AVENTICS

SMART PNEUMATICS
OPPORTUNITIES FOR INDUSTRY THROUGH INTELLIGENT PNEUMATICS

Pneumatics
It's that easy

Networking as the objective: the future of the industry

The history of industrialization extends over several centuries but the latest industrial revolution has triggered fast-paced changes like nothing before. It raises many questions but also yields a huge potential.

For years, terms such as the Internet of Things and digitalization have dominated many press releases, trade show discussions, and industry conventions. The more widespread the discussion, the more definitions vary and remain ambiguous.

We have compiled this brochure to review the current situation, to contribute to a clarification of the concepts and to examine the opportunities that AVENTICS offers companies and machine builders – now and in the future.

"Future standards for the Internet of Things are being defined right now - and AVENTICS has already been developing suitable solutions for several generations of products."

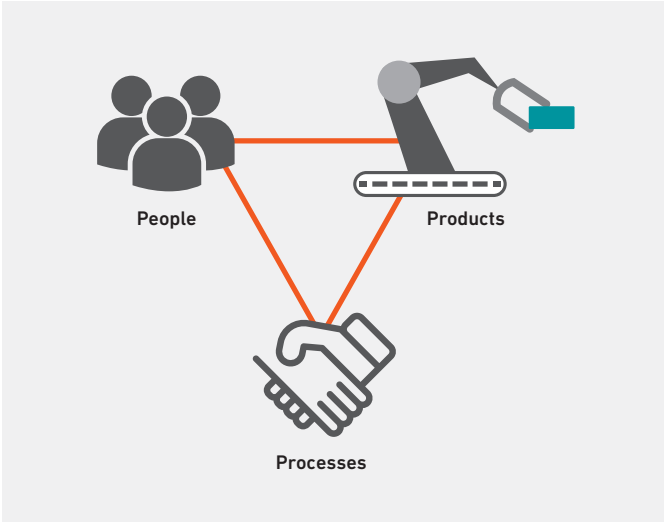
Wolf Gerecke, Director Strategic Product Management at AVENTICS

The Internet of Things

Smartphones, DSL, social media: Digitalization has changed our daily lives dramatically, making it faster-paced and more direct – and the same applies to industry which is currently also subject to a significant phase of reorientation. The current chapter: the Internet of Things.

We are currently experiencing the fourth industrial revolution: After the start of mass production around the 1800s, the invention of electricity and the assembly line towards the end of the 19th century, and the use of electronic, software-based control systems from 1970, everything is now focused on digitalization.

A predominant feature: interlocking production with the latest information and communications technology while simultaneously integrating customers and business partners into business processes. Today, all participants in the complete value-added chain are principally able to exchange information thanks to the advanced technologies used for networking, intelligent components, and workpieces - no matter whether it is a drive reporting its status in a production system or the operator's maintenance control station communicating with the machine manufacturer's spare parts service.



▲ The Internet of Things – connecting people, products, and processes

Challenges of the Internet of Things

People, products, and processes: Communication between these three cornerstones is at the core of AVENTICS' IoT strategy.

People:

Man, machine, and processes are interconnected, collection, analysis and visualization of data is easy to implement, only relevant data is passed on to users and errors and malfunctions reported directly.

Products:

Each product is a part of the information chain, data is processed by local hubs, product data can be accessed locally, and data transfer is standardized.

Processes:

The entire value flow is analyzed with a focus on critical points and data, relevant products and systems autonomously exchange data, and data that has a bearing on the target group is preselected automatically.

AVENTICS' pathway to the Internet of Things

AVENTICS combines know-how, application expertise, and professional user experience – and offers a wide range of products ready for any digital demands. Connectivity and the ability to communicate have been an integral element in AVENTICS' product policy and of our components and systems.

"With digitalization, pneumatics achieves a new level of productivity and efficiency," underscores Paul Cleaver, CEO of AVENTICS. This begins with selecting and configuring components in the design phase. Using the online configuration tools from AVENTICS, users can select not only the product, but also the matching accessories. Following configuration, the customer receives all relevant information right away, such as 3D models, dimension and position drawings, circuit diagrams, configuration files, and parts lists. The relevant configured products are always shipped ready-assembled and tested.

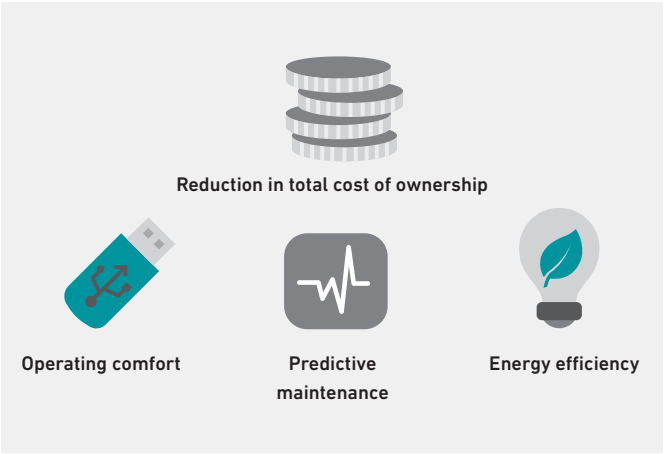
Added value to boost your success

AVENTICS offers direct added value for your IoT concept, with smart components that integrate seamlessly into a digital environment thanks to on-board intelligence and compliance with all relevant communication standards. Our solutions focus on the flexible further use of the generated information. Local evaluation and storage in the component, in a local database, in a private or public cloud – all options are covered.

AVENTICS consciously focuses on cooperation with other manufacturers. "The Internet of Things also means machine and automation suppliers are linked," emphasizes Paul Cleaver. "AVENTICS therefore works with numerous other companies to develop complete solutions that create added value for customers."

AVENTICS' focus for IoT

- **Predictive maintenance** through integrated diagnostics
- **Energy efficiency** through effective use of compressed air
- **Operating comfort** thanks to simple plug-and-run application



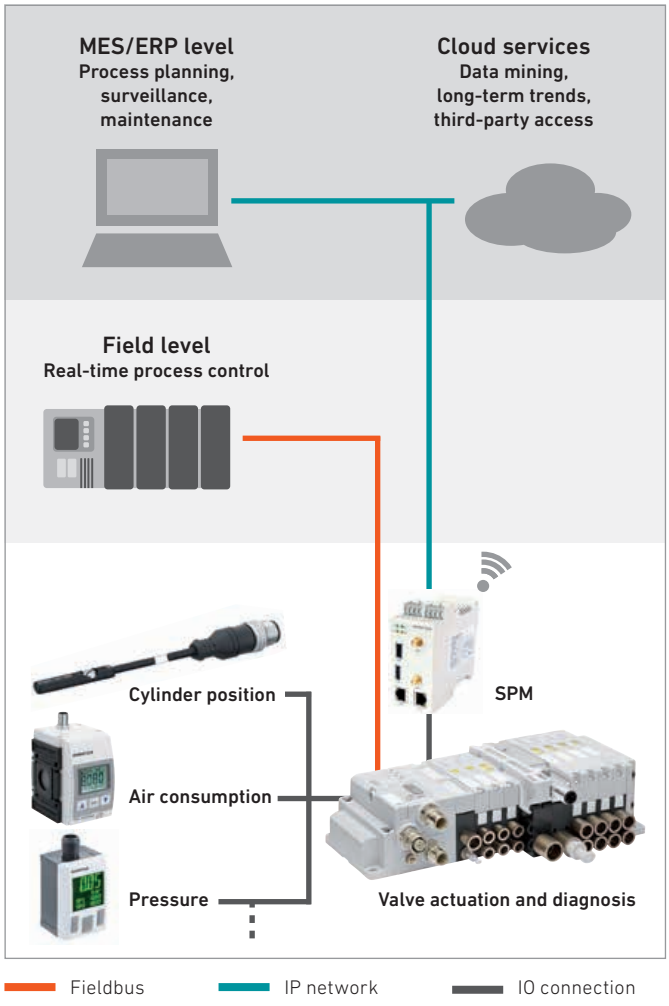
SMART PNEUMATICS MONITOR – the intelligent solution from AVENTICS

Want to check the state of wear? Need information on energy efficiency? The new Smart Pneumatics Monitor will provide you with reliable answers. It sends status messages to defined employees and parent IT systems without detouring to the machine controller. This minimizes the risk of machine downtime and substantially lowers operating costs.

Together with our AES fieldbus solution, the Smart Pneumatics Monitor (SPM) IoT gateway analyzes existing sensor signals and uses the result to generate status information. To monitor the wear of a shock absorber, for example, the SPM breaks down the end switch signals to evaluate the cushioning sequence. Algorithms written by AVENTICS based on the company's application experience analyze this data internally and send the information either to defined people or to the parent MES or ERP systems via the OPC UA interface.

Smart Pneumatics – it's that easy.
Using drag and drop, the components to be monitored are combined and linked in the SPM. On request, the module monitors the current energy consumption or the degree of wear, for example. Users can take measures for optimization early on and thereby meet the requirements set out in the EU Energy Efficiency Directive as well as minimize unplanned system downtime.

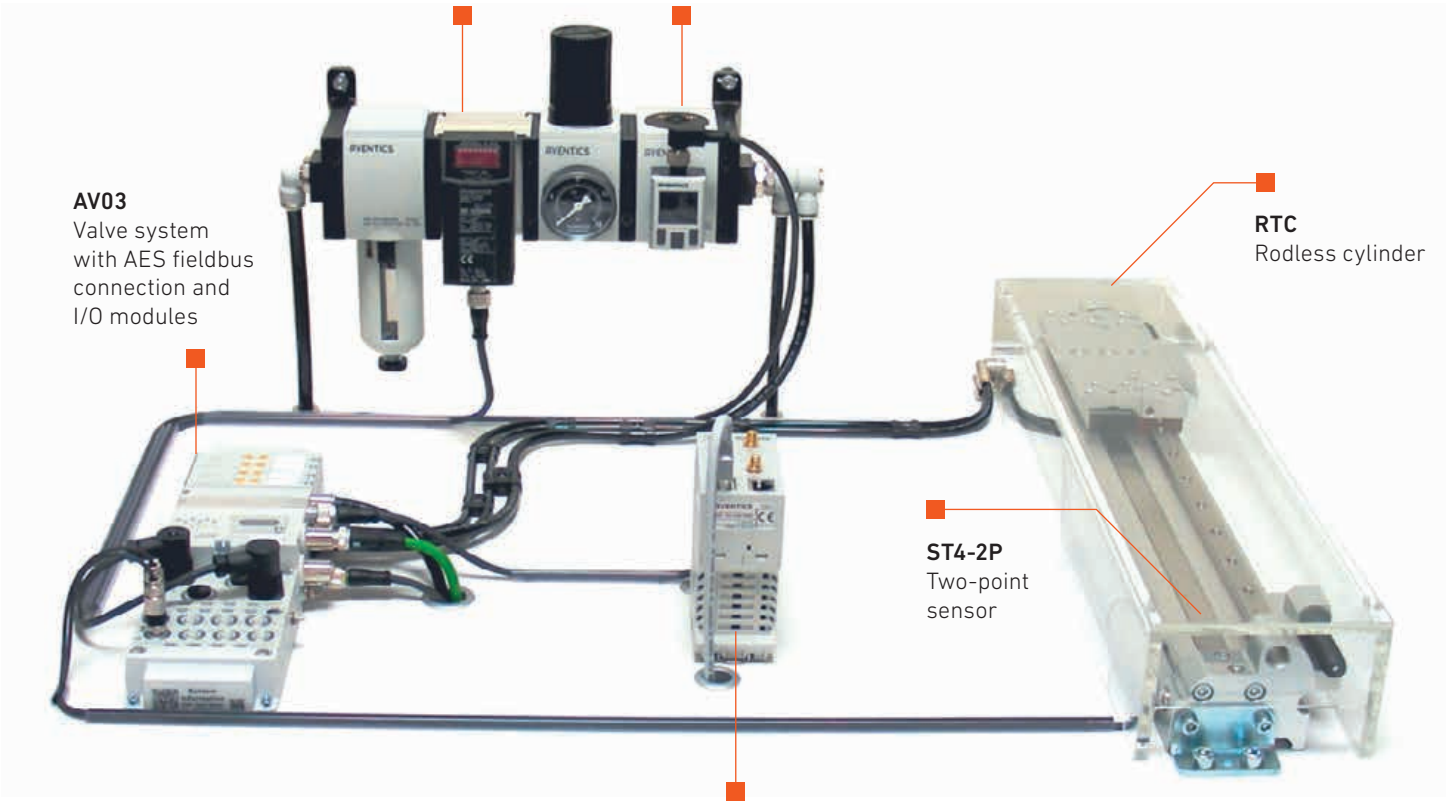
The SPM makes it easy for AVENTICS customers who are already using AV valves and the AES fieldbus system to take a further step towards implementing IoT solutions. Programming of the SPM can even be edited while the application is running, without any impact on communication to the controller.



Examples of SPM application

The four SPM applications listed below are characteristic examples that illustrate this innovative IoT gateway's simple operation, its great flexibility and outstanding efficiency.

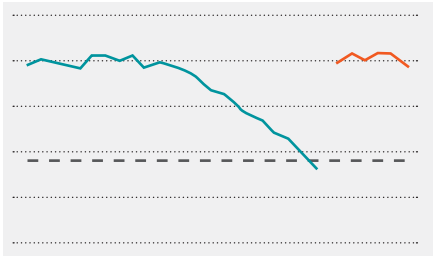
AES fieldbus node as data hub for IoT services



EXAMPLE 1

Maintenance monitor – determining wear

The shock absorber in this configuration had been replaced in regular routine intervals determined on the basis of past experience with the individual application – purely as a precautionary measure and not based on actual facts. The SPM now uses the cylinder sensor data to analyze the cushioning's timing characteristics. Because cushioning time decreases over the service life of the shock absorber, it provides direct proof of its state of wear. As soon as a critical value is reached, an error message can be output to exchange the shock absorber before it fails.



Shock absorber at the end of effective use

Acceleration limit value in the application

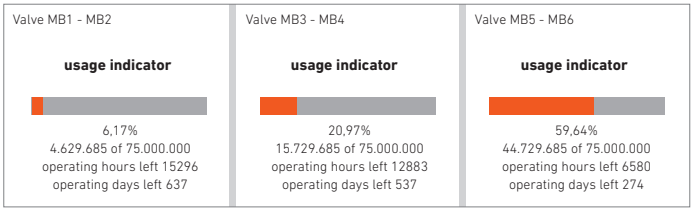
Newly deployed shock absorber

◀ Example: shock absorber monitoring. Change in acceleration over time (example 1)

EXAMPLE 2

Data management – counting switching cycles

A valve's state of wear is very difficult to determine from the outside but additional internal sensors would increase its size and add to costs. In contrast, the SPM is able to provide information on the expected service life of the valves – without incurring additional costs and effort. By measuring the valve's exact switching cycles it is possible to extrapolate the end of its typical service life. Preventive maintenance can then be carried out to avoid downtimes in critical applications.

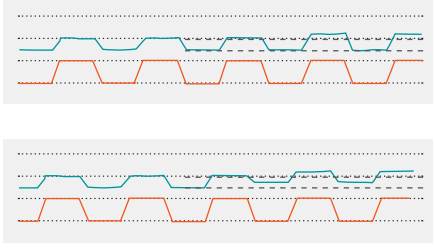


▲ Monitoring product life cycle (example 2)

EXAMPLE 3

Energy efficiency – detecting leakages

Energy efficiency is a key economic factor. The SPM gives a clear indication of where and how compressed air consumption changes – and allows users to determine the location of possible leakages. Predictive diagnostics is one of the main arguments for efficient use of the SPM.



Flow

Valve switching state

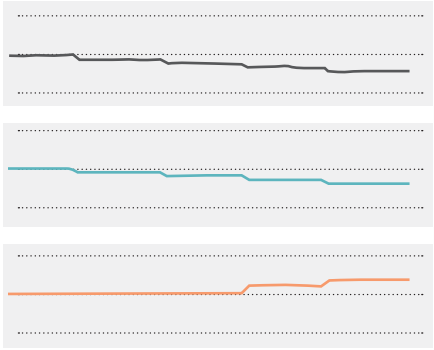
◀ Increase in consumption only when valve is actuated -> Anomaly/ leakage on or downstream of valve

◀ Overall increase in consumption -> Anomaly/leakage in supply or upstream of valve (example 3)

EXAMPLE 4

Optimized consumption – creating optimal compressed air balance

Whether during initial configuration or to improve ongoing operation: An optimum compressed air level saves money and prevents wear on the components. An SPM analysis helps you to determine the optimal operating point for a perfect balance of the work to be carried out and the supplied energy.



Set pressure

Compressed air consumption

Cycle time

◀ Example: optimization: The preset pilot pressure is reduced gradually and the impact on compressed air consumption and cycle time is monitored to determine the operating point where the cycle time can be maintained with the least energy consumption. (example 4)

Smart Pneumatics Monitor – the central module for networked pneumatics

The Smart Pneumatics Monitor module provides you with reliable information on the state of wear of the actuators as well as the energy efficiency of your pneumatic systems – without the need to involve the machine control. This minimizes the risk of unplanned machine downtimes and significantly lowers operating costs.

Digitized pneumatics achieves a new level of productivity

The collection of operating states and their prediction as the basis for anticipatory maintenance and control concepts offer direct advantages, particularly for customers using IoT applications. Together with our AES fieldbus system, the SPM module detects in advance when critical limits will be reached and provides users with key information for early intervention. Moreover, the sensor data collected via the I/O modules also provides a multitude of other options to optimize the pneumatic systems' energy efficiency, for example. In line with the IoT concept, the system records local data independently of the control, and prepares and supplies the information via standard interfaces wherever it is required, whether in a local IT network or in the user's cloud solution.

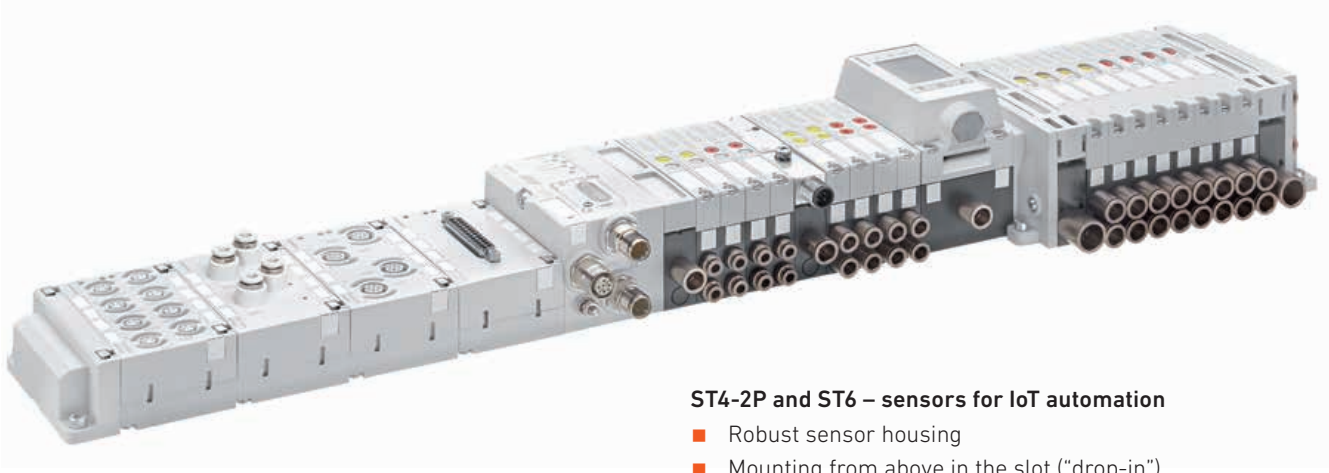
SPM basic equipment and connections

- eSOM/3517 with TI AM3517 32-bit ARM Corte @600 MHz
- Linux OS with VPN and firewall
- Graphical user interface for parameterization and programming
- Optional LTE modem (GSM, UMTS, HSPA)
- 10/100 Mbps Ethernet LAN, 10/100/1000 Mbps Ethernet LAN, USB 2.0 host, DVI/HDMI, RS232/RS485 bundled to RS422, real-time clock
- 12–24 V/DC power supply
- Communication protocols: OPC UA Server, OPC UA Client, Modbus Master, Modbus Slave, MQTT, S7 RFC1006, cloud connectors: SPA, Microsoft Azure IoT

- ✓ Local data collection and analysis independent of the controller
- ✓ Pre-installed analysis modules for condition monitoring and energy efficiency analyses
- ✓ Simple creation of individual analyses
- ✓ Support of IoT-relevant communication interfaces
- ✓ Open platform for extensive customization

Optimum interaction: Products for the Internet of Things

Simple commissioning and parameterization, predefined plug-and-play concepts, intuitive use – perfect for IoT applications. AVENTICS offers a solution package where each of the following products plays an important role.



AV/AES with I/O modules – the basis for your IoT application

- All relevant fieldbus protocols
- Consistent communication up to the valve
- Integrated web server
- Modular design
- Large variety of signals processed: analog and digital input/output modules, analog combination modules, control modules and pressure measurement modules

PE5 – electronic precision with extensive functions

- Measurement ranges for relative pressure (vacuum and overpressure)
- Large display for system pressure, switching states, and set switching points
- PNP, NPN switch outputs and optional analog output (current and voltage)
- Zero point offset function

ST4-2P and ST6 – sensors for IoT automation

- Robust sensor housing
- Mounting from above in the slot ("drop-in")
- LED function indicator
- Secure fixing through eccentric screw
- Shock and vibration-resistant

SM6-AL – analog sensor with high operating comfort

- Measurement range setting from 107 to 1007 mm via teach-in button
- LED function indicator
- Robust aluminum housing
- Output signal: 4–20 mA (0–10 V)
- High precision: resolution 0.06 mm, scanning rate 1.15 ms

AS3-AFS – flow rate sensor

- Measurement range: 10–2500 l/min
- Precise measurement of flow, consumption, and media temperature
- High precision, reproducibility, and measuremer dynamics
- With switch, analog and impulse outputs
- Can be integrated in AS3 series maintenance units
- Also available for AS2 and AS5 series

OPC-UA – the communication standard for the Internet of Things

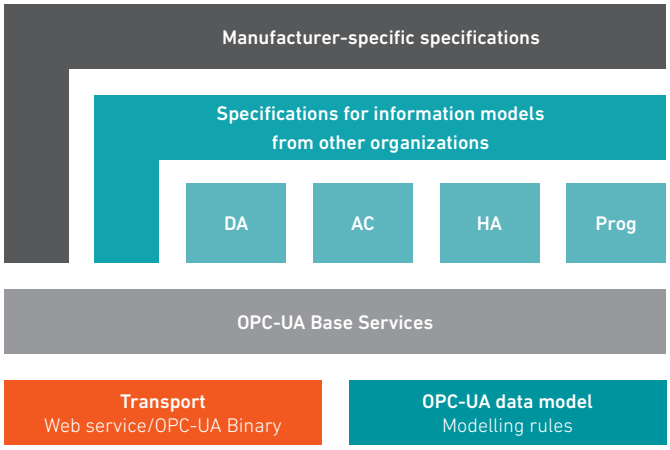
Open, high-performance, and globally available communication protocols are vital for the successful implementation of the Internet of Things. AVENTICS therefore supports further development of the OPC-UA architecture as the standard for smart components.

OPC-Unified Architecture (OPC-UA) is the innovative data exchange standard of the OPC Foundation. It ensures secure, reliable, and both manufacturer and platform-independent transfer of information that is not restricted or tied to any proprietary technology or manufacturer. OPC-UA allows access to any authorized application and to retrieve any information from anywhere and at any time.

Since 2007, the OPC-UA architecture has been providing a scalable, platform-independent solution, based on the concept of service-oriented architectures in industrial automation systems. This offers the advantage that web services and integrated security can be combined with a uniform data model.

OPC-UA is standardized in IEC 62541 and has become well-established as the leading communication standard for IoT applications.

The OPC-UA architecture is particularly versatile and flexible (see diagram) and offers access to historical data (HA) and locally executable programs, building on base services for data access (DA), alarms and events (AC). These can then be supplemented with information models, e.g. for fluid technology, but also for custom, manufacturer-specific functions and information.



▲ OPC-UA architecture, source: Wiki Commons

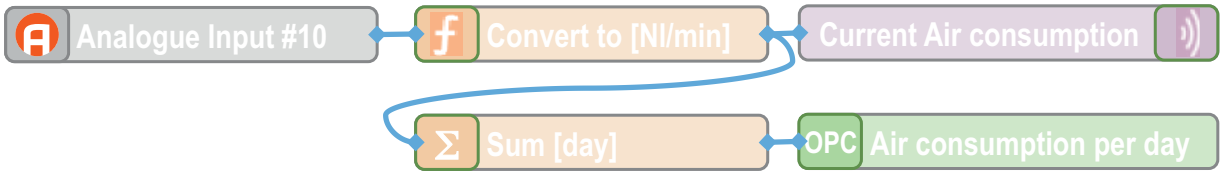
The SPM user interface: simple, intuitive, reliable

Easy to use and simple to configure, even during operation: The advantages of the interface are clear – and ideally complement the overall digital concept.

The Smart Pneumatics Monitor (SPM) enables access to a wide range of information from the pneumatic application and enables data analysis, storage, and provision. So the question is: how can I set this flexible and powerful tool so that it deals with the different, application-specific contents and conditions without having any user programming? The answer: Node-RED.

The open source software Node-RED is a graphic user environment to create flow-based applications for the Internet of Things. By linking input, function and output blocks, for example, data can be recorded, processed and forwarded without having to program a single line of code. Node-RED has been implemented on the SPM as a primary development environment for data transfer and analysis and its entire scope is fully available to users. For use on the SPM, AVENTICS has added input blocks to Node-RED, which provide information from the valve system and signals from the connected sensors.

▲ Example 1: The switching cycle count from valve 3 is read from the valve system and stored in the OPC-UA Server of the SPM.



▲ Example 2: A flow sensor is connected to analog input #10 on the valve system. The applied analog signal is converted to the corresponding flow rate value and passed on as the current compressed air consumption via an MQTT message. At the same time, the consumption is summed up over the day and stored in the OPC-UA Server of the SPM.

Criteria for the definition of IoT products

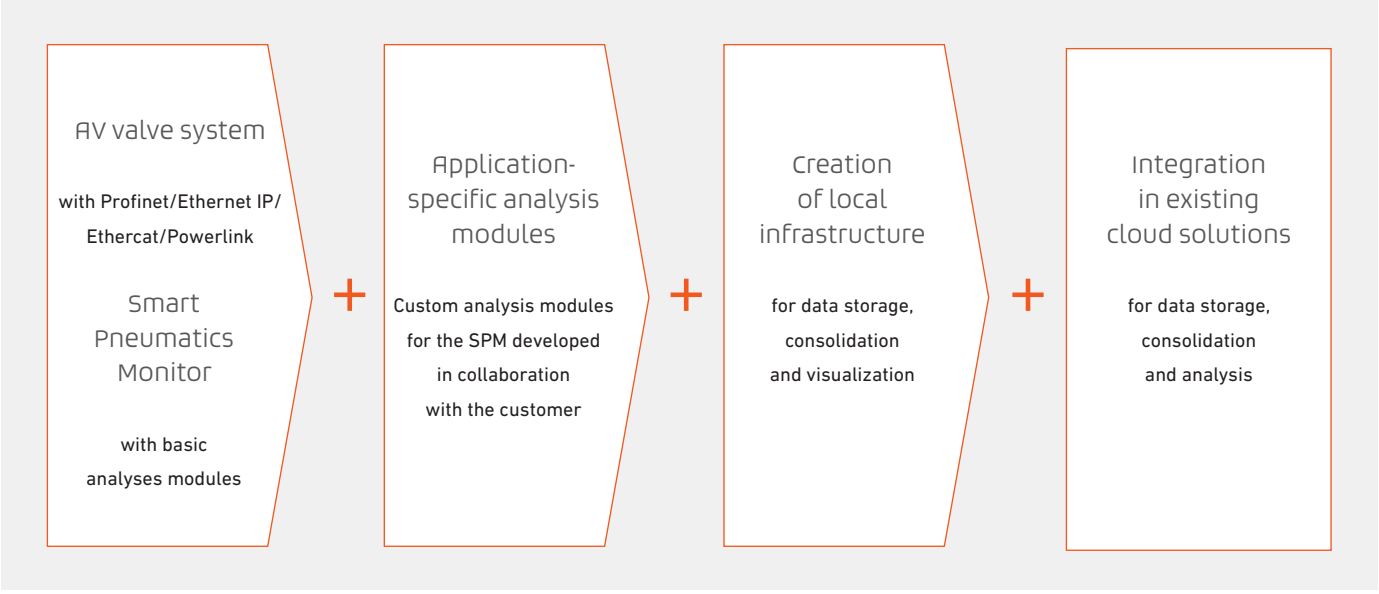
As a rule, industrial products require clear-cut definitions to provide guidance to customers but also distinct criteria for manufacturers. The ZVEI has therefore developed general, manufacturer-independent product criteria for IoT products which are used by AVENTICS as a firm guideline for product development.

	Criterion	Requirements	AVENTICS implementation in the Smart Pneumatics Monitor
1	**Identification**	Manufacturer-specific identification with clear/definite identifier (ID) on the product, electronically readable. Identification in: **1)** Development **2)** Goods traffic (logistics), production **3)** Sales, service, marketing **4)** Network	**1)** QR code **2)** QR code **3)** QR code **4)** Identification of participants via TCP/UDP and IP network
2	**IoT communication**	Transmission of product data and data files for e.g. design or simulation, product data in a standardized format. Product is accessible via network, supplies and accepts data, plug & produce via IoT-compliant services	3D CAD, parts lists, operating instructions, technical data, etc. can be accessed via QR codes. Relevant data can be read directly on the SPM via OPC-UA or other interfaces.
3	**IoT semantics**	Cross-manufacturer, clear identification of standardized data as features with syntax for e.g.: **1)** Commercial data **2)** Catalog data **3)** Technical data: mechanics, electrics, functionality, location, performance **4)** Dynamic data **5)** Data on product instance lifecycle	3D CAD, parts lists, operating instructions, technical data, etc. can be accessed via QR codes. Dynamic data as well as product instance lifecycle information can be read directly on the SPM via OPC-UA or other interfaces.
4	**Virtual description**	• Virtual image in IoT-compliant semantics • Virtual image over the entire lifecycle • Characteristic features of the real component, information about the relationships of the features among each other, production and production process-relevant relationships between IoT components, formal description of relevant functions of the real component and their processes	3D CAD, parts lists, operating instructions, technical data, etc. available via QR codes. Spare parts lists and service information available via QR codes. Additional relevant data and information stored on the SPM OPC-UA Server.
5	**IoT services and states**	• Definition still open (service system) • General interface for subsequently loaded services and status reporting. Necessary base services that IoT products have to provide and support.	All interfaces are open and described. OPC-UA Server is implemented. All relevant information can be depicted.
6	**Standard functions**	Basic standardized functions which are manufacturer-independent, run on different products and supply the same data for the same functions. Manufacturers can use this functionality as the basis for adding their own extensions.	Functions for preventive maintenance and energy management have been implemented. Functions can be parameterized for individual instances via the existing interfaces for the application.
7	**Security**	Minimum requirements to ensure security functionality	Available Linux operating system is documented and can be secured accordingly. Security concept for the application is implemented within the scope of the respective customer projects.

Source: based on ZVEI

AVENTICS provides optimal support for the implementation of your IoT strategy

Machines are becoming key strategic factors of success: maximum utilization of machine capacities, short maintenance breaks, short cycle times, and just-in-time production are essential topics. To prepare your company for upcoming demands, we offer solutions that dovetail with your existing IoT strategy.



Our aim is to support you in implementing your IoT strategy and to adapt it optimally to your needs. Whether you want us to provide components, develop custom analysis modules, or create the infrastructure for data recording and processing – locally or in your cloud: we will happily accommodate all your requirements.

- Smart components that can be seamlessly integrated in an IoT environment
- Decentralized intelligence
- Communication standards
- Added benefits for your systems

www.engineering-tools.com – the homepage for non-stop service

AVENTICS supports implementation of IoT applications across the entire product lifecycle: from configuration and selection with our calculation programs and configurators, to integration with 3D CAD data and configuration files, up to linking of product data and documentation via QR codes later on during operation. All this is free of charge and very much in the spirit of networking within the scope of the Internet of Things.

Our customers can join AVENTICS' product world at any stage of the product lifecycle.

CALCULATION PROGRAMS

With transparent calculations, our customers can determine the size or durability needed for their products and can even keep an eye on energy consumption.

CYLINDERFINDER

This free online tool helps our customers find the right cylinder for their application with just a few clicks.

ONLINE CATALOG

Our online catalog is the fastest way to obtain our products. With comprehensive search and filter functions, our customers can find the product they want along with a binding price and delivery date.

CONFIGURATORS

To create customized products matching their individual requirements, customers can set their parameters in the configuration program, which then presents a product tailored to their specifications.

CROSS REFERENCE TOOL

This tool shows our customers the right alternatives to competitor products from within the AVENTICS catalog.

CIRCUIT DIAGRAM SOFTWARE

With the D&C Scheme Editor, our customers can quickly and easily create circuit diagrams that are based on their components and linked to their catalog selection.

eSHOP

The eShop is our online shop for pneumatics that answers price requests and monitors the entire order process up to delivery.

QR CODE

The QR code on AVENTICS products provides you with direct access to technical documentation, service information, as well as operating and installation instructions.

Your AVENTICS contacts

If you have any questions on our products or the possibilities of IoT applications in your company, please feel free to contact us at any time. Our experts will be happy to advise you on investment security, compatibility with existing systems, and further ways to utilize data in your production.

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Your contact:

The data specified above only serve to describe the product. No statements concerning a certain condition or suitability for a certain application can be derived from our information. The information given does not release the user from the obligation of own judgment and verification. It must be remembered that our products are subject to a natural process of wear and aging.

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