Whitepaper

Industrial Internet of Things for hazardous areas:
potential for the optimisation of existing plants

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Whether oil and gas, chemicals, pharmaceuticals, mining or food, the development of an Industrial Internet of Things (IIoT) in combination with algorithms and artificial intelligence, releases an enormous optimisation potential - also and especially for existing plants. New business models transform CAPEX into OPEX and reduce the financial risk. For this, however, the information chain consisting of individual IIoT modules must not only be stringent, but also secure, scalable and ideally capable of being retrofitted during operation – from sensors and communication infrastructure to cloud analysis and user apps. There are also many success factors to consider at an organisational level.

THIS PAPER IS INTENDED AS A GUIDE.

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INTRODUCTION

The Industrial Internet of Things (IIoT) is probably the most powerful tool within the Industry 4.0 movement. As a further development of the previous M2M (machine-to-machine) communication, the individual modules (IoT building blocks) form an industrial Internet that can be used very flexibly, scaled easily and secured by optional encryption[1]. BARTEC opens up the associated potential benefits in the hazardous areas of the process industry based on decades of experience and a holistic approach to solutions including Ex-certified sensors, gateways and other IoT building blocks, which are also suitable for retrofitting existing plants. This allows important information to be obtained that has not existed before, or that can only be collected with exorbitant effort in order to make production processes economically transparent, also retrospectively, and to identify correlations of relevance to competition in combination with tailor-made algorithms, cloud computing and artificial intelligence[2]. The deepened or broadened understanding of processes can in turn be used to increase overall equipment effectiveness (OEE), further enhance security or align production with market requirements to an ever greater extent. To this end, the IIoT also permits completely new business and service models which gives prospects to reduce financial risk and fixed costs of producers and suppliers.

[1] See Chapter 4
[2] See Chapter 5.6

1 Transformation: How the IIoT changes the automation market

As "disruptive" technology, the IIoT is well on its way to questioning the previous business models and changing the automation market. More than seven billion IoT devices are already active today. By 2025, this figure will rise to 22 billion[3], with the number of devices for the Industrial IoT being many times higher than the consumer market[4]. Market analyst Bain & Company expects total sales of devices (things), network technology and gateways, cloud and analytics as well as apps and services[5] to double to 520 billion US dollars[6], and IoT Analytics experts even expect 37 percent growth to 1.6 trillion US dollars[7].

Global IoT Market Forecast
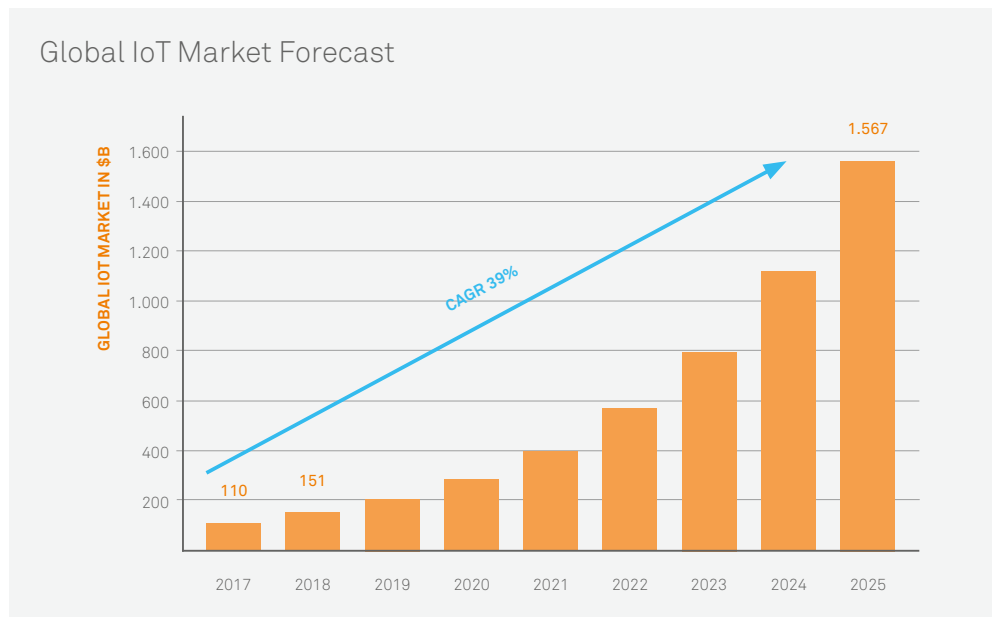
Sales development of the overall IoT market
(SOURCE: IOT ANALYTICS).

The Internet of Things is not a single market
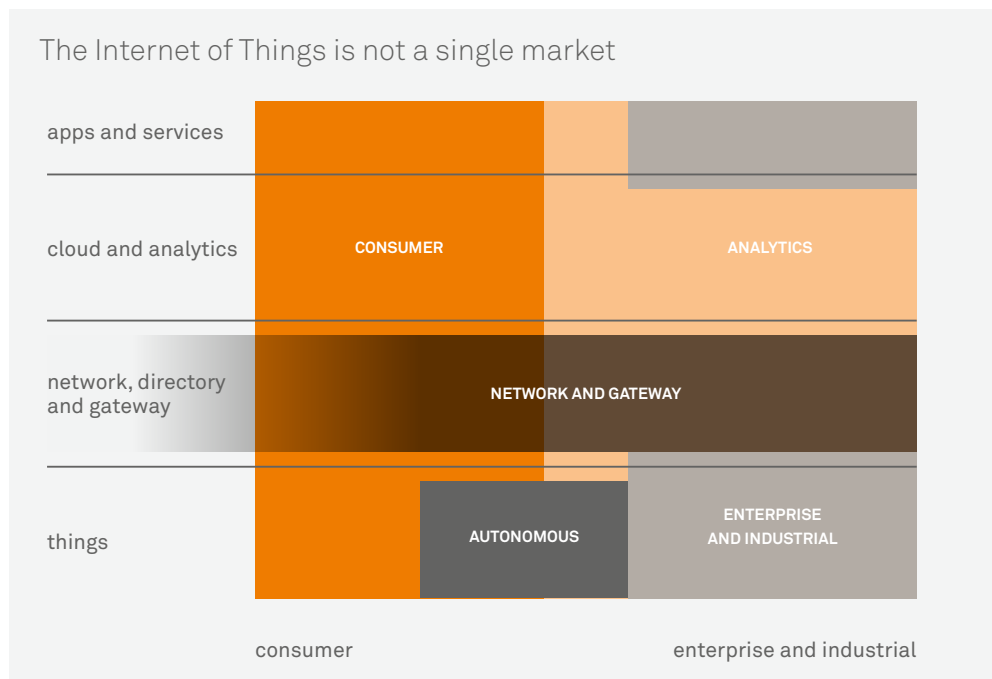
Not a single market: the IoT market consists of several overlapping eco-systems.
(SOURCE: BAIN & COMPANY)

[3] State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating. IoT Analytics 2018
[4] The Industrial Internet of Things, PwC 2016
[5] https://www.bain.com/insights/defining-the-battlegrounds-of-the-internet-of-things/
[6] https://www.bain.com/insights/unlocking-opportunities-in-the-internet-of-things/
[7] https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/

Not only the large cloud and service providers participate in this, but also players in the analytic space such as Trendminer and finally the hardware manufacturers. By gradually supplementing product sales with remote support and other software-based value-added services (software "as a Service", SaaS), they can ultimately act as platform providers (PaaS) and offer their customers device management, predictive maintenance or IoT analyses as a platform or service. Holistic service providers such as BARTEC are taking on a new role in the course of this development: they are becoming mediators and moderators between the business areas of automation, IT and management. At the same time, BARTEC functions as an IIoT enabler for the hazardous area with an extended eco-system, which enables step-bystep implementation with the best possible results and fast ROI.

Building platforms product-based offerings to service-based offerings by building platforms.

platform as-a-service

product + value-add service

product + remote support

stand-alone product

REVENUE EXPANSION

CUSTOMER ENGAGEMENT

IOT SERVICES ROADMAP
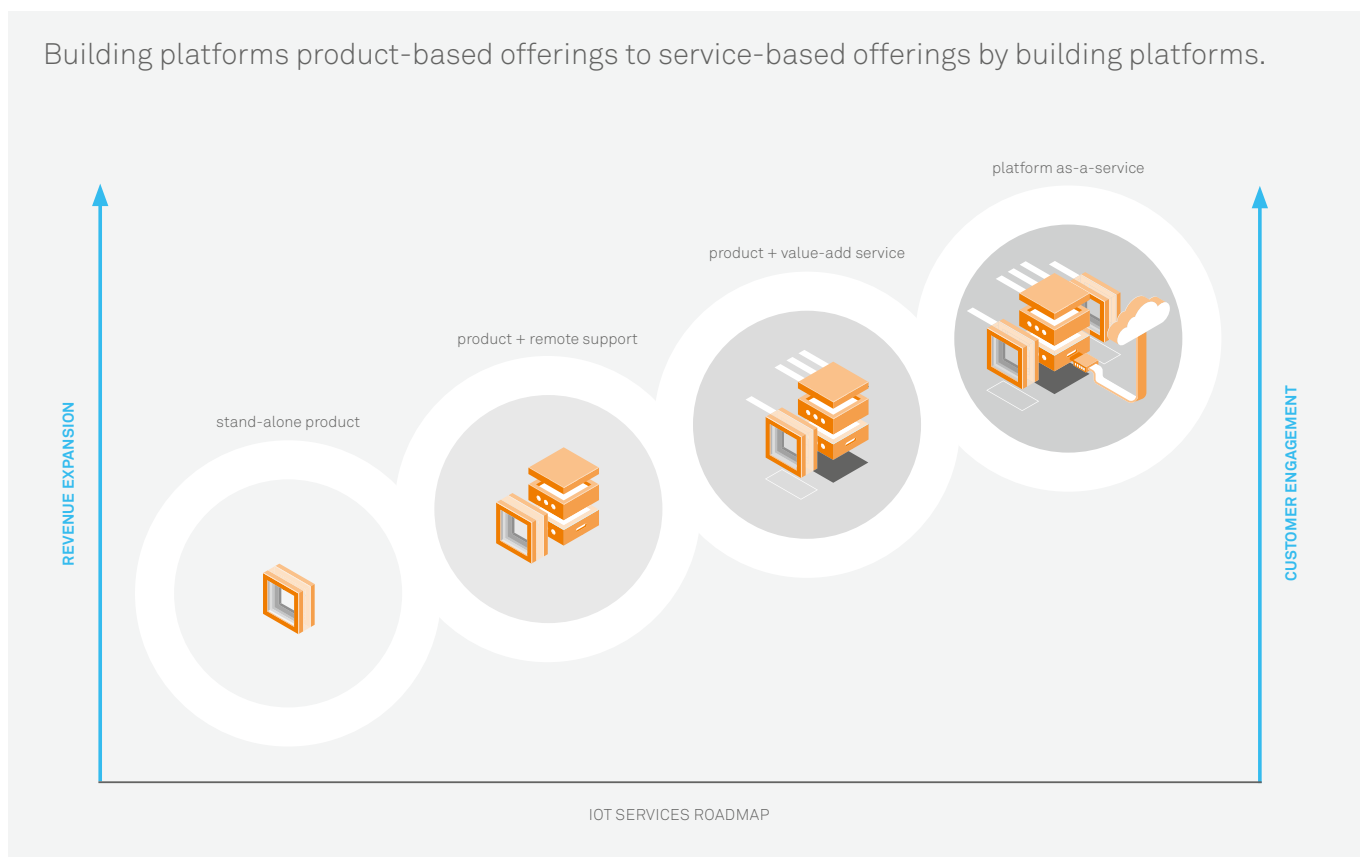
New business models: increase in sales and customer loyalty through the development of IoT services and platforms. (SOURCE: PWC)

New business and service models

In addition to the established cloud and service providers, hardware manufacturers are also participating in the new sales potential. By supplementing their products with remote support and other software-based value-added services (software "as a service", SaaS), they are gradually transforming themselves into platform providers (PaaS) that offer their customers device management, predictive maintenance or IIoT analyses, for example. Even holistic solution providers such as BARTEC are taking on a new role as a result: they are becoming mediators and moderators for their customers between the business areas of automation, IT and management. At the same time, BARTEC functions as an IIoT enabler for the hazardous area with an extended eco-system, which enables step-by-step implementation with the best possible results and fast ROI.

The most important IIoT services for the process industry:

With their new services, IIoT providers help the process industry to meet a wide range of challenges. Here are the most important business models:

1. Process optimisation

Processes, plants, machines and logistics are made transparent by the IIoT. By analysing the collected data, physical security, data security and efficiency can be improved, particularly in terms of time, energy consumption and the use of materials.

4. Asset tracking

In combination with positioning services, vehicles can be located and the transport of materials, products and equipment monitored and traced.
In this way, errors or damage can be tracked, occupational safety or logistics improved, and shutdown procedures optimised.

2. Predictive maintenance

Condition monitoring of plants and machines and subsequent analyses with artificial intelligence make it possible to detect immanent failures in good time. Maintenance can thus be performed with foresight, instead of at fixed intervals, as has been the case so far. This increases the serviceable life and reduces costs.

5. Automatic fulfilment

Analogous to the „Amazon Dash Button", stock levels (material, spare parts, etc.) can also be monitored in a professional environment through identification and localisation and reordered automatically.

3. Remote diagnostics & support

Through Internet-based remote maintenance, experts solve problems quickly and competently from a distance, either through direct access via a secure connection, or by supporting local staff. Using data headsets or tablets, critical situations can be better assessed (e.g. temperature, humidity, machine, plant and process conditions).

6. Compliance monitoring

Last but not least, the IIoT can also be used to comply with regulations and guidelines. This applies on the one hand to legal regulations on environmental protection and occupational safety, but also to specific safety regulations such as access monitoring in hazardous areas.

predict maintenance based on process data

reduce costs, while improving product quality

see if similar behavior happened before

predict heat exchanger fouling

monitor process behavior real time

find root causes through pattern recognition

solve 80% of your day-to-day production questions

send early warnings to the contol room

optimize energy efficiency

determine best operating zones based on process data

Examples of process optimisation through IIoT Analytics. (SOURCE: TRENDMINER)

New financing models

Another advantage of IIoT development for producers in the process industry is that they can use the new service models to convert CAPEX into OPEX and at the same time minimise the financial risk. Because the production performance of machines and systems becomes transparent, the manufacturer or operator can invoice them on a usage basis, for example for motors or pumps by the minute. This pay-per-use model represents a new alternative to traditional financing models. Operators thus have comparatively little or no investment to bear. The financial risk is minimised accordingly. In the future, it is even conceivable that suppliers, vendors or contractors will provide hardware and software free of charge, but will share in the resulting savings. IIoT projects could thus become a win-win situation for suppliers and operators, with all parties achieving the best possible results.

The IIoT extends the value chain from hardware to value-added services. For the operator, CAPEX becomes OPEX.

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2 Potential for benefits: What's to be gained by the process industry?

According to a study by the ARC Advisory Group, unplanned downtime costs the global process industry 20 billion US dollars annually[8], 80% of which is due to process-related operational disruptions. Until now, there has been a lack of efficient technologies to detect them. The IIoT now provides the means to gain insight into the existing processes, also retrospectively. With the help of modular IIoT building blocks, new and existing plants can be made transparent with an acceptable level of investment in order to increase overall equipment effectiveness (OEE) and release hidden capacity reserves in all three OEE disciplines: availability, performance and quality[9].

Overview: Potential benefits for the process industry

Service capacity	Explaination/Examples
Increase plant availability	e.g. through condition monitoring and analyses for predictive maintenance
Increase degree of performance	Continuous process improvements through data capture, analyse and resultant optimisations
Increase degree of quality	Constant / reproducible product quality, e.g. through monitoring quality-critical data and early notification
Increase productivity	Optimum exploitation of the production plants and logistics (supply and demand chain)
Increase flexibility	New planning and control possibilities for production by combining process, ERP and environmental data through to production in batch size 1 (modular type package, "one of production")
Increase process understanding	Improved understanding of plant dynamics as well as of material and product quality, e.g. forecast of the crude oil grade
Market-dependent production planning	Planning depending on the market development. For example, to determine the production volume of oil and gas as dependent on product quality and market price
Improve learning capacity of a machine	Self-learning systems and AI for continuous improvement
Optimise investment deployment	Transform investment expenditure (CAPEX) into operating costs with the assistance of service providers (OPEX)
Increase plant and human safety	For example, by monitoring and reporting deviations from standard values
Know-how transfer	Balance out skilled employee shortage, for example through sound remote assistance, assistance systems, troubleshooting capability, transferring employee expertise to digital processes
Efficient entry to digitisation	Fast entry via pilot project with ROI < 1 year, foundation for further iterative digitisation steps

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[8] https://www.industry-of-things.de/schluss-mit-stillstandszeiten-a-650427/
[9] https://www.business-wissen.de/artikel/oee-auf-der-suche-nach-den-verborgenen-kapazitaetsreserven/

New approach to the subject of digitalization

Thanks to its high flexibility and scalability, the IIoT allows a new, agile approach to digitisation in hazardous areas. This is because the ATEX-compliant modules including sensors, network technology, gateways and edge computing can be easily retrofitted during operation and allow additional data to be collected and evaluated simply even in relatively complex and rigid systems. Initial pilot projects are designed in such a way that the ROI is achieved in less than a year. The experience gained serves as a basis for further projects. Small iterative steps thus take the place of the „very large digitisation solution", which is financially, organisationally and economically unrealistic.

Digitalization is a journey; the IIoT is the vehicle.

Instead of working towards this for years, the idea is to first create transparency for a selected task with the help of a service provider and then to develop further opportunities, for example for a larger retrofit or other smaller subtasks. In this way, digitalization expertise grows continuously, while the time required and the ROI duration of the next projects decrease (see checklist in the appendix).
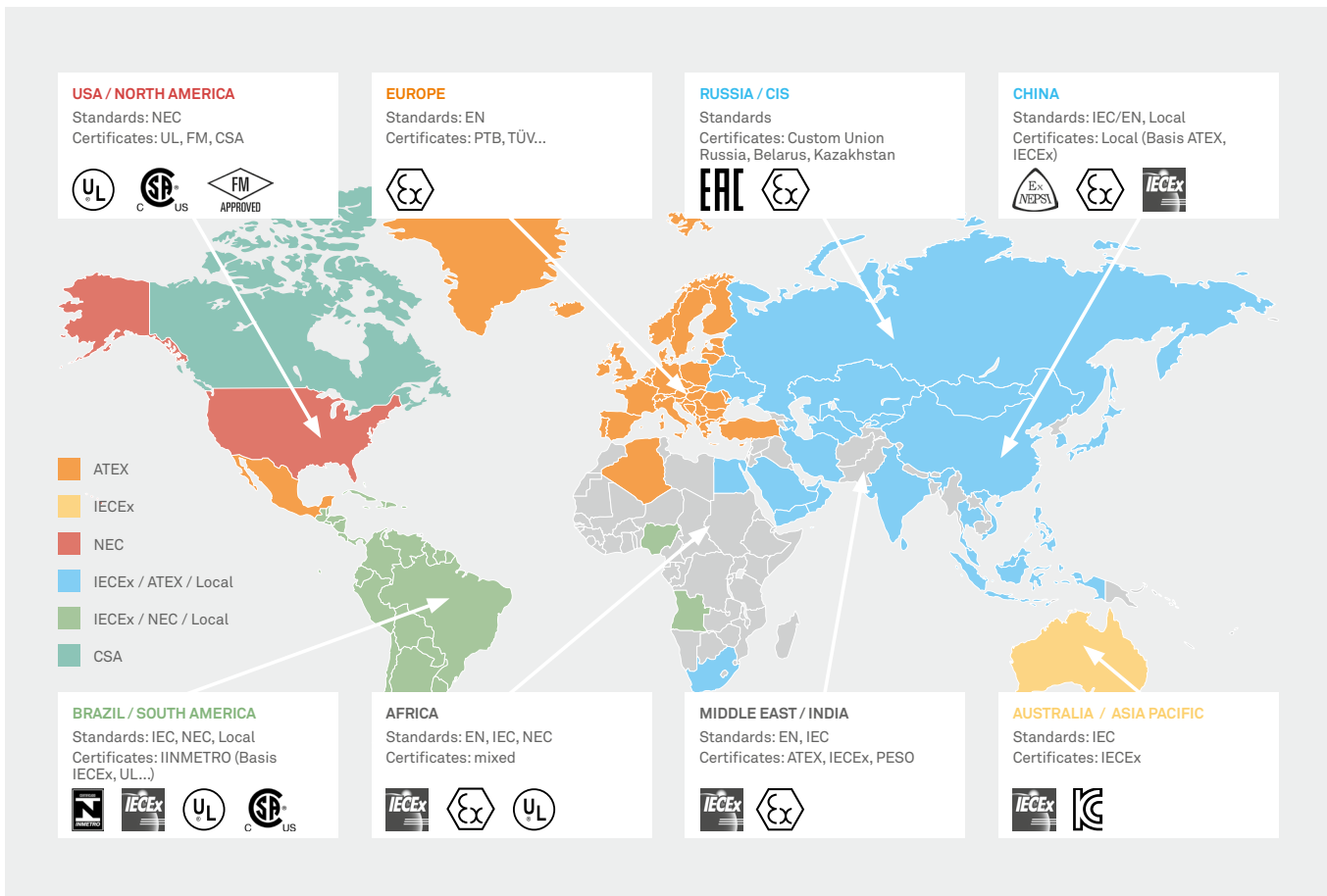
| 3 | # The challenges so far and overcoming them |

Why could this attractive potential not be exploited earlier? This is mainly due to the lack of the necessary technology building blocks, including computing and storage capacities, software and efficient possibilities for wireless and wired data transmission[10] as well as powerful and yet energy-efficient mobile hardware with high battery density for long wireless operation[11]. Accordingly, automation focused primarily on process control and safety. Because irrelevant plant components are not wired or do not support external data transmission, the control loop data cannot be further communicated, analysed and linked. As a result, the majority of the sensors currently used is not IIoT-capable and therefore cannot be used to optimise processes and occupational health and safety. Subsequent changes, such as cabling, are either very cost-intensive or not permitted at all, for example in the case of process or safety-critical controls or certified pharmaceutical plants. In addition, data collected in control loops cannot be further communicated, analysed or linked with other data. Last but not least, only certified hardware is permitted in hazardous areas. What is more, if a fire certificate is necessary for their operation, the hardware may not be installed in ongoing operations, but only during the next plant shutdown, costing valuable time. Another fundamentally important issue is that of IT security, which must of course also be met by wireless solutions[12].

The problem: the installed sensors are not IIoT-capable; data cannot leave the control loops. Control units may not be altered. Only certified hardware is permitted in hazardous areas.

USA / NORTH AMERICA
Standards: NEC
Certificates: UL, FM, CSA

EUROPE
Standards: EN
Certificates: PTB, TÜV…

RUSSIA / CIS
Standards
Certificates: Custom Union Russia, Belarus, Kazakhstan

CHINA
Standards: IEC/EN, Local
Certificates: Local (Basis ATEX, IECEx)

- ATEX
- IECEx
- NEC
- IECEx / ATEX / Local
- IECEx / NEC / Local
- CSA

BRAZIL / SOUTH AMERICA
Standards: IEC, NEC, Local
Certificates: IINMETRO (Basis IECEx, UL…)

AFRICA
Standards: EN, IEC, NEC
Certificates: mixed

MIDDLE EAST / INDIA
Standards: EN, IEC
Certificates: ATEX, IECEx, PESO

AUSTRALIA / ASIA PACIFIC
Standards: IEC
Certificates: IECEx

Use and acceptance of international Ex approvals. (SOURCE: BARTEC)

[10] See Chapter 5.2.
[11] See Chapter 5.1
[12] See Chapter 4

4 New architecture models: Freedom, flexibility and security

Thanks to the new possibility for energy-efficient collection and secure processing of data, the IIoT is an ideal complement to classic automation. Three architectural approaches offer the process industry a high degree of freedom and flexibility for implementation:

1. Developing new automation with already integrated IIoT functionality (greenfield)

2. In addition: existing automation and retrofitted IIoT. PLC systems and IIoT feed a common database[13] (brownfield)

3. Parallel: IIoT works as an independent system with separate data collection and processing (brownfield)

In the brownfield, the IIoT works in addition to or parallel with production and enterprise IT.
*SOURCE: HTTPS://WWW.INDUSTR.COM/DE/ ZUVERLAESSIGER-DATENFLUSS-IN-DER- DIGITALEN-PROZESSANLAGE-2331922 / **SOURCE: EMERSON AG

	AUT solution	IIoT solution
Sensor	Corded / 4...20man	Corded/ Wireless / battery powered
Precision capacity of a machine	high	Relatively low*
Connectivity / Protocol	HART COMMUNICATION PROTOCOL WiFi	WIREPAS Bluetooth LoRa GSM 4G NB-M 5G UMTS 4G NB-IOT
Gateway	Corded	Corded / Battery powered
Data Flow	bi-directional	one way / just read**
Cloud / ERP direct	realtime / nearly realtime	5 min / threshold***
Sales Modell	Traditional (product)	SaaS / Leasing / Pay per use

*   compared to corded in process industry
**   bi-directional only for updates / security patches over the air / depens on the IIoT solution
***   only if changes / timestamp

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13 Data diodes isolate the IIoT from automation, see Namur Open Architecture (NOA)

IIoT retrofit without shutdown

One of the revolutionary features of the IIoT is therefore that it can also unfold its potential benefits independently of automation and can be installed without a shutdown. An analogy from the automotive area illustrates this: here, older vehicles can be retrofitted with a tyre monitoring system regardless of the extent of the existing sensors. To this end, sensors are simply screwed on to the tyre valves, which measure the tyre pressure and transmit this data to a simple control unit where the information is processed and visualised.

BROWNFIELD

real time monitoring

beeper

wireless transmission

2 min DIY installation

Simplification!

GREENFIELD

VEHICLE SENSORS ≈ 100 SENSORS TODAY

lane departure system | front object CCD camera | front airbag sensors | ASCD | nightime pedestrian warning | drowsiness sensors | front object laser radar | nightime pedestrian IR sensor | active park assist | tire pressure sensor | rear object monitor CCD camera | rear camera | side curtain sensor | blind spot detection | cross traffic alert | cental computer | rear object laser radar | wheel speed sensor | tire pressure sensor | collision sensor | side airbag SRS | adaptive cruise control | steering angle sensor | automatic brake activator | etc.
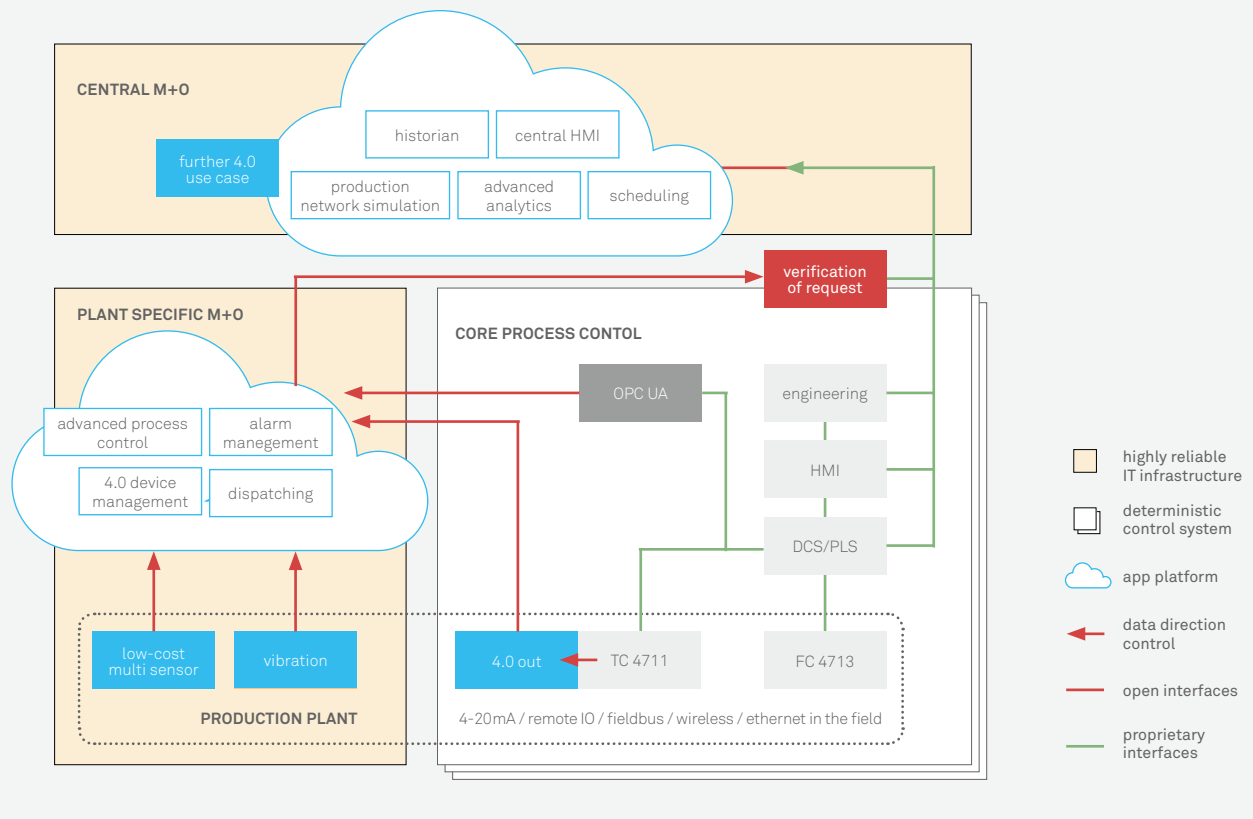
Vehicle analogy: modern car with numerous sensors (greenfield) and by comparison the retrofitting for older vehicles (brownfield): simple retrofit capability for a wireless tyre pressure system
(SOURCE: BARTEC)

Retrofitting data functions securely

Similarly, plants in the process industry can be retrofitted with wireless, Ex-certified sensors in order to be able to use new IIoT functions. The so-called NAMUR Open Architecture (NOA)[14] was developed in order to achieve the systemic openness required for this without endangering the elementary requirements of availability, function and safety. It describes, among other things, how the data of intelligent sensors and actuators are to be read and evaluated from the field level to the cloud. So-called "data diodes" as separating instances between automation and IIoT ensure that they flow exclusively "from inside to outside" and that the automation systems are not influenced in any way.

[14] https://www.namur.net/de/fokusthemen/namur-open-architecture.html

Companies moving from product-based offerings to service-based offerings by building platforms.

CENTRAL M+O

- further 4.0 use case
- historian
- central HMI
- production network simulation
- advanced analytics
- scheduling

PLANT SPECIFIC M+O

- advanced process control
- alarm menegement
- 4.0 device management
- dispatching

PRODUCTION PLANT

- low-cost multi sensor
- vibration

CORE PROCESS CONTOL

- verification of request
- OPC UA
- engineering
- HMI
- DCS/PLS
- 4.0 out
- TC 4711
- FC 4713

4-20mA / remote IO / fieldbus / wireless / ethernet in the field

Legend:
- highly reliable IT infrastructure
- deterministic control system
- app platform
- data direction control
- open interfaces
- proprietary interfaces

Industry 4.0 enabler: the standard-based, adaptive NAMUR Open Architecture (NOA) is simple to integrate. Data diodes (Data Direction Control) separate the area of monitoring and optimisation from the core applications (SOURCE: PROFIBUS NUTZERORGANISATION E.V.)
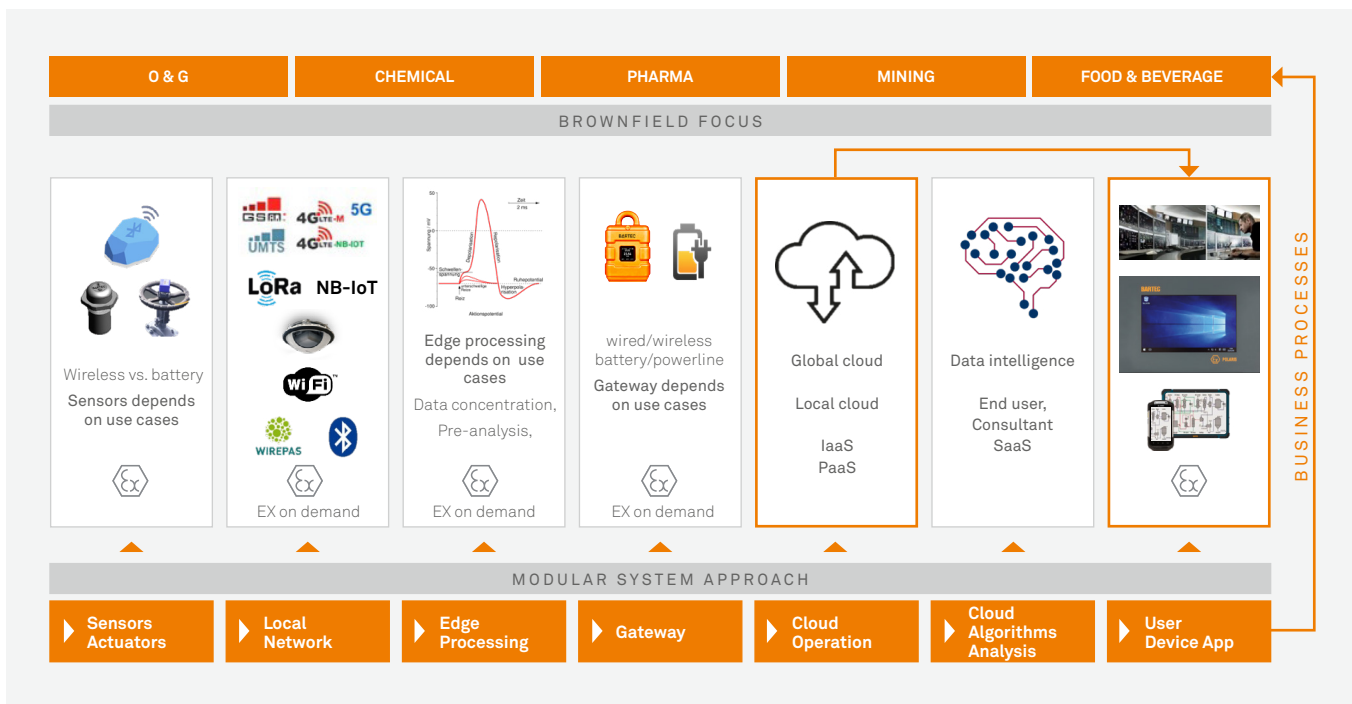
Data diodes separate the IIoT from the automation and ensure smooth and safe operations.

5 General solution approach to IIoT retrofitting

What does a resilient solution approach to IIoT therefore look like? It must extend stringently across all levels – from data collection (sensors), pre-processing (edge computing) and forwarding (gateway) to analysis (cloud) and the integration in business apps. At the same time, the IIoT retrofit must also be easily scalable, as economical and future-proof as possible – either as a supplementary data source for existing automation or as a completely separate parallel system. And of course, all hardware components must be certified for the respective hazardous areas. In addition, other compliance regulations must also be observed, not least IT and data security issues or works council topics[15].

Solution levels for modular IIoT retrofitting of existing plants
(SOURCE: BARTEC)

O & G	CHEMICAL	PHARMA	MINING	FOOD & BEVERAGE

BROWNFIELD FOCUS

Wireless vs. battery Sensors depends on use cases	Edge processing depends on use cases Data concentration, Pre-analysis,	wired/wireless battery/powerline Gateway depends on use cases	Global cloud Local cloud IaaS PaaS	Data intelligence End user, Consultant SaaS	
EX on demand	EX on demand	EX on demand			

BUSINESS PROCESSES

MODULAR SYSTEM APPROACH

Sensors Actuators	Local Network	Edge Processing	Gateway	Cloud Operation	Cloud Algorithms Analysis	User Device App

5.1. Sensors – beacons, MEMS, actuators, …

Installing an IIoT does not necessarily mean the use of radio technology. For example, there are also wired pressure transmitters and temperature probes for use in hazardous areas (classic automation) or devices with direct device to cloud communication (D2C). However, simple, wireless sensors greatly expand the spectrum of retrofit solutions. Most of them can be installed during operation, i.e. without a time-consuming shutdown procedure. Wireless sensor solutions such as beacons[16], which send data to a gateway at a defined interval, or energy-efficient MEMS sensors[17], which measure and transmit several values simultaneously, can work for years without battery replacement usi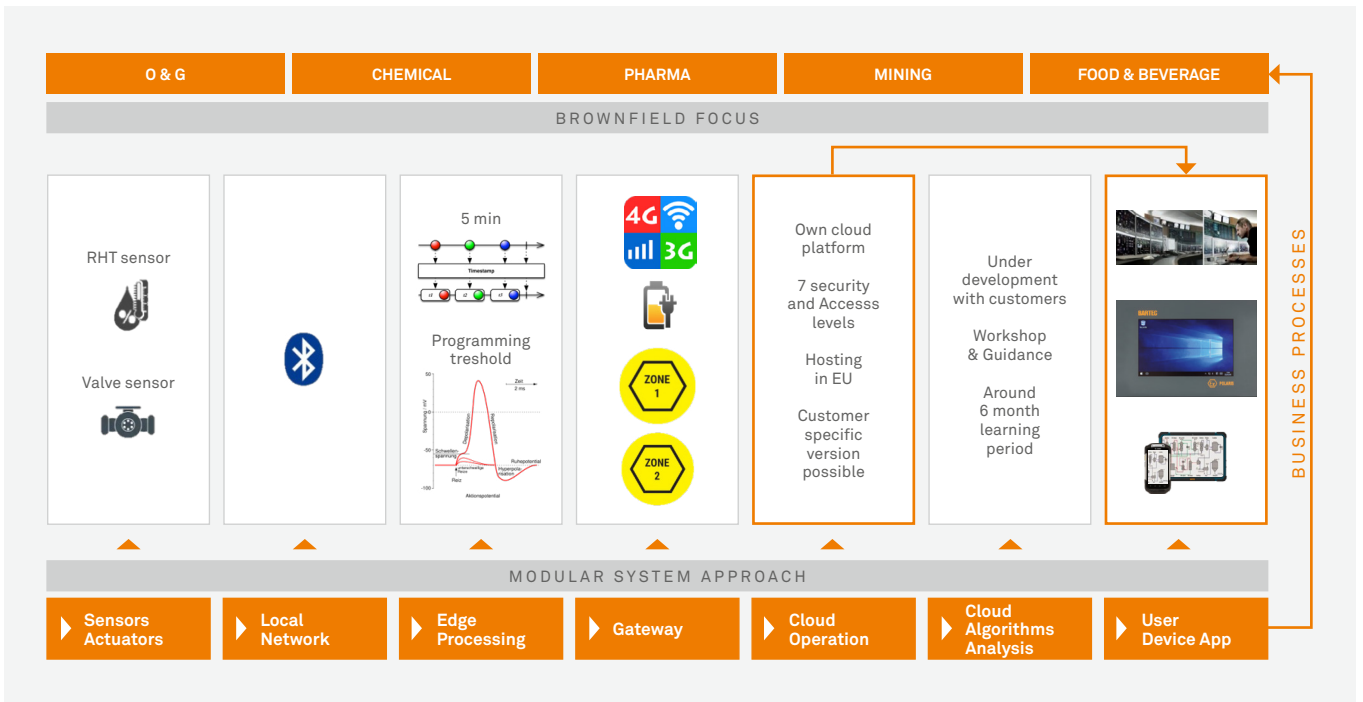ng the advertise mode in the Bluetooth Low Energy (Bluetooth LE) radio specification[18]. This dramatically reduces investment and maintenance costs compared to wiring. Examples are BARTEC's zone 1 certified sensor solutions for monitoring temperature, air and valve position. The gateway required for data collection and forwarding is available for zones 1 and 2 and can therefore be selected according to the hazardous area requirements.

IIoT retrofits must be simple, scalable, economical and future-proof but at the same time also Ex-safe, data-safe and reaction-free.

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15 See Chapter 6
16 See BARTEC White Paper „Kleiner Sender, großes Potential – Einsatz von Beacons in Ex-Bereichen" Bitte Link zum BARTEC Whitepaper Beacons einfügen
17 Micro-electro-mechanical system. MEMS sensors concentrate several measurement functions in a very small space and work, for example, in vehicles, fitness trackers, smartphones and virtual-reality headsets. In combination with a wireless and energy-efficient data transmission, they are also suitable for the Industrial Internet of Things.
18 See https://de.wikipedia.org/wiki/Bluetooth_Low_Energy

O & G	CHEMICAL	PHARMA	MINING	FOOD & BEVERAGE

BROWNFIELD FOCUS

RHT sensor

Valve sensor

5 min

Programming treshold

4G 3G

ZONE 1

ZONE 2

Own cloud platform

7 security and Accesss levels

Hosting in EU

Customer specific version possible

Under development with customers

Workshop & Guidance

Around 6 month learning period

BUSINESS PROCESSES

MODULAR SYSTEM APPROACH

| Sensors Actuators	Local Network	Edge Processing	Gateway	Cloud Operation	Cloud Algorithms Analysis	User Device App

Example of modular IIoT retrofitting of existing plants with sensors in Zone 1 and gateway optionally Zone 1 or Zone 2 as well as connection to cloud platform.
(SOURCE: BARTEC)

Performance and energy consumption

Sensors for 3D and infrared image recognition, which, as a self-learning system with the aid of AI, recognise hotspots by comparison with reference images, are correspondingly more complex, but are also adapted by specialists such as BARTEC for use in hazardous areas. In order to minimise battery life, the computing work can also be outsourced to a wired gateway (see 5.4, Edge Processing). Energy-efficient wireless data transmission, for example via Bluetooth LE (Low Energy), as well as sophisticated cycles of waking up, measuring, calculating, sending and falling asleep are important for long, maintenance-free operation. In this manner, the solution provider SAVVY thus achieves a battery life of up to 15 years even in hazardous areas[19]. A further success factor: simple, Ex-compatible installation on the object to be monitored during operation by screwing, riveting, gluing or clamping.

Wired sensors for hazardous areas e.g.: PT100 resistance thermometer.
(SOURCE: BARTEC)
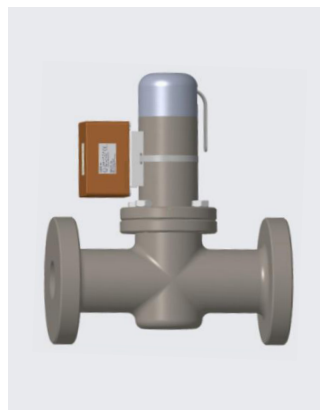
Wireless sensors can be simply retrofitted during operation.
(IMAGES FROM TRISENS.NO)

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[19] Source: SAVVY Telematic Systems SAVVY AG

What can be monitored?

The sensors form the smallest link in the IIoT information chain, with which the complete system stands and falls. Therefore, it must match the respective application precisely. Classic sensor technology is wired. As described above, wireless solutions are particularly simple and much more cost-efficient to retrofit, which is why they are the focus of particular attention in the following.

Whether wireless or wired - sensor technology can be used to monitor a wide range of process parameters in products, plants and supply chains. In addition to direct measurements (temperature, air pressure, humidity, light, etc.), it is also possible to derive information. For example, simple switches or optical sensors can detect certain lever positions. Strain sensors clamped to a carrier system of tank wagons, containers or pipes allow conclusions to be drawn about the filling level (weight), temperature and pressure. Position sensors provide acceleration values for vibration analysis, while magnetic field measurements provide information about the current flow. Here is an overview of various measured values and their application:
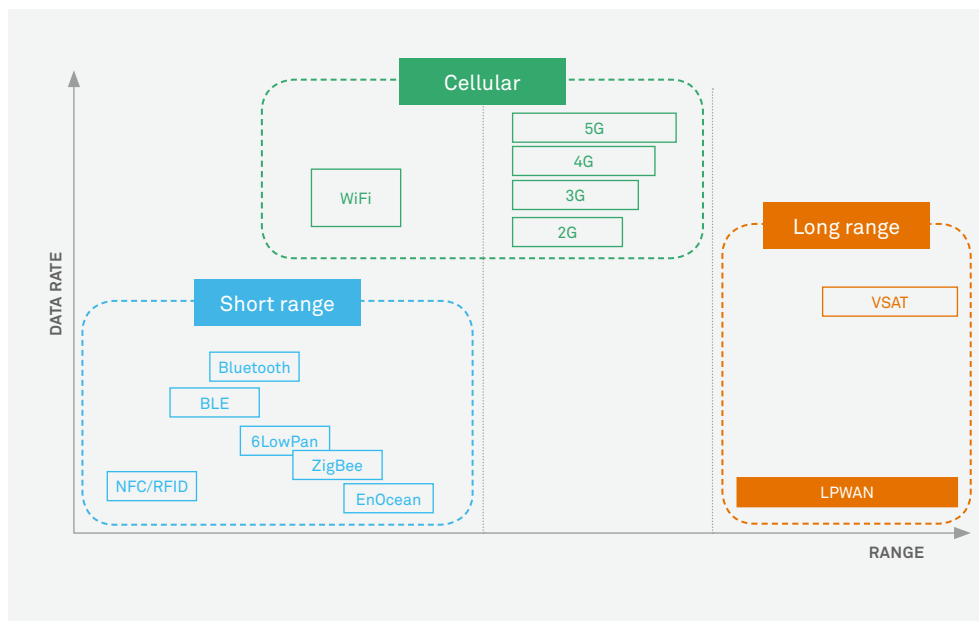
Overview: Potential benefits for the process industry

Measured value	Application examples
Temperature	Process monitoring, alarm on exceeding or falling below a threshold value, monitoring of overland lines
Air pressure	Process and environment monitoring (threshold)
Air humidity	Process and environment monitoring (threshold)
Light	Automatic switching on and off, energy saving
Magnetism	Monitoring of switch positions or power consumption (conclusions as to current flow)
Acceleration (inclination)	Plant monitoring through vibration analysis. Recognition of mechanical wear for predictive maintenance
Position	Position of switches and levers
Location (GPS)	Asset tracking, safety monitoring and access control for certain areas or Ex zone 1 / 2; person localisation
Battery level of the sensor	Service planning
Identification	Identification, localisation of products, ingredients and equipment
Distance	Geofencing, monitoring of Ex zones
Expansion	Monitoring of filling level (weight), temperature (longitudinal expansion) and pressure of tanks, pipes, tank wagons, etc.
3D and infrared images	Fault/damage monitoring and motion detection through intelligent comparison with reference images: Infrared: detection of hotspots 3D: position, clearance, speed, etc.
On/off switch	Recording of valve positions (switch mechanically measures lever or switch)

5.2. Communication – networks and protocols

The process industry also places specific requirements on the forwarding of data, which can be done classically and with near real-time capability via cable, for example via fieldbus or Ethernet protocols, or wirelessly if real-time data is not required. Their strength lies in the simple and economical retrofitting during operation. Radio communication is also suitable due to the sometimes harsh environmental conditions, for example in order to penetrate built-up areas and reach high plant sections without wiring and to cover long distances of up to several kilometres. Accordingly, the selection of radio technology is typically based on range, data rate (amount of data per time unit) and reliability (redundancy). The requirements for latency (50 ms to a few seconds) and error rate (less than 10 to 5 %) are rather moderate due to the relatively low processing speed. For efficient and secure data transmission, there are now several radio technologies with different characteristics, including standardised (e.g. MIOTY) and proprietary (e.g. ZigBee).

LPWAN technologies work either in the royalty-free sub-gigahertz range (e.g. at 915 MHz or 868 MHz), or in the royalty-payable mobile radio network (3G, LTE up to 5G). A distinction can be made between the following five groups according to the technology used[20].

1. Mobile radio / professional mobile radio (e.g. Tetra/DMR)

2. Low Power WAN technologies (e.g. MIOTY, LoRaWAN / IEEE 802.11ah, SIGFOX, NB-IoT, etc.)

3. Wireless LAN based on IEEE 802,11

4. Radio networking based on IEEE 802.15.1 (Bluetooth, WISA)

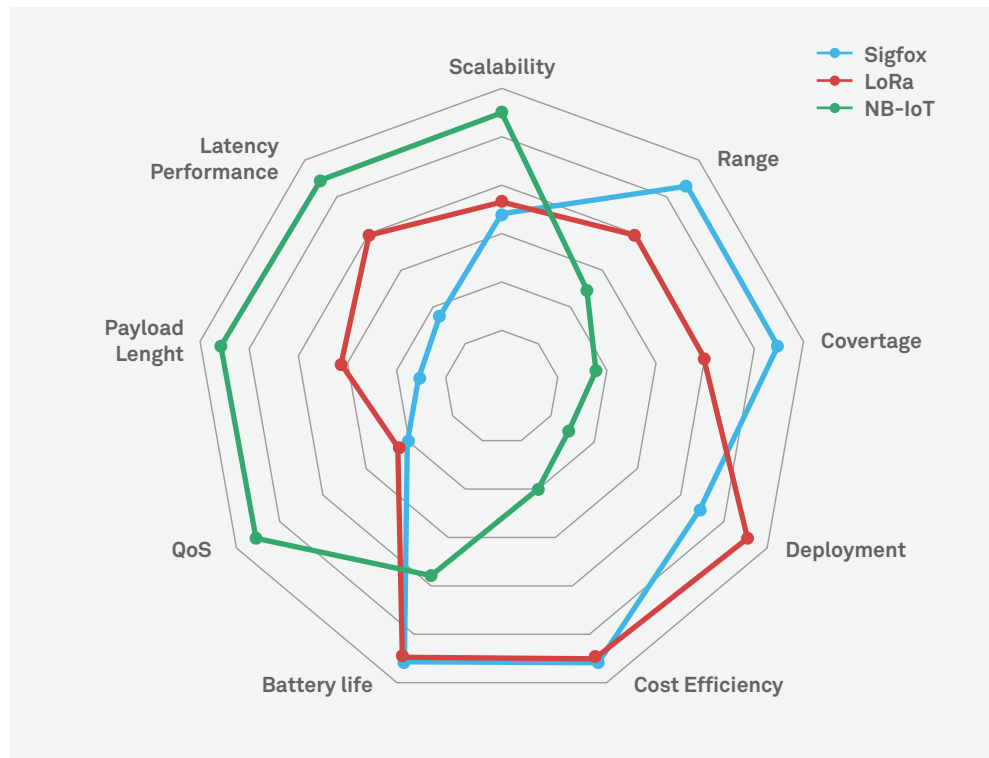5. Radio networking based on IEEE 802.15.4 (e.g. Zigbee, ISA100.11a, WirelessHART)

A comparative study of LPWAN technologies for large-scale IoT deployment.
(SOURCE: WWW.SCIENCEDIRECT.COM)

20 www.industrialradio.de/Attachments/Funktechnologien_Industrie_4.0_Web.pdf

Low-power WAN technologies

Low Power Wide Area Networks (LPWAN) are particularly suitable for typical IIoT tasks such as telemetry or condition monitoring over medium or long distances. Since they can transport small amounts of data with low energy consumption even over long distances or through densely built-up areas, they close the gap between mobile radio (3G, 4G, 5G) and near-field radio (Bluetooth, WLAN, Zigbee, etc.). LPWAN can be used to set up national, international and geographical networks for regionally limited tasks. A distinction must be made between cellular LPWANs that operate in licensed mobile radio and those that use the licence-free sub-GHz range.

Sub-GHz LPWANs use protocols such as MIOTY, LoRa or Sigfox, and can either be booked by a telecommunications operator (e.g. Sigfox) or operated by the company itself with its own base stations or gateways. In this way, the network data can be limited to the physical installation without connection to a service provider. However, the data rate is lower than with cellular LPWANs that use protocols such as LTE Cat M1 (eMTC) or LTE Cat NB1 (NB-IoT).

Software-defined standard protocols (e.g. MIOTY, but also NB-IoT), which work with standard hardware components are particularly interesting from an economic point of view. In the case of MIOTY or Lora, for example, an ordinary industrial PC with radio receiver can serve as a base station. A transmitter with a sub-GHz transceiver chip is sufficient as transmitter. The NB-IoT standard, which is also software-defined, is based on the LTE mobile radio standard and can also be integrated into the existing LTE infrastructure via a software upgrade. By 2025, five billion IoT mobile radio modules based on 4G, LTE Cat-M or NB-IoT are to be delivered worldwide.[21]
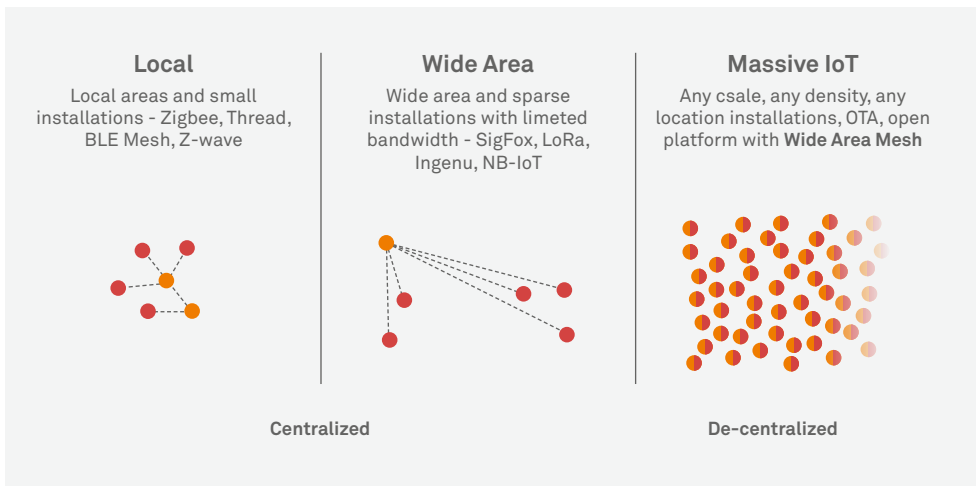

Comparison of LoRa and NB-IoT in terms of IoT factors.
(SOURCE: WWW.SCIENCEDIRECT.COM)

[21] https://www.counterpointresearch.com/5-billion-iot-cellular-module-will-ship-globally-2019-2025-4g-lte-cat-m-nb-iot-hyper-growth/

## Save on hardware with mesh networks

If IIoT networks become larger, denser and more decentralised, infrastructure costs will also rise. Mesh networks counteract this effect. The individual IIoT devices function as satellites in these networks and pass on the data between them to the final recipient (e.g. via gateway). Due to the lower use of hardware with a high number of nodes, mesh radio networks are an alternative to the classic star-shaped architecture of local or wide area networks (LAN / WAN). The software-based Wirepas connectivity protocol is particularly suitable for setting up networks in the sub-GHz range and 2.4 GHz band.

Local
Local areas and small installations - Zigbee, Thread, BLE Mesh, Z-wave

Wide Area
Wide area and sparse installations with limeted bandwidth - SigFox, LoRa, Ingenu, NB-IoT

Massive IoT
Any csale, any density, any location installations, OTA, open platform with **Wide Area Mesh**

Centralized

De-centralized

IoT connectivity: development from a local network to a randomly scalable Wide Area Mesh
(SOURCE: LONMARK.ORG)

Mobile radio networks for global telemetric applications

The advantage of cellular LPWANs, e.g. based on NB-IoT, lies in the higher data rate and the ability to communicate across long distances and national borders. Compared to sub-GHz LPWANs, the output power is less limited. The disadvantage lies in the chargeable use within the framework of a corresponding mobile phone contract. Global telemetric applications also require international coverage. For example, the Swiss service provider SAVVY Telematik Systems[22] offers a complete end-to-end solution for worldwide monitoring of tank containers and tank wagons. For international network coverage by water, rail or road, the Swiss offer their customers an international all-network subscription at a fixed monthly price. The technical basis for worldwide connectivity is provided by SIM chips in the telematics devices. The leading providers of IoT mobile radio modules include SIMcom Wireless, Sierra Wireless and Gemalto.[23]

SIMcom Wireless 23%

Others 35%

Sierra Wireless 17%

Telit 11%

U-blox 5%
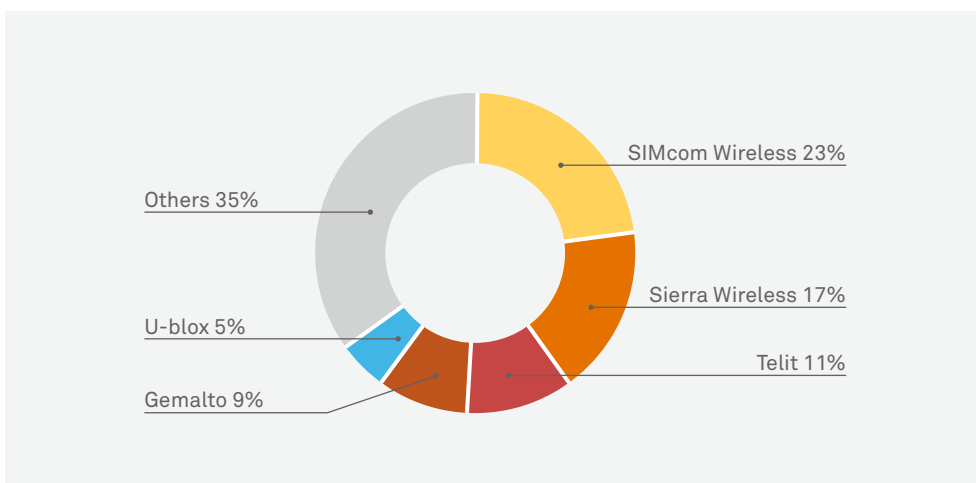
Gemalto 9%

Market shares in the global sale of IoT mobile radio modules according to unit numbers in the first half of 2017.
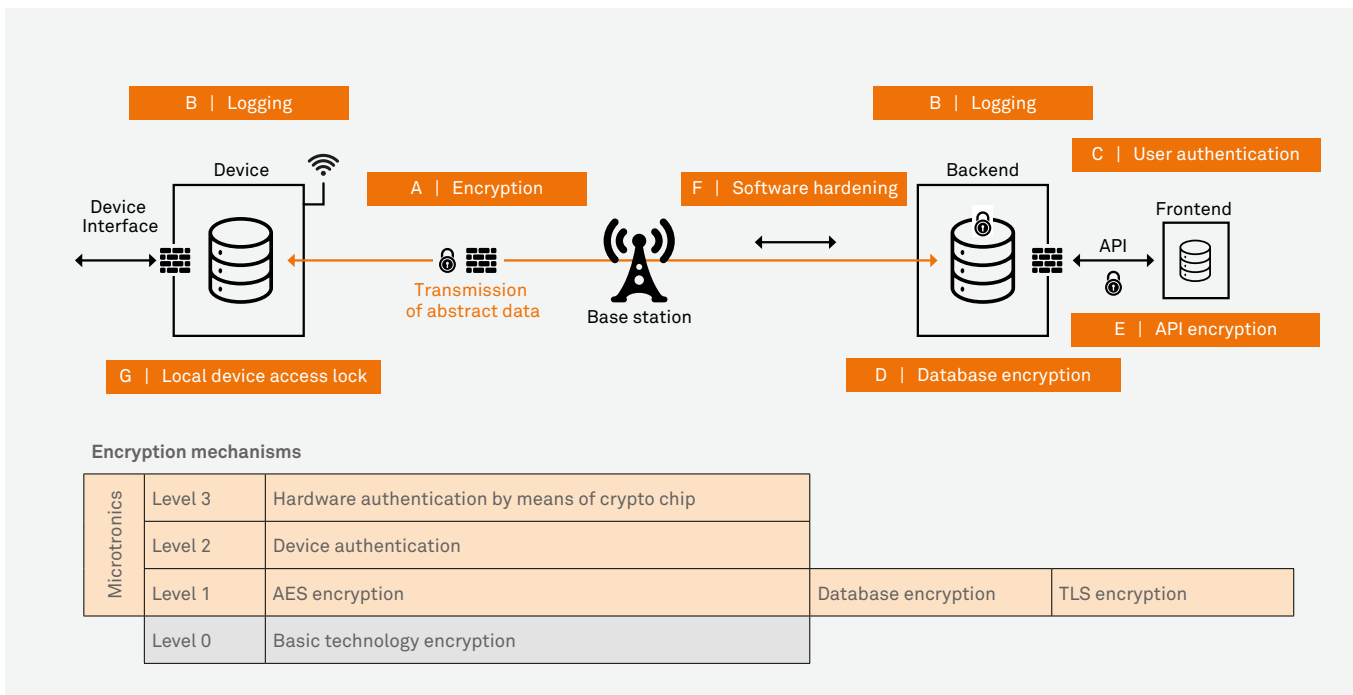(SOURCE: Q2 2017 IOT TRACKER)

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[22] www.savvy-telematics.com
[23] www.counterpointresearch.com/sierra-wireless-and-gemalto-lead-the-iot-cellular-module-market-in-terms-of-revenue/

Secure data transmission

The means of choice for data transmission are the standard protocols OPC UA and MQTT. BARTEC collaborates with experienced solution providers such as Microtronics[24] to map not only standard-based hardware and software solutions but also the critical points of scalability, security and future security. The technology leader from Austria has developed a multi-layer security concept consisting of encryption mechanisms that takes into account the entire information chain and includes comprehensive automation mechanisms for scaling. Microtronics uses the specially developed protocol UTO (Universal Transfer Object) which, compared to MQTT, always works with reconfirmation and is therefore more secure, as MQTT does not always contain reconfirmation. If only a few hundred or thousand IoT devices have to be managed and kept up to date, must software and security updates and device management inevitably be automated. BARTEC's IIoT framework, which is based on Microtronics technology, takes these requirements into account right from the start.

Success factor IT security: the multi-layer concept composed of encryption mechanisms covers the entire information chain
(SOURCE: MICROTRONICS)

Encryption mechanisms

Microtronics	Level 3	Hardware authentication by means of crypto chip		
	Level 2	Device authentication		
	Level 1	AES encryption	Database encryption	TLS encryption
	Level 0	Basic technology encryption		

24 www.microtronics.com

Low-power framework from BARTEC

For IIoT retrofits in the process industry, BARTEC offers a scalable and protocol-inde-pendent framework for the seamless interaction of terminal devices and IT systems based on Microtronics' leading technology. The individual components range from wire-less embedded technology to Ex-certified hardware and software to the easily integrated M2M platform with international data transmission at a uniform rate. (IMAGE SOURCE: MICROTRONICS)
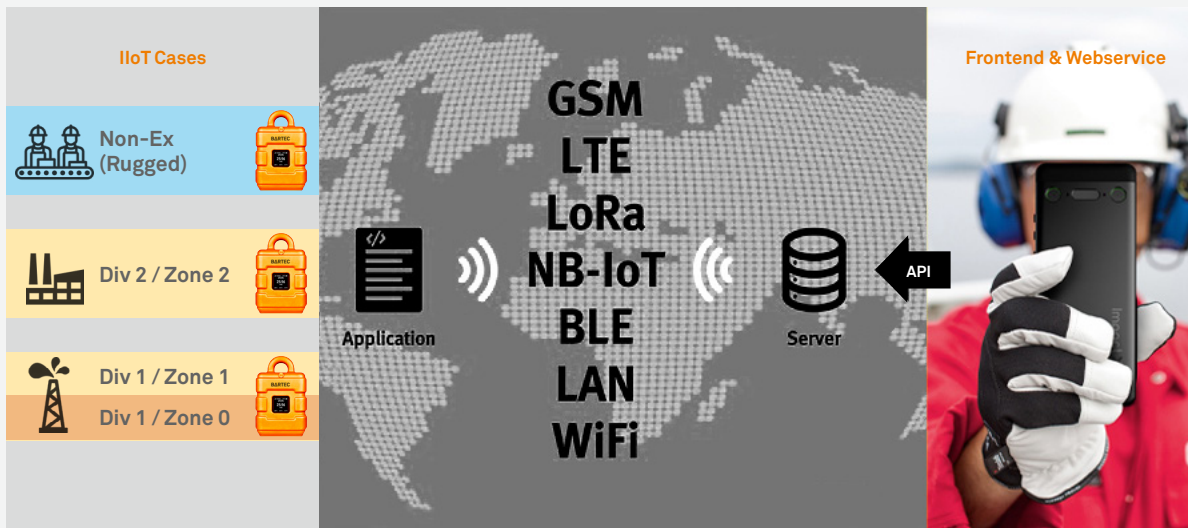
Summary: success factors of data transmission

A communication approach for seamless interaction of IIoT devices with higher level IT systems must be convincing in four respects:

1. **Efficiency** – lean transmission protocol, low data volume, high ranges, energy-efficient hardware, mesh networks

2. **Security** – multi-level security concept (data encryption, device and hardware authentication, see 6.5), multi-level end-to-end encryption, device virtualisation, certified security through standard protocols

3. **Stability** – optimised and certified hardware components, high availability: mirroring of data and software: complete and correct data transfer and synchronisation, etc.

4. **Internationality** – international network coverage, worldwide device management with European or global footprint, direct cost control of devices, fully automatic and configuration-free data transmission (plug & play), global and local certificates

5. **Future-proof** – standard protocols, standard hardware, availability of components (large, established manufacturers)

5.3. Communication – networks and protocols

The more work an IIoT device can do, the fewer resources will be needed later in the cloud. As part of edge processing, collected data is filtered or pre-processed in the field or at its "edge" (possibly in the secure area). By reducing data accordingly, bandwidths and the energy consumption of battery-operated sensors and devices can be conserved, but above all short and fast feedback loops can be realised in the process. In the course of edge processing, the data rate can also be regulated with the aid of an MQTT broker, so that a transmission takes place, for example, at a defined interval (e.g. every "x" minute) or only after exceeding or falling below a threshold value. This is particularly important for image sensors that compare 3D and IR camera images with reference images (visual threshold) or for vibration analysis. Here, edge processing can even lead to a self-learning system that has "learned" the basic characteristics of the still "healthy" pump over a longer period of time and recognises significant deviations based on the current values. Only then is the data escalated to the cloud for further analysis. The provider SAVVY uses such a procedure for the worldwide detection of damage to rail freight car wheels.

Local or global data processing?

The degree of edge processing depends on the required degree of accuracy and up-to-dateness of the data beyond real-time requirements. The aim is to achieve the desired result with an optimal relationship between local and global data processing under economic and qualitative criteria. For example, edge processing is the best method for image recognition, since data transmission is only triggered in the event of deviations from the reference images. This saves bandwidth and energy in the case of battery-powered gateways[25]. In hazardous areas, however, it must also be taken into account that local computing power is always associated with heat generation, which may limit the possibilities of edge processing compared to the safe area. If possible, frequent or larger computing tasks should take place outside hazardous areas. Gateways can also take over simple edge processing functions. MQTT brokers like Mosquitto run under Linux on different platforms like PC, Raspberry Pi or Arduino.

Distributed computing power for optimum data flow: from the local level via edge processing to cloud analysis.
(SOURCE: KNOWTION)

| Embeded Analytics | Edge Analytics | Cloud Analytics | Presentation and decisions |
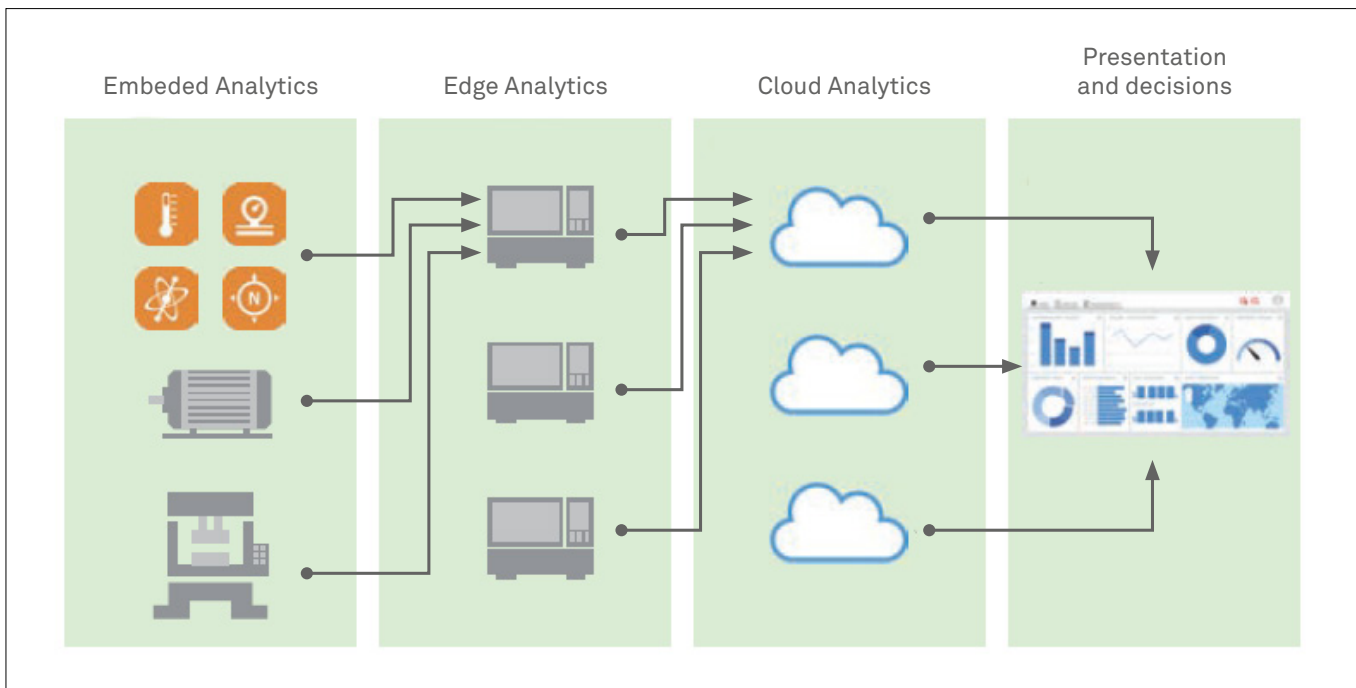
5.4. Gateways – data collection and forwarding

Once the measurement data have been captured, they must be collected and transmitted for evaluation, for example to a cloud or a local server. So-called gateways implement this task physically and logically. Gateways can display their own hardware components or run software-based on standard hardware, e.g. an industrial PC. In order for this key element for the IIoT setup to be usable everywhere, however, the respective hardware must always be certified for the respective area. There are solutions up to ATEX Zone 1. Data forwarding can be wired or wireless according to requirements[26]. The advantage of a wireless connection is the simple and timely retrofitting, a shorter project duration and, if necessary, it is possible during operation, i.e. without shutdown. However, the regular battery replacement must be taken into account, which can be reflected in the scope of the new IIoT service models if necessary[27].

Success criteria for Ex gateways

Equipped with the appropriate computing power, the gateway can also pre-process or further process data (see 5.3.). The hardware can be flexibly located: while devices with a large computing capacity are typically housed in the control cabinet, more compact, battery-powered units are mounted in the immediate vicinity of the data source. Even lighting components offer a simple and cost-efficient way of accommodating gateways thanks to the existing power supply and can even become part of an LPWAN mesh[28]. For wireless connection with wireless sensors, many gateways use the energy-efficient Bluetooth LE (Low Energy) wireless standard. Smartphones can also use this standard to connect to the network, for example to make simple parameter settings. If required, several gateways can also form a short-distance radio mesh network according to the worldwide standard IEEE 802.15.4, and thus pass on data over several hundred meters to the next base station[29]. The protocols for data transport to the cloud server are another success criterion and must be powerful ("rich") enough for the respective applications[30]. This is the case with most industrial protocols as well as with the higher-quality Industrie 4.0 protocols such as OPC UA or MQTT.

Robust and retrofit-capable: BARTEC gateway solution

BARTEC's battery-powered, easy to retrofit gateway is available for ATEX zones 1 and 2. The solution developed by Microtronics collects data from industrial sensors via an analogue 4-20mA standard interface and Bluetooth LE. Data transmission to the central web interface is via 3G / 4G. The IP68 housing offers chemical resistance and high robustness for industrial use. The battery life is 24 months with a 5-second measuring interval. The measuring points can be managed from any location via the Internet. The gateway is configured via smartphone app or web interface. A multi-level security mechanism ensures the accuracy of the data and protects them against unauthorised access.

BARTEC Ex-Gateway

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26 See Chapter 5.2
27 See Chapter 1
28 See Chapter 5.2
29 See Chapter 5.2
30 See Chapter 5.2

5.5. Cloud – local or global?

The actual data processing typically takes place in a cloud. Depending on the policy, this can be a hosted private cloud, for example as part of Microsoft Azure, AWS IoT, IBM Watson, etc. or a local cloud within the corporate network (on premises). For big data applications with artificial intelligence (AI)[31], there is usually no way around the large platforms. Computing capacities can be scaled here according to demand and rented based on usage (pay per use)[32]. The key success factors for the cloud strategy are compliance (IT security, data access, data protection, etc.) and cost-effectiveness, which is derived in particular from the ability to integrate into existing company applications such as control centres or maintenance systems.

Security concept and customer requirements determine the solution.

Cloud-based solutions are more easily scalable and can use the computing power of the cloud when needed. Many customers require hybrid solutions with local storage and subsequent transfer to the cloud. This depends on the platform desired by the customer. IIoT solutions, however, tend to consist of hybrid solutions.

Cloud or local storage. Depending on customer and application requirements as well as security concept, a customised solution will be elaborated.

(SOURCE: I-TECHGEEKS - CLOUD STORAGE VS. LOCAL STORAGE, HTTPS://WWW.I-TECHGEEKS.COM/2016/01/CLOUD-STORAGE-VS-LOCAL-STORAGE.HTML)

[31] See Chapter 5.6
[32] See Chapter 1
[33] See Chapter 2

5.6. Cloud – local or global?

The purpose of IIoT retrofitting is to obtain information which has not been transparent until now and which can be used to exploit the various potential benefits for the process industry[33]. The valuable information gain from the collected and possibly pre-processed data can be distributed over the three levels - local, edge and cloud - and differentiates between two basic approaches:

a) Automatic data analysis

In automatic data analysis, sensor data are automatically monitored and deviations are detected using mathematical algorithms. These algorithms extract the desired information directly from the data. This includes the entire spectrum of methods from machine learning, such as linear regression, neural networks, random forest or hidden Markov models. A typical algorithms pipeline for data-driven approaches that can be implemented on all three levels consists of the following components:

1. Data pre-processing
2. Feature extraction
3. Feature reduction
4. Actual machine learning algorithm

For this purpose, usually large amounts of measurement data are continuously evaluated and interpreted (big data), patterns and deviations are identified and automatically corrected if necessary. The advantages of this procedure are as follows:

- Verification of data in real time
- Early detection of outliers and faults
- Interpretation of data, e.g. process is running as expected / is completed / deviates from scheduled process, etc.

The typical field of application for automatic data analysis is the monitoring or adaptive control of processes. For example, "intelligent distilleries" can be realised that automatically recognise the end of the process. In another example, the supplier Knowtion has developed an automatic monitoring system for the production of extruded polystyrene rigid foam (XPS). The production process and extruder condition are evaluated to predict the final quality and properties of the product, and production is optimised and controlled accordingly.
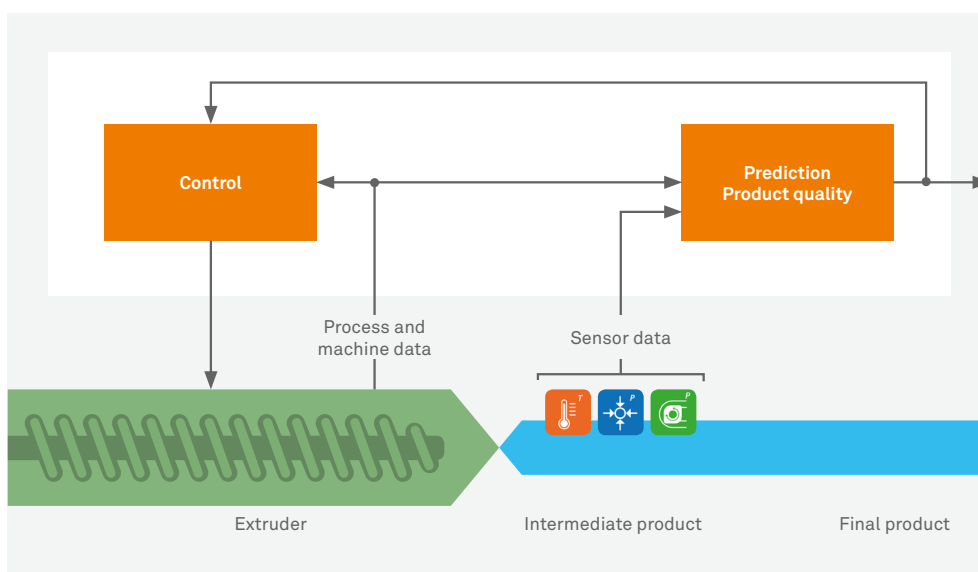
Adaptive Control using automated data analyses.
(SOURCE: KNOWTION).

b) Sensor fusion

The term of sensor fusion refers to the combination and aggregation of measurements with several sensors to form a coherent overall picture. These approaches assume that physical background knowledge is available in the form of a mathematical description. These so-called model-based approaches now combine the sensor data with this background knowledge in order to obtain a more accurate result of the desired information. The best known examples are the Kalman Filter (KF) for linear systems and Unscented Kalman Filter (UKF), Extended Kalman Filter (EKF) or particle filter (PF) for non-linear systems. The choice of filter greatly depends on the application. A typical algorithm pipeline for model-based approaches that can be implemented on all three levels consists of the following components:
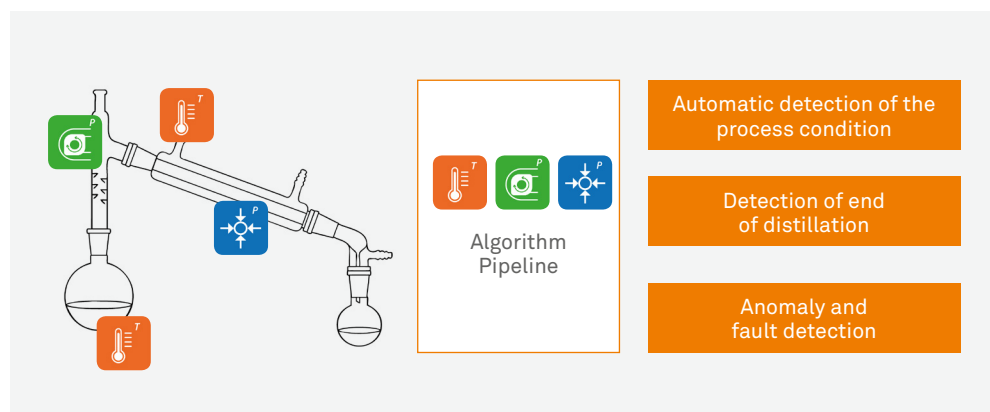
1. Outlier detection
2. Prediction step, and
3. Filter step

By merging different sensor types into a new virtual sensor, it is possible to calculate data that has not actually been collected. The combination of sensors with mathematical models thus creates added value through additional knowledge based on correlations[34]. This can also result in investment cost advantages, since the consolidated overall result of several more cost-effective sensors can be equivalent or better than the evaluation of fewer, but more precise or expensive special sensors. Further advantages are as follows:
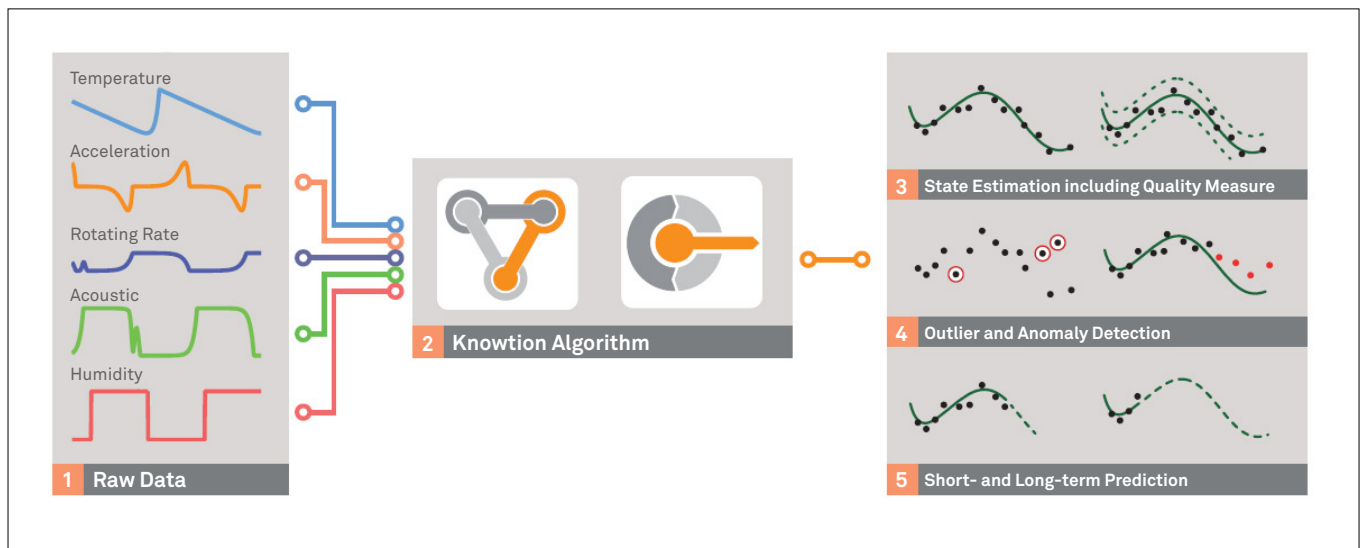
- Larger amount of information
- Lower investment costs with comparable accuracy
- Improved sensor coverage and reliability by combining different sensors

Virtual sensors are an important area of application for sensor fusion. They are used, for example, for automatic fault and error detection in the on-load tap-changers of power transformers, where previously invisible causes such as gas concentrations in transformer oil become visible. Other typical use cases include the monitoring, recognition and prediction of process and plant conditions.

Intelligent distillery: automatic regulation of distillation in the case of unknown volume and type of liquid.
(SOURCE: KNOWTION).

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[34] See following chapter

1 Raw Data — Temperature, Acceleration, Rotating Rate, Acoustic, Humidity	**2 Knowtion Algorithm** → **3 State Estimation including Quality Measure**, **4 Outlier and Anomaly Detection**, **5 Short- and Long-term Prediction**

Customised analysis

For automatic data analysis, providers such as Knowtion develop and program targeted software containing algorithms and AI according to certain standards of quailty and safety. Sensor fusion, on the other hand, is based on mathematical algorithms and models that use AI and machine learning to obtain higher quality information from raw data. For this purpose, the experts create various solution approaches within the framework of an agile process and evaluate them with the help of simulation (e.g. in Python and Matlab). This allows the following types of use cases to be implemented:

1. Self-monitoring of sensor systems
2. Detect errors
3. Determine / predict sizes
4. Predict failures / errors
5. Track and trace sensors
6. Control processes adaptively (using correlations with peripheral conditions).

Data analysis using models and algorithms.
(SOURCE: KNOWTION).

Example: Local anomaly detection on IIoT devices

The algorithms of the model-based and data-driven approaches above can even be optimised to the extent that they can be implemented on IIoT devices. This will be shown here as an example for anomaly detection in two different applications: vibration monitoring of a direct current motor and trajectory monitoring of industrial robots. The algorithms for both applications are identical, only the parametrisation is different, i.e. the time interval considered for vibration monitoring is short and for trajectory monitoring rather long. The acceleration and gyroscope data with a sampling rate of 1 kHz each were used as input data. For the vibration monitoring, the microphone and magnetic field data were also used as input data in order to take into account other conspicuous features such as acoustic changes. This combination of sensors using intelligent algorithms drastically increased the detection accuracy.

The results of the local calculation on the sensor platform are shown by way of example in the figures above. Both examples show the acceleration and gyroscope data, the locally derived characteristics and the locally calculated anomaly indicator. It can be seen that this indicator increases steeply with new signal behaviour and is much lower with repeated occurrence, i.e. the newly recognised signal was taken into account and updated in the model by the learning algorithm. In practice, after the algorithm has seen all "good data", a user would stop training to achieve stable behaviour."

Vibration monitoring of drives
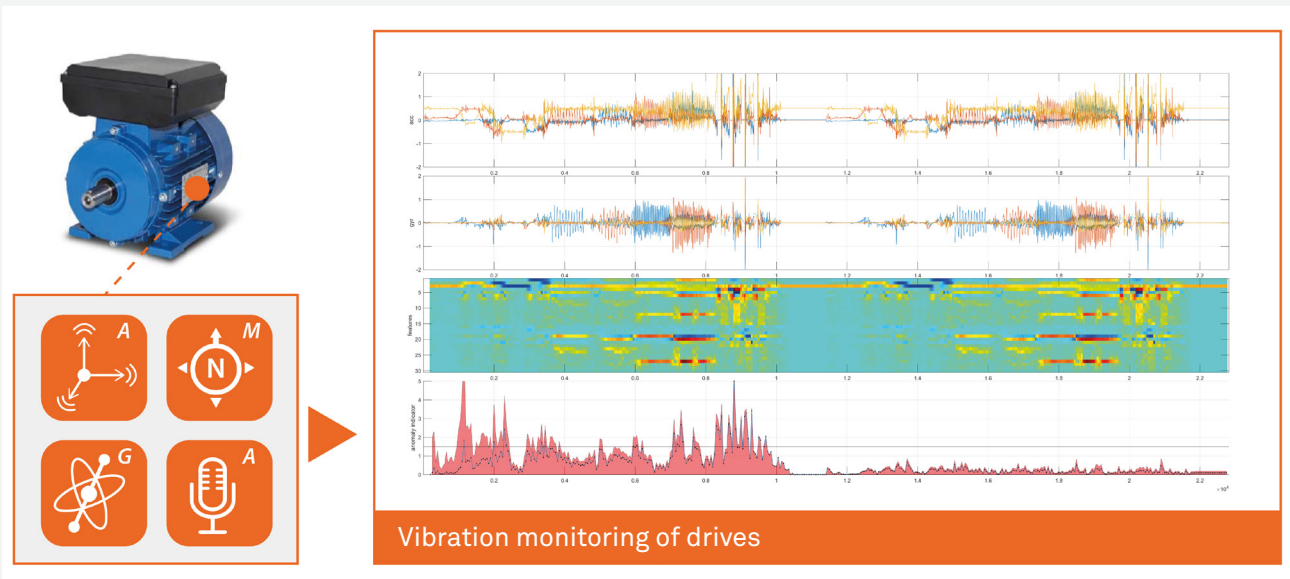
The vision of the self-learning plant

IIoT and artificial intelligence (AI) complement each other perfectly. The IIoT provides the necessary raw material for the AI with its connected sensor technology and the data collected using it. For its part, AI can improve the IIoT by evaluating large amounts of sensor data using machine learning, smoothing measurement errors and delivering structured data, making data exchange more robust. The ability to create context, interpret incoming information and trigger appropriate actions can ultimately contribute to the intelligent control and optimisation of the overall system[36]. Accordingly, the joint potential of AI and IIoT appears to be many times greater in the industrial environment than in the consumer market[37]. An example from the automotive industry illustrates this: the technology behind Tesla Service Autonomous Driving includes a self-learning system that constantly collects and evaluates data in order to learn from it and improve itself[38]. This is based on machine learning algorithms, wireless vehicle connectivity, and detailed map and sensor data collected by Tesla. The entire Tesla fleet is always online and works in a network. When one car learns something, they all learn it because the software is updated "over the air". In the future, this could also be used for plants to learn in this way in order to optimise their operation and share their knowledge in the company network.

In future, self-learning plants could optimise operations and share the existing knowledge in the company network.

(SOURCE: WWW.TESLARATI.COM)

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[36] https://digitalweltmagazin.de/2018/02/20/iot-und-ai-eine-co-evolution/
[37] https://aibusiness.com/ai-nothing-without-iiot/
[38] http://fortune.com/2015/10/16/how-tesla-autopilot-learns/

Employee empowerment through self-service analytics

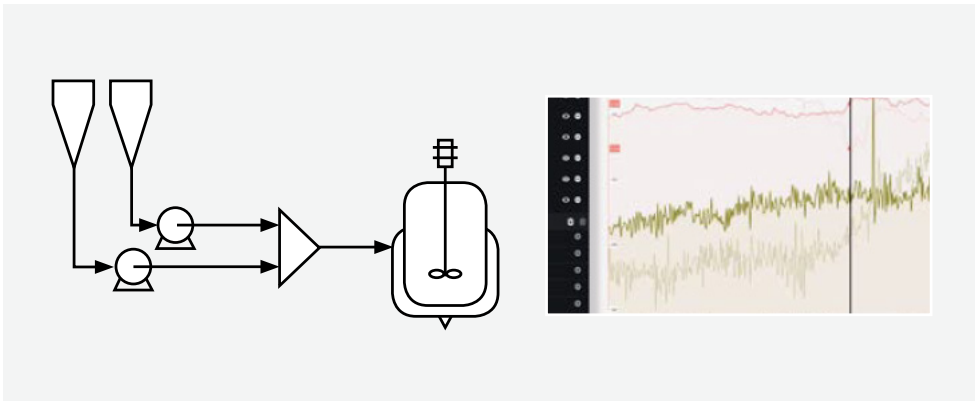The growing range of analytics services can be roughly divided into three groups with different needs:

1. Generic offers of large IoT platforms such as Microsoft Azure IoT[39] or AWS IoT Analytics[40] with adaptable default functions
2. Tailor-made solutions from expert firms developing and evaluating algorithms and models
3. Self-service analytics that empower employees to analyse existing data and timelines

The large platform providers score particularly well with their randomly scalable computing power and ready-made, easily adaptable analyses and dashboards. In addition, powerful scripting languages also enable tailor-made analyses. The strength of the software companies specialising in IIoT analyses lies in their high level of development and application competence. In both cases, however, a more or less high degree of internal or external know-how is required in order to develop the appropriate analyses. This is where an innovative self-service offer from the provider TrendMiner[41] comes in. With easy-to-learn tools, process and asset engineers and managers can carry out process and asset analyses themselves, take measures, continuously improve processes and share the acquired knowledge within the company. In this way all operational stakeholders can contribute to improving operational excellence, reduce costs and increase overall profitability.
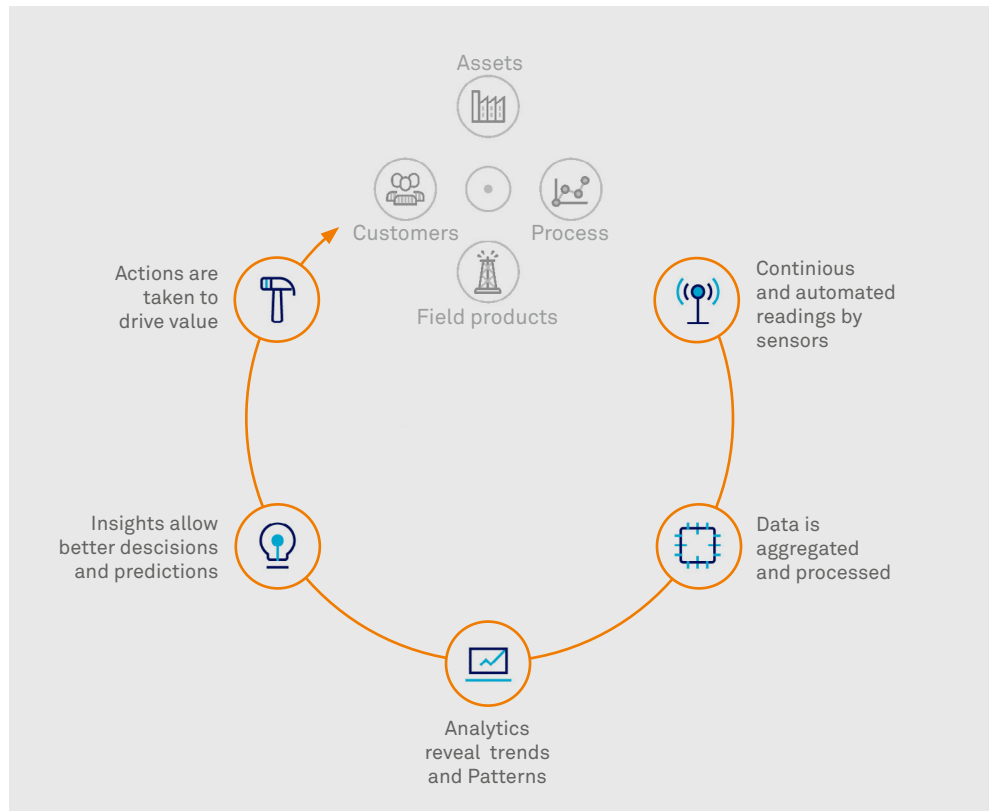
Self-service analytics empower process and asset Engineers and managers to make continuous improvements.
(SOURCE: TRENDMINER).

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[39] https://azure.microsoft.com/de-de/overview/iot/industry/process-manufacturing/
[40] https://aws.amazon.com/de/iot-analytics/
[41] https://www.trendminer.com/

Self-service analytics in polymer production: in this case the process engineer recognises the cause of a recurrent problem by overlapping several measurement curves.
(SOURCE: TRENDMINER).

Summary of IIoT analytics – success factors

In the analytics layer, the collected and possibly pre-processed measurement data are converted into usable information. Consequently, it significantly determines the return of investment, but is also directly dependent on the quality and reliability of the data collection. The essential success factor is therefore a well-integrated information chain and perfect cooperation between the solutions and partners involved - at the cloud level at the latest. Essential prerequisites for a seamless information chain are as follows:

- Hardware compatibility (partner and customer systems)
- Seamless collaboration between device suppliers with consulting companies and system integrators
- Intensive, continuous exchange

As an integrated solution provider, BARTEC is in intensive exchange with the economically and technologically leading players in the IIoT market. They include device suppliers such as Samson, consulting companies such as CGI Group[42], system integrators (e.g. Augmensys[43]) and service providers such as Sitech Services[44], Bilfinger Digital Next, SAVVY or TrendMiner – the basis for sustainably successful projects and joint growth.

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[42] www.de.cgi.com/de
[43] www.augmented-industries.com/
[44] www.sitech.nl/

5.7. Application level – user devices and apps

Even for the last link in the IIoT information chain, cooperation with experienced partners is essential for the success of the project. In addition to the necessary interfaces (APIs) for integration into the corporate IT, the visualisation on different HMIs in Ex and Non-Ex areas also requires corresponding know-how. The success factors here are as follows:

- High user acceptance
- Minimal IT costs
- Platform-independent display (apps)

As an experienced solution provider, BARTEC convinces with a sophisticated, modular and scalable solution concept for visualisation and interaction in hazardous areas - from stationary PC- and thin client-based HMIs to mobile devices such as tablet PCs and smartphones with certified accessories. In addition to a platform for Mobile Device Management (MDM), standardised solutions such as the Agile Tablet PC series, which - as a uniform platform for Ex and non-Ex areas - minimises project and IT management costs, are also important for acceptance by the IT department. BARTEC also supplies certified automation technology, including HMIs, remote I/O and bus systems as well as switching and control components, from a single source for comprehensive digitisation projects[45]. This overall platform is continuously extended in collaboration with other leading suppliers.
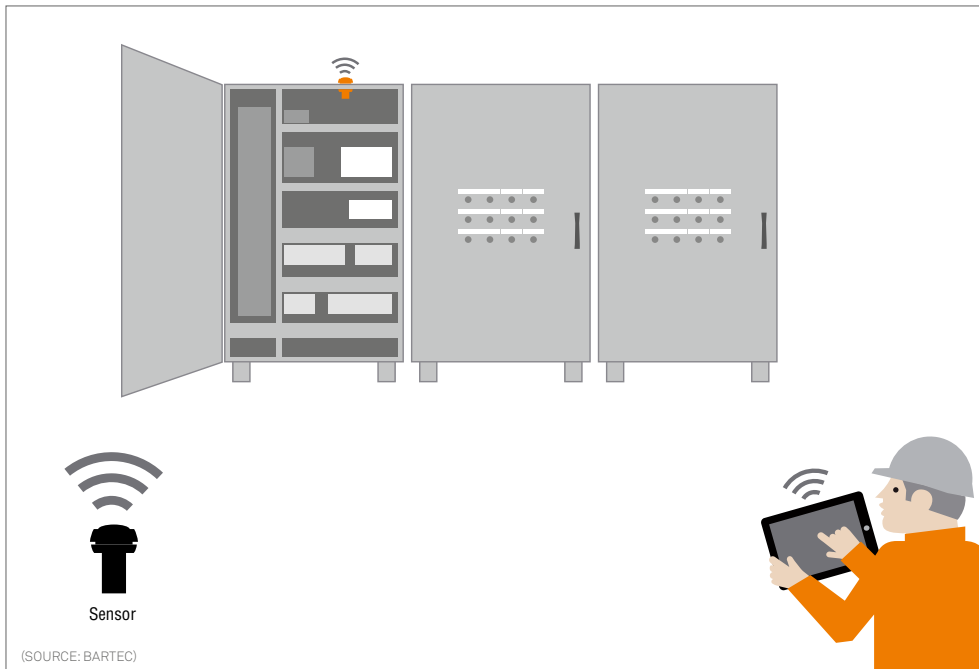
BARTEC Portfolio and continuity of the digital platform
(SOURCE: BARTEC)

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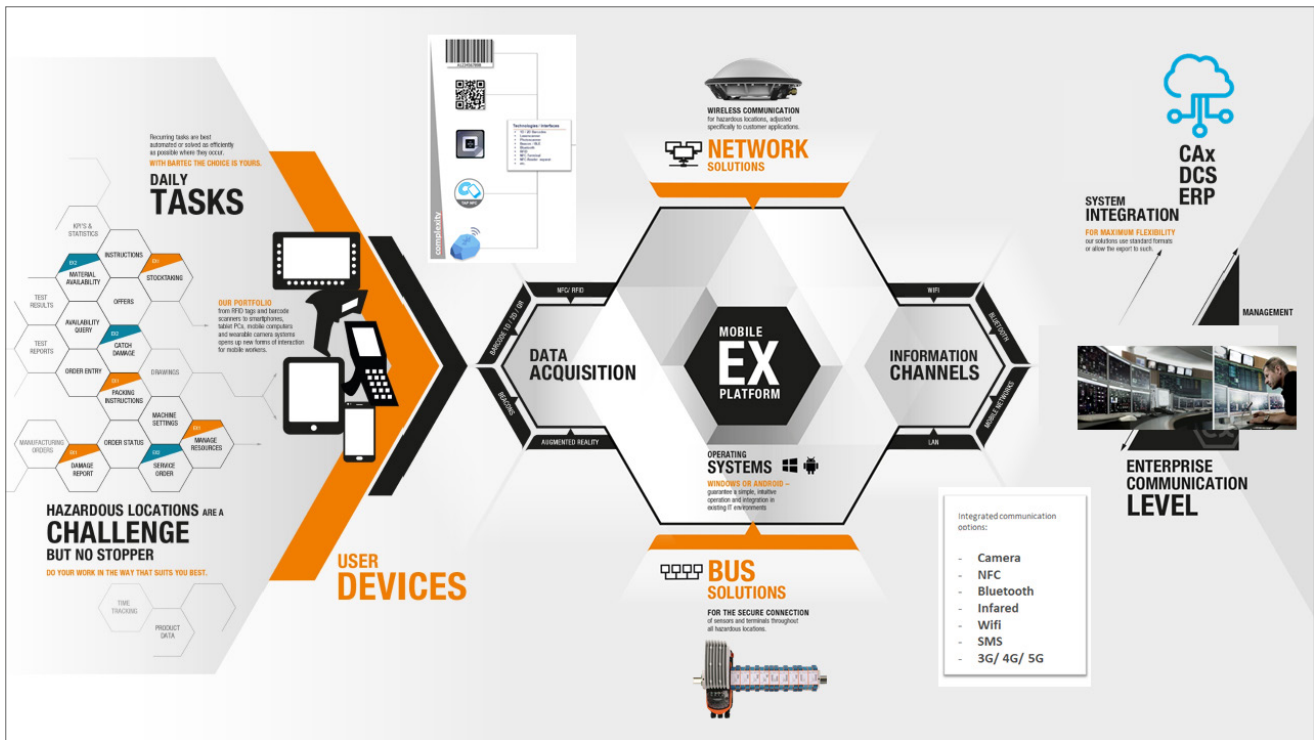
45 www.bartec.de/de/produkte/automation-enterprise-mobility/

6 Specific implementation examples

6.1. Beacon/ RHT sensor for the simplification of O&M

Sensor

(SOURCE: BARTEC)

Sensors send their measurement data via Bluetooth or wired to a gateway. In this way, previously non-existent data can be collected and made available for use in digital processes, for example.

Advantages:

- Increased plant availability; no need to open the switch cabinet door or the Ex d housing (plant shutdown)
- Simple and fast installation / retrofit
- Increased transparency: time stamp for inspections / maintenance (date / time / person of inspection)
- Storage of temperature and air humidity data (thresholds for falling below/exceeding) and therefore control of the area of application in the event of faults
- Convenient monitoring directly in the customer's control system (integrated via standardised interfaces)
- Convenient monitoring, directly in optionally available control system
- Reliable data transmission

6.2. Track & trace of mobile assets under Ex conditions (SAVVY)

The oil, gas and chemical industries produce and transport huge quantities of valuable but also dangerous goods worldwide. Today, companies lack the transparency in the supply chain to determine where the goods are or where their capital is, and whether there are transport disruptions or dangerous situations can arise. To create this transparency, SAVVY has developed a standard solution for the following applications:

The user monitors the process parameters of the product, the plant and the supply chain in real time - in stationary and especially decentralised plants as well as in globally mobile containers (rail freight cars, tank containers and containers) - under the harshest and potentially explosive conditions. This is to ensure the safety and availability of product and plant at all times.

The user is automatically informed of any deviation of the process parameters from the expected state. Current and historical values can be viewed worldwide via the SAVVY Synergy Enterprise Portal or can be integrated into the user's ERP system or shared with external parties.
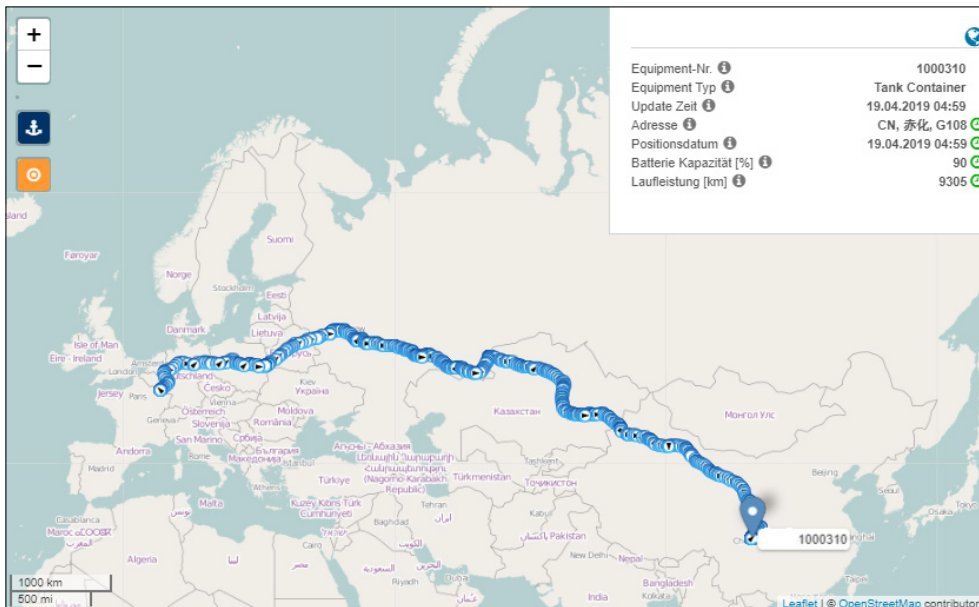
The operation of the existing system or the mobile containers is not affected by the installation of the monitoring solution. The solution can be retrofitted with minimal intervention in the existing system to keep installation costs and downtimes low and inspection costs minimal.

The solution is easily expandable and adaptable in order to grow flexibly with the project or operation of the plant.

The monitoring solution combines sensors with worldwide approved, standardised IEEE 802.15.4 wireless technology and LTE Cat M1 with NB IoT and 2G backup mobile network. The solution is therefore no longer limited by wired installations and at the same time enables increased reliability with low life cycle costs. Critical data is protected by 128-bit AES security keys.

The following example shows the fitting of the Ex telematic device SAVVY® CargoTrac-Ex to a intermodal waggon of truck WASCOSA.

Equipment-Nr. ⓘ	1000310
Equipment Typ ⓘ	Tank Container
Update Zeit ⓘ	19.04.2019 04:59
Adresse ⓘ	CN, 赤化, G108 ✔
Positionsdatum ⓘ	19.04.2019 04:59 ✔
Batterie Kapazität [%] ⓘ	90 ✔
Laufleistung [km] ⓘ	9305 ✔

The following example shows the monitoring of a container on the new Silk Road between Europe and China, where impacts, downtimes and schedule deviations are monitored.
(SOURCE: SAVVY)

The SAVVY® CargoTrac-ExR-M1 telematics device is allowed to travel in danger zones with potentially explosive atmospheres, because the telematics device is approved in accordance with Directive 2014/34/EU for potentially explosive areas in zones 1 (gas group IIC) and 21 (dust group IIIC) and is also IECEx-certified.

Thanks to its highly efficient battery supply, the monitoring solution is completely self-sufficient and maintenance-free, with the exception of battery replacement after 10 to 15 years, for example.

Advantages:

- Transparency in the supply chain for the consignor and the consignee as well as for all service providers involved in transportation
- Estimated time of arrival (ETA) determination
- Hazard detection thanks to sensor technology
- Predictive maintenance thanks to on-board vibration analysis
- Localisation of damage to product or container
- Increased plant and container availability
- Reduction of failures thanks to immediate intervention options
- Convenient monitoring directly in the customer's control system (integrated via standardised interfaces)
- Convenient monitoring directly in the SAVVY Synergy Enterprise web portal
- Reliable and secure global data transmission
- Simple and fast installation / retrofit even during operation

6.3. Valve position monitoring


(SOURCE: BARTEC)
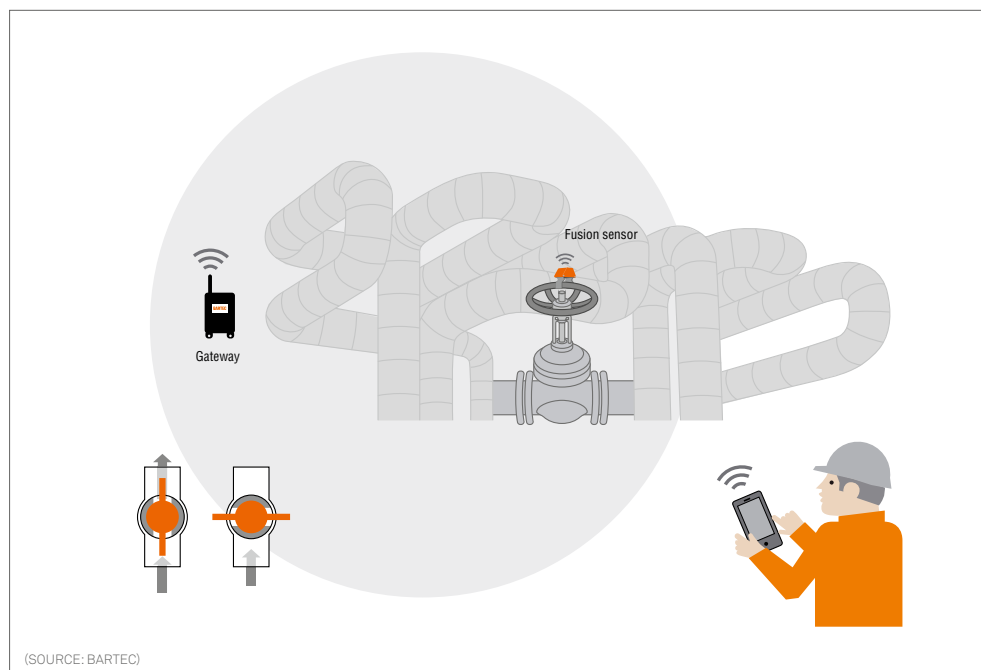
There is a large number of manual valves in process plants; many existing plants have been working successfully and effectively with them for a long time. Valve positions are increasingly monitored in order to optimise process operation and prevent operating errors. For this purpose, a valve position sensor is attached to the valve. In the event of a position change, the sensor sends a signal to a gateway, which transmits the information to the control room, where the personnel can oversee the valve positions.

Advantages:

- Greater plant availability due to continuous valve position monitoring
- Reduction of failures thanks to immediate intervention options
- Convenient monitoring of manual plant parts directly in the control system
- Reliable data transmission
- Simple and fast installation / retrofit

6.4. Corrosion monitoring of pipelines

(SOURCE: BARTEC)
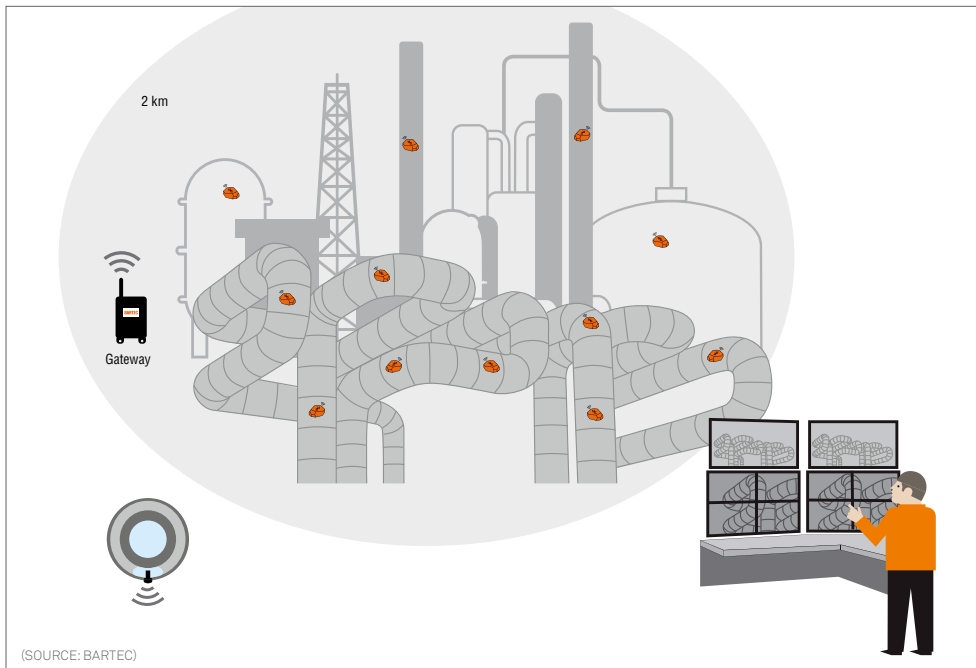
The corrosion monitoring of pipelines for perfect function is an essential prerequisite for the availability, performance and safety of plants. The quality management of these pipe systems includes a thorough analysis of the actual condition. This is done today by visual inspection and mainly during plant shutdowns. Digital monitoring holds great potential for service companies and ultimately for the operator / owner.

For this purpose, sensors are installed between the insulation and the pipeline. They send the position / temperature and humidity to a gateway via Bluetooth. Here, the data is collected and sent to the control room or to an evaluation system in the cloud. Using suitable algorithms, the corrosion can now be viewed as a function of ambient temperature and process.

Advantages:
- Greater plant availability through continuous monitoring
- Reduction of failures thanks to immediate intervention options (transparency)
- Savings on manual, expensive tests through automatic measurements
- Convenient monitoring of pipeline parts directly in the control system
- Reliable data transmission
- Simple and fast installation / retrofit

# 7 Barriers and success factors in IIoT retrofitting in hazardous areas

Security, IT/OT integration and unclear ROI: these are the three points that Bain & Company's customers cite as the biggest obstacles to introducing the IoT[46]. This reflects the high priority the market places on securing and integrating IoT networks. Compared to the previous survey, the importance of interoperability, data transferability, vendor risk and network constraints has also increased.

Vendors needs to address customer barriers - especially security, integration and unclear returns on investment

What are the most significant barriers limiting your adoption of IoT/analytics solutions?

Change since 2016

PERCENTAGE OF RESPONDENTS (TOP THREE BARRIERS)
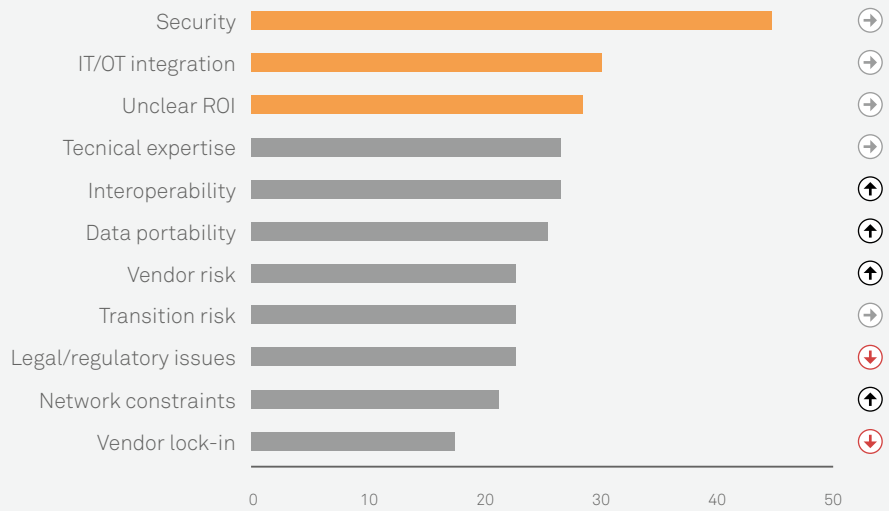
Customer survey: the most significant barriers limiting adoption of the IoT.
(SOURCE: BAIN & COMPANY)

The business consultancy therefore recommends that providers narrow their focus to a few target groups. With its eco-system of solutions and partners geared to the process industry, BARTEC already meets this important requirement today. The most important success factors to significantly simplify the complex task of setting up IIoT are as follows:

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[46] www.bain.com/insights/unlocking-opportunities-in-the-internet-of-things/

Application examples	
Technical success factors	Process monitoring, alarm on exceeding or falling below a threshold value, monitoring of overland lines
Process security	Terminal devices and IT systems interact seamlessly
IT security	Stringent, multi-layer IT security concept: encryption, data protection (information in containers), role-based data access, etc[47].
Economic efficiency	Energy-efficient design of all partial solutions (long battery life, low maintenance); efficient network infrastructure (minimal use of hardware, e.g. by mesh networks); sensible use of edge processing (transmission only in case of deviations); continuous improvement through self-learning systems, etc.).
Simplicity	Reduce complexity through sensors that can be retrofitted easily, efficient networks, device management, automatic software updates, efficient analysis development, user and IT friendly modular solution design for visualisation and interaction with the user
Integration	Interfaces to existing IT systems and partners (e.g. tracking warnings and forwarding them to maintenance partners); business intelligence tools for setting up customer-specific dashboards, mobile apps for fault documentation, etc.
Future-proof	The complete solution must take into account the complete product life cycle of all individual components. Independence of the overall solution from communication protocols (see 5.2.) Size of the producer, availability of components, future prospects for implementing protocols
Scalability	When selecting solutions, pay attention to scalability, e.g. device management with automated SIM management and software updates.
Organisational success factors	
Human factor: know how transfer and empowerment	Transfer of employee know how into digital processes. Constructive handling of scepticism towards innovations. Opportunity to replace simple activities with knowledge work. Empowerment of employees to actively improve processes: e.g. through self-service analytics, thereby also sharing know how in the company or across locations; direct monetary participation of employees in improvement processes; transparency in the field through enterprise mobility
Access to Ex know how	Selection of an experienced partner with holistic solution approach: - mobile Ex platform with option for data acquisition and integration of existing information channels - comprehensive range of ATEX-certified terminal devices and accessories
Start small, improve quickly	In reasonable steps from the small to the big solution. First small use cases with fast results (ROI < 1 year), then further use cases. End-to-end solutions with concrete benefits.
Project support	Experienced partner to support and moderate between departments and solution partners

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[47] See Chapter 4

Checklist:

how do I incorporate the IIoT in the company?

☐ Find the right strategy together with an experienced partner (workshop).

☐ Identify an initial use case with focus on the right sensor concept (the right sensor will be the fundament of the use case). ROI < 1 year.

☐ Technically discuss the use case in detail and define the hazardous area environment (Zone 1/ Div 1 or Zone 2/ Div 2). For global roll out, see chapter 3 regarding local certificates.

☐ Decide for a final protocol and connectivity option (Continious costs vs. one time costs vs. service over the life time vs. ownership of the infrastructure vs. traffic costs vs. need of bandwith). (See chapter 5.2).

☐ Think on a service partner plan (know how/ long-term cooperation / repair / service and battery exchange for e.g. wireless sensors).

☐ Create acceptance within the company. Involve C-level and affected departments at an early stage (IT, service, partner sales, etc. BARTEC as moderator).

☐ Clarify price and billing model (CAPEX -> OPEX).

☐ When developing the technology concept, pay attention to compliance, practicability (possibly during operation) and future security (energy supply, communication solution, edge computing, automation, cloud platform, IT security, data protection, etc.).

☐ How the data should be accessable (e.g. dashboard vs. mobile APP vs. integration of the existion ERP eg. SAP).

☐ Implement the pilot project (possibly during ongoing operation).

☐ Recap and plan further steps and projects.

8 Summary and conclusion

The Industrial Internet of Things is now also about to make a breakthrough in the process industry. In combination with various analysis options, retrofit-capable solutions release enormous optimisation potential and open up completely new service and business models in order to reduce CAPEX. The importance of software is increasing significantly; former hardware providers are becoming brokers and service providers. With the availability of infrastructure for hazardous areas and new technologies for energy-efficient data collection, processing and transmission, the last hurdles to economical retrofitting are falling. In combination with AI as a "game changer", the IIoT will become the key technology for continuous and economic process improvement in the long term.

The greatest benefits are promised by holistic solution approaches, which are developed together with experienced solution partners. As an enabler for the introduction of IIoT in Ex environments, BARTEC is developing a complete and scalable "ECO system" - with tailor-made hardware, leading solution partners, decades of integration know-how and worldwide presence.

Anyone wishing to fully exploit the possibilities of the IIoT must think holistically and strategically, but also take their first small steps. Those who miss the start will have a hard time catching up with the knowledge lead of competitors.

Would you like to be at the forefront? Find out how you can increase efficiency, transparency and thus security in your company?

Launch your first IIoT project in the Ex zone now with BARTEC at your side! Our experts are at the ready. You can count on it!

Digitisation is an opportunity, not a threat. Hazardous areas are no longer show stoppers. Take the first steps now with BARTEC at your side!

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