Collo Liquid Intelligence Platform

Analyzer, Data-analysis & Automation + Technology comparison

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1. Executive Summary

Collo is a real-time liquid analyzer based on radio frequency electromagnetic sensing technology that provides continuous inline monitoring of industrial liquid processes. The system uses an RF resonator immersed directly in the liquid medium to generate electromagnetic waves that interact with molecules and particles, producing an 8-parameter "liquid fingerprint" for real-time analysis.

The technology offers universal compatibility with both transparent and opaque liquids, including creams, slurries, emulsions, and high-solid-content fluids. Unlike optical or mechanical sensors, the RF measurement principle remains unaffected by sensor fouling or contamination, enabling long-term reliable operation without frequent maintenance.

Collo's liquid fingerprint can be processed into simplified formats, such as a 2D representation of chemical and physical properties, or converted into customer-specific process variables – such as concentration or viscosity – through machine learning algorithms.

The system has been validated across food and beverage production, chemical processing, and industrial cleaning applications. The analyzer consists of a measuring head with embedded CPU connected to an Edge Computing Unit that supports industrial protocols and can operate locally or integrate with cloud platforms.

Collo bridges the gap between laboratory analyzers and traditional process sensors by providing multi-parameter, real-time analysis suitable for continuous industrial processes, replacing multiple single-parameter sensors with one intelligent platform.

2. Collo Analyzer: Hardware and Data

Collo is designed for inline monitoring of industrial liquid processes. It’s **measuring principle** works equally well with clear liquids like water or alcohol and more challenging, opaque, high-solid-content fluids such as creams, slurries, gels, emulsions, pastes, or suspensions. The sensor is built into a proprietary **analyzer** that connects directly to standard process inlets. It continuously computes the **liquid’s fingerprint** in real time and manages **data delivery** through Collo’s edge computing unit. This unit can serve as a local touchpoint or a secure gateway to an enterprise cloud platform or plant automation network making it possible to integrate Collo into modern and legacy setups.

Collo not only gives sensory data and a process variable but also works as a real-time analytics engine. The multivariable electromagnetic raw signal is enriched with Collo’s embedded data-analytics that give real-time indicators such as “product present”, “cleaning complete”, “anomaly detected”, or “recipe stable”.

Benefits of RF-measuring

Collo’s measurement principle is built around a radio frequency (RF) resonator that is directly immersed in the liquid. As the resonator emits electromagnetic waves, they travel through the medium and interact with the liquid’s molecules and particles. The sensor detects these interactions and generates raw data, which Collo’s analyzer converts into a unique fingerprint that reflects the liquid’s composition, phases, and dynamic behavior. This fingerprint can then be further refined for more actionable insights.

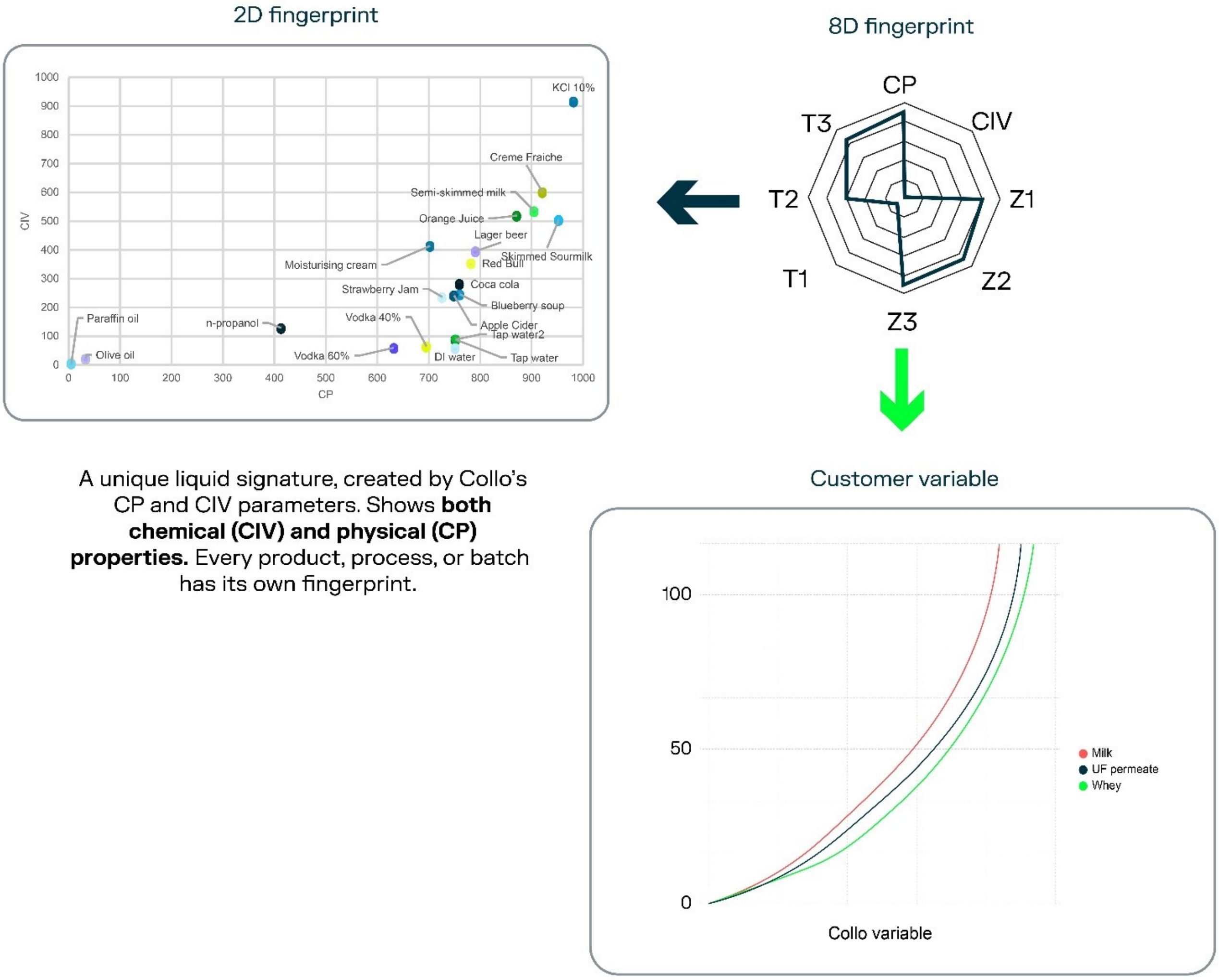
What makes Collo’s RF approach unique is how it overcomes the limitations of many other analyzers:

1. **No restrictions on liquid type**: Radio waves propagate just as easily through non-transparent, high-solid-content liquids — like creams, slurries, or emulsions — as they do through clear liquids like water or alcohol. This means Collo can monitor process streams that traditional optical or mechanical sensors cannot.
2. **Not sensitive to fouling**: Unlike optical or mechanical probes, Collo’s RF sensor does not rely on clear line of sight, nor does it require moving parts. This allows Collo to deliver reliable data over long periods without frequent cleaning or wear.
3. **Responsive to almost any change**: The RF field reacts to changes in the liquid’s chemical or physical properties, even when the color, transparency, or thickness stays the same. This makes Collo sensitive to subtle variations — like contamination, phase separation, or blending — that other inline sensors might miss.

2.1. Collo: Actionable insights from Liquid Fingerprints

2.1.1. From fingerprint to actionable insights

Every liquid measured by Collo generates a unique fingerprint made up of eight parameters. This full fingerprint can be simplified into practical forms of insight (see



A unique liquid signature, created by Collo's CP and CIV parameters. Shows **both chemical (CIV) and physical (CP) properties.** Every product, process, or batch has its own fingerprint.

Collo's fingerprint can be converted into a customer-specific value – like mixing time or dilution level. Whether from a standard library or a custom algorithm, this turns the data into practical, real-time process insights.

Figure 1). First, the 2D fingerprint condenses the data into two main variables splitting them into chemical (CIV) and physical (CP) properties. Then, with advanced data analysis, the fingerprint can be refined into Customer variables such as concentration level, mixing homogeneity, or apparent rheological viscosity.

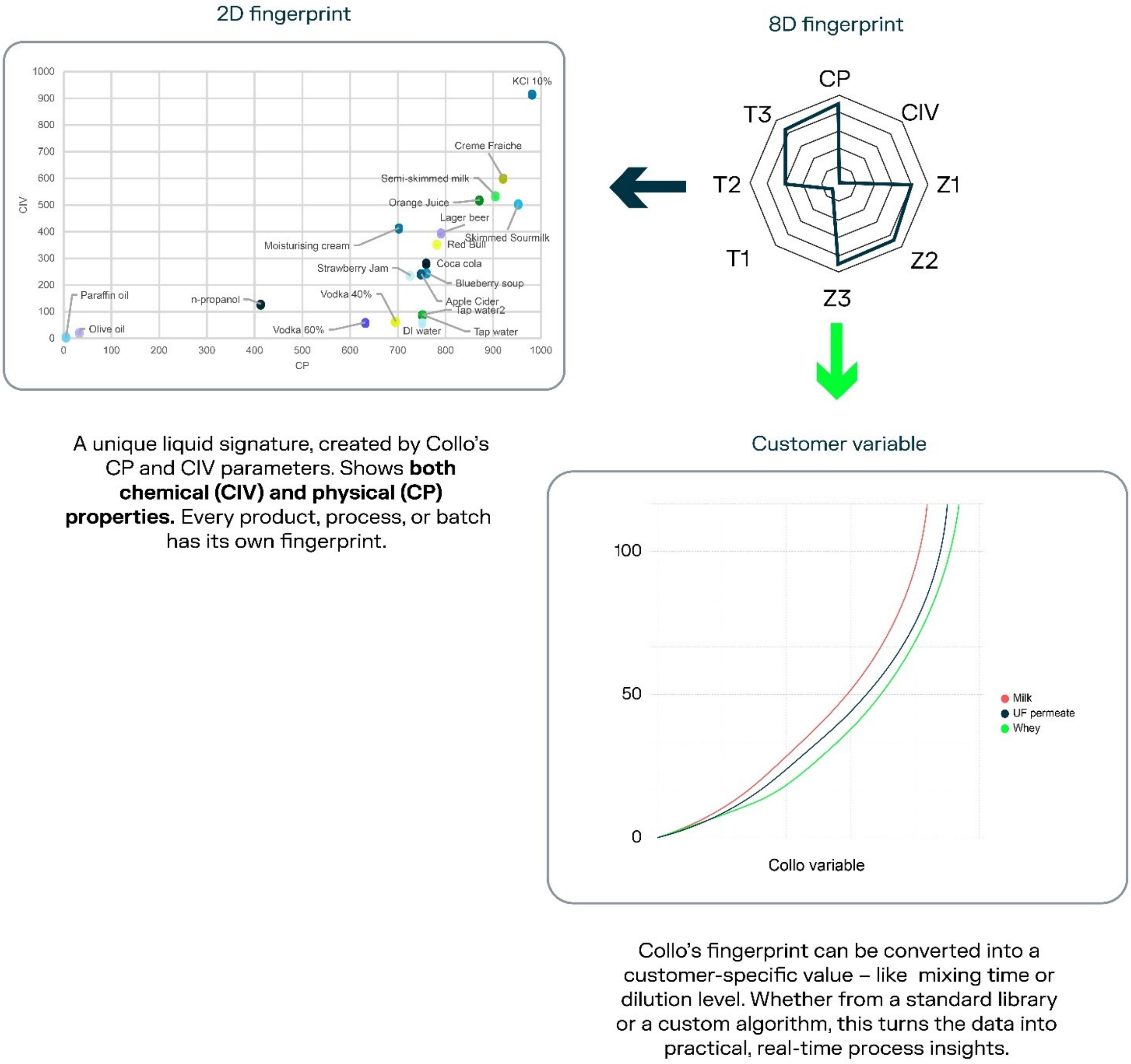


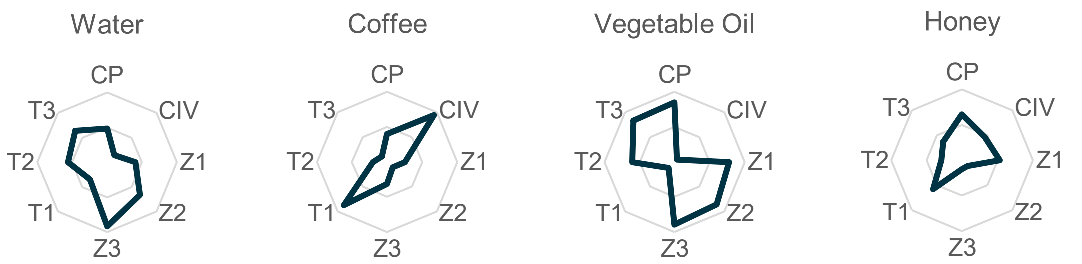
Figure 1 Refining the full Fingerprint to 2D-map or concentration for more insights.

2.1.2. The Liquid Fingerprint

The Liquid Fingerprint is a unique signature of your liquid, created by Collo's proprietary parameters. Every product, process, or batch has its own fingerprint.

A Collo Liquid Fingerprint is a set of 8 parameters that Collo extracts from the RF-sensor raw data in real time. These parameters can be used to identify the liquid and see changes in them.

As an example, the graph below shows the fingerprints of several common household liquids.



The fingerprint is defined by two main parameters: **Collo Permittivity (CP)** and **Collo Ion Viscosity (CIV)**. In addition, there are six auxiliary parameters—**T1 to T3** and **Z1 to Z3**—which are partially linked to the main parameters.

Analysis always begins with the main parameters. The auxiliary parameters are used either for *customer variable conversions* or in experimental cases where one of them provides better resolution for a particular phenomenon.

Focusing only on the two main variables—**CP** and **CIV**—we can plot liquids on a “fingerprint map”. This map can be used, for instance, to differentiate liquids from one another or to verify that the liquid is what it is supposed to be.

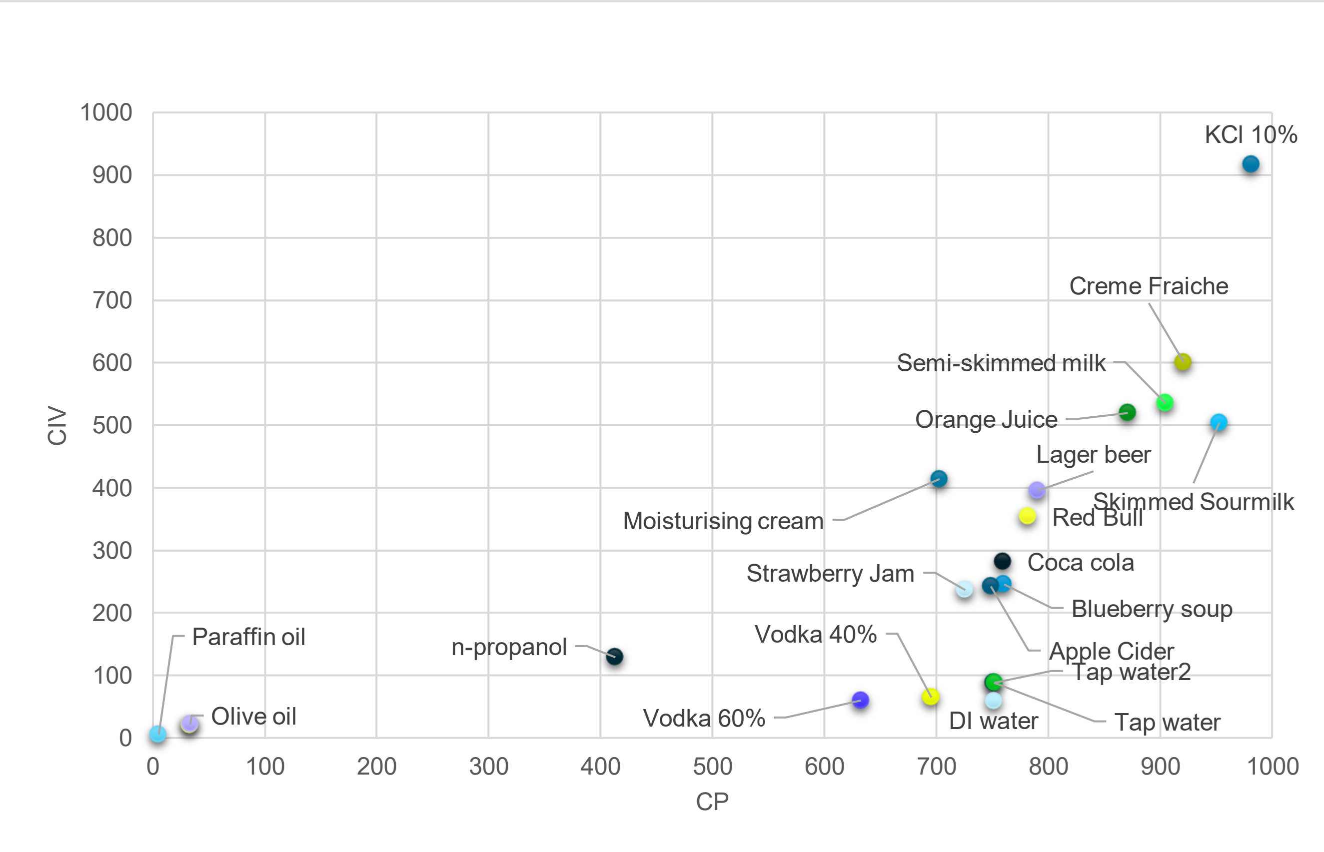


Figure 2 2D fingerprint with different liquids

The scientific background of these parameters is describes in detail in the scientific whitepaper. In general, **CP** is sensitive to phase composition, while **CIV** responds to chemical composition. This makes it possible to use Collo for monitoring both separate phases (such as oil-in-water) and dissolved chemicals (such as salt-in-water).

2.1.3. Converting the Fingerprint to a Customer-Specific Variable

Beyond simply showing the fingerprint, Collo can translate this information into a process value that directly supports operations — like product concentration, mixing readiness, an anomaly warning, or the estimated viscosity. This is done via teaching processes that apply advanced data analysis methods, including machine learning.

For product concentration, Collo can either use its existing fingerprint library of common liquids or create a custom fingerprint profile experimentally for your specific product. For instance, cream and water each have distinct fingerprints stored in Collo's library. Using a **cream dilution algorithm**, Collo can continuously calculate in real time how much the cream is being diluted with water.

In the same way, fingerprints can be used to track a blend ratio, detect when a batch is fully mixed, alert operators to an unexpected deviation, or estimate an indirect property such as resin viscosity — all while the process is running. This makes the fingerprint not just a measurement, but a practical, actionable signal that connects directly to your process targets.

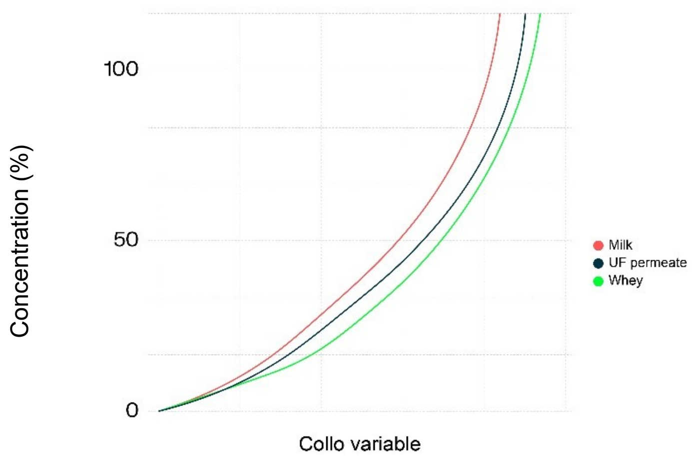


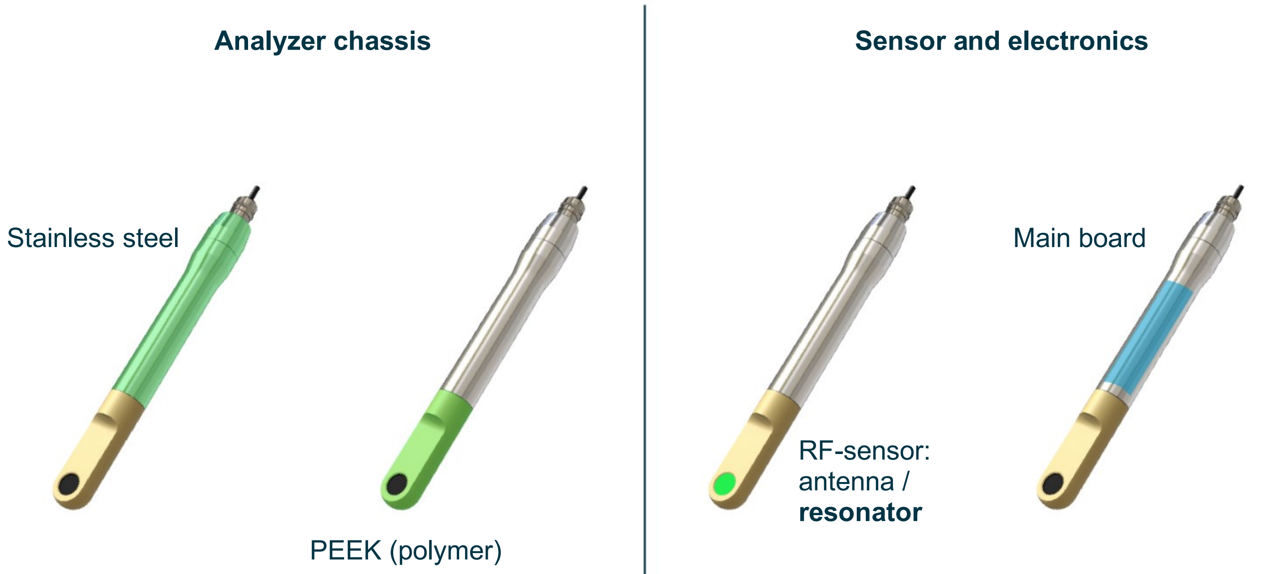
Figure 3 Fingerprint converted into dilution curves with Collo's proprietary algorithm.

2.2. Analyzer designs, Computing unit and Operating System

The **analyzer** is composed of the sensor, chassis, and the embedded control system. It connects to an **Edge Computing Unit (ECU)** that powers the analyzer and handles the data delivery to automation or **Collo's own software**.

2.2.1. Analyzer Components

The Analyzer wetted parts include: RF-resonator (sensor) covered with a layer of food-grade material and chassis made of food-grade polymer and stainless steel. The analyzer is equipped with a standard instrument connection[1]. The rf-resonator is excited and read by the Main Board that has an embedded CPU. The readings are converted into The Liquid Fingerprint and can be further refined to customer-specific variables and delivered to automation or monitored through Collo's own user interface.



The chassis of Collo analyzers is made from food-grade materials.

The resonator and main board are specialty components designed by Collo and produced by trusted partners.

Figure 4 Analyzer components. This example points out the components of the Probe model. Same materials are used in other product variables.

2.2.2. Edge-Computing Unit

The data from Analyzer is delivered to ECU that also supplies power to the analyzer and acts as a gateway. The fingerprint can be converted for example into a customer variable, such as product concentration.

The ECU supports modern industrial protocols[2] and connects to automation or Collo's own remote software. Customers retain full ownership and access to their data. For specific use cases, Collo also offers analytical dashboards that provide deeper process insights. These dashboards can, for example, help analyze **losses during pushouts** or track **water consumption** throughout a process.

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[1] See spec sheet for materials, dimensions and available connectors.

[2] See automation spec sheet for available communication protocols.

AUTOMATION

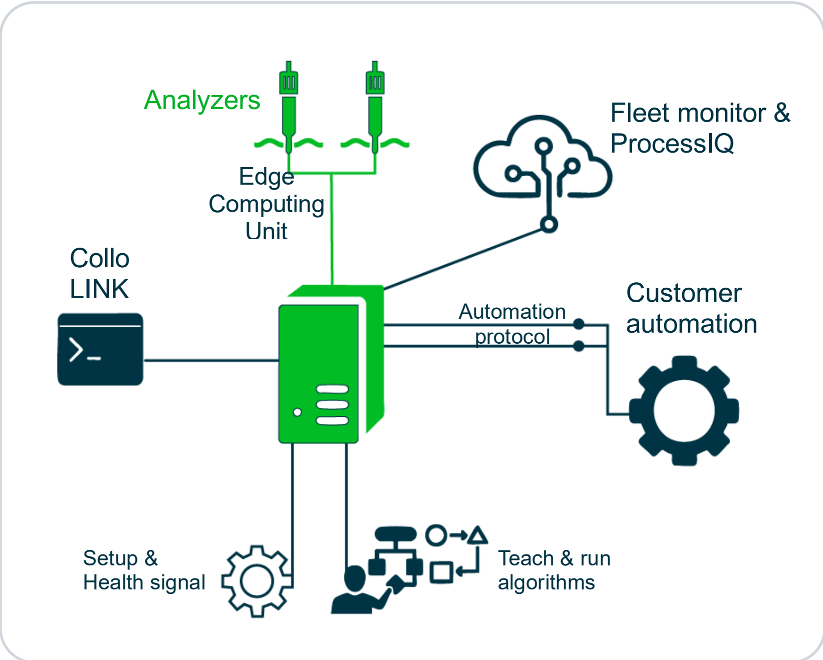

Figure 5 Data delivery from the analyzer to Collo's software platform or automation.

2.2.3. Using Collo with PC

In addition to integration with automation systems, users can operate the Analyzer and view live fingerprints, monitor trends, compare batch performance, and deviations in liquid using Collo's own user interface

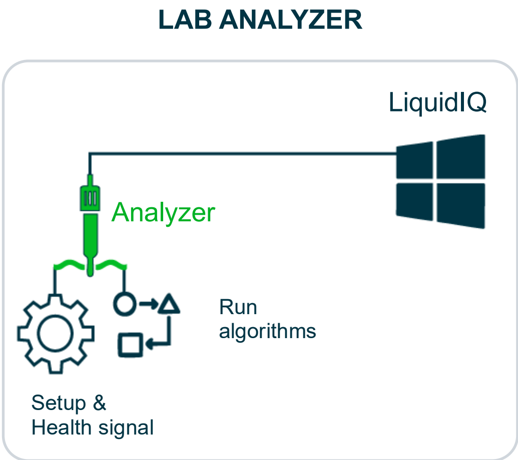

Figure 6 Data delivery from the analyzer to Collo's software platform or automation

3. Application Examples Across Industries

Collo has been deployed across a wide range of industrial processes — especially in food and beverage industry. It has been validated in numerous deployments and at our public references.

It brings continuous insight into liquids that are otherwise hard to track – opaque, sticky, foaming, or chemically complex. Below are some real-world examples of how Collo is used.

3.1. Dairy Production

In dairy production, Collo's multiparameter sensing technology provides a reliable way to distinguish between product, cleaning chemicals, and rinse water in real time. This capability is particularly valuable during product changeovers and line emptying, where misidentification of interfaces can result in unnecessary product loss. By identifying these transitions more accurately than traditional turbidity or conductivity sensors, Collo enables producers to recover significant volumes—often on the order of **200 liters per pushout**. Every liter saved represents direct margin, highlighting the tangible economic benefit of more precise monitoring.

Beyond minimizing losses, Collo also supports **anomaly detection**. Abnormal events, such as the presence of cleaning chemicals in product or product loss into sewage, can be visualized directly in the fingerprint signal. When such deviations occur, the system can automatically trigger alerts, allowing for immediate corrective action and preventing larger-scale quality or compliance issues.

Collo further contributes to process efficiency through **automation control**. By linking the fingerprint signal to valve operations, it is possible to automate switching sequences based on the actual liquid identity rather than relying on fixed timers or turbidity sensors. This reduces the risk of human error, improves consistency, and enhances overall process reliability.

3.2. Beverage and Brewing

In the beverage and brewing industries, Collo provides a versatile tool for monitoring and controlling complex liquid processes. One important application is **syrup and recipe control**, where Collo can measure the concentration of syrups, sugars, or alcohol in real time. This capability also applies to blending and carbonation, helping ensure recipes remain consistent.

Collo is also well suited for **clean-in-place (CIP) verification**. In brewhouses, soft drink bottling lines, and distilleries, it can accurately track detergent strength as well as the transition between rinse phases. By providing continuous, in-line feedback, Collo helps optimize cleaning cycles, reduce water and chemical consumption, and maintain hygiene standards.

Another area where Collo adds value is **interface detection**. During tank changes or filter backflushes, the system reliably identifies push-out fronts, even in challenging conditions such as foaming or non-transparent beverages. This enables more efficient product recovery, minimizes waste, and supports consistent process performance.

3.3. CIP (Clean-in-Place) Systems

In Clean-in-Place (CIP) systems, Collo enables precise monitoring and optimization of cleaning cycles. By measuring the **real-time concentration of acid and alkaline cleaners**, the system eliminates the need for manual sampling and provides continuous assurance that cleaning agents are being applied at the correct strength.

Collo also improves **rinse validation** by detecting when water quality is sufficient to confirm that residues have been fully removed. Unlike approaches that rely on conductivity alone, the fingerprint signal provides a more comprehensive view, ensuring that rinse completion is verified with higher confidence.

A key outcome of this approach is **cycle optimization**. By accurately identifying cleaning and rinse transitions, Collo makes it possible to reduce rinse duration while maintaining hygiene standards. This translates directly into measurable resource savings: shorter rinse times **reduce water and chemical consumption**, **lower energy use**, and free up system capacity for production. In many installations, this has enabled reductions of up to **10% in rinse duration**, saving **thousands of liters of water each week** and improving uptime—all without compromising safety or quality.

These examples illustrate how Collo consolidates multiple sensing functions into a single, fingerprint-based platform that provides reliable, real-time insights across diverse liquid processes. By precisely detecting interfaces between product, water, and cleaning chemicals, Collo helps recover material that would otherwise be lost—often amounting to hundreds of liters per push-out. In CIP systems, the same approach enables shorter rinse times and reduced use of water, chemicals, and energy, while still ensuring hygiene compliance.

Because the fingerprint method works equally well with clear, opaque, foaming, or high-solid liquids, Collo eliminates the need for several single-variable instruments and simplifies process monitoring. The system is scalable, from

Starter Pack deployments to multi-plant automation, making it a practical tool for both immediate efficiency gains and long-term operational resilience. In this way, Collo supports sustainable production by reducing waste, lowering costs, and improving overall process control.

4. Competitive Landscape: Collo vs. Traditional Approaches

4.1. Competition Landscape in Process Liquid Analytics

The process industries are undergoing a significant shift driven by the need for greater sustainability, tighter regulation, and increasingly complex manufacturing processes. In this context, **Process Liquid Analyzers (PLAs)** play a central role. These are engineering precision devices used for continuous monitoring of liquid and gas properties during manufacturing. Their purpose is to determine the **chemical composition and physical properties** of substances in real time, supporting process optimization, compliance, and asset protection.[3]

Historically, the industry has relied on **laboratory analyzers** or **single-variable sensors**. While these systems have their merits, they are often either expensive and rigid or lack the integration and real time capabilities needed in today's dynamic production environments with extended raw material pools and wider product portfolios. This is the cause for the shift toward **smart, connected sensor systems** that combine real-time data with digital intelligence. This trend aligns with broader shifts toward Industry 4.0, where **data-rich automation, digital twins, and condition-based maintenance** are becoming the new standard.

Within this evolving landscape, Collo offers a smart, radio frequency field (RF)-based analyzer that can adapt to various process conditions and industry verticals [8][9][16][17]. Collo functions as a multipurpose platform capable of fingerprinting liquids through AI-powered signal analysis, replacing several traditional analyzers.

Collo eliminates the need for sensor stacking or lab-grade installations:

- Works equally reliably with thin, thick, opaque, or chemically complex fluids
- Measures multiple properties from a single point of contact
- Continues delivering accurate insights even when buildup occurs on the sensor
- Supports remote diagnostics for easier maintenance

The sections below break down the competition landscape by looking at three key dimensions:

1. The differences between lab analyzers, traditional sensors, and smart sensors.
2. The advantages of multiparameter sensing over traditional single-parameter devices.
3. The landscape of sensing technologies—electrochemical, optical, electrical, and EMF.

[3] [1] NAMUR - User Association of Automation Technology in Process Industries, *Technology Roadmap Process Sensors 2027+*, 4th ed., Nov. 2021. [Online]. Available: https://www.namur.net

4.2. Lab Analyzers vs. Traditional Sensors vs. Smart Sensors

The landscape of liquid analytics in the food and beverage industry can be broadly divided into three categories: laboratory analyzers, traditional sensors, and emerging smart/IoT sensors. Each represents a different approach to measuring and interpreting liquid process data, with varying trade-offs in accuracy, usability, and cost.

4.2.1. Lab Analyzers

Laboratory or at-line analyzers are designed to deliver highly precise, specific insights—often at the molecular level. These tools are typically used for quality control or product development due to their high fidelity and resolution. However, their limitations lie in their cost, complexity and requirement for special expertise. Because of their high price point and need for sampling, analyzers are not suited for continuous, in-line monitoring across the production process.

4.2.2. Traditional Sensors

Traditional sensors measure one variable based on a physical principle such as conductivity or light absorption. While they are cost-effective and widely deployed, they offer limited insight. Users must define measurement protocols, calibrate and maintain the sensors, and handle analytics independently. This creates a fragmented workflow that places a burden on plant operators and often lacks flexibility or depth in the data collected.

4.2.3. Smart Sensors / IoT Sensors

Smart sensors represent a new generation of connected measurement solutions. These systems integrate advanced sensing hardware with data analytics and platform software, providing not just raw values but actionable insights. They are capable of continuous, in-line monitoring, and can be sold traditionally or “Measurement as a Service” by delivering complete solutions—combining hardware, software, and maintenance into one offering leaving the plant more time to focus on its core business.

One of the defining advantages of smart sensors is their **ability to self-monitor and support remote diagnostics**. These sensors generate not only primary measurement data but also **vital condition data**—such as signal integrity, calibration status, or internal temperature—which can be used to predict failures, trigger maintenance, and reduce downtime.[3] Through integration with digital twins and cloud platforms, smart sensors can also be configured or recalibrated remotely, simplifying commissioning and minimizing human error.

These features make smart sensors especially valuable in industries facing a shortage of sensor and automation personnel or complex, fast-changing production environments. By embedding intelligence directly at the edge, smart sensors help plants achieve both **operational efficiency and higher-quality decision-making** in real time.

4.3. Single-Parameter vs. Multiparameter Sensors

4.3.1. Single-parameter sensors

The evolution from single-parameter to multiparameter sensing reflects a broader trend in process industries toward efficiency, automation, and deeper process understanding. Traditional process sensors typically measure **one specific variable**—such as pH, conductivity, turbidity, or dissolved oxygen—based on the physical or chemical principle the sensor is built on. While reliable and well-understood, these devices are narrow in scope and require multiple sensors to capture a full process picture.

4.3.2. Multi-parameter sensors

In contrast, **multiparameter sensors** are designed to observe and interpret multiple simultaneous changes in a process stream, offering a **richer and more contextual understanding** of the system. Rather than focusing on one predefined variable, these sensors—like Collo's RF-based analyzer—measure a complex signal (or "fingerprint") that can be correlated to several parameters using algorithms and machine learning models.

This approach has three major benefits:

1. **Increased Sensitivity and Versatility:** Multiparameter sensors can detect subtle changes in complex mixtures—e.g. the presence of multiple dissolved chemicals or solids, or changes in viscosity or composition. For instance, Collo has demonstrated sensitivity to substances like aluminum, ammonia, chlorine, and changes in pH and dissolved oxygen—capabilities that would normally require several individual sensors
2. **Operational Simplicity:** Because a single sensor can replace multiple traditional devices, system complexity is reduced. There is less need for configuring thresholds, calibrating multiple probes, or integrating various data sources. Instead, the analytics engine behind the multiparameter sensor interprets the signal and delivers actionable insight, often through a unified digital interface.
3. **Better Process Insight and Anomaly Detection:** Multiparameter systems are inherently more adaptive. When combined with machine learning, they can learn the normal behavior of a process and identify deviations, making them powerful tools for predictive maintenance, anomaly detection, and optimization. This is particularly useful in batch processes or operations with variable raw materials, where fixed-threshold single-variable sensors can easily fail or provide misleading data.

Industry 4.0 has made this approach possible, and as industrial processes become more integrated, sustainable, and quality-driven, the value of multiparameter sensing continues to grow. These systems not only consolidate hardware but also provide **a systems-level view of process dynamics**, paving the way toward more **autonomous, efficient, and resilient operations**.

4.4. Sensing Technologies: Electrochemical, Optical, Electrical, EMF

Different sensor technologies play distinct roles in process analytics, each with unique strengths, limitations, and application contexts. Understanding the core characteristics of these technologies is key to evaluating their suitability for modern production environments.

4.4.1. Electrical Sensors

Electrical sensors (e.g. conductivity probes) are among the most **robust and simple technologies**, used widely across industrial applications. They provide **accurate single-variable readings** tied to bulk properties like ion concentration or resistivity. However, they offer limited adaptability and generally lack the analytical depth required for complex or dynamic processes. Their key role is in **simple and repeatable measurement tasks**, particularly in utilities and clean-in-place (CIP) monitoring.

4.4.2. Electrochemical Sensors

Electrochemical sensors, including pH, ORP, and ion-selective electrodes, are widely used due to their **low cost and specificity for certain chemical components**. They are effective for **single-point, single-parameter measurements**, such as detecting chlorine, ammonia, or fluoride. However, their performance often depends on **direct sensor contact with the medium**, which leads to **frequent calibration needs, high maintenance, and limited durability**. These sensors typically measure from a narrow spatial perspective and are best suited for stable conditions where a specific analyte is consistently present.

4.4.3. Optical Sensors

Optical sensing technologies cover a wide range of principles and applications, from simple single-variable devices to advanced multivariate spectroscopic systems.

At the simpler end, instruments such as **turbidity sensors**, **refractometers**, and **Brix meters** use light scattering or refraction to measure specific properties like particle concentration, sugar content, or total dissolved solids. These tools are widely applied in industries such as water treatment, beverages, and dairy. While they are fast and reliable, they typically measure only a single parameter and can be prone to **fouling or contamination**, often requiring frequent cleaning to maintain accuracy.

More advanced optical systems—such as **NIR (Near-Infrared)**, **Raman**, and **UV/Vis spectroscopy**—capture full spectral data from the process medium. These methods can extract multiple parameters simultaneously by applying chemometric models to the spectral signal. This enables a deeper understanding of liquid composition and process behavior, making them valuable for quality control, end-point detection, and real-time multivariate monitoring. However, they still face challenges related to optical path stability, window maintenance, and calibration complexity, especially in harsh or highly variable media.

4.4.4. Dielectric Sensors

Dielectric sensors represent a new class of multiparameter process analyzers that respond to both chemical and physical changes in a liquid. Instead of targeting a single molecule or property, they measure the **complex permittivity** of a liquid—capturing how the material interacts with an applied electromagnetic field across a defined sensing volume.

Because permittivity is influenced by a wide range of factors—including ion concentration, molecular polarity, solid content, viscosity, phase transitions, and emulsions—dielectric sensors can detect and differentiate subtle shifts in composition, structure, and state. This makes them uniquely suited to capture **multi-dimensional process changes** that traditional single-variable sensors may miss.

Unlike conventional sensors that depend on point contact or optical visibility, **dielectric sensors operate reliably in opaque, foamy, or fouling-prone conditions**, where optical or electrochemical methods often fail. They produce a **fingerprint signal**—a complex, high-sensitivity response curve—that can be interpreted using machine learning, pattern recognition, or statistical modeling. This allows the system to correlate the signal to key process metrics or detect anomalies in real time.

Dielectric sensors are also low maintenance, typically requiring no calibration and offering long-term stability. However, their effectiveness depends on the sophistication of the signal interpretation layer—making them most valuable when integrated into platforms that combine sensor hardware with adaptive algorithms and process-specific learning.

Collo's Positioning

Collo is a dielectric technology combining **universality**, **robustness**, and **the adaptability of AI-powered data interpretation**. It offers multivariable, in-line measurements with **little maintenance, and process-wide applicability**. Compared to traditional sensing technologies, Collo adds unique value by measuring **any change in any liquid**, making it well-suited for dynamic environments and optimization use cases.