend on the application and used equipment. Considering a 1000 kg/h spiral freezer with a power of 215 kW for meat (e.g., chicken filet) products. Assuming a 3% savings in electricity per degree evaporation temperature, an increase of 3°C translates in a 15000 EUR cost reduction. In most cases, the evaporation temperature can be increase more than 3°C, leading to 25000 to 35000 EUR annual gain in energy. This a pure electricity profit, not even considering the gain in production capacity.

Reducing the retention time

Another parameter which can be used to optimize the freezing processes is the time of the product in the freezer. Tests with the CALLIFREEZE® installed after a spiral freezing, showed a significant reduction in retention time. For a production line with meat (e.g., poultry) products on a 1000 kg/h line, the retention time was reduced from 85 to 70 min while maintaining the freezing quality. This translates in a **17% increase in production capacity** for the same energy consumption.

Evaporation temperature	$\Delta T = +3^{\circ}\text{C}$	$\Delta T = +5^{\circ}\text{C}$	$\Delta T = +7^{\circ}\text{C}$
Electricity savings per unit Evaporation temperature	3%/°C	3%/°C	3%/°C
Relative electricity savings	9%	15%	21%
Annual savings electricity costs*	14 896 EUR	24 826 EUR	34 756 EUR

Table 1: Annual savings for a 1 ton/h line (215 kW) using the CALLIFREEZE®.

* Based on the average electricity prices EU 2021S1 (Eurostat)



ENERGIE-EFFICIENT AND SUSTAINABLE PRODUCTION



Lower your energy consumption

The CALLIFREEZE® allows to continuously adjust the freezer parameters lowering the average energy cost with 10-20%. This efficiency makes your production process more carbon friendly and sustainable.



Positive environmental impacts

- Significant reduction in electricity consumption.
- Less product waste due to inadequate freezing
- CO2 reduction

INCREASED FREEZING EFFICIENCY



Increase your production capacity

Due to the lower retention times of the product in the freezer, more product can be frozen increasing the production capacity significantly.



Continuous and consistent quality control

The current delay of $\pm 15-30$ minutes between the manual measurements and changing the freezer's settings is replaced by real-time information.



Key to profitable food chain of tomorrow - Industry 4.0

The inline freezing data makes it possible to see the interactions of the different process parameters on the freezing quality and make as such a self-regulating production model

MAIN FEATURES

Our inline technology has various benefits compared to conventional methods:

- **Measurement at core:** The emitted electromagnetic waves penetrate through the products. This guarantees that both the surface and the core of the products are measured
- **Non-stop LOF readout:** The sensor performs 500 measurements/sec on a 24/7 basis. This gives non-stop, real time measurement results.
- **Representative measurement:** Since, the electromagnetic waves propagates through the products, the user obtains both surface and core information of the product.
- **Non-destructive measurements:** The used electromagnetic waves do not affect the measured product in any matter due to the very low power.

TECHNICAL SPECIFICATIONS

Item	CALLIFREEZE®
Sensing Technology	Millimeter wave technology
Measuring range LOF	70 - 100% *
Measuring precision	±1% *
Sampling rate	500 Hz
Field frequency	ISM frequency band
Emitted power	~10 dBm (~10 mW)
Housing	Food-grade Stainless steel AISI 304 - Hygienic design
IP class	IP66
Dimensions transmitter unit (W x H x D)	177 mm x 187 mm x 178 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 40 °C
Data connection	Ethernet RJ45 plug
Power input	AC Single Phase 100-240V~ 0.5A 50-60 Hz
Industrial interface	Modbus TCP/IP server
User interface	Web-based user interface

Table 2: Technical specifications of the CALLIFREEZE®.

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

FURTHER CUSTOMIZATION IS ALSO POSSIBLE

Aquantis also provides **customized sensor solutions** tailored to the individual needs of a customer. Further customizations of the CALLIFREEZE® are possible to fit the application(s)-dependent needs. The same technology can be used to measure the **defrosting** of different products, meat blocks, fish etc. To ensure our technological solutions fulfill your needs, each of your requirements will be evaluated by conducting a series of studies.

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.

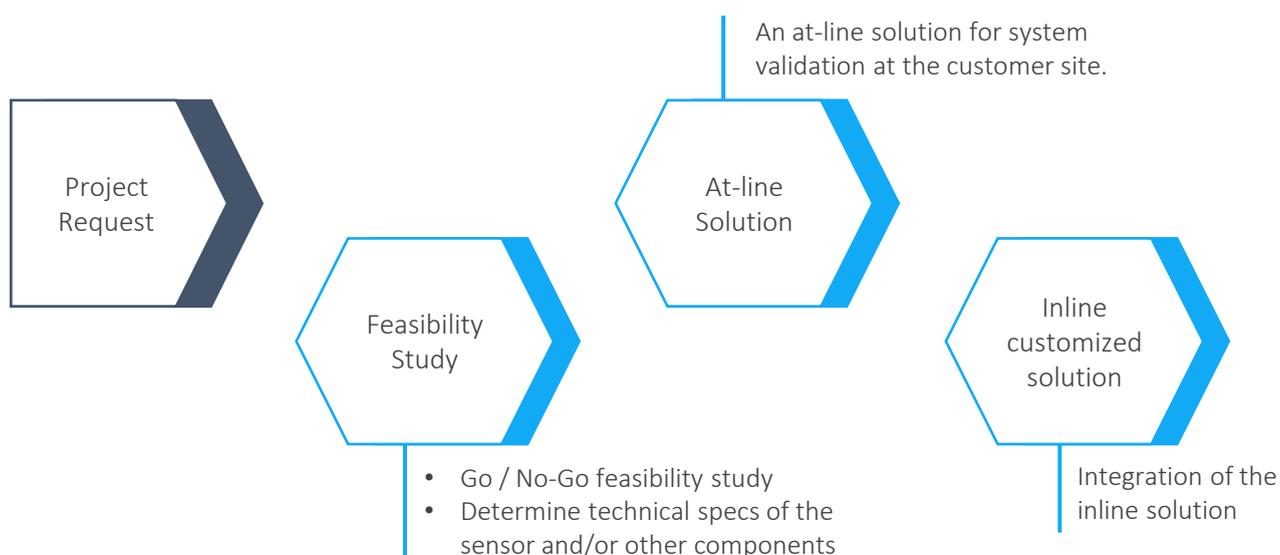


Figure 9: Project-based approach for inline customized solutions.

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