Milestones

PROFIBUS – 20 years of standards for industrial communication

Klaus Bender — Jörg Freitag — Klaus-Peter Lindner (Editor)

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Impressum

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Greeting

It was a great pleasure to be invited to write this Greeting. Not just because this book represents a milestone in the history of the world's most successful fieldbus but also because it represents a significant marker for those of us in the PI community who have lived with the technology since almost its beginning.

I say 'almost' because the internationalization of PROFIBUS really only began in earnest in 1994. Previously, the technology was focused on Germany, where far-sighted people from government downwards recognized the need for a networking technology to bring the automation industry into the digital age. Germany wasn't alone in this of course, but it did understand better than anyone that a country-specific solution was never going to succeed in a world getting smaller by the year.

In 1994, I was working in the electronics industry. When my then boss – Josef Kreidl – came to me and suggested I set up a North American branch of the embryonic PROFIBUS User Organization I thought he was mad. Colleagues told me that North American industry would never accept a European technology and in any case 'we have better solutions'. It didn't take me long to discover they were wrong and the challenge to literally 'start from scratch' became irresistible. Not only was the technology elegantly designed and brilliantly engineered but the people involved also saw the essential need to get outsiders like me on board. Many of them became close friends and I firmly believe that the success of PROFIBUS is mostly due to that 'community' and the team work that arose from it.

I would like to say a big thank you to all those people who have supported me – and PROFIBUS – throughout the past 16 years. Many of them are mentioned inside, but there's one who deserves special mention here.

By 1994, Geoff Hodgkinson had already been writing about fieldbuses (and, surprisingly, Ethernet!) for 7 years, so when a PROFIBUS brochure dropped onto his desk (that man Kreidl again!) he acted immediately. The UK User Organization span directly out of that serendipity. Geoff's knowledge and advice helped me make my decision to come aboard and he has stayed a supporter (and even mentor) ever since. He became editor of PROFINEWS early on, a post he holds to this day, and his ability to understand and write about technical matters is unequalled. His strategic marketing talents lie behind many key PI projects. During the fieldbus wars he acted as International PR Director and he holds the distinction of facing legal action for describing the (then) proposed world fieldbus standard as 'intrinsically unsafe'. Intended as journalistic irony the description was mis-interpreted in some quarters, though Geoff insists that it marked the exact moment when commonsense finally prevailed! Outside of PI he has driven many of his own projects in the field of automation but his biggest talent seems to be invisibility. I welcome his contribution as further evidence of that crucial 'internationalization' process.

Another of those close friends was Edgar Küster, who sadly passed away in 2007. He and I together oversaw PI as it expanded its influence and grew in strength. I believe that his contribution to PI was immense. Now, under the guidance of his successor Joerg Freitag, our strong and thriving organization continues to thrive. Joerg's contribution has been substantial, especially in taking PI into new regions of the world such as Spain and India, driving the introduction of new technologies such as PROFIenergy, and facilitating a growing range of international collaborations. PI is flourishing under his guidance and I look forward to working with him and the PI community to achieve even greater things in coming years.

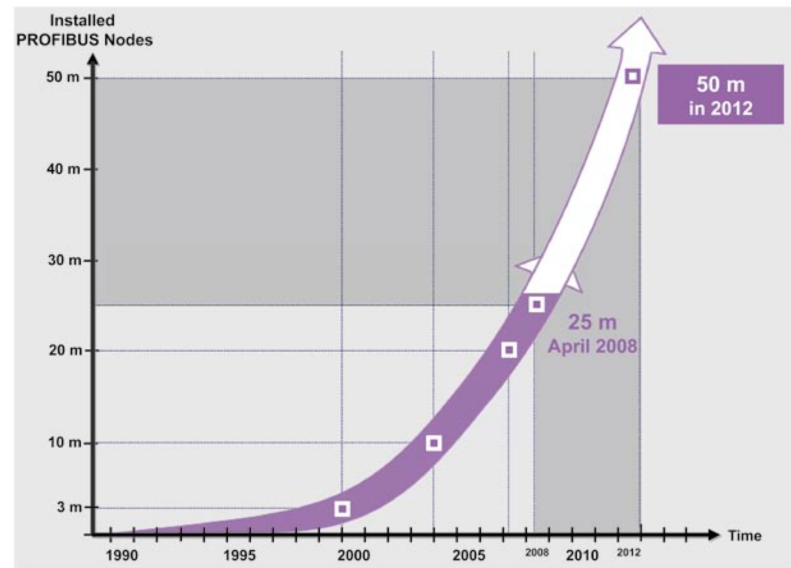
Michael J Bryant
Executive Director PTO and Deputy Chairman of PI
Scottsdale, Arizona, February 24th 2010

Michael J Bryant


PROFI
BUS

Preface

We can look back on 20 years of PROFIBUS with pride. Since its introduction, PROFIBUS has succeeded in becoming the world's leading fieldbus system. Today, well over 30 million PROFIBUS nodes (and more than 2 million PROFINET nodes) are installed, while the number of installed PROFIsafe nodes will soon top 1 million. Moreover, the PROFIBUS project continues to expand dynamically: whether the application is breweries, automobile manufacturing, PET bottle manufacturing, newspaper printing, pharmaceutical manufacturing



Development of PROFIBUS into the global market leader

or the oil and gas industry, the increasing importance of automation makes the use of high-performance fieldbus systems essential. For many years fieldbuses have been regarded as a key technology for industrial communications.

Yet, these overwhelming numbers are not the only thing that we can be rightly proud of today. PROFIBUS is a collective achievement


Board of Directors of the PNO: Klaus-Peter Lindner, Jörg Freitag, Prof. Dr. Klaus Bender

in which many experts from around the world played a role as part of a collaborative network. Each participant contributed significantly to the success of this achievement and deserves special thanks. And where would we be today without the dedication of the PROFIBUS User Organization (PNO)?

Since its establishment on December 11, 1989 in Frankfurt, PNO has undergone rapid development, and has passed all tests with flying colors. Within 2 years of its founding, an astonishing membership boom set in, which has continued to this day. In 1992, the first national user organizations were established in Switzerland and the United States. By 1995 PROFIBUS had advanced to become the market leader. The founded organizations set out to establish PROFIBUS International (now PI) as a platform for information exchange and the coordination of activities among this growing international network. Today the PI umbrella organization encompasses 26 Regional PI Associations (RPAs) and provides its more than 1400 members with first-class global support. In addition, there are now 16 PI Training Centers, 10 PI Test Labs (PITL) for certification testing, and 42 PI Competence Centers (PICC).

What is the secret of success? From the earliest development phases, PI has been able to rely on the support of all major providers of automation systems and field devices. Further strength lies in the openness and transparency of PROFIBUS (and now PROFINET) technology. Added to that is the wide range of PROFIBUS products available and the large number of device vendors. To cut a long story short: For 20 years PI has stood for innovation, internationality, and 100 percent service for its users. It will proceed all-out in this manner in the future, as well.

This book re-examines the background of PROFIBUS and its family of associated technologies, including PROFINET, PROFIsafe, PROFIdrive, and PROFIBUS PA. It puts the technology in a historical context and explains in an easy-to-understand way the stories that lie behind the headlines.

Share our Vision for Automation!

Klaus-Peter Lindner – Jörg Freitag – Prof. Dr. Klaus Bender

A journey back to the origins of industrial communication

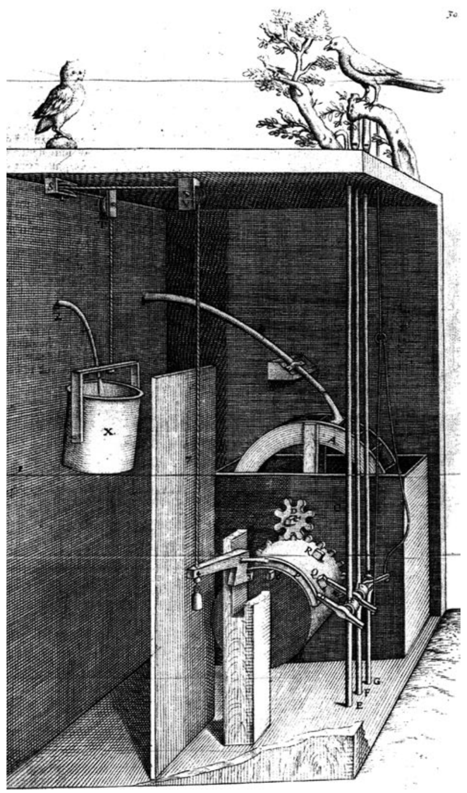
The history of industrial communication and fieldbus technology is closely tied to the automation of production processes. Although PROFIBUS – the primary, global, leading provider of standardized fieldbus systems today – is just 20 years old, its history started a lot earlier. PROFIBUS provides a solution to issues that have always faced engineers: How do I engineer my production processes? How can machines communicate with each other? How can the wide variety of machines used in production processes be matched to one another so as to achieve the most cost-effective, high-quality results possible?

These are old questions, to which new answers have been identified over and over again for several hundreds of years. In order to understand the achievement of PROFIBUS in Automation today and the significance of fieldbuses, you have to go back to the beginnings of automation.

When fieldbus technology was introduced to the market in the 1980s, it represented a paradigm shift in the history of industrial communications. The basic need was to quickly and easily obtain a large amount of information from production equipment and

The introduction of fieldbus technology was a paradigm shift in industrial communication.

Klaus-Peter Lindner, PNO Director



Representation of an automatic music machine from the early modern era.

processes and to use this to achieve more cost-effective production, reduced resource consumption, and increased quality. Or simply put: to optimize production processes. Fieldbus technology is today an important means of achieving this objective.

Take, for example, the manufacture of automobiles. Here, it is necessary to optimally control the production process, link the ordering, inventory control and manufacturing systems together, and coordinate individual production steps ranging from body construction to quality control. This is based on wanting to know more about the individual steps in the process and what is happening, faster and more precisely. This ultimately means a new level of information exchange, something that fieldbus can facilitate.

Higher quality information from the production process is also a necessary precondition for creating a product according to specification. For example, steel makers used to make steel more or less according to "feel", but a completely different situation exists today due to the higher standards for production available from automation and the new communication techniques. For precise processing, good information from the operating process – obtained during actual production – is essential.

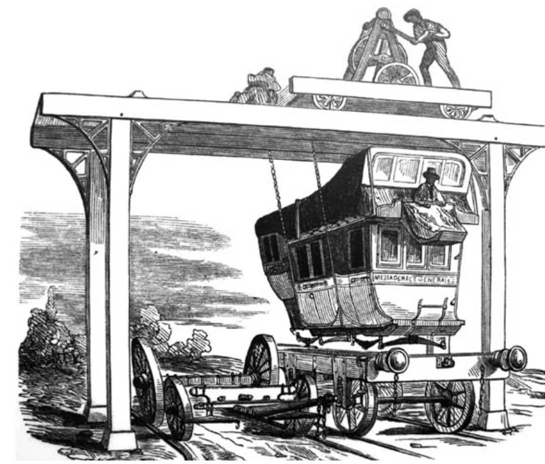
Servants as interfaces – The first automatons

The principle behind fieldbus technology is an age-old one – only the implementation has changed. Back in ancient times, people produced things too; they initially used primitive tools on which to base collaborative work processes, but they constantly innovated until they achieved results that we take for granted today.

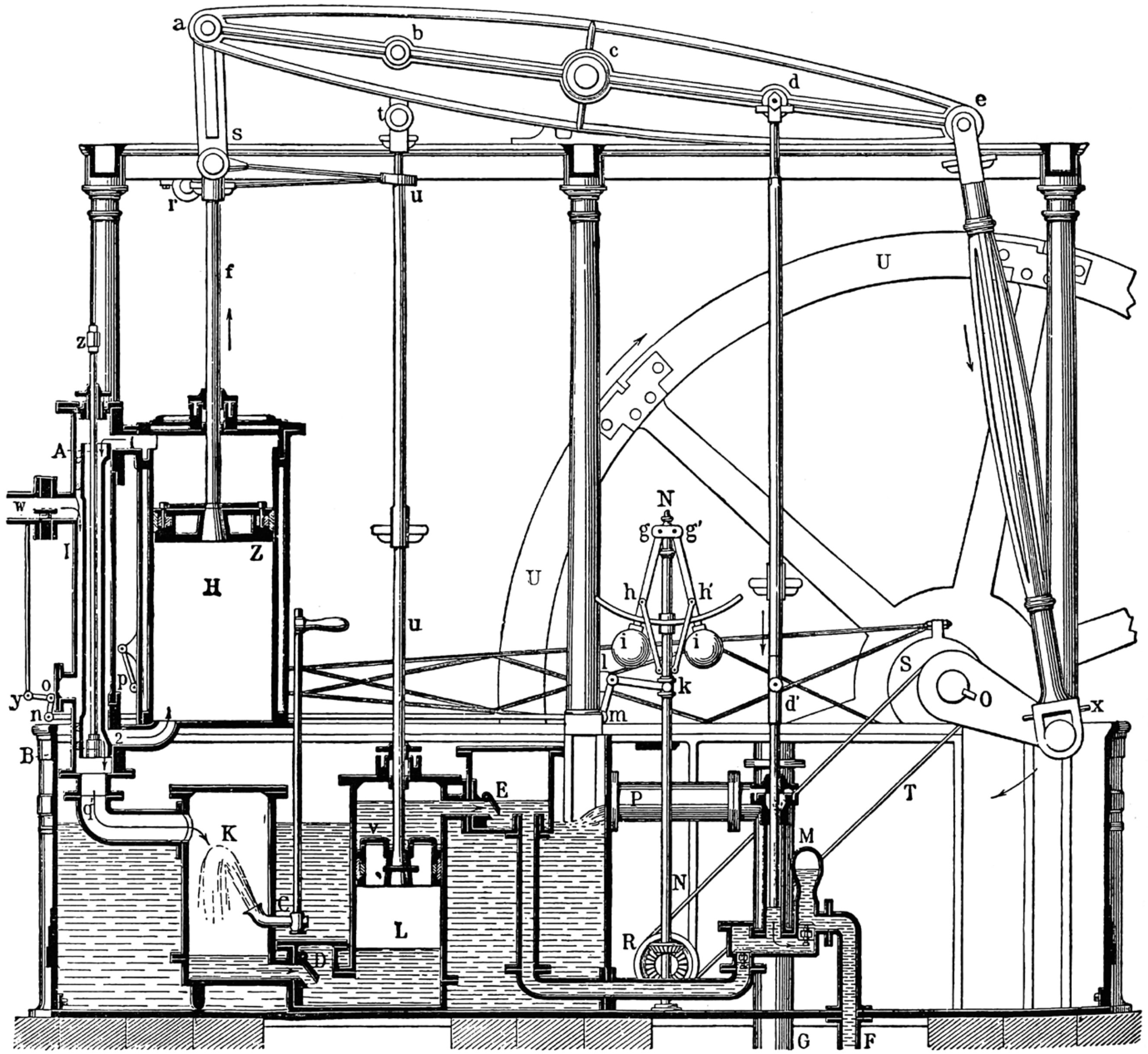
The first automatons were not intended to reduce work for people. They served exclusively for entertainment in noble courts - and this can be traced back to antiquity. Initial records date from the 3rd century B.C. Hydropower was the first and most important motive power for technical marvels of all types. The first "applications" were vessels, figures and fountains, which worked in combination with air and water pressure to aspirate, squirt, or generate strange noises. They elicited fear and astonishment from chroniclers, as in the case of a 10th century Byzantine emperor, whose throne was surrounded by artificial chirping birds and growling golden lions that struck their tails against the ground. In a further design, the ruler's throne was raised up to the ceiling so that he appeared even further removed from his subjects.

You are asking: how does this relate to PROFIBUS? Well: the interaction of the machines was arranged via oral commands and directions given to servants – we are still at the simplest stage of machine-to-machine communication here! Work processes connected in series could only function by means of interpersonal communication. Of course, this was not yet true automation, but perhaps it was a driving force for identifying better solutions, building more complex machines, expanding their areas of application, and perfecting them.

In the early modern era, technology became the instrument for a new occupational group who recognized engineering principles as a means of operating, in a positive sense, "against nature." During this time, ideas emerged for using machines to facilitate work processes. From this came ideas for automating these processes using the simplest of means. Automatons changed from being an object of entertainment to something useful. Thus began the metamorphosis of automation from symbols of power to the essential elements of production, which ultimately led to the far-reaching technical progress and social changes we see today.



Machine for converting stagecoaches to rail cars, ca. 1844. The image shows the conversion of a luggage compartment of the French postal service to a freight train.



Schematic representation of a steam engine, early 19th century

Turning points in automation history

The decisive turning point was the Industrial Revolution of the 18th and 19th century, particularly the invention of the steam engine, which became the main driving force behind subsequent developments. This created the conditions for industrial automation in the modern sense. At the beginning, mechanically-controlled machine tools and/or equipment were developed, in which a specific workpiece was processed automatically according to a predefined, fixed program. Because workpieces were still being fed and removed by hand, and thus only a portion of the overall work was performed automatically, we refer to these machines as semi-automatons.

In this second phase of automation history, mechanization encompassed auxiliary processes too. People were still responsible for inspection, measurement, and the control functions of the machine. For example, automatic lathes, which were developed mainly in the United States during the latter third of the 19th century, formed the main universe of automated machine tools for several decades. Around 1880, the first automatic cutting machines and blanking presses for sheet metal processing came into being and in 1893 the first automated rail rolling mill was developed in the United States. These were followed by automatic bending and welding machines (1903, Switzerland), injection molding machines (1905, Germany), forming machines (1910, USA), as well as the automatic bottle blowing machine by Owens (1903, England) and automatons for light bulb manufacturing.

The next big step came in the 1920s, when the use of electrical switching and control elements became increasingly common. A short time later, the first prototypes of interlinked machine tools emerged in Great Britain, the United States, and the former Soviet Union. These so-called transfer lines, however, were isolated cases and had a fixed work flow arrangement. Many of the electrical and electronic elements had been invented earlier, perhaps for other

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Automaton

Originally from ancient Greek, it means "self-acting" or "self-moving." An automaton is an apparatus that, once installed, performs previously defined actions independently. In the technical arena, an automaton is understood as a cybernetic process. Automation provides numerous advantages: The rationalization of complex work sequences increases productivity significantly while simultaneously reducing costs. Of particular importance, too, are the safety gains. Many of the safety risks associated with industrial production can be minimized through the use of automatons.

Man caught in gears of automated factory – Charlie Chaplin in the 1936 film "Modern Times"

purposes. This pertains in particular to the temperature recorders and transducers used in the chemical industry. The electrical industry contributed the telephone relay, and radio engineering the radio amplifier circuit.

Transfer lines and assembly line production

Large-scale introduction of line production, especially in automotive manufacturing, led to the third phase of automation. People were freed of transport work in the production line. The first mechanically-controlled transfer line in the world was built in England (Morris Motors in Coventry) in 1923 for processing automobile cylinder blocks; it comprised 53 production steps! This was followed in 1928 by the construction of a factory for the automated production of passenger car chassis with a daily capacity of 10,000 units. It involved automating a wide range of metal working processes: inspecting, leveling, cutting, bending, punching, assembling, riveting, brushing, and painting. Up to the end of the 1930s, however, the development of transfer lines remained limited to a few examples (Junkers plant in Dessau (1934) and tractor factory in Volgograd (1939)). This was mainly due to the lack of satisfactory technical solutions for the (mostly) mechanical control of machinery, and because of inadequate quality assurance by the monitoring and control equipment available then.

Therefore, the next phase of automation was characterized by the introduction of automated control, especially for quality assurance of automated machines, machine lines, and systems. In 1947 the Massachusetts Institute of Technology produced the first examples of numerical controlled machines (NC machines), which used punched cards or magnetic tapes to assume control of works steps. Thus began the age of digital control, which replaced the principle of mechanical

Links: Assembly line production at Mercedes-Benz in Sindelfingen in 1956

Right: Partially automated manufacturing – Refrigerator production in 1962

control. People were freed from routine measurement and control tasks. This phase of automation is the first to be associated with our modern automaton concepts.

Breakthrough in automation: The 20th century

The fourth phase marks the breakthrough in automation. The chemical industry gave important impetus to this. "Large-scale synthesis" of ammonia and methanol involved closed-circuit chemical processes

Schwedt oil refinery paraffin unit in 1972. Over 30 years later, a unit based on PROFIBUS PA was built here by the Verbio Group, a leading manufacturer of biofuels and the only large-scale industrial producer of biodiesel and bioethanol in Europe

State-of-the-art automation technology in today's automotive industry

using continuous pressure, constant temperature, and adherence to precise amounts of raw materials. Measuring and monitoring equipment allowed operating personnel to quickly identify and, if necessary, correct setpoint deviations. Separate open-loop and closed-loop control functions were required for proper functioning of mechanical units – a further quantum leap.

The principle could also be applied to consumer goods: Gas boilers, electrical refrigerators and central heating systems - which caught on slowly during the middle of the 20th century - required the use of pressure and temperature controllers to enable unsupervized operation. Automatic closed-loop and open-loop control technology was therefore a necessary precondition for allowing these goods to become mass-produced commodities.

The 20th century was the century of automation. By the second half, the concept that had begun with the wonder machines of ancient times had fully caught on in economic life and began to shape the social realities of people. Some aspects were not necessarily seen as "a good thing". Relieved from performing many routine tasks, workers increasingly looked at automated machines as competition. Unlike what some critics feared, however, this did not result in less work. Professional qualification requirements have risen while work has become more efficient.

The development of new communications technology for automation using fieldbus-based systems has brought further significant improvements in efficiency and represents the latest phase in our automation history. It is closely tied to the "programmable logic controller" (PLC), an invention with its own 40-year history. In 1967 a handful of developers at Siemens Schuckert formulated the concept of a PLC having a magnetic core memory as the storage medium. In the end, however, the risks associated with an unproven technology, market uncertainties, and the costs involved, led to the decision not to implement the concept. The first companies to implement PLCs were Modicon and Allen-Bradley in 1969 in USA. The brains behind the initial PLCs were Richard Morley (Modicon) and Odo J. Struger (Allen Bradley). Morley introduced the "Modicon 084" as a "solid-state sequential logic solver" in 1969. Struger then led the formulation of associated Standards in the United States. Siemens in Germany jumped in, in 1973, with the Simatic S3. Shortly after, in 1974, Klaschka introduced another PLC, also in Germany.

Thus we have almost reached the present on our journey through time. But let us linger awhile in the 1980s, where the new chapter in automation and industrial communication began.

INFO

PLC

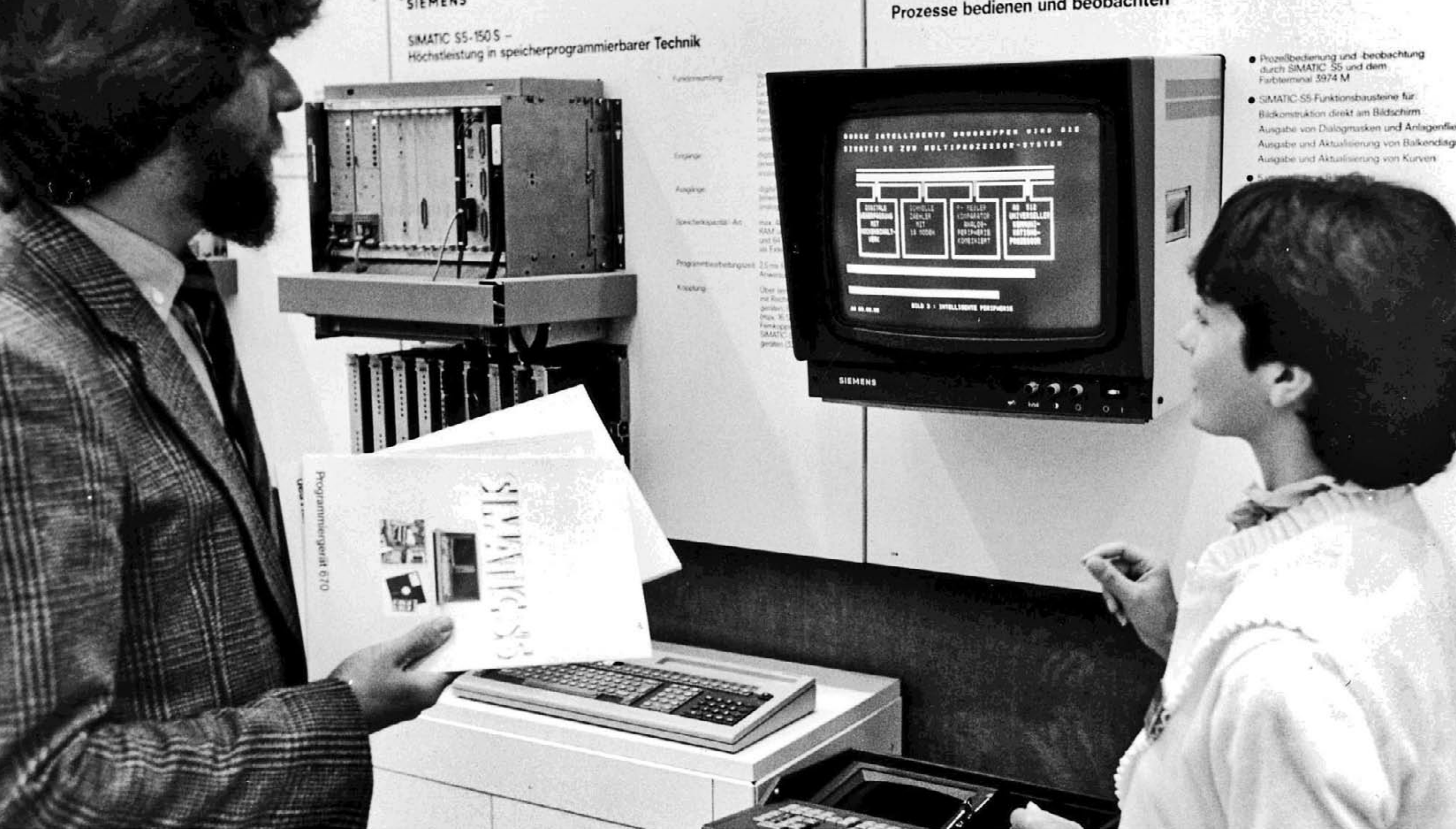
A programmable logic controller is a special computer used to control a machine. Control is based on user programs. Sensors monitor what is happening in the machine and this information is made available to the user program. Based on this information, the user program switches the actuators on and off in such a way that the machine functions as desired. In modern automation systems, communications between sensors, program and actuators is fieldbus-based. The PLC replaces the hard-wired relay logic formerly used in automation.

Neat and clean: modern control cabinet with PLCs

PROFIBUS — how it all started …

The 1980s were a decade of far-reaching changes in automation. Technical development was influenced significantly by electronics and microprocessor technology and the age of digitization arrived. It was the beginning of software in automation, with programmable logic controllers, process control computers, and process control systems all playing a role.

Control tasks were set in application programs and function blocks. As a result, changes could easily be made to the process independent of the hardware used. This in turn led to improved communications and information exchange between controllers and computers, and to the concept of universal, fully-integrated automation. "Horizontal integration" through the replacement of traditional analog interfaces such as 4-20mA, became the watchword.



Introduction of the computer into automation, advertisement photograph in 1983

Consistent configuration, data management, communication, and information, in short: the vision was to network all areas of the production process.

Prof. Dr. Klaus Bender, Technical University Munich

By the end of the 1980s, it was clear that the system view – and not just the device view – would take the foreground. Open system configuration, transparent data management, improved communications, and better information exchange were required for this: In short, it was necessary to network together all areas of the production process using a "bit-serial bus" approach, the origin of the term "fieldbus". This had the added benefit that traditional analog cabling could be replaced, reducing installation effort and costs because not every wire would have to be individually pulled. Automation equipment in the field, such as sensors, actuators, transducers, and sequence controls, could be enhanced by the potential of microprocessor electronics. For information exchange between the automation system and the digital field devices, fieldbus completed the jump into the digital age.

Control pulpit in a rolling mill in 1989

Implementation did not happen overnight. First, a new generation of computer-savvy engineers had to grow up who wanted to use these new solutions as a matter of course. The idea of using a "bus" to control a factory at a time when computers were still not common was foreign to many; a basic change in the thinking of many experts was needed first.

But the trend could not be stopped as the potential rewards were too great. Also enticing was the notion of transferring "Information Technology" to the automation environment.

First experiences with fieldbuses

At this time, first users in Germany had already gained experience working with company-specific fieldbus solutions. These so-

I N F O

Fieldbuses

A fieldbus is a digital serial communication bus that connects – either directly or via so-called distributed I/O modules – sensors, (e.g., those for measuring temperature, flow rate, pressure, rotational speed, or positions), and the actuators, (e.g., the drives, valve blocks, or switches), with the controllers and master computers of a production process. The fieldbus is used for data exchange between components. Unlike the Local Area Networks (LAN) used in IT, fieldbuses are designed for use in harsh environments. Besides PROFIBUS, the best known fieldbuses include Interbus, Foundation Fieldbus (FF), DeviceNet, and CAN.

called proprietary solutions came on the market little by little – each attempting to independently implement the vision of a communication revolution for automation. However, the commitment by these "first movers" posed an obstacle: If fieldbuses were to find widespread use, users needed a standardized approach that allowed products of different manufacturers to be easily used together. But, a fieldbus standard would require technogical agreement to be reached collectively. From the start, therefore, one of the main challenges was whether there could be an international standard for fieldbus that all field device providers would support.

This question - which came to shape the history of PROFIBUS - could not be solved by working in an "ivory tower". It was clear that it was a complex issue, also that there were too many rival concepts and too many different fields of application. At the end of the 1980s one trade journal wrote presciently: "An international standard may not be ready before the beginning of the 1990s."

So were these just dreams? Not entirely. The vision was certainly valid. Preliminary standardization work had been underway in Germany since 1985 under the auspices of the German Federation of the Electrical and Electronics Industry (ZVEI) and the German Commission for Electrical, Electronic & Information Technologies (DKE), the primary German bodies responsible for organizing standards and safety regulations.

A "fieldbus" working group of the ZVEI trade association for "Measuring technology and process automation" was formed to define the requirements for fieldbus systems in various applications. This focused on the following: The desire for a simple medium; different topologies; cable lengths up to several kilometers; an optional increase in data availability; auxiliary power supply via the bus; use in hazardous areas; different transmission rates; safety; short messages; and simple reports with little effort.

At the start of 1987, members of ZVEI agreed to make a fieldbus solution created jointly by Siemens, Bosch and Klöckner-Moeller (now Eaton) the basis for a new fieldbus standard. PROcess FIeld BUS, or PROFIBUS, became the name of the project. Initially little more than a proposition, it was a very ambitious one nevertheless. Interestingly, as the name suggests, the main focus at that time was on process automation.

Still, it was the manufacturing industry that was to incorporate the concept first, as Roland Heidel, one of the original players, remembers. And, at the start, buses were "pure theory", recalls Dr. Hans-Peter Lerch, a former development engineer for automation at Bosch. He explains the motivation of his employer at that time: "The automation business unit at Bosch was still very small. It was clear that a proprietary protocol would not succeed on the market. Proprietary protocols had no chance." The need for a common approach remains the cement that binds such companies together to this day.

Getting the ball rolling

A joint project sponsored by the German Federal Ministry of Education and Research set the ball rolling. With this all paths converged, providing the impetus to advance debate and develop usable systems. A broad coalition was formed in the summer of 1987 when 18 companies and institutes joined forces to turn the PROFIBUS concept into a proven Standard.

The German Federal Ministry for Research and Technology (BMFT, now BMBF), under then Minister Prof. Dr. Heinz Riesenhuber, sponsored the "Fieldbus" project for two years. Its strategic basis was the so-called "Queisser Report", which was prepared on behalf of the German Federal Government by physicist Hans-Joachim Queisser. (See box next page).

The report tackled the "technological gaps" that had emerged between the United States and Europe in the middle of the 1960s and suggested strategies for more innovation. The report highlighted

I N F O

Partners in the joint fieldbus project

- AEG Aktiengesellschaft, Frankfurt am Main, Germany.
- ASEA Brown Boveri Aktiengesellschaft, Mannheim, Germany
- Robert Bosch GmbH, Stuttgart, Germany
- EM-Gerätebau GmbH, Mannheim, Germany
- Research Center for Information Technology at the der University of Karlsruhe (FZI), Karlsruhe, Germany
- Honeywell Regelsysteme GmbH, Offenbach, Germany
- Fraunhofer Institute for Information and Data Processing (IITB), Karlsruhe, Germany
- Rhine-Westphalia Technical University Aachen (Institute for Control Engineering, IRT; Laboratory for Machine Tools and Business Operations, WZL), Aachen, Germany
- Klöckner-Moeller Elektrizitäts-GmbH, Bonn, Germany
- Landis & Gyr GmbH, Frankfurt am Main, Germany
- Phoenix Elektrizitätsgesellschaft H. Knümann GmbH & Co. KG, Blomberg, Germany
- Technical University Munich, Chair in Process Control Computers, Munich, Germany
- Rheinmetall Meß- und Prüftechnik GmbH, Neuss, Germany
- Samson AG, Frankfurt am Main, Germany
- Sauter-Cumulus GmbH, Freiburg/Breisgau, Germany
- Schleicher GmbH & Co. Relais-Werke KG, Berlin, Germany
- Siemens Aktiengesellschaft, Karlsruhe, Germany
- Ernst Tesch GmbH & Co. KG, Wuppertal, Germany

INFO

Queisser Report

The Queisser Report focused on new strategies for promoting information technology in Germany. The authors of the report were Hans-Joachim Queisser (Chairman), Friedel Hoßfeld, Ernst Lüder, Max Syrbe, and Norbert Szyperski. The report was prepared on behalf of the German Federal Minister for Research Technology, Prof. Dr. Heinz Riesenhuber, who asked for a status report on information technology as well as strategies for strengthening this sector. Among other things, Queisser recommended funding for at least 2500 additional scientists. The report placed particular emphasis on microelectronics, the semiconductor industry, software technology, computer architectures, communication technologies, and issues regarding the social and economic importance of information technology. The goal was to strengthen German information technology within the global marketplace on a sustainable basis.

individual fields of technology – so-called key technologies – for their central importance in protecting the structure of the economic and social systems. As a consequence of this report, the German Federal Government concentrated its policies in support of Information Technology, which benefited the PROFIBUS project greatly.

Groundbreaking research policy

The project, conducted under the responsibility of the VDI/VDE-Technologiezentrum Informationstechnik GmbH in Berlin, was the first of four sponsored and joint research projects for realizing the bit-serial fieldbus. The total cost of the projects at the time was DM 24 million. The government sponsorship was intended to extend the global market position of German companies in the area of microelectronics, as similar consortia had also been formed in other countries to develop communication technologies for automation. It was clear to everyone involved that fieldbuses would produce an innovative edge.

The slogan for the sponsorship was "Build on your strengths" Ministry representatives were fully aware of the economic-political importance and knew full well that in the end only one technology would be successful in the market. Nonetheless, a (separate) European fieldbus project (EUREKA) was started at almost the exact same time (1986). PROFIBUS and EUREKA were both well supported and there was a wait-and-see attitude as to which project would emerge as the most promising. However, PROFIBUS proved to be significantly more agile, focused and better managed, and was therefore the more successful.

The PROFIBUS project was groundbreaking in more than one respect. For example, standardization activities accompanied the development phase as a primary goal, and value was placed on the fact that the government sponsorship of infrastructure measures meant that the Standard being developed would be disseminated widely and would remain open (i.e. non-proprietary).

In hindsight, this "openness" was one of the most important factors in making the project successful. Looking back, it would not have been feasible for any one company alone to have prevailed with a proprietary solution.

Work could now begin!

German Federal Chancellor Dr. Helmut Kohl and Minister of Research Prof. Dr. Heinz Riesenhuber in 1987

Proprietary solutions did not help us because products of different manufacturers were increasingly being brought together in applications.

Dr. Hans-Peter Lerch, formerly of Bosch

Off we go: Goals and objectives of the joint fieldbus project

The approval letter from the Ministry of Research for the joint project represented the “kickoff” for all parties involved. Work packages and meeting schedules were now defined, and a detailed research catalog was established in which objectives, persons in charge, contributors, and funding quotas were specified. Even though the project was open, and many medium-sized companies were included, there were naturally some “heavy hitters” which were necessary for development. However, other aspects also came into play for the proper functioning of the project.

Eduard Hofmann

Eduard Hofmann studied electrical engineering at the University of Karlsruhe (TH) and started at Siemens in the area of signal control systems. As head of a leading-edge department, and chairman of IEC Technical Committee 65, he later worked on the digitalization of remote process measurement and control equipment as well as on digital communication. It quickly became clear that a consistent, open communication system was needed from the field level all the way to the factory level. Eduard Hofmann became one of the drivers of the cross-vendor initiative to tackle the challenge. The fact that in 1987 the joint "Fieldbus" project was able to be established can be traced directly back to Hofmann. As project leader, he also insistently pursued the goal of a "single international fieldbus". He played a critical role in the establishment of the PROFIBUS User Organization (PNO) in Germany and served as its Chairman from 1990 to 1995.

Just as important was the ability to keep the network of almost 20 participating institutions together and on course. Most of the original PROFIBUS participants are in agreement today that besides the institutions involved, an key role was played by Eduard Hofmann of Siemens, whose tremendous energy - sometimes in the face of strong resistance from forces standing in the way of innovation - significantly advanced the project.

Cooperation among competing companies was a relatively new concept at that time. Hofmann utilized the highest possible level of diplomacy in order to ensure the collaboration of people from vastly different company cultures. He also possessed a critical strategic vision during those early years; his main achievement was to "sell" the vision of an open and standardized solution.

In order for devices to communicate jointly over a fieldbus, extensive up-front services had to be provided. What could be easily put down on paper as a requirement, however, represented an enormous effort when it came to the detail – and yet the work had to be carried out within a clearly defined period of two years.

While the grant from the Ministry represented an achievement in itself, it also marked the countdown to the specific task in hand: the realization and standardization of the fieldbus protocol. Test systems for conformity and interoperability also had to be developed, as did techniques for maintenance and diagnostics. At the same time, the industrial community had to be kept informed, since market acceptance was essential for the fieldbus to be introduced.

These general goals were later expanded: From the start, PROFIBUS was to be developed both for applications in factory automation and process automation. Furthermore, it should be possible to pass on information transported on a fieldbus to a higher-level backbone bus. In addition, the costs to connect to PROFIBUS should be in line with the costs of the device being connected.

The mission to achieve fast marketability and dissemination was to turn out to be another exciting chapter in the history of PROFIBUS.

The market launch and implementation was scheduled for four years later, in 1987. A precondition was timely publication of all results.

Open communication standards were much-quoted goals at the time, which needless to say provoked some fears. Competitors not involved in the joint project could participate in the research efforts without major expense. Here, even more cultural obstacles had to be overcome, despite the benefits of open communications being obvious.

Dr. Klaus Bender, who participated in the project at the outset and is now a professor at Technical University Munich, recalls that there were simply too many fieldbuses at that time: "Different devices simply did not fit together." Anyone who was realistic knew that even large global players could not supply devices to fit all approaches. This supported the argument for developing a truly open system, in which specifications are stipulated in such detail that anyone can use the information without a license and implement it in their own products.

At the end of the 1980s there were too many fieldbuses – the components simply did not fit together.

Prof. Dr. Klaus Bender, PNO Director

Prof. Dr. Klaus Bender

Prof. Dr.Klaus Bender was born in 1943 and studied electrical and telecommunications engineering at the University of Karlsruhe (TH). He earned a PhD in Control Engineering in 1973. In 1979, he was made an Associate Professor of Computer Engineering at the University of Karlsruhe. In 1985 he was appointed to the Board of Directors of the Karlsruhe Research Center for Information Technology and in 1992 was appointed Chair of Information Technology in Mechanical Engineering at the Technical University Munich. His research work concentrated on intelligent mechatronic products with special emphasis on automation, communication, development methodology, and quality management. In addition to his academic endeavors, Prof. Dr. Bender also belongs to numerous technical and scientific societies and organizations. For example, he is a member of VDI, the Gesellschaft für Informatik (GI), the Fraunhofer Gesellschaft, and the Internationale Akademie für Informatik in Belarus. Prof. Dr. Bender served as a founding member of the Board of Directors of the PROFIBUS User Organization (PNO) in Germany and has served the Board for 20 years, during which he has been a key contributor to the development of fieldbus technology.

INFO

ISO/OSI layer model

An OSI model (Open Systems Interconnection Reference Model) refers to a "layer" model for software defined by the International Organization for Standardization (ISO). It was developed as a design basis for communication protocols. In this model, the communication tasks are subdivided into seven functional layers that build on one another. Each layer has an accompanying description that stipulates the performance requirements for that layer. Communication protocols must meet these requirements.

Standardization as a goal

Without doubt, the single greatest challenge was international standardization. One project description stated this in sober terms: "The resulting international fieldbus standard shall be largely shaped from PROFIBUS properties. The conversion of the PROFIBUS concept into products and the establishment of an infrastructure for certification will give the project's contributions added weight during international standards development work." Not one of the participants knew then that it was just this point that was to shape the path of PROFIBUS for a long time to come!

First, a variety of work packages had to be defined and tackled. Work package 1 involved the realization of the transmission technology and the Logical Link Control protocol; these are layers 1 and 2 of the ISO/OSI reference model (see left).

Work package 2 combined all development tasks for realization of the user protocol - layer 7 of the ISO/OSI layer model. Finally, work packages 3 and 4 involved application of the results in factory and process technologies. For example, the fieldbus should be tested in building automation and in the machine building industry. In addition, the project partners were to configure two multi-vendor systems, set up interoperability test centers and demonstrate the results in 1989 at trade fairs such as ISH (Plumbing-Heating-Air Conditioning) in Frankfurt, EMO in Hanover, and INTERKAMA in Dusseldorf.

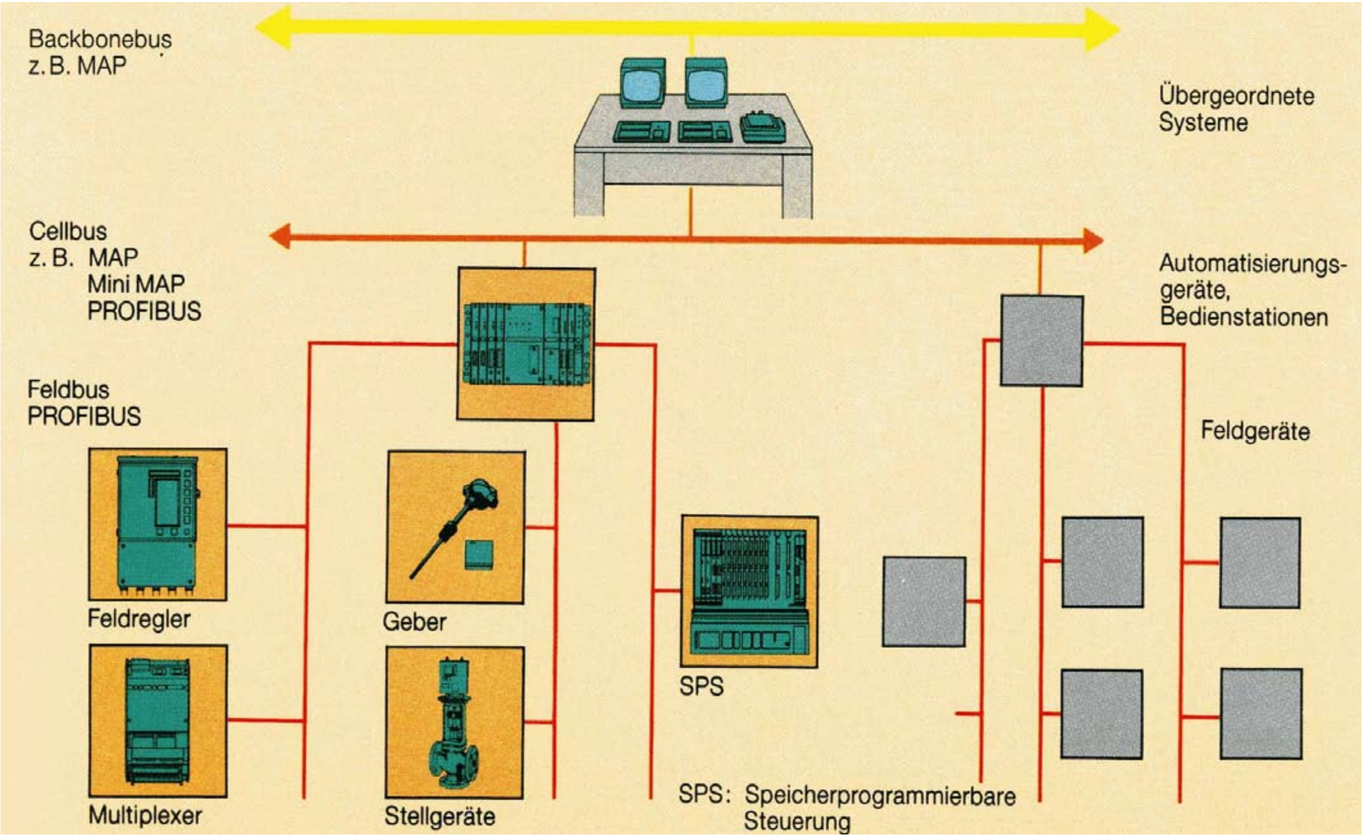
That was a considerable work program for just two years! A few dozen engineers from the 20 or so companies involved in the project participated in the work. It was not always plain sailing, even if the participants now say that, all in all, everything ran smoothly!

Everything? Well, not entirely! Some of the day-to-day details make the participants smile even today. For, ironically, those who were preparing to revolutionize industrial communications could only use communications methods themselves that seem antiquated today. There was no Internet or e-mail yet and cell phones were only a dream. Their communications relied on mail and fax; stacks of diskettes and mountains of copies were delivered by post with a transmission speed of one to two days! Nevertheless, all agree that this was not detrimental to the project as those involved were working in a world, far different from today's.

Leaving the well-trodden path

But things did become difficult when the various technical approaches had to be harmonized. After all, having to develop something new meant that textbook knowledge was scarce, so it became necessary

The fieldbus project set the goal for itself to establish PROFIBUS as a fieldbus and a cell bus and to create an interface to a backbone bus.



INFO

Field devices

Both actuators (controlling elements, valves, etc.) as well as sensors (transducers) are referred to as field devices (FD) in factory and process automation. Modern field devices are connected to a PLC and host system, usually via a “fieldbus”. The data are evaluated in the controller and then used for closed-loop and open-loop control, and for additional processing such as visualization and the display of results (e.g., valve open/closed, pressure, flow rate, temperature, etc.) to personnel.

to leave well-trodden paths and think through alternatives. In the early stages of PROFIBUS there was simply no “right” or “wrong”. Reason and logic, as well as entrepreneurial vision, played decisive roles during project work. For example, when two or three technical solutions were on the table that could not be harmonized readily, the ability to assert one's position was often the crucial factor in reaching agreement!

The joint project on the final stretch

Initial studies soon confirmed that the chosen decision-making processes, when viewed as a whole, were positive and that the project was on the right track. That fieldbus users could save 40% by eliminating conventional cabling was quickly confirmed. Rapid financial advantage was a decisive factor in arousing interest at management levels and attracting the attention of the technical community.

Two years of joint project work came to an end in 1989. Work packages were checked off and contentious issues were reconciled, even if not everything could be harmonized! A good mood prevailed: They had done it!

The results were turned into a German Standard – DIN V 19245. A technology had been created: Now all that had to be done was to implement it!

The founding of the PROFIBUS User Organization

The end of the joint project marked the start of a success story that nevertheless began during a turbulent time: In 1989, in East Germany, crowds had taken to the streets; the Wall fell; socialism was proved bankrupt; and German reunification was not far off.

Despite global political unrest, the participants in the project had to define their next steps – they too were on their way to destroying "walls."

The fundamentals of an implementable fieldbus had been created. Now it was time to perfect and optimize the project, and to make results available to all interested parties. It was recognized if that the technology had to be maintained and enhanced; effective marketing was urgently needed.

It was essential to highlight that PROFIBUS was not just the offspring of a few companies who stood to profit from its promotion. A neutral platform for ongoing tasks was required: The PROFIBUS User Organization e. V. (PNO) was born!

The inaugural meeting of the PNO was held in Frankfurt am Main on December 11, 1989 – just a few weeks before the end of the "Fieldbus" project. Invitations to attend were sent out by Eduard Hofmann, who had already worked with partners to develop rules for the proposed User Organization in the form of a legal "Association". A neutral platform offered advantages in keeping with the spirit of the joint project: through memberships, it would be possible to involve any number of players in future work since the Association format allowed all members to participate. Later, this also ensured that international companies could join in, even if the founding members had all initially come from the German market.

The Association unites

To establish an Association meant to agree on bylaws and to select a treasurer, Board of Directors, and Advisory Board. Everything took its course. When the initial Board of Directors was selected, the Association members placed their trust in Eduard Hofmann, Prof. Dr. Klaus Bender (then at the Research Center for Information Technology in Karlsruhe) and Dr. Rainer Döring (of Schleicher).

Ten companies, four technical/scientific institutes, and the Zentralverband Elektrotechnik- und Elektronikindustrie e. V. (ZVEI) took part in the founding.

During this early phase, the PNO was supported by well-known vendors. Its main goal was outlined as follows: "The purpose of the organization is to support international dissemination of a communication system for networking field devices, called PROFIBUS."

Board of Directors of the PNO

Eduard Hofmann:
December 11, 1989 to April 5, 1995

Prof. Dr. Klaus Bender:
December 11, 1989 to present

Dr. Rainer Döring:
December 11, 1989 to March 30, 1993

Rudi Boldin:
March 30, 1993 to March 23, 1994

Josef Kreidl:
March 23, 1994 to April 21, 1999

Edgar Küster:
April 5, 1995 to October 24, 2007

Klaus-Peter Lindner:
April 24, 1996 to present

Klaus-Peter Willems:
April 21, 1999 to April 17, 2002

Jörg Freitag:
November 28, 2007 to present

Goals of PNO

- Promotion of information exchange with all interested parties
- Development of draft standards for further development of the PROFIBUS concept
- Support of transactions for realizing expanded services
- Assigning the name "PROFIBUS" to qualified products
- Sales promotion through marketing and publicity (including trade fair participation, information for trade journals, advertizing and literature)

That basic objective has not changed to this day, but it has been expanded and specified in greater detail. For example, the weight of international cooperation has increased significantly through the establishment of PI (originally PROFIBUS international, now just PI), and its associated Regional PI Associations (RPAs) around the world. Members of PI can be hardware, software and system providers, planners and OEMs, users and operators, research institutes and universities, as well as other associations whose task is to develop and use devices and systems.

The first General Meeting

The agenda for the first General Meeting of the PNO, held on March 27, 1990, included the organizational structure of the Association and the definition of its substantive work. In response to the latter item, Technical Committees and Working Groups were established.

Everything was relatively straightforward. Shortly after it was established, the Association had 45 members. However, there was already a database of over 1200 names of parties interested in PROFIBUS, who had taken advantage of opportunities to receive information about PROFIBUS. Word was spreading that something important was taking place and people wanted to be a part of it!

The PNO Support Center

In spite of its well-known member companies, the PNO initially had few resources and no staff! A support center needed to be set up to coordinate the work program and to provide support to the Technical Committees. How could this be done?

The Board of Directors decided to retain the services of a provider to take on the basic work. This service provider had to collect membership dues, organize the first trade fair booths, and coordinate the technical development activities as directed by the Board of Directors and the Advisory Board. The service provider hired at that time was probably the first to earn money from PROFIBUS. But others were only a few steps away!

In the beginning things were turbulent! Members had different interests, and it was essential to agree a lot of new tasks even though only limited financial resources were available.

While internal conflict grew, the competition among other technologies was raging outside. PROFIBUS even had its own German competitor (Interbus, a Phoenix Contact project) and this was very active internationally.

American competitors also showed their flags and employed significant marketing power in an attempt to seize the initiative. Japanese companies meanwhile, were relying on proprietary solutions. As a result, diversification in the fieldbus market was seen from the start – and later this was to become even more pronounced. It was clear that if the young PNO wanted to win the fieldbus battle, it would have to bring more power to the field.

Nothing less than the full professionalization of PNO was needed, and that required a Support Center of dedicated staff working from a dedicated office and utilizing professional marketing skills. It began work in 1994 with two employees under the management of the then Executive Director Michael Volz. Initially housed in the Offices of HPB, in Frankfurt, in 1995 it moved to Karlsruhe. Today, a total of eight persons work in the Support Center under Executive Director Dr. Peter Wenzel.

The PNO as technology driver

The members of the PNO quickly realized the benefits of its neutral status and the many joint opportunities for participation. In Working

Founding members of the PNO

- ABB
- AEG
- FhG-IITB
- FZI
- Honeywell
- IRT/RWT Aachen
- Klöckner-Moeller
- Landis & Gyr
- LPR München
- Phoenix Contact
- Schleicher
- Siemens
- Softing
- Tesch
- ZVEI

The first full-time Excutive Director Michael Volz with co-worker Frauke Becker

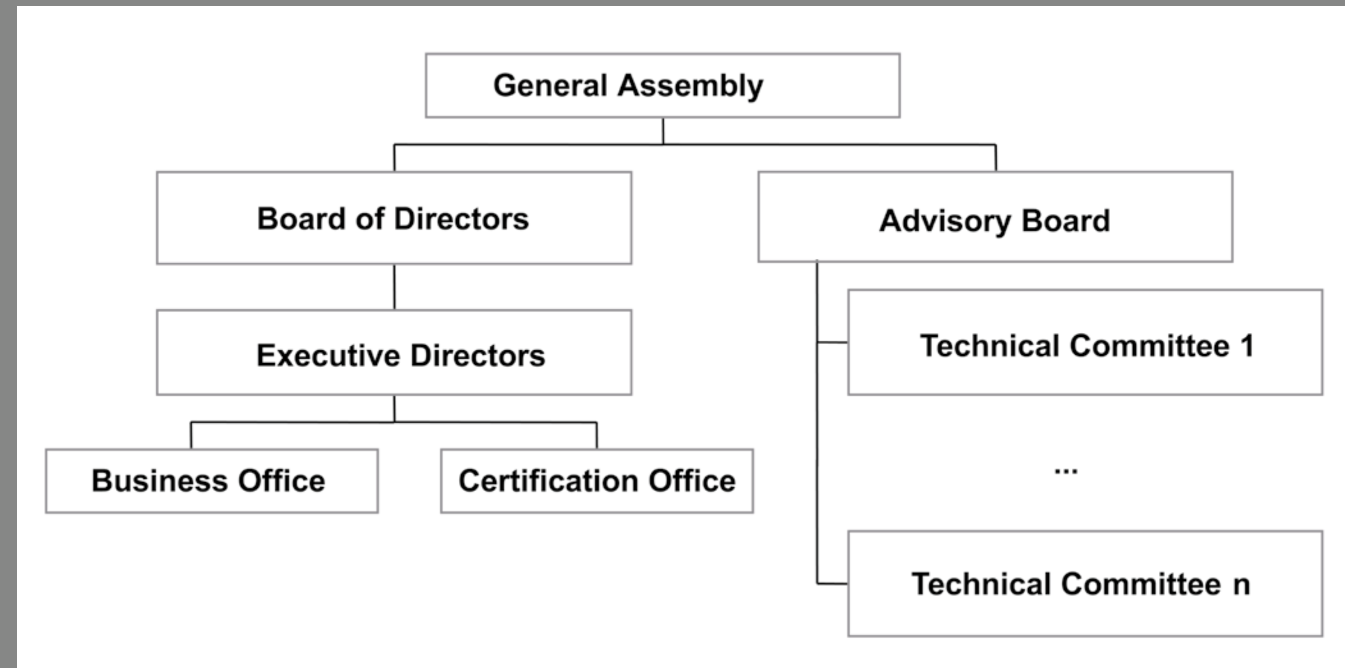
Employees of the PI Support Center in Karlsruhe in 2002 (r to l): Dr. Peter Wenzel and Dr. Volker Oestreich (both Executive Directors), Andreas van Eckendonk, Yvonne Auer, Barbara Weber, Claudia Hundertmark, Petra Mayer

Groups, members jointly develop solutions to problems and thus exert important influence on the development of the technology. All new PROFIBUS specifications and guidelines developed by the Working Groups are also presented to all members for comment before they officially take effect. The wide range of services offered in the marketing, technology and training areas delivers additional economic and technological benefit. The Advisory Board of the PNO contributes significantly in steering the technological developments.

Competition among technologies was already raging outside.

Michael Volz, former PNO Executive Director

The organization of the PNO – Functions of the Board of Directors and Advisory Board of the PNO



The main authority of the PNO resides with the General Meeting of all members, held regularly. This elects the Board of Directors (which consists of the Chairman and two or more deputies), and an Advisory Board, (which consists of the Board of Directors, the Technical Committee Leaders, and at least five elected members). Both Boards serve for a period of three fiscal years and their terms of office coincide.

The Board of Directors manages the Association and presides over the Advisory Board. The Support Center is available to the Board of Directors for administrative work.

The Board of Directors and Advisory Board are responsible for guiding the Association, executing decisions of the General Meeting and administering the Association's funds. The Advisory Board receives no compensation for its work.

In addition to the rights and obligations governing the Association, the Advisory Board is responsible for specifying the goals of the Technical Committees, monitoring their work, the coordination of work among the Technical Committees, and approval and release of work results.

The Advisory Board in 2009 (l to r): Jörg Freitag, Prof. Dr. Christian Diedrich, Martin Müller, Klaus-Peter Lindner, Dieter Staniczek, Jürgen George, Prof. Dr. Birgit Vogel-Heuser, Uwe Ruttkamp, Harald Hammon, Prof. Dr. Klaus Bender, Dr. Thomas Albers, Christoph Behler, Achim Laubenstein, Dr. Peter Wenzel, Gerhard Mutter, Dr. Raimund Sommer

Advisory Board members

Dr. Thomas Albers	2002 – present
Manfred Baumeister	1990 – 1996
Christoph Behler	2005 – present
Dr. Rainer Besold	1993 – 1995
Rudi Boldin	1992 – 1993
Dr. Rainer Besold	1999 – 2005
Prof. Dr. Christian Diedrich	2008 – present
Michael Gawol	1996 – 1997
Jürgen George	2005 – present
Joachim Göddertz	1990 – 1991
Dr. Heinz-Ulrich Gogrewe	1996 – 1999
Harald Hammon	2004 – present
Steffen Himstedt	1997 – 2000
Friedrich Keglowich	2002 – 2008
Achim Laubenstein	2004 – present
Dr. Hans-Peter Lerch	1993 – 2007
Klaus-Peter Lindner	1992 – 1996
Peter Mischitz	1996 – 2005
Walter Moeller-Nehring	1997 – 2000
Martin Müller	2007 – present
Gerhard Mutter	2008 – present
Prof. Dr. Peter Neumann	1990 – 2006
Prof. Dr. Karl-Heinz Niemann	1999 – 2002
Dr. Manfred Patz	1996 – 2009
Prof. Dr. Tilo Pfeifer	1990 – 1993
Axel Pöschmann	2006 – 2008
Uwe Ruttkamp	2008 – present
Karl-Heinz Schwarz	1991 – 1997
Thomas Schott	1996 – 2008
Karl-Peter Simon	1993 – 1996
Reinhard Simon	1996 – 1998
Dr. Raimund Sommer	1995 – present
Dieter Staniczek	2005 – present
Dr. Wolfgang Stripf	2000 – 2004
Joachim Thomsen	1994 – 1997
Peter Tomasik	1999 – 2005
Prof. Dr. Birgit Vogel-Heuser	2009 – present
Dr. Michael Voits	1992 – 1993
Peter Wendt	2002 – 2004
Dr. Wolfgang Freimann von Werder	1991 – 1994
Klaus-Peter Willems	1998 – 1999

PROFIBUS can be found everywhere today: in amusement parks, on cable cars and in building automation; across the spectrum in manufacturing, and in virtually all the process industries. At the start of the 1990s, this kind of success was far from evident, even if it was the goal of all participants. Would PROFIBUS become quickly established in the market? An exciting race began.

The PNO gets in shape for the competition

With the PNO, an effective User Organization had been created. Now, the dominant question was: Will the technology function in practice? Can customers used to traditional methods be convinced to change to fieldbuses?

The work of the Technical Committees

The instruments used by PNO to pursue technology developments were the Technical Committees, which had already been created at the first General Meeting of the PNO in March 1990. The Advisory Board proposed 4 Technical Committees:

Technical Committee 1: Quality Assurance and Certification
The purpose of Certification was to provide all PROFIBUS users with the basic assurance that products certified by the PNO could operate with one another correctly. Armin Schwarz assumed the leadership of this Technical Committee.

Technical Committee 2: Standardization
This Technical Committee, under the leadership of Prof. Dr. Peter Neumann of Magdeburg (ifak), dealt with general issues regarding standardization and specific issues regarding intrinsic safety within PROFIBUS.

Technical Committee 3: Profiles
Led by Joachim Göddertz of Klöckner Moeller, this Technical Committee was assigned to handle – especially at first – sensors/actuators.

Technical Committee 4: Tools and Commissioning
Manfred Baumeister of Softing in Munich initially led this Technical Committee, whose focus was on developing a configuration tool for PROFIBUS networks and for evaluating their performance.

Use of PROFIBUS at the Coca-Cola Company

All the Technical Committees worked hand in hand, establishing subsidiary Working Groups where needed. Noteworthy here was that countless experts from different companies came together. The PNO with its Technical Committees and Working Groups was therefore both a platform and an ideas laboratory in one. And all experts took part without compensation.

In practise, each Technical Committee and its Working Groups delivered "modules" for making PROFIBUS more attractive step by step. The work of the Technical Committees was - and continues to be - the backbone for the evolution of PROFIBUS. Only through

INFO

Profiles

Application Profiles are mandatory specifications that apply to all devices or subsystems of a particular application class, such as robots, drives, encoders, pumps, process devices, low-voltage switchgear, identification devices (RFID and bar code), and weighing and dosing devices. Each Application Profile describes a minimum set of properties that all devices of the class must fulfill and that manufacturers must implement when developing "Profile-compliant" devices.

Device Profiles are mandatory specifications that apply to all devices of a particular type. These Profiles are standardized in IEC 62390. However, device manufacturers are at liberty to implement additional, manufacturer-specific properties in their devices in order to encourage technical advances and market differentiation.

joint work, ongoing technological development, standardization, Profile development, and marketing can new application areas and markets be opened up.

In the process, serious market resistance and fear of change has been encountered. The PROFIBUS community has had to show that the whole package worked. It was a process that took years – although it came as no surprise to Dennis van Booma, PROFIBUS expert from The Netherlands: "We knew that PROFIBUS was the coming thing – but it takes time for people to accept and use innovation!"

Start of Standardization and Profile work

One of the first items to be tackled at the start of 1992 was to settle on a common "language". Transparent communication among all fieldbus nodes demanded use of the same nomenclature throughout, since the absence of such uniformity would lead to proprietary solutions.

The experiences of the early years showed that systems and networks might consist of dozens of field device types from various manufacturers, with just as many operating programs. This huge variety meant significant installation effort and cost, and continual version management. The prevailing wish of the Technical Committees was to enable open and universal communication – and thus eliminate the installation and maintenance nightmares of the past.

To achieve this, the Technical Committees worked on developing standardized Profiles (see box left). During the first stage, it was imperative to define optimum subsets of the PROFIBUS protocol for use in Device Profiles. During the second stage – which took place in parallel to some extent – work began on the standardization of Application Profiles.

Over time, various Device and Application Profiles have been developed covering the needs of production and process automation. By the middle of the 1990s, the PROFIdrive Profile was made available for drive technology applications together with the PA Profile for process automation, while by the end of the 1990s, safety-related applications were made accessible through the PROFIsafe Profile – just to name the most important.

Thanks to Profiles developed over the years, all PROFIBUS nodes today speak a uniform "language". The open specification of PROFIBUS and its Profiles enables compatibility and independence of individual company solutions, so that products from many different manufacturers can work together within one system.

PROFIBUS FMS – the first product of the Technical Committees' work

PROFIBUS FMS (Fieldbus Message Specification), the main outcome of the joint "Fieldbus" project, was optimized first. However, because PROFIBUS FMS had large frames and, furthermore, could only accommodate relatively small quantities of data, it was not ideally suited to the real-time applications of general automation. While it had a high level of functionality, its response times were relatively long. Its main advantages were object-oriented data exchange with complex application layers, especially suited to communication among programmable logic controllers (PLCs) and industrial computers. It was primarily intended for use in complex machinery and equipment. It was used extensively in building management systems, manufacturing technology, and in plant construction.

From a historical perspective, PROFIBUS FMS represented the first standardized version of PROFIBUS. Today the variant is no longer part of the international fieldbus standard and has been removed from the PROFIBUS specifications.

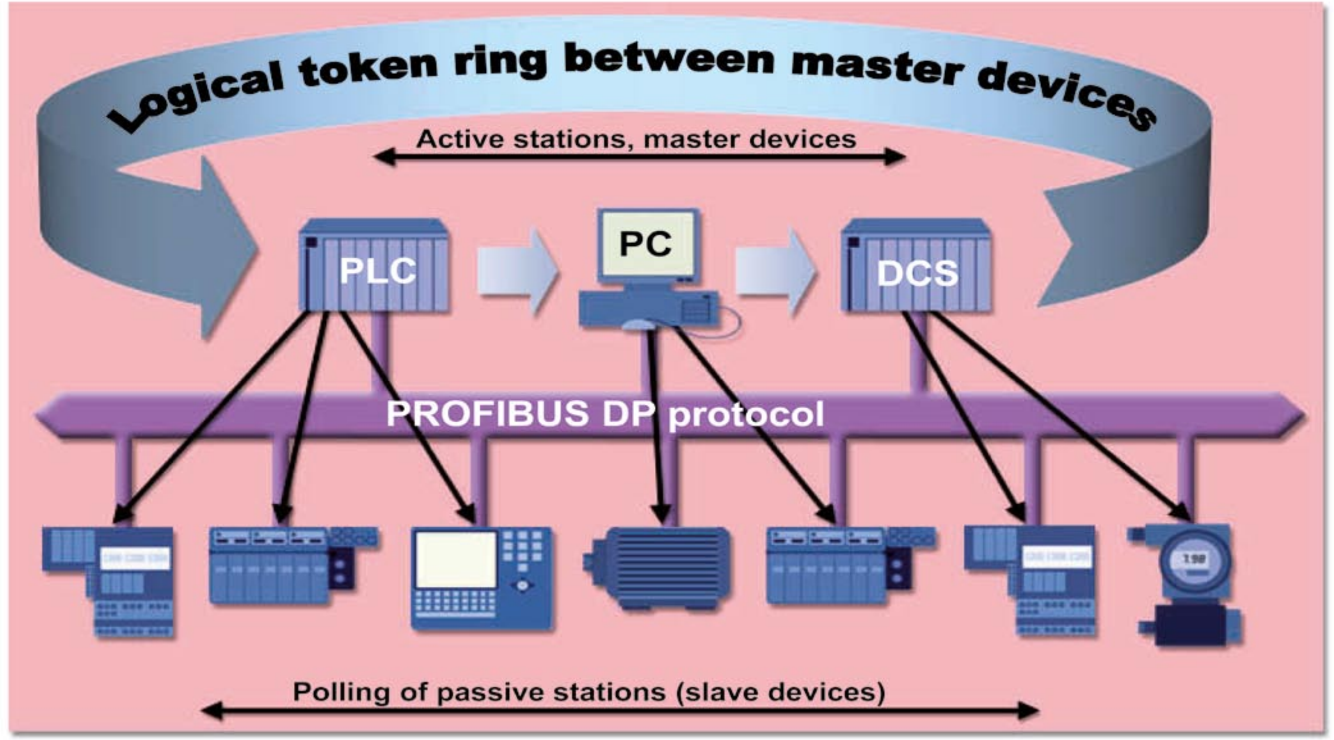
INFO

PROFIBUS FMS

In PROFIBUS FMS, several masters can be used in one system. It supports master-master and master-slave communication. Communication among the different masters takes place in a logical token ring in which only the master that currently possesses the token can initiate communication. The master possessing the token must pass it to another master during an agreed maximum time period. Master-slave communication uses a polling operation, that is, only a slave that has been polled by the master can send data. The topology is a line structure with terminating resistors for reflection avoidance. FMS is primarily suitable for communication at the cell level, in which mainly PLCs and PCs communicate with one another.

PROFIBUS DP

In PROFIBUS DP, a centralized controller device (master) communicates with decentralized field devices (such as I/O, drives, valves, or transducers), over a fast serial connection. Cyclic (that is, precisely timed) communications are used to exchange data with the decentralized devices. The functions necessary for this are specified by the PROFIBUS DP specification. The central controller (master) reads input information from the slaves and then writes output information back to the slaves.
In addition to cyclic data transmission, PROFIBUS DP also allows powerful diagnostic and commissioning functions to be employed acyclicly (that is, during spare cycles).
Special diagnostic functions make it easy to isolate errors. The diagnostic messages are transmitted over the bus and compiled in the master. They are divided into 3 classes:
1. Station-related diagnostics: messages regarding readiness for operation, such as overtemperature.
2. Module-related diagnostics: messages regarding errors within an I/O subarea.
3. Channel-related diagnostics: Messages regarding malfunction of an individual input/output, such as a short circuit.
Mono-master or multi-master systems can be realized with PROFIBUS DP. Communication takes place either master-master within the logical token ring, or master-slave via polling.
126 devices - masters or slaves - can be connected to one bus. The specifications for system configuration include the number of stations, assignment of the station address to the I/O addresses, data consistency of I/O data, format of diagnostic messages, and the utilized bus parameters. PROFIBUS DP systems differentiate between the following device types: DP slave, DP class 1 master (DPM1), and DP class 2 master (DPM2).
A DP slave is an I/O device that reads in input information and supplies output information to the master. The DP class 1 master regulates the cyclic data traffic. PLCs or PCs are typical examples of a class1 master.
DP class 2 masters are engineering or HMI devices. They access the bus acyclically and thus enable the configuration and parameterization of intelligent field devices. To achieve general device interchangeability, the system behavior was also standardized for PROFIBUS-DP.



The PROFIBUS protocol

Keep it simple: PROFIBUS DP

In 1993, the PROFIBUS DP (DP = distributed peripheral) protocol, a simplified and faster variant, was published as a Standard. Through a centralized controller, PROFIBUS DP acts to manage the sensors and actuators typically found in a production line. Many standard diagnostic possibilities are available. PROFIBUS DP is designed, in particular, for efficient data exchange at the field device level and is optimized for the real-time, deterministic operations found in industrial automation.

Today, PROFIBUS DP has proved itself widely in products and equipment used in industrial automation systems. It forms the backbone of all ongoing developments by the Working Groups.

The first Test Labs for PROFIBUS field devices in Aachen (left) and Karlsruhe (right)

Certification as a success criterion

How certain could users be that the modules they purchased for automation could actually communicate over PROFIBUS? The PNO had to provide a straightforward answer. As a result, recommendations for interoperability tests, certification, and the awarding of test logos were developed by Technical Committee "Quality Assurance and Certification."

Test Labs and their certification activities were necessary because the open communication standards represented by PROFIBUS and the aim of interoperability could only succeed if the associated promises could actually be kept. It had to be ensured that all fieldbus devices could communicate – independent of the manufacturer.

A kind of TÜV was needed, as Manfred Popp of Siemens relates. So, authorized Test Labs came into being. The first had already been established for PROFIBUS FMS at the Fraunhofer Institute in Karlsruhe in 1992. Popp was a key player in setting up the first Test Lab for PROFIBUS DP, in 1994.

The PROFIBUS experts involved in certification set about drafting not only the test specification but also a manual for the Test Labs, defining exactly what was to be tested and how. This paper was subsequently made available to Test Labs as test instructions so that a uniform procedure could be guaranteed. This resulted in the setup of a quality assurance system that has stood the test of time. To date there have not been any problems with certified devices with regard to communication. According to Popp: "The only time problems have occurred is during installation, or when manufacturers or customers change something in the devices after certification."

Tools and Commissioning

The objective of the Technical Committee "Tools and Commissioning" is to ensure the general independence of tools from a PROFIBUS product and its application. The Technical Committee sees itself as a forum for developing requirements, and for planning development projects for realizing these tools.

The following Working Groups were initially envisaged to ensure a smooth work flow: "System Configuration and Commissioning," "Network Management," and "Maintenance." In 1999, the Technical Committee was renamed Technical Committee "Engineering" and took on the additional objective of defining description methods in support of system configuration.

It was the work of this Technical Committee that yielded the GSD (General Station Description) for PROFIBUS. The GSD describes both general and specific definitions regarding the communication

INFO

Test Labs

PI currently supports ten authorized PI Test Labs (PITL) in six countries around the world for certifying products with a PROFIBUS or PROFINET interface. They offer their services on a company-neutral basis within the framework of an agreed body of rules. The testing services provided by the Test Labs are regularly audited in accordance with a strict accreditation process to ensure that they meet the necessary quality requirements.

Manfred Popp was a key player in setting up the first Test Lab for PROFIBUS DP in 1994.

functions of a device in the form of keywords, which are evaluated automatically by the configuration tool when the system configuration is created.

The Electronic Device Description Language (EDDL) and Field Device Tool/Device Type Manager (FDT/DTM) integration methods were added later for describing application-related parameters and features of field devices. EDDL is a formal language for vendor-neutral description of operator control and parameterization of field devices. The FDT/DTM concept supports the notion of a cross-vendor concept that enables a single program to parameterize field devices from various manufacturers.

Do good and talk about it

To start all of these activities were extremely important since the goal was – and still is – to establish PROFIBUS in all sectors of industrial automation, covering both production and process automation with a single solution. This strategy has paid off significantly as hybrid automation plants - production lines having both process- and production-related parts - have become increasingly more important. It is primarily this hybrid capability of PROFIBUS that has made it the global market leader.

Barbara Weber has been responsible for PR for PROFIBUS since 1998

To bring about success, however, the benefits of PROFIBUS had to be advertized aggressively: openness, reliability, speed, flexibility, investment protection and interoperability were the main arguments communicated by the marketing campaign. This effort was primarily the responsibility of the Working Group "Public Relations," which was later elevated to a Technical Committee as the importance of marketing grew.

This Technical Committee, with the active support of the Support Center in Karlsruhe, not only manages traditional press relations and advertizing, but also plans and executes trade fair appearances

Open communication with the press:
Former Board of Directors Chairman Edgar Küster at a press conference

(including Hanover Fair and other automation trade fairs). In addition, this Technical Committee is responsible for publications such as newsletters, documentation, and magazine articles. Hundreds of published articles, which started appearing in the early years, attest to the success of the marketing campaign.

In 1999, the decision was made to focus marketing activities worldwide. In addition, individual Profiles and services were reinforced by ad-hoc marketing groups. That it succeeded in quickly convincing the market of the advantages of this offer – more recently for PROFINET as well (see Chapter 11) – speaks in favor of the clout of the marketing activities, which today utilize the Internet in addition to conventional marketing tools. The website at http://www.profibus.com is one of the primary reference sites for industry and represents an irreplaceable tool for everything concerning



Presentation of PROFIBUS at international trade fairs in the 1990s

industrial communication in automation. It contains comprehensive information about PROFIBUS and the global community that supports it, plus case studies and contacts, and addresses of Test Labs and Competence Centers.

Market leader in Europe

At the General Meeting in Hanover, Germany, in April 1995, the Board of Directors declared: "PROFIBUS has established itself as the market leader in Europe." This was the initial breakthrough and could be traced back not only to the intensive Technical Committee work of preceding years but also to a handful of recent events that had influenced the market situation. For example, General Motors had spoken out in favor of using only automation systems with a PROFIBUS interface for all its factories in Europe. This decision had a profound effect on the world market. In addition, PROFIBUS was also integrated into the European fieldbus standard EN 50170, which above all provided protection to users and was proof of the intensive efforts of the Technical Committee "Standardization."

By now it was clear that a multi-vendor network of experts could successfully collaborate on a common platform and produce excellent results without a large setup, expensive management, or a giant marketing budget. The business model worked – and by the start of the 1990s hopes were raised even higher.

The innovative business model with its distinct community culture turned the thinking of many managers upside down. PNO stood for a new logic, in which product development was community-based. The key competency of this organization was not the ability to stand out from the competition or to develop proprietary solutions, but rather the interaction of the community in all relevant markets.

In other words, the PNO did not market its product top-down. Rather, its "customers" participated in the production, distribution,

Decision in favor of PROFIBUS in 1995: Opel headquarters in Rüsselsheim, Germany, bottom: Opel manufacturing plant

Research Minister a. D. Prof. Dr. Heinz Riesenhuber at the 10th anniversary of the PNO

PNO Director Prof. Dr. Klaus Bender (left) and Edgar Küster (right) with Prof. Dr. Heinz Riesenhuber

and marketing processes. The technological openness of PROFIBUS is also an expression of the PNO as an organization. "That's the beauty of it," as Michael Bryant of the PROFIBUS Trade Organization in the U.S summarized.

Changes in the PNO

Although the basic concept of the PNO remained unchanged, its tasks were re-defined as circumstances required. In the first half of the 1990s, it focused mainly on the development of a stable technical base. Towards the end of the 1990s, it began concentrating not only on further technical development activities but also on developing the international market. It soon became apparent that the PNO would increasingly assume the role of an international industry

association for automation technology. By the end of the 1990s – on the occasion of its 10th anniversary – the PNO could already communicate this with confidence.

A critical step was an organizational restructuring, which commenced with a white paper presented at the Advisory Board meeting on September 28, 1999. The increasingly global focus made itself known if nothing else through the wider use of English. Technical Committees were collectively merged or renamed, and new topics were addressed. One major topic ultimately became the cooperation with other players in the automation industry as, in this way, it could react more quickly to current trends, as exampled by the collaborations with EDDL and FTD/DTM.

A first version of FDT/DTM had already been developed and published by ZVEI, and the results handed over contractually to the PNO for further development. In 2003, this project was forwarded to the newly-established FDT Joint Interest Group for further, fieldbus-neutral, development.

EDDL is now undergoing a similar fieldbus-neutral development in the ECT (Engineering Cooperation Team). The first version of EDDL was created by a consortium of global companies in the middle of the 1980s and this is now being further developed by the ECT. With the establishment of the ECT, the relevant working group supplies PROFIBUS-related input as part of an international cooperative effort and organizes review processes within the PI. Since 2007, the ECT has been working on Field Device Integration (FDI) as a successor technology to FDT/DTM and EDDL.

There was cooperation in other areas as well. In collaboration with the INTERBUS Club, PI has advanced the topic of PROFINET as a common Industrial Ethernet solution. The WCT (Wireless Cooperation Team) has developed the wireless connection of sensors and actuators in process automation using a technology called WirelessHART. And the joint development of IO-LINK with the IO-LINK Consortium began as a Working Group of the PNO.

INFO

Edgar Küster (1948–2007)

Edgar Küster was a long-standing Chairman of the Board of Directors of the PNO and Chairman of PI (PROFIBUS & PROFINET International) and rendered outstanding service to PROFIBUS. After taking office in 1995, Küster brought his extraordinary creativity and team building skills to bear and was a major contributor in making the PNO, as an industrial trade association, and the global umbrella organization PI into the leading international organizations they are today.

During his time in office, PROFIBUS technology underwent crucial developments for use in process automation, drives technology, and safety-related automation and became quickly established in these respective sectors. In 2000, he co-started the development of PROFINET and worked tenaciously to advance it up until the time of his death.

IO-LINK is a standardized, point-to-point communication system for connecting intelligent sensors and actuators to a higher fieldbus-based automation system. The specification encompasses both the electrical data and a digital protocol which the sensors and actuators use to exchange data with the automation system. In order for the technology to be independent of PROFIBUS and PROFINET, the companies involved (sensor and device manufacturers for production automation) have established their own Consortium, along with bylaws governing the Consortium's inner workings and how it operates in association with the PNO.

Market leader worldwide

The activities of the early years as well as the continuing technological developments made PROFIBUS the undisputed global market leader by 2003. By the end of 2003, the number of installed PROFIBUS devices exceeded 10 million. The forecast was for continued dynamic growth. "PROFIBUS is the driver behind development of new production processes, in both production and process automation," said Edgar Küster, Chairman of the Board of Directors in 2003. "In addition, the market demand for PROFIBUS shows no sign of a slow down. We are firmly convinced that we will double the number of installed devices to 20 million by 2008. This means excellent business prospects for our member companies," he said.

Image photo of 2003

Excellence in Automation

Excellence in Automation – this was the name of the international conference held by the PNO in Karlsruhe in March 2009 on the occasion of the 20-year anniversary of PROFIBUS technology.

Excellence in Automation stands for 20 years of PROFIBUS: 20 years of technical expertise, know-how and experience in the field, of global collaborative effort and successful marketing campaigns. Visitors to the two-day conference attended presentations by experts and users, participated in discussion forums and saw live demonstrations of the advantages and features of PROFIBUS, and development trends in industrial automation.

The scope of the conference reflected trends in the PROFIBUS world of recent years but extended through PROFIBUS, PROFINET, and IO-LINK as well, to safety and wireless technologies and, finally, to device integration, diagnostics, and asset management.


In 2009, eight staff members work under Executive Director Dr. Peter Wenzel (far right) to ensure the success of PI (l to r):
Barbara Weber, Wolfgang Quint, Kathrin Holzer, Andreas van Eckendonk, Petra Mayer, Tina-Maren Weith, Marianne Schell

Invitation flyer and mood (left) at the conference on the occasion of the 20th anniversary of the PNO

PROFIBUS goes global – Internationalization and greater support

The international focus of the PNO was in evidence even at its inaugural meeting: "The purpose of the organization is to promote international dissemination of a communication system for networking field devices called PROFIBUS." Thus, as early as 1991 the PNO set out to establish regional, financially independent user organizations abroad.

The establishment in 1992/1993 of the PROFIBUS Switzerland Organization with 21 members marked the first successful effort to position a Regional PROFIBUS Association (RPA) in the market. The driving forces in Switzerland were Dr. Rudolf Bünger and Prof. Max Felser.

Driving force behind internationalization:
Michael Bryant, PTO USA

We had no money, no members, zero market share – that was in fact the huge challenge we faced.

Michael Bryant, PTO USA

Prof. Max Felser, University of
Applied Sciences at Bern

The establishment of this initial RPA as a stand-alone organization was initially an accident. In fact, Prof. Felser merely wanted to set up a branch of the German PNO. This request from a neighboring country forced PNO representatives to grapple in a more concrete way with their generally-stated plans for internationalization. They quickly realized that the only way to ensure a successful, active international community was to provide individual countries and regions with extensive autonomy. This was because sufficient consideration of the market characteristics of individual countries could never be achieved from a central point of contact in Germany. The motto "Every country or region has its own experts" was coined. RPA Switzerland was thus established as a stand-alone organization.

Further steps in Europe

Internationalization was advanced first in Europe, before the strategically important markets of the United States and Asia were tackled. Thus, additional RPAs quickly followed that of Switzerland – in Austria, Great Britain, France, Belgium, and the Netherlands, as well as in Sweden, where Lars H. Larsson has been involved with PROFIBUS from the outset and is still active in the RPA there.

Larsson's enthusiam to establish an RPA was typical of many others, such as Maurizio Ghizzoni in Italy, Kai Atle Myrvang in Norway, and Bob Squirrel, in Great Britain. Larsson was able to introduce PROFIBUS to Sweden and all of Scandinavia quickly. He recruited numerous important members, primarily from the manufacturing industries which are strongly represented in Scandinavia. The breakthrough came in 1995 when he organized a road show with some dozen stops throughout the country. Suddenly, everyone in the automation industry was interested in PROFIBUS. Larsson took advantage of this interest in his subsequent marketing initiatives so that, today, PROFIBUS is the dominant fieldbus system in Sweden.

Global expansion

Although the internalization efforts at the start of the 1990s were focused on Europe, other PROFIBUS participants had already begun to organize their worldwide market presence in parallel. Success would only be achieved if PROFIBUS was represented in the largest automation market - the United States of America, which alone accounts for over 20 percent of the global automation market. Following preparatory steps in 1992, the PROFIBUS Trade Organization was established as the RPA in the United States in 1994.

The establishment of an RPA was always a true “start-up” experience say participants – but this was even more true in locations where PROFIBUS was not strongly positioned ... as Michael Bryant of the PROFIBUS Trade Organization (now just PTO) recalls: “At the outset the market situation for us in the USA was clear: We had no money, no members, zero market share – that was in fact the huge challenge we faced.”

Nevertheless, after only 6 months Bryant was able to record his first successes. Over 100 members, mainly from manufacturing industries, were active by that time. Bryant knows that the breakthrough came with PROFIBUS DP – and from the untiring publicity activities of all other RPAs, which were demonstrating the potential applications and benefits of fieldbus technologies to engineers throughout the world. “PROFIBUS is the best solution for the fieldbus problem,” was the global message.

By the end of 1994 a total of 11 RPAs were established in important industrialized nations. Additional RPAs were soon established in other relevant markets, such as the CIS, Japan, China, and Korea, representing excellent progress toward achieving the strategic mission formulated in 1995 – to become the worldwide leader. Today, the spotlight is increasingly on emerging markets, such as the Middle East and India – efforts to establish RPAs there are nearing completion now.

INFO

RPA

Regional PROFIBUS Associations (now Regional PI Associations) are local organizations throughout the world that represent the PROFIBUS global community. PI establishes the guidelines for these organizations, but each RPA is responsible for generating its own members and programs. The main purpose of the RPAs is to market the PROFIBUS and PROFINET technologies in their respective countries. This includes participation in and hosting of trade fairs, seminars, workshops, and press conferences, as well as translation of publications into the local language. RPAs are an effective first point of contact for interested companies and first-time users because they are closely networked with other local entities, such as the PI Competence Centers, Test Labs, and Training Centers. Members of all RPAs meet several times a year to learn about the latest research results and to discuss current topics and strategies.

Similar experiences to those of Bryant in the USA were repeated around the world, according to Dariusz Germanek of PROFIBUS Organization Poland and Shinichi Motoyoshi of the Japanese PROFIBUS Organization (JPO), whose efforts began in 1997. Each of these RPAs had to confront specific challenges within their national markets. In both USA and Japan, a country-specific solution from the domestic automation technology suppliers was already active. Depending on their market power, these suppliers wanted to promote their own solutions.

However, given the opportunity to present the principle behind PROFIBUS and the advantages of the growing international PROFIBUS community, the rest almost took care of itself. Initially, Motoyoshi had to battle for every participant at his meetings. His seminars were free of charge because no one was willing to pay to attend. However, within 3 years, the tide had turned. Now, the JPO no longer has to advertize its events, and companies pay the participant fees for their employees as a matter of course.

The situation in Japan was related to the fact that PROFIBUS initially registered dynamic growth in China. Because PROFIBUS grew quickly in China, it took a lot of effort for Japanese providers to penetrate that market with their own fieldbus solutions. If the Japanese companies that were strong exporters of automation technology wanted to get in on the act, they would also have to provide PROFIBUS. Motoyoshi is sure of this: "PROFIBUS made its way to Japan through China." PROFIBUS was the trend in the Land of the Rising Sun.

First presentation of PROFIBUS at the ISA Show in the United States in 1993

Shinichi Motoyoshi, engine behind the establishment of PROFIBUS in Japan

Establishment of PROFIBUS International

In 1995, the RPAs joined forces to form the international umbrella organization known then as PROFIBUS International (PI).

Josef Kreidl was selected as the PI Chairman and Michael Bryant as the Deputy Chairman at the first General Meeting. As a service and coordination center for international activities, a PI Support Center (PISC) was also established and transferred to the existing Support Center of the PNO in Karlsruhe under the management of Executive Director Michael Volz.

top: Founding of the Organization in Japan in 1997; bottom: Founding of the Chinese PROFIBUS Organization in 1997

With the establishment of PI, a global fieldbus interest group was effectively formed, having more members (over 450 companies and institutions) than any other similar group. This was another

Meeting to establish the RPA in India in 2009

Trade fair booth of RPA in South Africa

RPAs around the world

1992 The first user organization was founded in Switzerland,

1993 Establishment of France PROFIBUS, PROFIBUS i Sverige, The PROFIBUS Group UK

1994 PROFIBUS Trade Organization in the USA, RPA Belgium, PROFIBUS Nederland, PROFIBUS Network Italia, PROFIBUS User Organization Southern Africa

1995 RPA Australia and New Zealand, Finland, PROFIBUS User Organization Russia

1996 Associação PROFIBUS Brazil, PROFIBUS User Organization Norway

1997 Chinese PROFIBUS User Organization, Japanese PROFIBUS Organization, PROFIBUS Association South East Asia

1998 PROFIBUS Association Czech Republic and PROFIBUS Denmark

1999 Irish PROFIBUS User Group, Korea PROFIBUS Organization

2000 PROFIBUS Slovakia

2002 PROFIBUS Thai Association

2004 PROFIBUS Polska

2007 RPA Middle-East (Dubai)

2009 RPA India

PI Chairmen/Deputy Chairmen

Josef Kreidl (1995–1997)

Michael Bryant (1995 to present)

Klaus-Peter Lindner (1997–2001)

Edgar Küster (2001–2007)

Jörg Freitag (2008 to present)

expression of the increasing success of PROFIBUS. Since becoming the market leader in Europe one year earlier in 1994, the PNO Board of Directors in Germany had issued a new goal in conjunction with PI: "Internationalization will be the main focus in the future." That was the task of the new PI Chairman, Klaus-Peter Lindner, who took office in December 1997 and set new benchmarks year after year: be it membership numbers for existing RPAs, which exceeded 1000 by the end of the century, or the establishment of additional RPAs, or an international media presence.

While there was still a significant emphasis on Europe at the turn of the century due to the development history of PROFIBUS, the main potential for growth was in Asia, where the RPAs in China, Japan, and South Asia recorded dynamic membership growth.

Later, under the leadership of Edgar Küster, global expansion entered another important phase, marked by the work of Küster in close cooperation with Michael Bryant. The motto "Strategize globally, act locally" was born. Individual aspects of the global marketing strategy were developed step by step during many meetings. One of the most important was the marketing of all technologies as a whole and the transformation of an organization for industrial communication into an organization for automation solutions – as expressed in a new mission statement (see right). Küster deserves credit for the way this was implemented in the different regions, as he pursued this objective tenaciously. The result today is a well-functioning global community – in spite of widely differing economic and cultural backgrounds.

INFO

Mission statement

"We are and will remain the world's leading organization in the field of digital networking for industrial and process automation, serving our customers, our members and the press with the best solutions, benefits and information. We are committed to setting and protecting the standards for open communication and control in the automation and process market"

With the establishment of PROFINET (based on the guiding principle "PROFINET is forcing PI to change into an Automation Organization"), the mission statement was revised in 2006:

"We are and will remain the world's leading automation organization for communication solutions, serving our users, our members and the press with the best solutions, benefits and information."

Development of the PI logo: today it features the combined colors for the PROFIBUS and PROFINET technologies

Objectives of PROFIBUS International: Networking – Marketing – Training – Competence

The umbrella organization PROFIBUS International had one very clear objective: to use the network of regional RPAs to become Number One worldwide. This objective unified all parties – the international PROFIBUS family could become even larger and even more successful. This was and still is the common, driving vision, according to conversations with RPA representatives such as Dolf van Eendenburg from Belgium and the Netherlands, Dariusz Germanek of Poland, Michael Bryant of the United States, and Shinichi Motoyoshi of Japan. Out of PROFIBUS has grown a large family with many faces and many languages, spread around the world – a fascinating outcome that was barely believed possible at the outset of the development project.

PI Meeting in Sonoma Valley, California, United States

But visions require effort. PI worked in a dedicated manner to organize international promotion activities for PROFIBUS, and later for PROFINET, and to coordinate its members' interests. A set of actions were implemented to achieve this:

- Manufacturer-independent member support
- Support of user groups
- Organization of seminars and workshops
- Setup and support of Competence Centers
- Regional marketing activities (organization of shared booths at trade fairs, publication of brochures and magazines, public relations)

Later, a logical consequence for PI was the addition of PROFINET to its activities. The PI brand therefore expanded to become PROFIBUS & PROFINET International, although it retained its "PI" nomenclature.

All RPAs work – in line with the specific market requirements – in their local language, although English is their common point of

Certified PROFIBUS Installer Course at PITC Manchester Metropolitan University, UK, held by Andy Verwer

reference. A factor common to all RPAs is that they provide local support not only to manufacturers but also to users.

Competence Centers and Training Centers

Exchange of information between the RPAs is a central market advantage of PI's international community. Over many years, RPAs have joined in the coordination and collaborative activities of international Standards development. A particularly successful marketing emphasis has been the support of RPAs for local marketing activities, but this also extends to activities for certification, training, and competency building.

Membership growth

Since the start of activities, PI has expanded its membership rapidly. While at the outset, a manageable handful of a few dozen companies collaborated in committees, PI currently has over 1,400 members.

Hands-on work of the Competence Centers: Technical Support in China for a wind farm by PROCENTEC, Holland by Dennis van Booma (top). Training at PICC ComDeC by Manfred Popp (bottom)

Participants at PI-, PICC- and PITC-meetings in Krakow, Poland, Spring 2009

Excellent support during implementation and operation of PROFIBUS is an important factor. In order to achieve this, the international PROFIBUS network offers a variety of services. Since 1998, a growing band of PI Competence Centers (PICCs) have been offering technical expertise and they collaborate closely with the RPAs. Currently, there are 42 PI Competence Centers in 22 countries – a guarantee of global support for the PROFIBUS family. PICCs must be accredited before they are allowed to operate, and they provide technical support according to common, uniform quality criteria.

You are not alone

Dennis van Booma, General Manager Procentec/NL and head of PI Training Centers

“You are not alone” – serves as the motto for the PICCs, as well as for the 16 global PI Training Centers established in parallel, as Dennis van Booma, General Manager of Procentec in the Netherlands, likes to explain. He was one of the first PICC auditors and had the idea in 2006 to form PI Training Centers (PITCs). According to him, PROFIBUS is not just a technology; it also matters that the technology is understood. To support customers around the world, there is a need for qualified personnel who can convey the necessary knowledge.

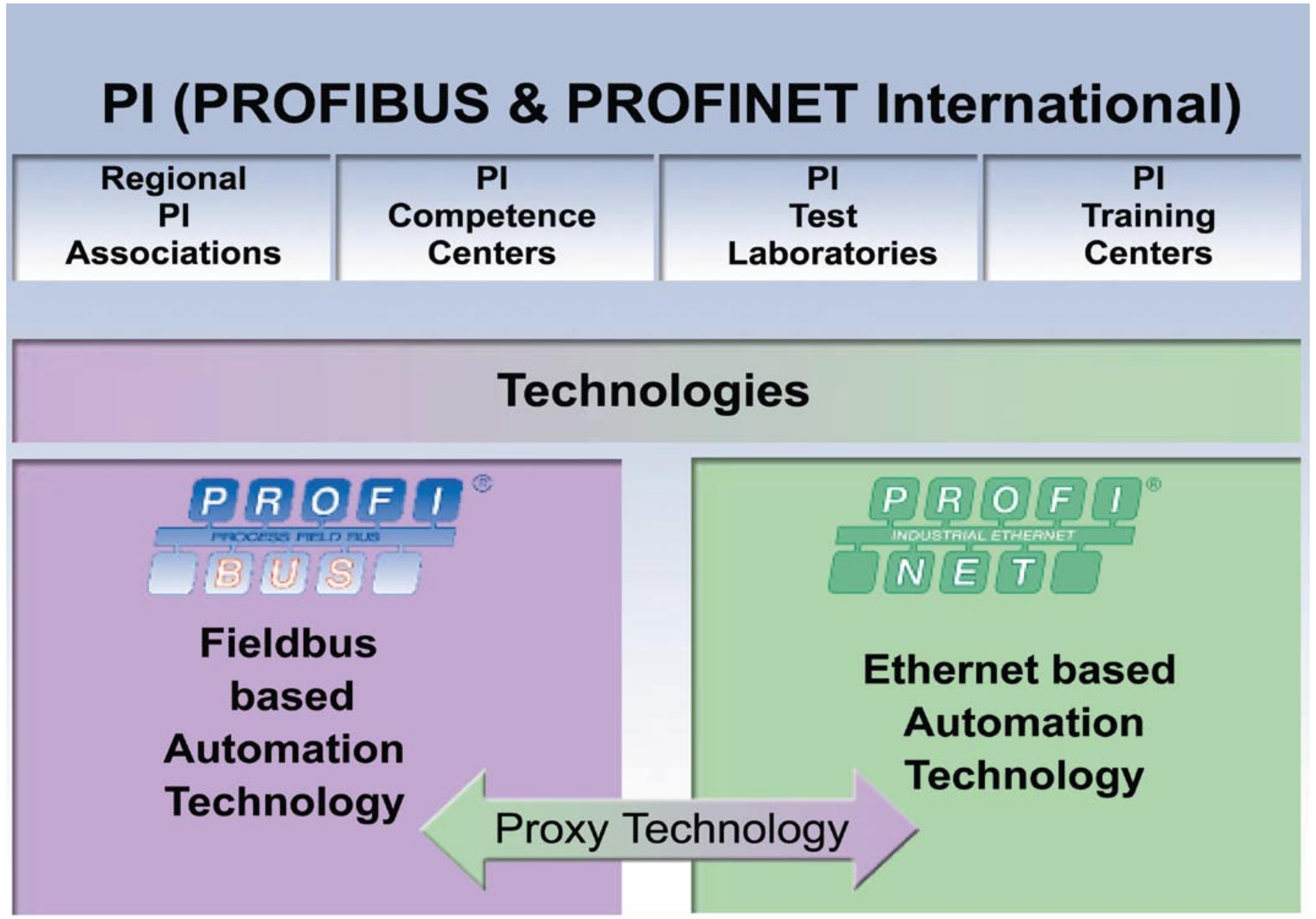
PI today

Currently, PI has more than 1400 members worldwide. There are 26 Regional PI Associations, 42 PI Competence Centers, and 16 PI Training Centers. With representation on all continents, PI is the largest industrial communication interest group in the world. PI provides a vendor neutral platform, on which competitors can come together within a culture of cooperation.

This global community is a constant in the fast moving automation world. The advantage of such a community is that numerous partners having a wide range of interests can support a single goal: They only have to join the bandwagon, which in turn helps them to strengthen their own market position because they can be noticed more easily and, in fact, appear larger as a result of their involvement. Access to the user and to the customer is made considerably easier too.

Every member can think proactively, exert influence, take action – the important thing is pursuit of a common objective. What began as a start-up activity when the first pioneer RPAs were established has developed today into a powerful organization. Today it is self-evident that PROFIBUS leads the world of automation and represents “state of the art.”

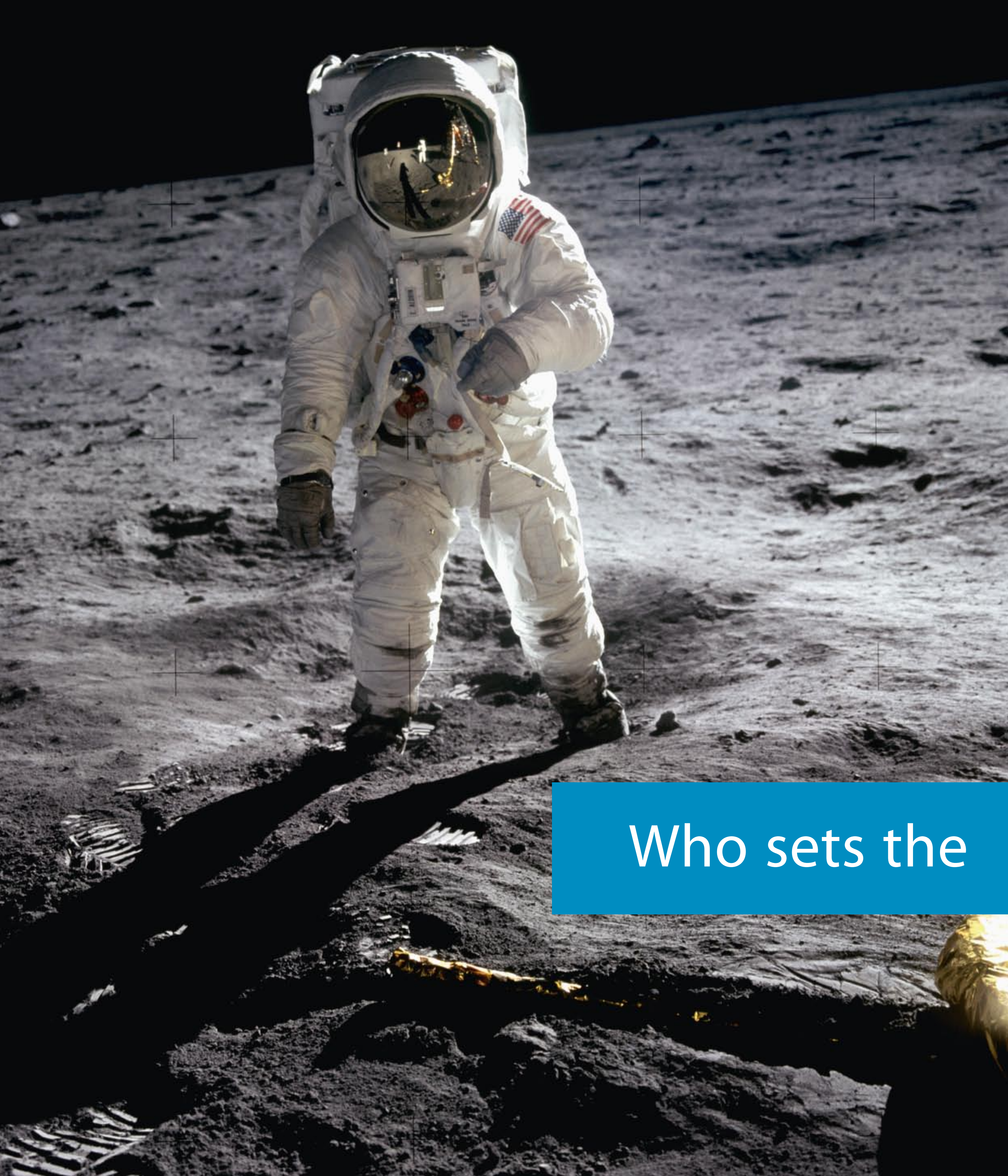
As for PI: “Share our vision for automation” is its motto. It’s an invitation to join an international community of automation experts without equal, and take full advantage of what the future holds!



Structure of PI

Every member can think proactively, exert influence, take action – the important thing is pursuit of a common objective.

Dolf van Eendenburg, RPA Belgium/Netherlands



During the 1990s, a volatile phase of market positioning took place within various industries and regions of the world, due to the many competing systems on the market, such as Interbus, WorldFIP, and later Foundation Fieldbus. The phase was characterized by a vigorous open competition in the international Standards organizations which we now refer to as the "fieldbus war."

Who sets the international Standard?

Large scale manufacturers increasingly recognized that proprietary solutions would have only limited success. Rapid dissemination of a Standard could only be achieved if a system was kept open and promoted widely. In this way, producers of fieldbus components have the opportunity to develop interoperable equipment and give customers the freedom to choose which products to use with their automation systems. PROFIBUS followed this path from the outset and was supported by many companies. In other words, everyone felt that PROFIBUS should be the international Standard. But, would it actually succeed in becoming the international fieldbus Standard?

No Standard, no market success

"No Standard, no market success" was the simple formula, since Standards are required for all international bidding processes. To establish a Standard meant for the PROFIBUS fieldbus system to become the official international Standard. However, developing Standards requires global influence and a high level of skill and diplomacy. The process is full of political pitfalls. PROFIBUS participants can tell a thing or two about it even to this day! The Standards development work was accomplished not just with great acrimony but also with a great deal of hard work behind the scenes in the committees of the many global Standards authorities.

The difficulty of achieving an international fieldbus Standard was taken up and discussed in detail as early as that PNO General Meeting in Karlsruhe of February 19, 1991. Already, at that time, members realized that the development of a Standard in IEC (the key to global success) would be problematic. As Eduard Hofmann (former Board of Director's spokesperson) noted with restraint at this meeting: "The international fieldbus standardization is shaping up to be a very difficult and slow process. Based on the current situation, a future IEC fieldbus may not be compatible with PROFIBUS!"

INFO

Phases of the "fieldbus war" – The battle for a fieldbus standard

1986–1990	Prolog: The field is marked out	National standardization of the PROFIBUS and FIP fieldbuses (PROFIBUS in DIN 19245)
1990–1994	The German-French fieldbus war	Efforts to develop a general specification based on WorldFIP and ISP
1995–1998	The international fieldbus war	Development of the Foundation Fieldbus (FF) in the United States; emergence of the CENELEC standards with multiple fieldbuses in one document (EN 50170). Blocking of proposed international Standard by minorities.
1999–2000	The breakthrough	The 8-type specification becomes the Standard (IEC 61158)

Standards development work in Europe (1990–1994)

Since the beginning of the 1990s there had been two main competing European fieldbus systems: the French FIP system and PROFIBUS. Although superficially involving competition between major players in the private sector, the establishment of international fieldbus Standards revealed significant national interests in terms of research and economic policies. The problem was that FIP and PROFIBUS represented fundamentally different solutions to the same challenge. PROFIBUS, based on distributed control, supported vertical communication according to the client-server model from the very first version. FIP, on the other hand, was based on central, stringent real-time control and the

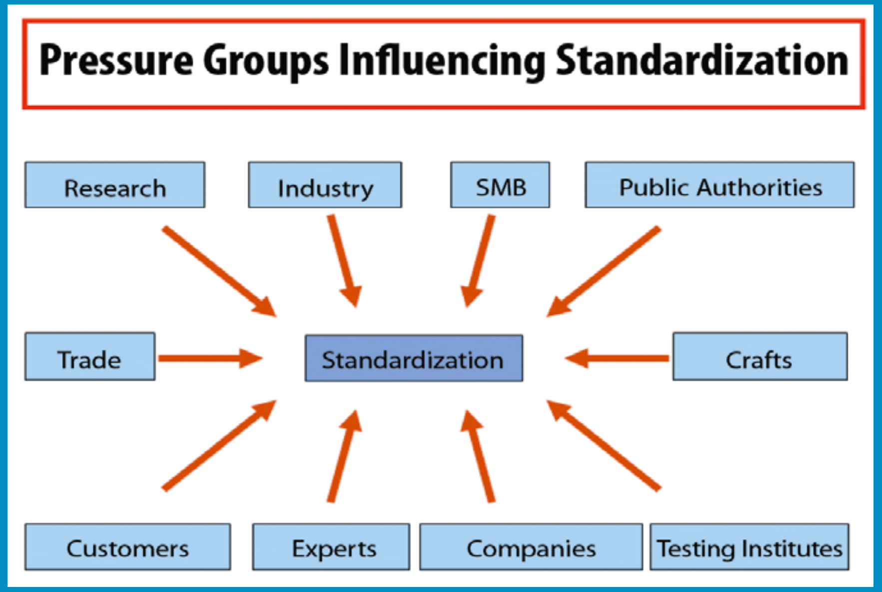
Standardization

Standardization is the systematic creation and enactment of rules, which are used to formalize both tangible and intangible articles.

The aim of standardization is to avoid obstacles in technical applications – both nationally and internationally – by means of defining uniform specifications and to promote the exchange of goods and services. Standardization also promotes choice, and encourages cost-effectiveness, compatibility, and protection when using products and services. A further aim of the standardization process is to establish commitment and dependability.

A standardization process normally proceeds in several stages. Within national boundaries, Standards are developed jointly by experts chosen from companies, businesses, technical universities, consumers, testing institutes, and agencies.

Standards development activities in Germany are mainly organized in Standards Committees and Working Groups within the Deutsche Institut für Normung e.V. (DIN) (German Institute for Standardization) as well as the German Commission for Electrical, Electronic & Information Technologies (DKE) – the two most important bodies in the Federal Republic of Germany responsible for standardization.



In Europe, Standards development is organized within three organizations: CEN, CENELEC, and ETSI. The European Committee for Standardization (CEN) describes itself as a "system of formal processes for establishing Standards that is supported by the 30 national member organizations." CENELEC is responsible for developing European standards in the area of electrical engineering. CENELEC, together with ETSI and CEN, forms the European system for technical standards. The European Standards are voted on and implemented by national member organizations.

Three organizations are at the center of international standards development: the "International Organization for Standardization" (ISO), the "International Electrotechnical Commission" (IEC), and the "International Telecommunication Union" (ITU).

The "Vienna Agreement" of 1991 governs the cooperation between ISO and the European Committee for Standardization (CEN). A similar set of provisions called the "Dresden Agreement" exists between IEC and CENELEC.

publisher-subscriber model for horizontal communication. As a result, the FIP system was not nearly as flexible as PROFIBUS. It was obvious to the promoters of FIP that it would have to support both models in order to become a universal fieldbus.

The expansion of the French FIP solution into the international "WorldFIP Consortium" was intended to enable this step. The features of the client-server model were added to FIP, while options were being outlined as part of another project called the "Interoperable System Project" (ISP) to add the publisher-subscriber model to PROFIBUS.

The ISP, announced in October 1992, whose goal was to create open systems with a single international fieldbus, temporarily took care of the uncertainty of many PNO members. After weighing the pros and cons, the Board of Directors viewed the ISP as an opportunity to establish PROFIBUS in both the international market and in Standards development activities and, thus, protect the heavy investments made to date.

Despite far-reaching efforts, after more than eight years the international Standards development work yielded no tangible result, with one exception. A bit transmission procedure (today known as MBP) at the physical layer (PHY) of the bus was universally agreed. This layer, which is the basis of both PROFIBUS PA and Foundation Fieldbus, was adopted in 1993 as IEC 61158-2 and remains the Standard for network connections in process automation to this day.

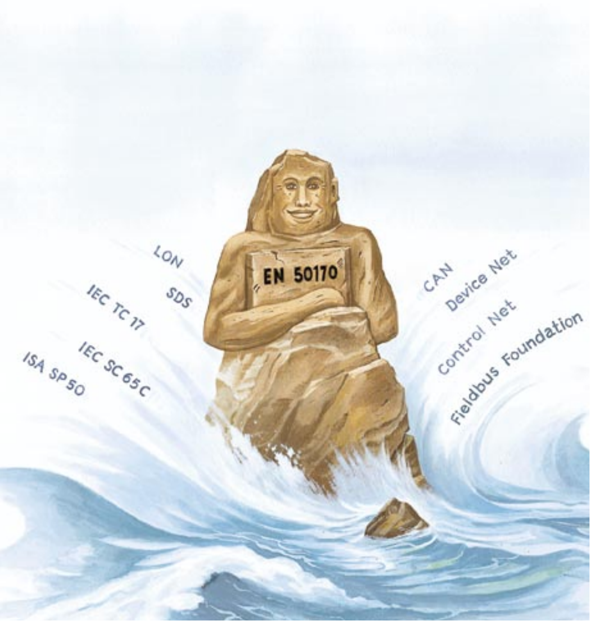
Elsewhere, the draft Standard was increasing in scope and complexity, but it had still not been possible to arrive at a concrete conclusion. For example, three different tokens had been introduced into the access control of the Data Link Layer (DLL) for different tasks in the communication system.

It became increasingly clear that devices made according to this specification would either be too expensive or, if only portions of the specifications were implemented, they would be incompatible and unable to communicate.

Standards development work on the international stage (1995–1998)

A standoff between the German and French experts led in 1995 to a spectacular and momentous initiative on the North American side, with the definition of a fieldbus optimized for process technology. The result was Foundation Fieldbus (FF). The “Fieldbus Foundation” user organization was founded in September 1994 through the merging of “WorldFIP North America” and the “Interoperable Systems Project.” Work in the SP50 Committee of the ISA (then the “Instrument Society of America”, now the “International Society for Automation”) was pushing ahead, while work in the SP65C committee of IEC (“International Electrotechnical Commission”) in Geneva appeared to have “gone to sleep.”

Probably not without justification, European fieldbus supporters viewed this as jeopardizing their chances of having their national Standards adopted internationally. If the North American initiative succeeded, the Europeans could lose years of research and development investment. European fieldbus systems had already been successfully introduced to the market and none of the European participants could afford to abandon their respective solutions.



EN 50170 – the solid rock during the fieldbus war. This characteristic was also ascribed to Udo Döbrich, the main protagonist of this solution

A groundbreaking compromise

This precarious situation led to a groundbreaking compromise in CENELEC (“European Committee for Electrotechnical Standardization”). The European fieldbus standard EN 50170 was ratified with an overwhelming majority of 90 percent. Of the 18 voting countries, 15 voted in favor of the proposal. An agreement was also reached that all national Standards should be subsumed into relevant European standards: One part of the Standard should always contain a copy of the national standard; thus, every part of a Standard represented a functional and compatible system.

To counteract excessive complexity, the fieldbuses for general automation – including PROFIBUS – were combined into EN 50170. By contrast, fieldbuses for fast, distributed I/O were bundled into EN 50254, and different solutions based on CAN (Controller Area Network) technology were bundled into EN 50325.

The British played an interesting role in this as they assumed the representation of various North American groups and were thus later able to bring FF, DeviceNet, and ControlNet into the European Standards.

Causus belli

Work on an initial IEC draft fieldbus Standard (IEC 61158) continued, mainly via the ISA’s SP50 Committee in North America. During its creation, the access method of WorldFIP and the application protocol of PROFIBUS FMS were merged. A combination of FF and WorldFIP was then proposed, in which all of these drafts were again included! This proposal reached a first voting phase in 1996, precipitating the final act of the international fieldbus war.

A contemporary ironic representation of the situation surrounding fieldbus standardization

The “causus belli” was that PROFIBUS DP and its family of solutions was no longer represented at all! Another problem proved to be international law, which stipulated the replacement of European and/or CENELEC Standards if the proposed IEC Standard was adopted. With this stipulation alone, FF would have gained a significant competitive advantage, while PROFIBUS would have lost significant ground. Consequently, the voting countries in which PROFIBUS already enjoyed the lion’s share of the market exercised their blocking minority and prevented this proposal from being accepted.

A possible stumbling block was the voting procedure of the IEC Committee. “No” votes required technical justification, while “Yes” votes were handled preferentially. In the end, the negative vote was made easy by a long list of deficiencies in the draft Standard, as well as various other discrepancies.

Still, FF did not give up without a fight. It used all legal means to fight for "its" Standard. Noteworthy in this regard was the request to cancel all negative votes for "insufficient" technical justification. If this initiative had succeeded, the result of the vote would have been overturned.

The situation escalated when the "Yes" vote of the Brazilian committee was disqualified because it did not arrive at the IEC headquarters in Geneva until after the last day of voting! The Brazilian committee was outraged over the IEC's decision, noting that the fax machine of the IEC in Geneva had not been able to receive their transmission; so the vote had been sent instead to the secretary of the IEC's SC65C Committee in France, just before the deadline expired.

To prevent uproar, a "Committee of Action" (CA) was set up to consider how to proceed and this allowed the objection of Brazil on February 25, 1997. Thus, the initial draft was accepted. As a result, both the Data Link Layer (DLL) and the Application Layer (AL) of the proposed IEC61158 fieldbus standard were put to the 2-month vote as a Final Draft International Standard (FDIS).

Was the end now finally in sight? No, the protagonists were not able to come to a consensus in this final voting phase, either. Thus, all efforts to create an international fieldbus Standard threatened to go down in a clash of political and economic interests.

The breakthrough (1999–2000)

The CA finally succeeded in ending the stalemate on June 15, 1999. In a Memorandum of Understanding, they proposed a that a Standard (IEC 61158) should be agreed in which "at least two" fieldbuses be integrated. Eight were ultimately proposed! The breakthrough came with the consent of the main players (including Fieldbus Foundation, Fisher Rosemount, ControlNet International, PI, and Siemens) to this memorandum. This compromise marked the end of the fieldbus war.

The solution provided for IEC 61158 to continue to be structured according to different layers, but also subdivided according to services

All in the same boat – PR photo on the occasion of the agreement of the fieldbus standard in 2000

and protocols. Experts subsequently created this compromise draft Standard under tremendous time pressure and it reached the formal voting phase very rapidly. Thanks to their work the IEC 61158 Standard was finally brought into effect on December 31, 2000.

The version of IEC 61158 adopted at that time contains seven different fieldbus Profiles that, in turn, can be subdivided further. The cost of the fieldbus war was that on its own, IEC 61158, as extended by its twin standard IEC 61784, contained all the major national fieldbuses for production and process automation side by side. The value is that all major interests are protected. PI eventually brought all performance levels of PROFIBUS DP into this Standard.

End of conflict

The fieldbus war had far-reaching political and economic consequences. Had the adversaries not come to a consensus, the consequences for all fieldbus systems would have been disastrous in all likelihood.

Later, to prevent the fieldbus war from extending to the burgeoning Industrial Ethernet market, experts decided to apply the same approach to follow-up versions of IEC 61158/61784. This meant that the first version of the the embryonic Ethernet-based PROFINET could be placed in an international Standard from the outset!

PROFIBUS opens up process automation

The fact that PROFIBUS kept on growing to become the global market leader was due mainly to the demand from production automation. PROFIBUS was unbeatable here. Another important sector still holding strong potential, however, was process automation, where exceptional focus is placed on safety, reliability, and availability.

If we want to operate ever more complex plants with ever fewer employees in more effective ways and produce products with fewer quality fluctuations, we can no longer work with analog devices. We need the diagnostic capabilities of an intelligent field device.

Dr. Thomas Tauchnitz, Sanofi-Aventis

In the process industry, experts estimate that up to 80 percent of plants still rely on the 4-20 mA technology introduced decades ago. Here, the migration to fieldbus technology is progressing much more slowly, a fact that is also related to the life cycles of equipment in the process sector. These are considerably longer than in manufacturing and, thus, the opportunity to try out new technologies does not present itself every day. By comparison, the service life of equipment in manufacturing is approximately 2 to 4 years while process equipment can remain in service up to 20 or even 30 years.

Process automation differs from manufacturing in many important aspects because the continuous and batch processes typically involved pose very specific requirements. They require a fieldbus system with a two-wire cable, which both transmits data and supplies power to the field devices (Remember that MBP agreement in the previous chapter?). In addition, the bus system must be suitable for use in hazardous areas. "If a malfunction occurs in a chemical plant, for example, the whole plant can blow up," wrote Dr. Ulrich Jecht, author and original PROFIBUS participant, regarding the worst-case scenario. Because of the stringent safety requirements, a key question for the chemical industry was: "What happens if we use PROFIBUS for communication?"

The migration from conventional communication to fieldbus communication in process automation required time. It was particularly important to show what PROFIBUS could deliver: a consistent, robust system with completely coordinated components, a standard communication protocol and uniform engineering, reliability, consistency and high performance, not to mention diagnostic concepts that allowed, for example, the "working reserve" of mechanical devices subject to wear (such as actuators or pH analyzers) to be monitored. Of particular interest was the need to support hybrid automation in plants having both process technology and manufacturing technology segments operating side-by-side.

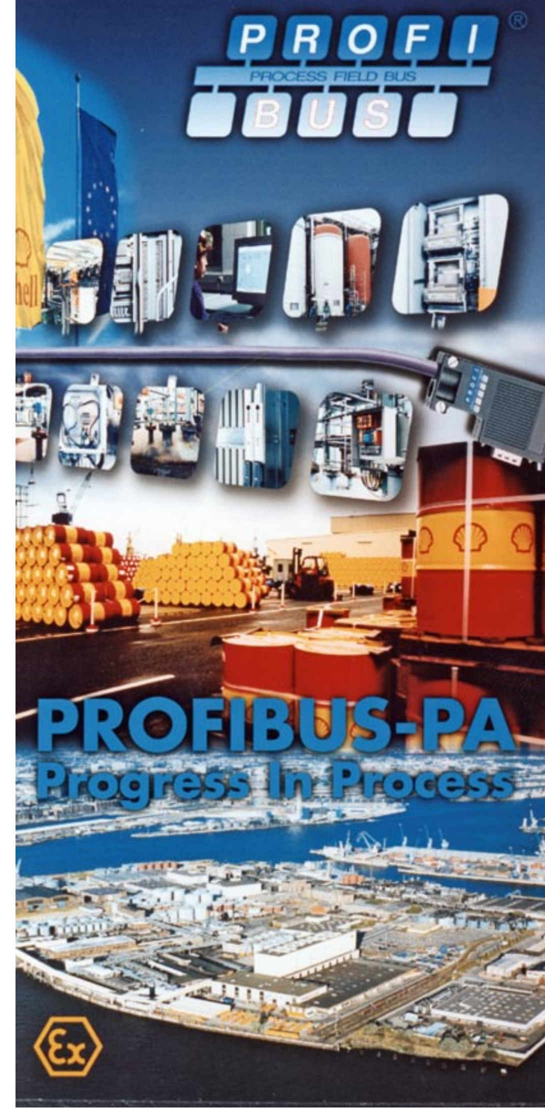
The Advisory Board followed a well-proven template for introducing PROFIBUS into process automation. The Working Group "Protocol Stack" was established in 1994. The requirements of process engineering, and the chemical industries in particular, were considered first. As always, the member company representatives participating in the working group performed diligent work without compensation, and after a year of intensive work it presented its first results to the Advisory Board as a draft of the PI Guideline "PROFIBUS PA Protocol Specification."

Ironically, the Guideline was based on work performed as part of the Interoperable Systems Project. Through a cooperative agreement with ISP, PI was able to take the results of the ISP project and to integrate the resulting solution into the PROFIBUS family.

Initial interest was shown by industry as early as 1995. As a result, PROFIBUS PA was talked about well before it even came to market. This was due not in small part to the active collaboration of users from the chemical industry, but especially to the inclusion of NAMUR as a reviewer. As a result, all special requirements of process application area were included from the outset.

With the adoption of the PROFIBUS PA Profile in March 1995, PI now targeted the process industry sector area specifically. At its meeting in 1995, the Advisory Board decided to establish a separate marketing working group under the leadership of Klaus-Peter Lindner to play an active role in bringing PROFIBUS PA to the market.

Barely a few months later, preparations began for the INTERKAMA '96 trade fair, where PROFIBUS PA was to be presented to the technical



"Progress in Process" – PR photo for PROFIBUS PA, mid-1990s

PROFIBUS PA

PROFIBUS PA is the PROFIBUS solution for process automation, an application area which is mainly characterized by intrinsically safe operation, power supply to devices via the fieldbus cable, and the use of the Application Profile for process devices (PA Profile). The PA Profile plays a fundamental role in process automation. It defines a set of properties that different device manufacturers must implement uniformly for industrial process devices, such as transmitters, servo-drives, valves, and analyzers. As a result, it provides the foundation for standardized applications, simplified engineering, interchangeability of devices, and increased availability due to standardized diagnostic information. Despite its physical difference, PROFIBUS PA uses the same protocol as PROFIBUS DP and thus the two can be closely integrated on process plants, where hybrid automation applications are common.

community for the first time using a trade show model. The trade press reported on a new addition to the PROFIBUS family.

Elsewhere, the response was consistently positive. Trade journalists recognized that PA was built on the many years of experience gained from the communication technology of PROFIBUS DP and therefore it expanded the possible uses dramatically. The decision to ratify the German draft Standard DIN E 19245 Part 4 - covering PROFIBUS PA - was made on December 15, 1995 by the DKE.

What was most captivating, however, was that PROFIBUS PA was the first vendor-neutral fieldbus system for the process industry.

The first demonstration system at INTERKAMA showed the particular advantages of the system. Over 18 field devices from 12 different manufacturers were interconnected using only two cables over which the intrinsically safe field devices exchanged data and were supplied with power. The "two-wire revolution," wrote a trade publication, would save up to 40 percent in commissioning, maintenance, and hardware costs according to a study by NAMUR.

At the same time, it was also reported that digital technology would provide gains in functionality and reliability. Thus, with PROFIBUS PA, not only is the measured value of a transducer read via the bus, but the control system can also write the scaling, filter conditions, and upper and lower limits of the device at any time. Maintenance is also simplified as the control system can read out the device status and its special diagnostic information when needed. The demonstration system also showed the very thing that the chemical industry depended on: For the first time, intrinsically safe transmission technology (according to international standard IEC 61158-2) had been implemented in products.

However, the success of PROFIBUS PA was not based just on INTERKAMA and the trade press. The marketing working group had reported positive results in October 1995: "PROFIBUS PA is generating a lot of interest from users in the chemical industry." Parallel work was underway at ifak (Institut für Automation und Kommunikation e.V.) in Magdeburg under Prof. Dr. Christian Diedrich on early preparations for certification testing. At the same time, ifak applied to become a PI Test Lab for PA devices.

First applications

As always, changes need "first movers," whose example and practical experience then attract additional applications. When modernizing their production facilities back in 1991, the Bitburger Brauerei Th. Simon decided in favor of PROFIBUS. Since then, numerous expansions and modifications have increased the portion of the plant using PROFIBUS. The foresightedness and readiness to accept innovation demonstrated by Bitburger with their decision for PROFIBUS has paid for itself more than once.

The PROFIBUS-based automation solution offers Bitburger numerous advantages beyond the targeted cost reduction for cabling. With PROFIBUS, the principle of horizontal and vertical consistency is realized throughout the plant, both at the factory level and the process level. All process instruments communicate using a single communication protocol. This includes drives in the filling plant as well as the frequency converters, pressure gages and thermometers. The effort for installation, data management, documentation, and training is significantly reduced.

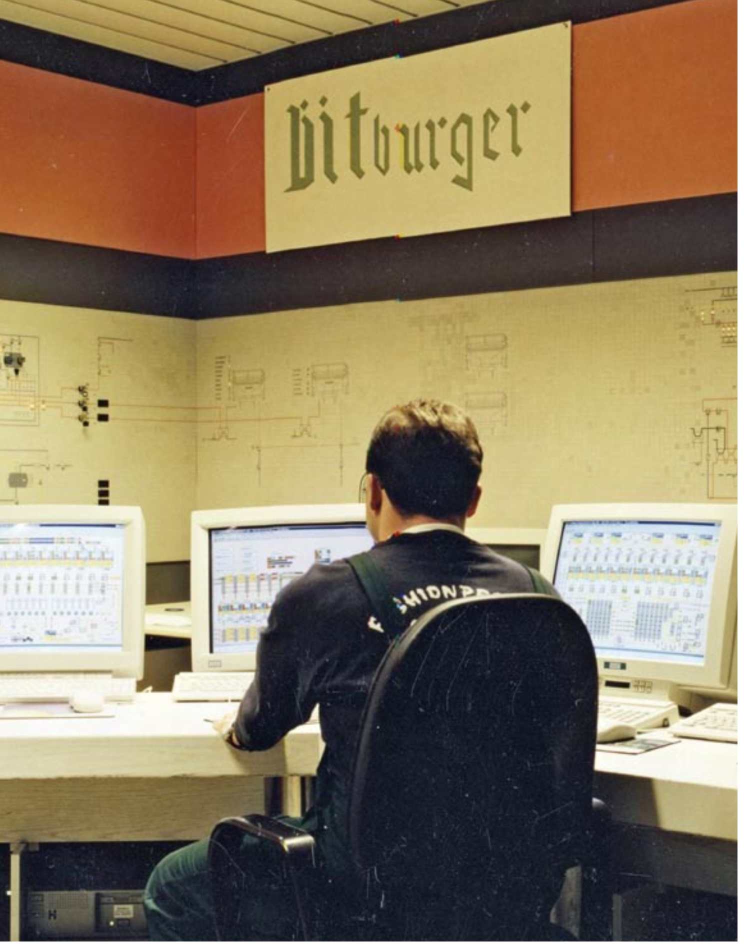
Thanks to the PROFIBUS communication protocol, Bitburger is now operating completely without "island" solutions. In addition, digital communication is increasing the accuracy of process measurements and is thus opening up new ways for optimizing production. Last but not least, Bitburger can fully take advantage of the possibility to further distribute intelligent devices in the process and, for example, to use the diagnostic options of PROFIBUS to optimize maintenance and service of the automation infrastructure. As a result, on the one hand, unnecessary measures and costs can be avoided,

NAMUR

NAMUR is an international association of users of automation technology in the process industries. It was founded in 1949 in Leverkusen, Germany, as the Standardization Association for Measurement and Control in the Chemical Industries. To allow for technological changes, the name of the association was changed in 1996 to the Process Control Systems Interest Group of the Chemical and Pharmaceutical Industries. In November 2005, the name was changed again to the Automation Systems Interest Group of the Process Industry.

PROFIBUS PA was a further milestone in the history of PI – since then the importance of fieldbus technology in process automation has gained significant momentum.

Prof. Dr. Christian Diedrich, University Magdeburg



First mover: the Bitburger brewery has relied on PROFIBUS since 1991

while on the other hand, failures of components and systems can be preempted.

The first successful use by Bitburger of PROFIBUS PA and PA process instruments came in the fermenting and storage cellars in 1997. After additional modernization, Bitburger now has more than 1600 devices networked via PROFIBUS DP and PA.

Never more without PROFIBUS PA

Bitburger – and Wacker Chemicals as well as the Heide Refinery (now Shell) – are just a few other examples of many applications that now rely on PROFIBUS PA.

Wacker Chemie has relied on PROFIBUS PA at its Cologne facility since the 1990s

By 1997, the Advisory Board noted that acceptance of PA in Germany had been achieved. Today, well-known global players, such as Merck, Roche, DuPont, BP, Cargill, Sanofi, BASF, and many other companies in the chemical and process industries, and also industries such as wastewater treatment, are also placing their trust in digital communication with PROFIBUS PA. These systems are becoming more and more complex over time and the requirements for communication are increasing.

In a newer example, Degussa has equipped facilities for manufacturing fillers with PROFIBUS PA. These facilities are networked with other facilities that deliver the raw materials and/ or further process the product. This concept results in very stringent requirements being placed on the operational reliability and process quality of the plant technology used.

Degussa has tested the suitability of fieldbus technology and, in particular, of PROFIBUS PA for these demanding requirements across multiple facilities and has amassed detailed results. The fact that cabling is simpler and less expensive was not the only reason to use PROFIBUS PA. Above all, the migration to PROFIBUS PA was linked with the expectation that with it the process could be more effectively monitored and optimized, that product quality could be maintained at a high level, and that plant availability could be maximized through easier device replacement and parameterization.

These expectations were met from the first installation, and over the course of time, a learning curve has been experienced which has led to even more confidence in PA technology.

Smart and cost-effective modernization

Anyone who thinks that fieldbuses are only suitable for automating new plants is wrong. With the help of fieldbus, the degree of automation in conventional plants can also be significantly increased. A good example of this is Clariant Produkte (Germany) GmbH in the Höchst industrial park, which uses a few PROFIBUS PA nodes to reduce the number of manual interventions needed and, thus, has raised the quality and reproducibility of its processes.

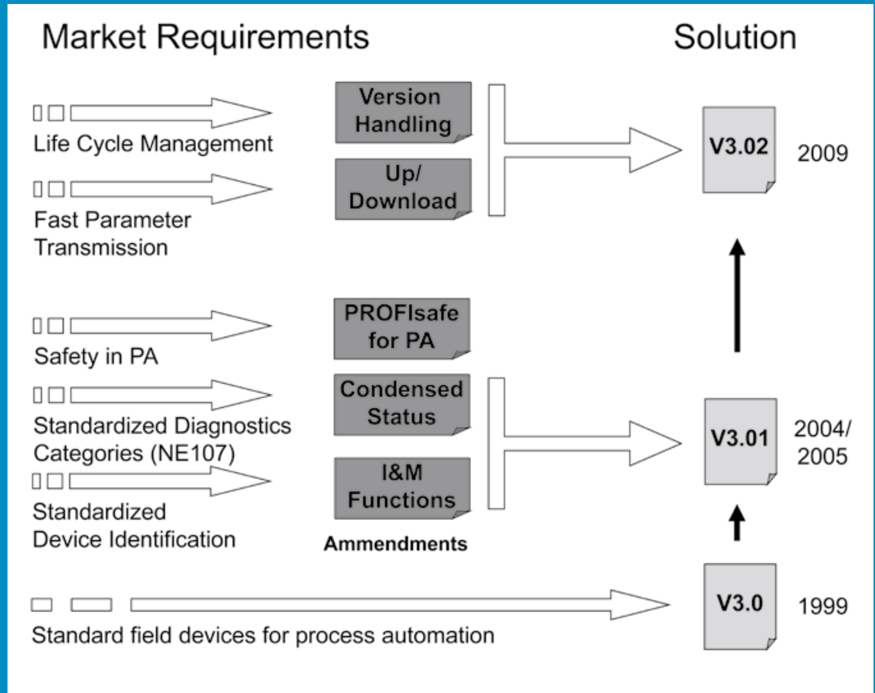
In 2008, Clariant modernized one of two production lines making high-quality pink pigments for paint, plastic, and printing applications. The chemical company wanted to eliminate an obsolete visualization system from the 1980s for which there were no more spare parts.

The company took the opportunity to replace its old controllers too. As a result, an internally open control system was created that covers all requirements while costing much less than other solutions. "It simply worked for us to move to PROFIBUS PA because we had gained a lot of experience with this technology in the past when building a new plant," stressed Thomas Eichhorn, Plant Engineer for Electrical, Measurement, and Control Technology at Clariant. Although Clariant converted only a tiny portion of its measuring points to PROFIBUS (224 out of approximately 6000), the company was available to fully modernize this plant.

In September 2008, the company recommissioned the "pink line." Since then the plant has run without problems and without the susceptibility to failures that were typical before the modification. The conversion to PROFIBUS saved money. "It is certain that the installation costs were significantly less than for a point-to-point connection," explained Eichhorn. Even the project implementation times were shorter with PROFIBUS PA. Clariant was able to complete

The production facility of Clariant Products (Germany) GmbH for high-quality pink pigments for paint, plastic, and printing applications is automated with PROFIBUS PA

PROFIBUS PA Profile 3.02



The PROFIBUS PA Profile specification has undergone continuous and compatible further development in recent years to enhance user benefits.

In 2009, PI introduced the new Version 3.02, which contains innovations and simplifications implemented in response to user requests regarding the PA Profile. For example, requests from users for descriptive diagnostics and status information (NE107) led to specification of "Condensed Status and Diagnostic Messages."

Similarly, "Identification and Maintenance Functions" are in response to requests for plant-related asset management for process automation field devices. Simple field device integration means that it does not trigger any maintenance expenses. This calls for a suitable version management system for devices, device files, and software platforms that minimizes maintenance efforts associated with device integration over the life cycle of a production plant. PROFIBUS PA Profile 3.02 ensures that the replacement device is adjusted automatically to the required variant so that reconfiguration is not required in the first step while the plant is idle.

The requests of operators for safety-related applications have been taken into consideration in the Profile amendment "PROFIsafe for PA Devices." The benefits resulting from making the Profile document more uniform and easier to read are apparent in further improvements in quality achieved when implementing Profile-specific features in process automation field devices. The PROFIBUS PA Profile Version 3.02 is a uniform and workable foundation for future enhancements in touch with the desires of plant operators and market requirements.

the full automation of the "pink line" within only 14 days, as planned, not least because the fieldbus greatly accelerated the commissioning of the measuring points.

Clear case with Wiener Charme

"Becoming the most modern wastewater treatment plant in Europe with PROFIBUS" is a description that can be applied to an impressive project from the wastewater treatment sector. The background: In 2000, a decision was made to expand and modernize a main treatment plant in Vienna, Austria. The modernization involved the process technology used for actual wastewater treatment as well as the new process control system. After careful testing, instrumentation using PROFIBUS was chosen for the field level of the process control system.

PROFIBUS satisfied the operator's specifications for the most modern, yet well-proven technology, as well as – due to the size of the plant – faster communication speeds and lower cabling costs. An additional criterion was the suitability of PROFIBUS for use in hybrid process plants having both discrete and continuous operations, as is typical in wastewater treatment applications.

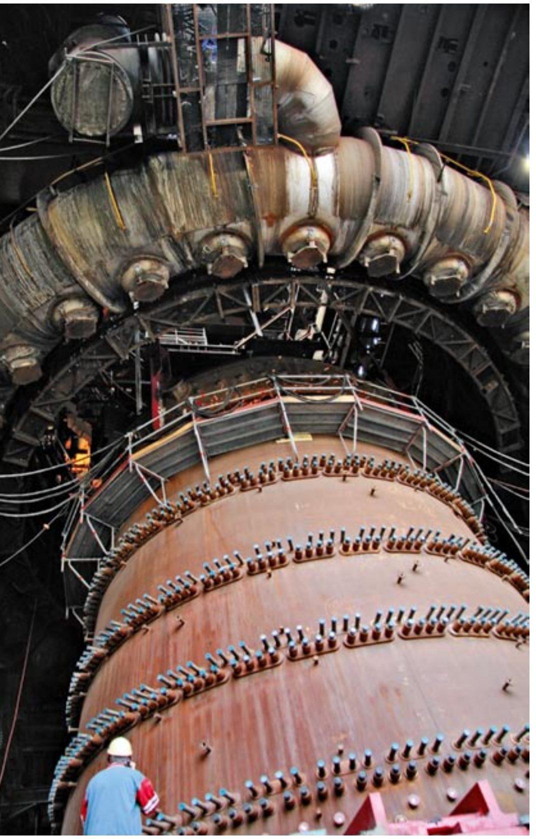
The field level of the expansion facility included more than 5000 bus nodes of all types, ranging from servo-drives and motor controls, to measuring instruments for pressure, temperature, and flow, and to analyzers. Thanks to the interoperability of PROFIBUS devices, the wastewater treatment plant operator was able to select the most suitable devices from a variety of manufacturers.

The unrestricted control of the sweeping wastewater treatment plant, the fast reaction speed for process monitoring, the low amount of investment for cabling, and the high level of operational reliability of the system thanks to its comprehensive diagnostic functions are only a few of the features of PROFIBUS that explain why the wastewater treatment plant has earned the reputation of having the most modern process and automation technology in this sector.

The wastewater treatment plant in Vienna relies on PROFIBUS PA – and is one of the most modern facilities of its type in the world.

The enhanced features of PROFIBUS PA Profile V3.02 satisfies the latest requirements for device integration and diagnostics. The uniform self-monitoring and diagnostics now mandatory for all PA devices, including error classification and representation of status signals according to NE107, is a significant step in the right direction.

Michael Pelz, Leader of NAMUR WG 2.6 "Fieldbus"


Success with PROFIBUS PA – ArcelorMittal acknowledges its market leadership position

Steel works in South of France

Steel furnaces are used to produce pig iron as a starting material for steel and are unique due to their enormous dimensions and extreme operating conditions. They are operated continuously for months and a shutdown has a significant financial penalty associated with it.

ArcelorMittal, by far the world's largest steel producer, faced the challenge of a complete modernization of the process technology for a steel furnace in its plant in Fos-sur-Mer in the South of France. Planning, installing, and commissioning the most modern technology under the harshest conditions and in minimum time represents a real acid test for the technology and support functions of leading companies. A total of 600 companies have undergone complete modernization and passed the challenging project in just 95 days.

A total of 1100 field devices for measuring pressure, temperature, and flow were installed directly on the steel furnace and an additional 700 field devices in other parts of the plant, such as for gas cleaning and slag processing. All these devices were networked via PROFIBUS. To avoid delays, the devices were preconfigured and checked at the supplier factories. "I wanted not just new sensors, but sensors with PROFIBUS," stressed Alphonse Fabiani, the person responsible for measurement technology at ArcelorMittal. "We are instrumenting our plant for the next two decades, and with PROFIBUS we are leaving our future steel makers with instrumentation that is forward-looking and future-proof."

Refinery in Rotterdam

A project "unlike any other in the world" involved the simultaneous replacement of 1200 servo-drives within the plant, according to the Manager of Control Systems at the BP Refinery in Rotterdam. The layout of the plant required 90 km of buried cable and an additional 30 km of above-ground cable, needing fast reaction speeds to enable the processes to run ever closer to their optimum operating conditions. For this reason, PROFIBUS was selected for a new, redundantly designed communication system, which when combined with the new servo-drives easily achieved the required reaction time.

The overall system consists of 14 control systems linked via Ethernet, to which 80 servo-drives are connected via remote I/O modules. The use of PROFIBUS resulted in savings of 6000 permanently wired I/O. Maintenance personnel can perform all maintenance work from a central location using a PC; all information from the servo-drives is available at a mouse click and all parameters, including torque curves, can be directly referenced. The time-consuming, long-distance searches to find failures or implement changes have been eliminated.


BP Refinery in Rotterdam servo-drive on PROFIBUS

PROFIBUS PA sets standards

The trade journal atp recorded in 2009 that modern communication technology has gained in importance in the process industry in recent years: "Today, networked automation systems are standard. Cross-system communication, horizontal and vertical information integration, and remote access are now typical. Reliability and availability, sustainability and investment protection – these are the basic conditions that every new solution must fulfill in order to be used successfully in industrial process plants." The fact that digital communication is now regarded as routine in process automation can be attributed to the success of PROFIBUS PA, whose recently published Profile 3.02 raises further options for better plant management, not least of all through its compatibility with PROFIBUS DP, since hybrid applications involving discrete applications operating in conjunction with process automation networks are increasingly common in today's process markets.

PROFIdrive: The right drive for drive engineering

Drive technology is increasingly being used to improve the productivity and flexibility of machines, also to raise product quality. This is because drive solutions, on the one hand, can provide distributed intelligence around the machine while, on the other hand, allowing intelligent networking with the control system. However, to achieve this means ensuring consistent communication among drive modules from different suppliers. PI knew that it had to deliver a solution for this special motion control requirement if it was to to establish PROFIBUS in this market. As always, the same proven approach was used, i.e., develop strategic plans, set up Working Groups, agree a specification and finally develop products. The result? PROFIdrive, a special PROFIBUS Profile for Motion Control.

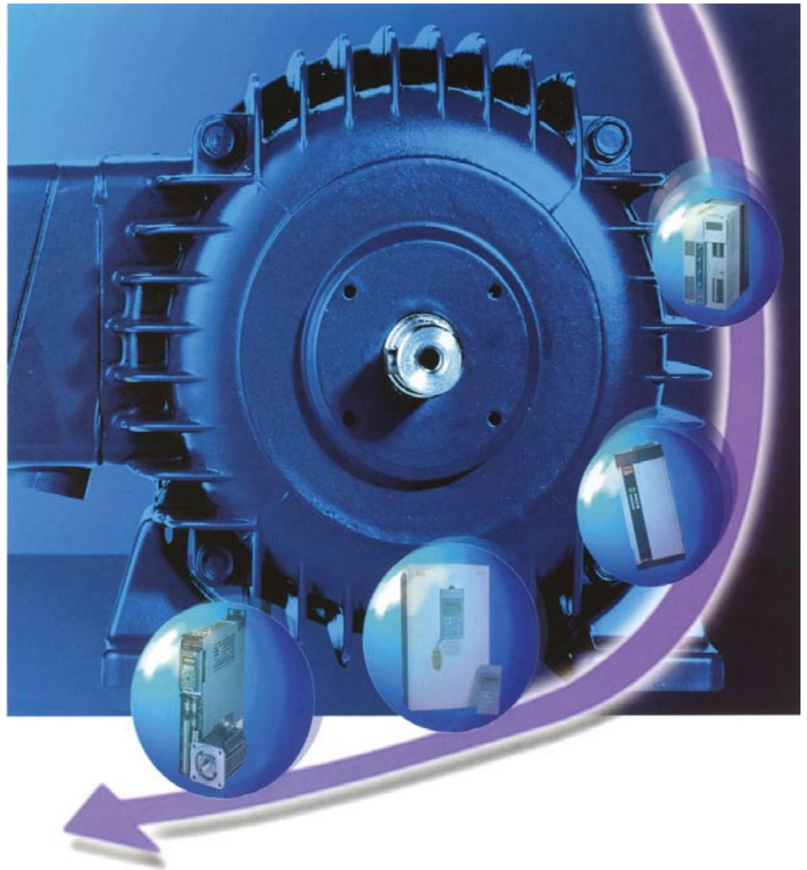


Image photo for introduction of PROFIdrive

PROFIdrive is another important Profile in the PROFIBUS family. The Profile fulfills the special requirements of drive technology in conjunction with both PROFIBUS and PROFINET and offers unbeatable scalability in terms of communication performance. This benefits both device and system manufacturers as well as integrators and end users. Significant cost advantages result from using a single communication solution for the drives, the controller, the I/O, operator control, and monitoring. This pays off not only during planning and installation but also for training, documentation, and maintenance, because only a single approach is involved.

Bus systems were also needed in drive applications. Traditional point-to-point connections were much too slow – with PROFIdrive we also wanted to satisfy the growing demand for information.

Walter Möller-Nehring, Siemens AG / Drive Technologies Division

PROFIdrive goes its own way

PROFIdrive's development history sets it apart from other Profiles. Building on the earlier results of the joint "Fieldbus" project, PROFIdrive e.V., an Association independent of PI, took on the role of developing and disseminating the PROFIdrive Profile.

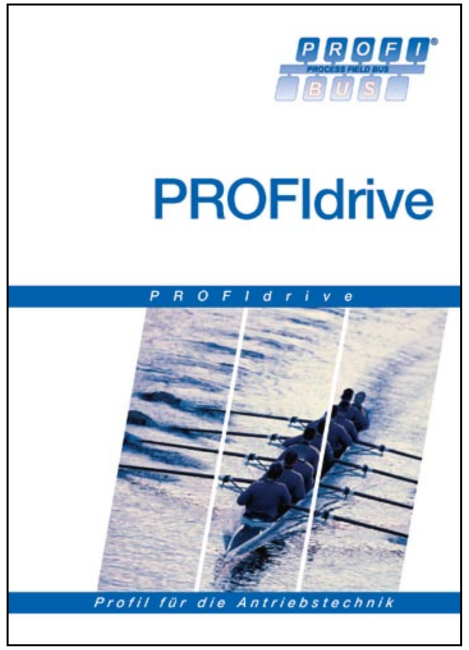
Key companies in drive technology, such as Siemens, AEG, Bauer, Flender ATP, Seidel, ELPRO, and Danfoss, had set the goal back in 1992 to develop a separate software program based on VDI/VDE Guideline 3689. This aimed to create a uniform interface to solve complex tasks for the control devices of different manufacturers. In addition to a Working Group handling technical developments, PROFIdrive e.V. also had a separate marketing group.

After working independently for two years, the decision was taken to merge with PNO/PI and, in 1994, the two organizations signed a cooperative agreement. In a second step, in mid-1996, PROFIdrive e.V. was dissolved and integrated into a Technical Committee, which assumed its work under the leadership of Michael Gawol.

At the very first session of this Technical Committee, Walter Möller-Nehring, who later succeeded Michael Gawol as leader, introduced a new version of the PROFIdrive Profile based on the VDI/VDE Guideline 3689 and furnished with additional features. To be added were an interface to PROFIBUS DP, the "positioning" mode needed for motion control, and a reference to EN 50170. Special weight was to be given to the issue of clock synchronization for coordinating the timing of drives. Once clock synchronization was completed, the PROFIdrive Profile was also to be mapped onto DP-V1.

Walter Möller-Nehring at a presentation at the Hanover Fair in 1999

Like clockwork: the work of the Technical Committee for PROFIdrive



Marketing flyer for PROFIdrive

In 1997, the PROFIdrive Profile was completed and presented for adoption. At that time 12 companies were active with PROFIdrive. Following a subsequent restructuring of the Technical Committee and Working Groups in 1999, PROFIdrive was integrated as a Working Group under the Profiles Technical Committee, and a corresponding marketing Working Group was set up under the newly established Marketing Technical Committee.

The first version of the PROFIdrive Profile related exclusively to the cyclic channel of PROFIBUS (DP-V0). In 2002, Version 3.1 of the Profile added PROFIBUS DP-V2. Profile 3.1 was introduced in response to increased demands from industry. These included not only standardized interfaces (because motion control was exercised via the drive interface,) but also the interoperability that allows drives of different manufacturers to be operated with a single controller. Data for diagnostics and maintenance also had to be transmitted over the drive interface, for example for the purposes of preventive maintenance.

However, a standardized communication interface was not sufficient to ensure full integration. It also had to be possible to integrate the software tools for commissioning and servicing drives into the system of the control manufacturer. Version 3.1 responded to these requirements in particular. In 2002, PI noted: "PROFIdrive, the drive interface for production machines and machine tools, combined with PROFIBUS communication, is the key to integrating drives into the automation world. PROFIdrive supports central and distributed automation concepts and enables vertical integration for the IT world as well as synchronization during motion control."

PI pointed, in particular, to functions such as clock synchronization, direct data transmission, and acyclic communication that were made possible with PROFIdrive. Walter Möller-Nehring stated confidently: "The interaction of PROFIdrive features represents a new level of quality in the fieldbus landscape. Up to now, no bus system could satisfy all the features described." Often, special buses had to be used in drive engineering, but now only a single bus system is necessary. As a consequence, users save money for hardware, installation, wiring, and engineering.

These were compelling arguments in favor of PROFIdrive, but technological developments didn't stop there. Test procedures for the verification of drives and a PROFIdrive conformity test were developed; both have now been implemented. At the same time, the PROFIdrive Standardization was folded into ongoing Standards development activities, particularly with regard to IEC 61800-7, to ensure international acceptance and guarantee long-term investment protection.

PROFIdrive is now a recommended technology of user organizations such as OMAC (Organization for Machine Automation and Control). Secure operation of devices is guaranteed thanks to independent certification by accredited Test Laboratories. The test specification and test cases were completed in 2003.

The inclusion of PROFINET as a second communication system took place in 2005, extending PROFIdrive's relevance still further. Version 4.1 has been available since 2006.

PROFIdrive is also setting the benchmark for safety. Because PROFIdrive and PROFIsafe complement one another, they create a unified whole that can be used for controlling safety functions and standard drive functions on the same bus.

PROFIdrive in action

In recent years, many companies have come to rely on PROFIdrive. How about an example? Manufacturers of packaging machines

INFO

Assurance based on PI certificate

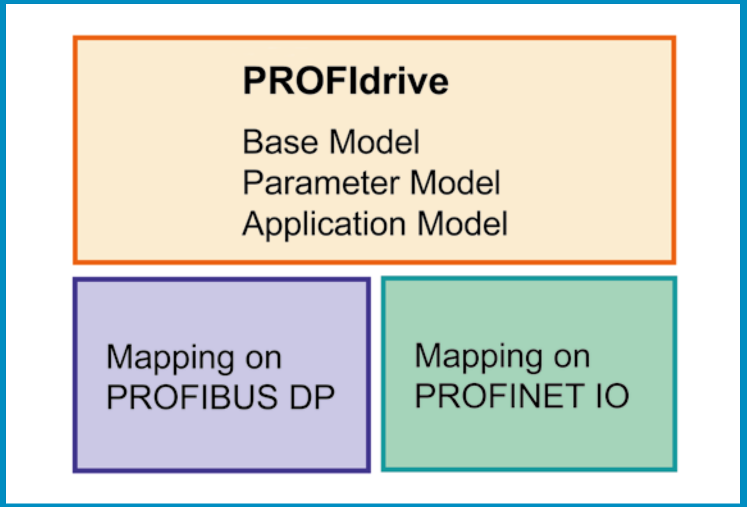
Although the PROFIdrive Profile is an international standard according to IEC 61800-7, the "PROFIdrive-compatible" attribute is still no assurance that the PROFIdrive features required for seamless interoperability have been fully implemented. Therefore, the PNO has defined tools such as the PROFIdrive Profile Tester and established independent Test Labs to test and certify the conformity of drive devices to the PROFIdrive Profile according to standard guidelines. Only PNO-certified devices provide full assurance of interoperability.

Packaging machine manufacturer PEMCO relies on PROFIdrive: flexible giant wrapping machines for layered or laminated paper and polypropylene film

are specialists when it comes to optimizing their machines. Their motto: fast, safe, and cost-efficient. To bring machines to production readiness even more quickly, the U.S. packaging manufacturer PEMCO has relied on PROFIdrive since 2005. For its new generation of giant wrapping machines, PEMCO wanted to minimize the control cabinet and cabling and modularize the hardware and software in order to continue using individual components.

PROFIdrive displays its advantages especially in plant automation systems with many drives and high-speed movements

PROFIdrive



PROFIdrive is the standard Profile for drive technology used in conjunction with PROFIBUS and PROFINET. Application of the Profile aids the simple and consistent connection of drives and controllers of different manufacturers. Key sections describe the mapping onto PROFIBUS DP and PROFINET IO. From this emerges the architecture of the Profile: basic, parameter, and application models describe the features that are independent of the communication system. In this way, operation with PROFIBUS DP and PROFINET IO is possible without changing the application. This means that the drive technology can be connected with scalable communication performance from the basic fieldbus to an integrated Ethernet network – consistently and without any changes to the automation system.

A motion control system was connected to the drives of the PEMCO machines via PROFIBUS to enable positioning commands, cam functions, etc., to be executed autonomously from an industrial PC motion controller. The 15 motion axes are connected in two groups to the two PROFIBUS interfaces of the PC. A controller is connected via one of the interfaces, as is the control panel.

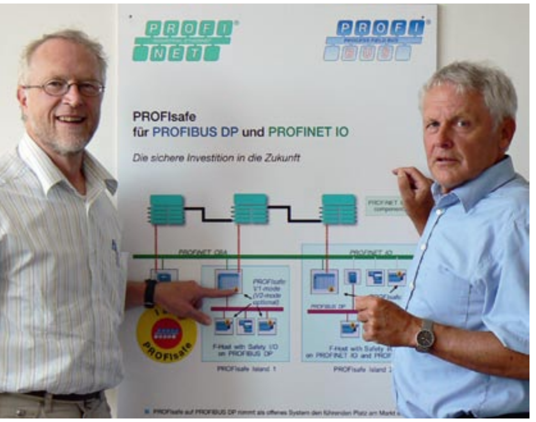
The controller and motion control system work together smoothly as a result of the open, standardized PROFIBUS features. In addition, the cabling has been reduced dramatically: The packing machines now have only a PROFIBUS cable and power cable. All other cabling has been eliminated! Conclusion: with the help of PROFIdrive it was possible to bring an innovative machine to production readiness and, above all, to improve the quality of maintenance and service right down to the last drive.

Success stories like these are common. Meanwhile, the market has recognized that the many features of PROFIdrive accommodate all requirements in the machine building and plant construction industries. The Standardization activities in coordination with user organizations are also a contributing factor to the high level of acceptance of end users. In addition to ensuring ease of operation through uniform service features, involving diagnostics, remote maintenance and software features, investment protection is also ensured.

The market leadership of PROFIBUS and PROFINET, and international Standardization under IEC 61800-7, means that application programs will remain stable over the long term.

Are you PROFIsafe? I am PROFIsafe! In recent years, the PROFIsafe logo has established itself as the quality mark for safe fieldbus communication. It is one of the major innovations to come from the PI community. The starting point was the simple observation that a block to further development of PROFIBUS had turned out to be conventional safety technology. Dr. Wolfgang Stripf, the "father" of PROFIsafe, and Herbert Barthel, the technological "guru" working in the background, noted that the main deficiencies of conventional safety technology included the lack of flexibility, high cabling costs, and the possibility of external interference.

Staying safe with the right Profile: PROFIsafe comes to market



Herbert Barthel and Dr. Wolfgang Stripf

In 1988 PROFIsafe marked the advent of a new era in safety engineering.
Dr. Wolfgang Stripf, Siemens

Safety applications protect people from injuries (e.g. from presses, automatic handling devices, moving parts) or, in the process industry, from damage due to escaping hazardous materials (e.g. overrun, overpressure, temperatures), and they protect machines and products from damage.

Up to the late 1990s, the safety issue had not been addressed by fieldbus experts and "old" safety technology continued in use. This was generally relay-based, but that hardly suited digital fieldbus technology. There were too many relays and wires and the diagnostics possibilities were minimal or non-existent. Furthermore, fieldbuses and conventional emergency stop buttons were no longer compatible. For this reason, a paradigm shift was needed in the safety engineering sector.

Many people were in denial about this at first. As with any change, it was essential to carry out diplomatic persuasion management. "The topic had to take root slowly. A culture change was necessary – even at PI," states Dr. Wolfgang Stripf. Nonetheless, the experts recognized the excellent prospects for PROFIsafe and convinced the Advisory Board in 1998 to take action: "The market for safety-related applications is hundreds of millions of Deutsche Marks."

Herbert Barthel recalls the organizational phase of the project well: "We started in September 1998 by convening a roundtable of experts from 25 renowned safety engineering companies. There, we not only discussed the requirements of the individual manufacturers, but we were also able to put forward a possible concept for this type of communication. In the months that followed, the roundtable worked on the safe communication Profile - which in the end was called PROFIsafe - under high pressure.

The first PROFIsafe version

The Profile development advanced rapidly. PI cooperated with TÜV and BGIA on the development of PROFIsafe from the outset. PROFIsafe Version 1.0 was ready for presentation at the Hanover

Panel discussion at the first presentation of PROFIsafe at the Hanover Fair in 1999

Fair in 1999. The response was overwhelming: "That was a surprise coup". The belief was that safety could only be hard-wired and had to based on relay technology. Conventional safety technology may be simple in design, but it brings significant disadvantages when it encounters modern automation.

Dr. Stripf summed things up thus: "The disadvantages included costs associated with labor-intensive cable routing, the lack of flexibility, and the significant effort and expense required for restart following a stop."

PROFIsafe logo

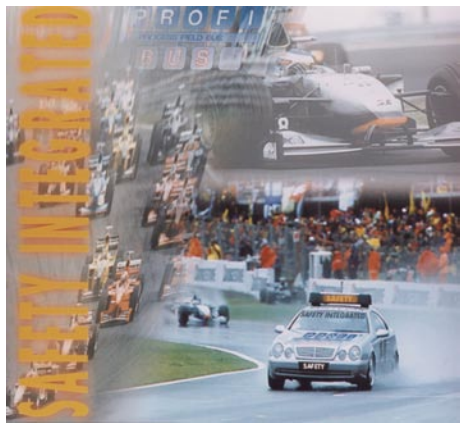


Image photo for PROFIsafe

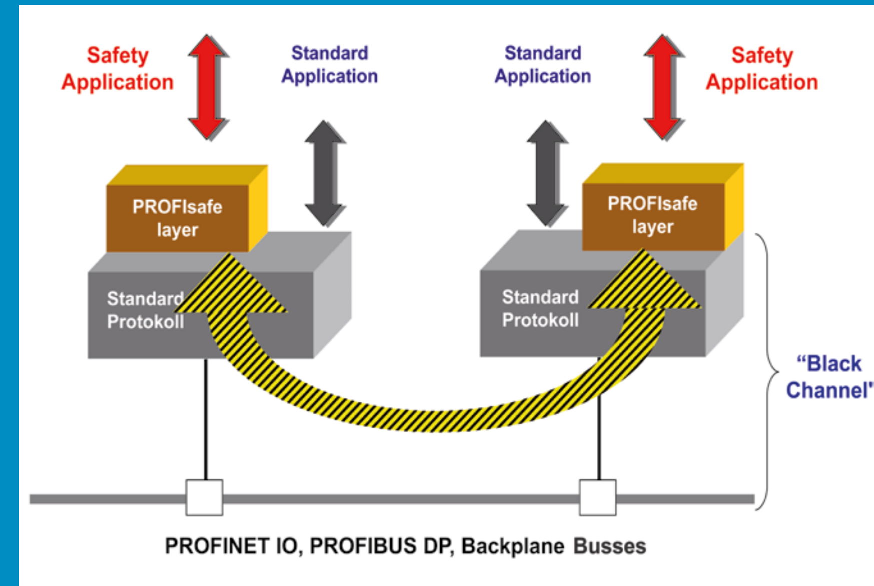
Unique was the fact that the PROFIsafe protocol functions without affecting the standard PROFIBUS communications. The safety-related data are transmitted together with the conventional data over a common bus cable. The safety transmission channel is regarded as a "black channel," making PROFIsafe independent of the transmission channel used for control. According to Dr. Stripf, "The black channel principle realized in PROFIsafe allows safe transmission of data from end point to end point, thus, not just over PROFIBUS and PROFINET, but also over proprietary backplane buses."

Besides the innovative strength of the project, the simultaneous development of new safety standards with their actuarial approach and the introduction of SIL as a measure for failure probability benefited the project greatly: "This cleared the path for use of microprocessors, software, and communication so, with PROFIsafe, proper functioning could be confirmed mathematically, even if more than two mutually independent errors or failures occurred," states Herbert Barthel.

Certified safety

An important contributing factor to user acceptance of PROFIsafe was the introduction of a certification system and an associated testing environment. To fulfill the most stringent quality requirements, PROFIsafe requires devices to undergo a safety-related test at an independent test institute. With V2.0 of the specification, PI set forth the requirements for operating safety-related products both with PROFIBUS and with PROFINET. The path was now paved for wide-spread use of PROFINET in the automotive industry. PROFIsafe V 2.0 was accepted by TÜV and BGIA in 2005.

PROFIsafe



PROFIsafe is an Application Profile for safety-related automation based on PROFIBUS DP or PROFINET IO. It connects safety-related sensors, controllers, and actuators. PROFIsafe can be regarded as a single-channel "software solution" that is implemented in devices as an additional layer above PROFIBUS or PROFINET. Standard components, such as cables, connectors/ network components, ASICS, or protocols remain unchanged. Particularly important is the fact that the PROFIsafe Profile allows devices to be operated together with standard devices on the same bus cable without limitations.

During development of PROFIsafe, the aim was to develop specifications that would eliminate the errors that typically occur during serial communication - such as corruption, loss, delay, and insertion of data, as well as incorrect addressing - through suitable countermeasures such as numbering, time monitoring, authentication, and additional data protection (CRC). A crucial aspect here was that in the event of two simultaneous errors, a device will always go to a safe state.

PROFIsafe enables realization of safety functions using the PROFIBUS and PROFINET fieldbuses already established in all sectors of industrial automation. Introduction of the black channel principle enables safe transmission from end point to end point, not just over PROFIBUS and PROFINET, but also over proprietary backplane buses. PROFIsafe enables the use of integrated safety functions in drives. PROFIsafe not only supports flexibility; it achieves material-conserving motion operations. In addition, it enables higher availability due to fast restart after an emergency stop.

PROFIsafe gained acceptance

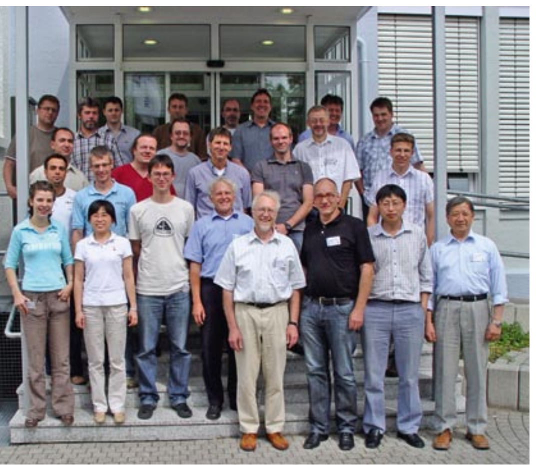
Consistent technological development quickly gave PROFIsafe an imposing market position. A PROFIsafe specification based on wireless networks with WLAN or Bluetooth was defined in April 2007. The scales were tipped, not least of all, by the commitment of AIDA (the Automation Initiative of German Automobile Manufacturers). "We are consistently changing to PROFINET with the PROFIsafe safety protocol," stated AIDA spokesperson Arjen Kreis. "We started back in 2006 with PROFINET/PROFIsafe in body construction and will continue all the way to robotics," added BMW representative Peter Ziegler.

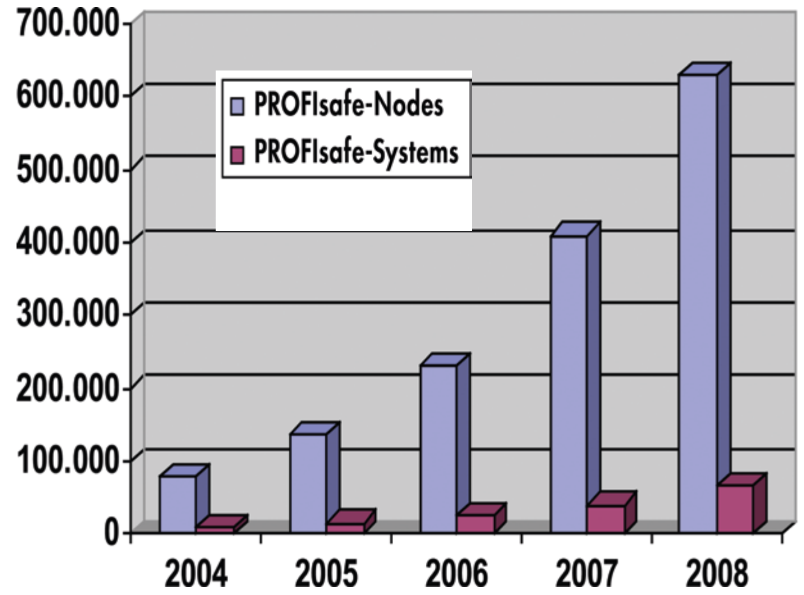
Numerous other users in different industrial sectors have been added. As a consequence, PROFIsafe has been able to prevail over all other existing or emerging solutions and is today the market leader with almost a million PROFIsafe nodes. There are PROFIsafe-compatible controllers from a variety of manufacturers and approximately 50 different field device types. Users therefore have access to a wide selection of certified products and benefit from no less than 10 years of networked safety experience.

An important argument is the seamless consistency between PROFIsafe and PROFINET IO, which contributes to the high level of customer acceptance. The same consistency exists between PROFIsafe and PROFIBUS PA, which enables a complete solution in the area of process automation. More than 4,000 PROFIBUS PA systems currently integrate PROFIsafe. Linear integration in PROFIBUS and PROFINET, including wireless transmissions, lower wiring costs and delivers greater flexibility. Users also gain from improved safety over the entire life cycle of a system.

Former PI Chairman Edgar Küster foresaw the success of PROFIsafe back in 2003 when, at an Advisory Board meeting, he remarked that PROFIBUS with PROFIsafe would rapidly position itself as the market leader for open safety solutions.

PROFIsafe demonstration at the Hanover Fair in 2006


Participants at an international PROFIsafe Designer Workshop in Karlsruhe



Number of PROFIsafe nodes and systems since 2004

Field-tested safety

PROFIsafe has been field proven for years, for example, at BASF Catalysts Germany, which faced special challenges with their catalyst production: Coating of catalysts for gasoline engines is a complex process and, due to the expensive materials involved, also requires a high level of process reliability. Added to this is the fact that catalyst development is advancing and products have to be constantly adapted to the design of new automobile models.

Against this backdrop a rotary indexing machine was built for the development department at BASF Catalysts Germany in Nienburg for the purpose of coating test parts. The machine was provided with a convenient-to-use safety concept based on PROFIsafe. With its reduced effort for installation, it succeeded in granting the

Safety thanks to PROFIsafe at Ebner Industrieofenbau

maximum flexibility needed to meet the complex requirements of the BASF Development Department. Other modules included fail-safe frequency converters, which communicate directly with the controller via PROFIsafe. They integrate a series of important safety functions as well as supply valuable diagnostic information. "The hardware configuration is very clearly laid-out and requires a minimum of cabling effort, and moreover the software provides us with maximum flexibility to define a wide range of different safety shutdown circuits," explained Kai Schmitz of the Maintenance Department at BASF Catalysts Germany.

PROFIsafe is also an attractive solution for highly complex processes such as the handling of protective atmospheres in the heat treatment of metal parts. Considerable expertise is required for this. Ebner Industrieofenbau, a leading manufacturer of oven equipment for the heat treatment of semi-finished products for ferrous and non-ferrous metals, has developed a process in which pure hydrogen is used as the protective atmosphere. But, the combustibility of hydrogen poses stringent safety requirements.

International Standards govern the control technology to be used. These stipulate that standard PLCs and I/O do not fulfill the safety-related requirements for pressure monitoring. For this reason, the corresponding switching functions are executed using both software programs and relays, which means additional costs are incurred for devices, wiring, and quality control. Especially annoying is the fact that every subsequent optimization requires significant effort. This is why a pilot plant was set up in 2002 for a vertical bright annealing line to use safety-related modules connected via PROFIsafe. The findings were positive. In 2007 Ebner Industrieofenbau was the first large-scale plant to become equipped with PROFIsafe-based fail-safe circuits.

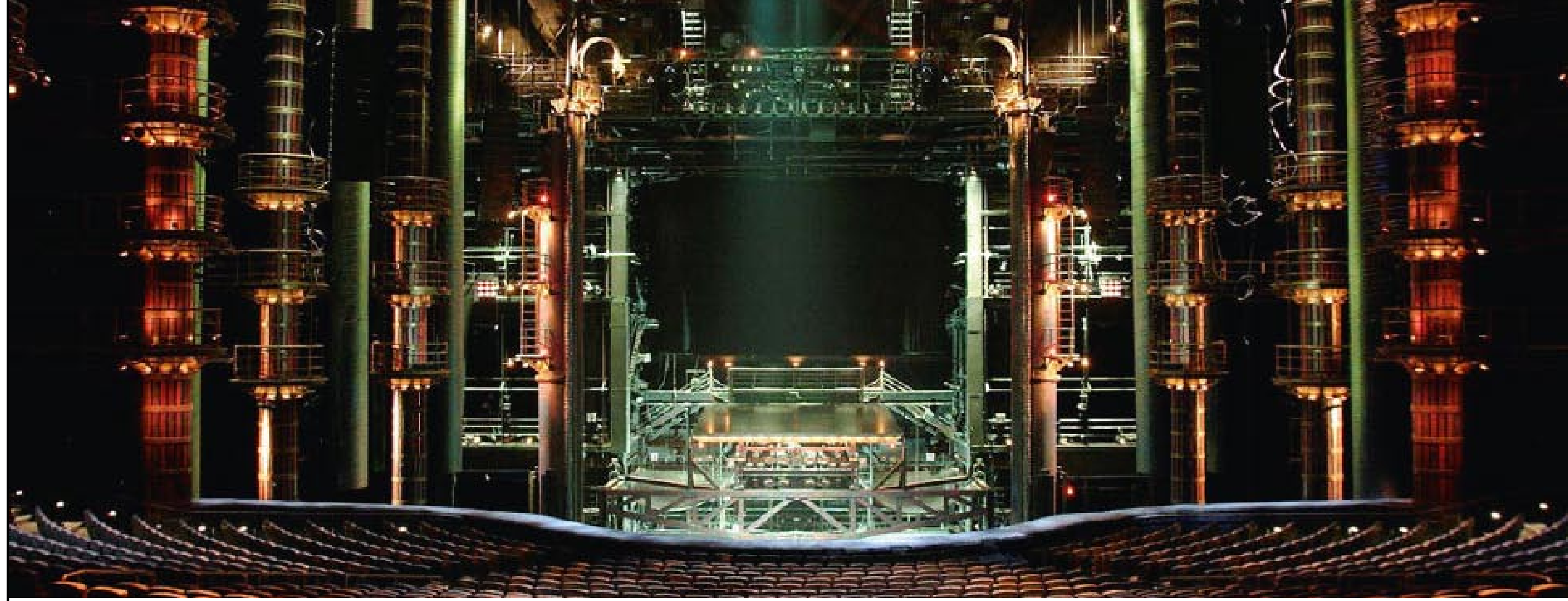
During the conceptual phase, the primary emphasis was placed on eliminating devices with contacts. Through the use of fail-safe controllers, which perform both standard and safety-related tasks in one device, it was possible to reduce the number of devices generally and, thus, the failure probability. Terminals were generally eliminated as the field devices are connected directly to the distributed I/O. The resulting reduction in wiring is accompanied by a reduction in effort for quality control. Further, safety-related updates are possible without any wiring effort and developed software Standards can be used identically for all equipment concerned.

This approach is generally faster and the error probability is less. “We are meanwhile planning a standardized control cabinet. The different oven concepts will then differ only in terms of the program used and the number of inputs and outputs used,” reported Erich Stelzhammer, Manager of Electrical and Automation Engineering at Ebner. “With the successful commissioning of the large-scale plant, our expectations have been fully met. In the future, we want to use the control concept devised here worldwide,” concluded Maximilian Kreindl, a member of the Ebner sales staff. “We expect that the reusability of the software blocks will reduce our costs, but more importantly, also increase the quality and safety in our plants, which in the end benefits our customers.”

Fantasy worlds, beguiling costumes, entertaining stories! The Cirque du Soleil has been attracting international audiences to its shows for years. Here, as well, PROFIsafe is providing safety. Expensive stage technology is used for the “KÀ” show at the MGM Grand Hotel and Casino in Las Vegas, USA, The show features complex acrobatics performed on a 3-dimensional movable stage equipped with “flying” apparatuses to achieve breathtaking effects. Altogether, 32 PLCs, 186 drives, and 206 coordinated motion axes are used for controlling this stage – and with PROFIsafe the show has run for years without hitch.

PROFIsafe in the future

PROFIsafe technology is fully mature today. Although no changes to the protocol are expected, the PI Technical Committees and Working Groups are now working on making engineering more convenient for



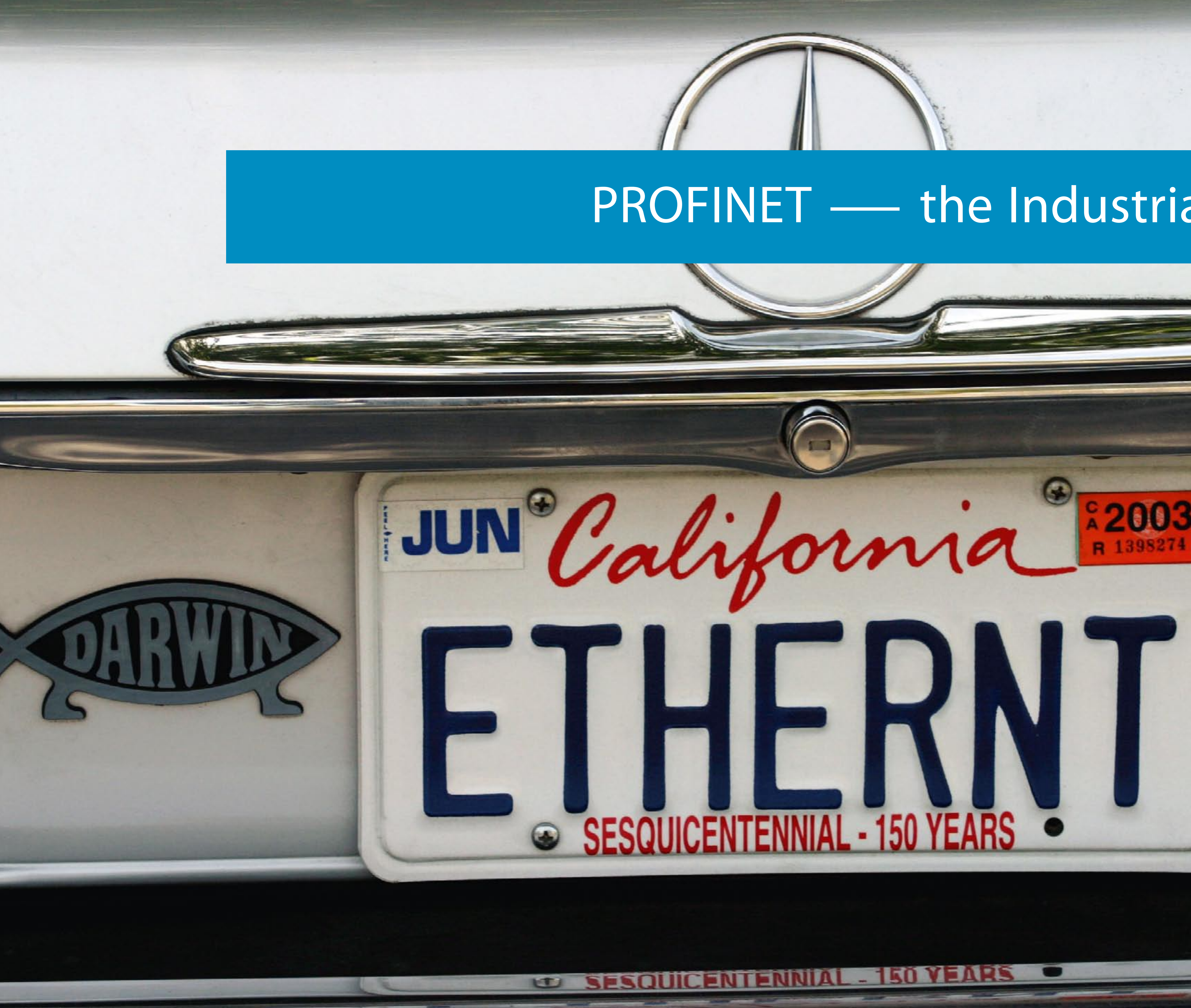
Star in the background: PROFIsafe in use at MGM Grand Hotel Las Vegas for “KA” show by the Cirque du Soleil

users and on providing the calculations customers need for planning purposes. PI will also focus on international distribution. PROFIsafe has meanwhile become an international standard (IEC 61784-3-3) and detailed system descriptions are available in a number of languages. A special web portal (www.profisafe.net) keeps users up to date. In addition, an improved version of the PROFIsafe development kit has been introduced.

“We hope that this will win over still more device families to direct safety connection, such as robots, encoders, gas and fire detectors, overfill safety systems, pressure transmitters, and so forth,” stated Dr. Wolfgang Stripf. This will be supplemented by regular personnel training courses for “PROFIsafe Certified Designer” status, which are conducted jointly with the TÜV.

Over ten years after the introduction of PROFIsafe, it can be said: things are becoming PROFIsafer and PROFIsafer!

PROFINET —— the Industrial Ethernet solution



The PROFIBUS story is one of engineering excellence in an international setting, with a constant search for innovation in industrial automation technologies. These days, networked automation systems are the norm, as are cross-system communication, horizontal and vertical information integration, and remote access via the internet. But, requirements keep growing: Users are no longer satisfied with single variable measurements; there are many process variables to be communicated; users need better diagnostic information; systems, plants, and processes become ever more sophisticated.

Image photo for introduction of PROFINET

The more complex an application is, the greater the need to configure it easily and to have simple remote maintenance. Increasingly, images and even voice data, (e.g., for automatic alarm systems), are being transmitted over the automation infrastructure in real time so higher performance in terms of bandwidth, availability, and security are needed. So the question is: What is the next step after fieldbus?

What is the next step after fieldbuses?

PROFIBUS experts respond unanimously to this question with a new keyword: Ethernet. However, the topic is not new. Ethernet has been employed in automation for a very long time, though not at the device level.

As long ago as the late 1990s, experts began thinking about how Ethernet could be employed in monitoring and control. Initial discussions took place outside the established Working Group structures at the invitation of the PNO Board of Directors. Initial requirements of users were collated. It was imperative to structure and systematize these as the first objective was to compile a complete requirements catalog, with priorities. Different approaches were discussed. Experience of Ethernet in the office world was incorporated.

At the General Meeting in 2000, specific strategies were presented for the first time on how to come to grips with Ethernet. The arguments in favor of Ethernet were compelling. Bandwidth and performance are greater than for fieldbuses, the costs for Ethernet-based systems can be relatively low because of synergies with the office world. Above all, vertical communication and distributed automation solutions can be implemented more consistently and more quickly.

Promotional activity for PROFINET with robots at the Hanover Fair in 2001

This Ethernet "offspring" was christened "PROFINET." The Advisory Board formed the "PROFINET Steering Committee" in October 2000 to explore and develop the possibilities and keep activities on the right track. More than 20 individuals, including representatives of the Board of Directors, experts on Ethernet and Ethernet software development, and the leaders of the Working Groups responsible for issues and solutions for different aspects of PROFINET, participated in this Steering Group, which is still active today.

The Steering Committee operated across multiple Working Groups. This was an essential role that enabled presentation at the Hanover Fair in 2001 of a pilot application of the first PROFINET specification. As always, the technological development was followed up by marketing activities, tests, certifications, and Test Lab accreditations.

In December 2002, the first certificates for PROFINET products were issued by the Support Center Executive Director Peter Wenzel. On top of that, PROFINET was Incorporated in IEC 61158 during 2003. Both steps were crucial to gaining the confidence of users.

The Marketing Working Group was established at almost the same time. It was very important to start marketing activities at this early date because the competition was not far behind. IAONA had already started specifying Ethernet solutions. However, the main spotlight was on two other systems – the IDA and CIP concepts. These two were being developed by groups of providers and were based on different approaches. Then, IAONA discontinued its activities.

From the beginning, the Marketing Working Group had its hands full. Flyers, slide presentations, system descriptions, web pages, and professional articles, just to name a few, were developed and distributed. These were urgently needed in order to brief members, RPAs, and PI Competence Centers as there were still too few experts at this time who could effectively introduce the idea worldwide. It was necessary to host a number of different events, including trade fair appearances, seminars, workshops, and user training workshops,

to introduce the idea on a widespread basis. Only in this way could the advantages of PROFINET be made known to the broadest public in a short amount of time.

Awarding of the first PROFINET certificates in 2002

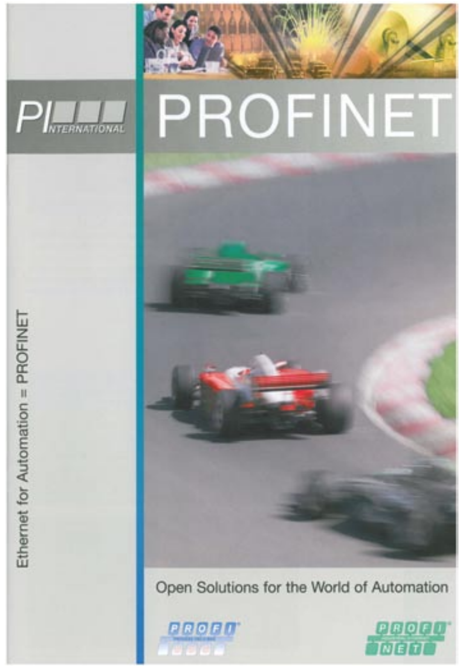
Large-scale breakthrough for PROFINET with AIDA

The project for defining a standardized user-friendly solution for PROFINET paid off. After establishing applications in industrial sectors such as food and beverage, logistics and pharmaceuticals, the large-scale breakthrough for PROFINET came in 2004 in the automotive industry. At a joint press conference, the PNO and the Automation Initiative of German Automobile Manufacturers (AIDA) stated: "A group of German automobile manufacturers, comprising AUDI AG, BMW AG, DaimlerChrysler AG on behalf of Mercedes Car Group Aufbauwerke (Standard Integra MCG), and Volkswagen AG on behalf of the Volkswagen brand, have agreed in favor of a common approach for Industrial Ethernet. The PROFINET protocol standard with integrated personnel safety will be used in the future. The goal is to achieve a simple, uniform connection of automation components. PROFINET will be used if these criteria are met, namely, technical advantages for the use cases, and economic benefits. The protocol

The decision of AIDA contributed significantly to the successful market launch of PROFINET. The backing of the major German automobile manufacturers had an enormous signaling effect.

Jörg Freitag, Chairman of the Board of Directors of PNO specification is available to any component manufacturer from the PI Support Center."

It didn't take much to see that the commitment of these companies would increase the likelihood of further market penetration with PROFINET – this in spite of the fact that competitors such as Ethernet IP, Modbus TCP, Ethernet Powerlink, Sercos III, and Ethercat, were already in the starting blocks, too.



Marketing flyer for PROFINET

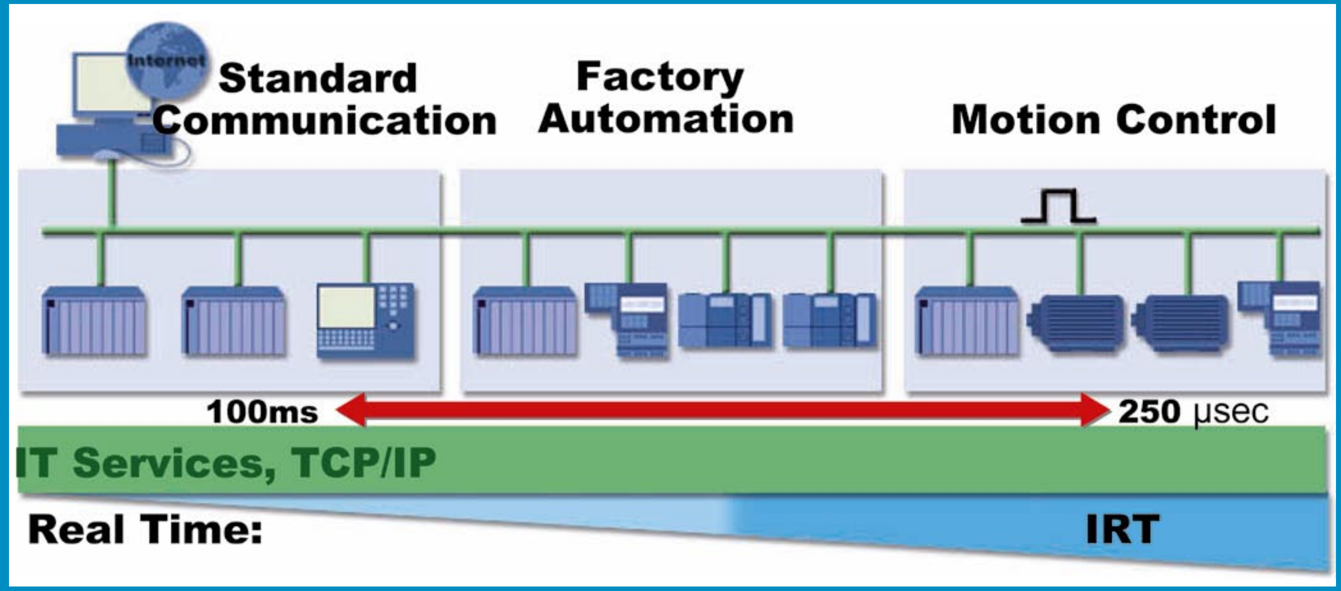
One of a kind for all

Because widespread use of PROFINET was the declared goal, PI quickly expanded the Profiles available for PROFINET to enable their use in different application areas, especially in industrial process applications. The PROFIdrive and PROFIsafe protocols, as well as Profiles for identification systems, angular encoders, and low voltage switchgear, were soon made ready for use with PROFINET. The Profile for intelligent pumps was mapped onto PROFINET from the start. Additional Profiles, e.g., for weighing and dosing systems, remote IO for process control, and the laboratory devices Profile are being made PROFINET-capable as needed.

A Train Applications Profile represents the first one developed exclusively for use with PROFINET. This Profile defines the application layer for devices used in rail car automation. Through PROFINET, Ethernet-based real-time and IT communications are now available for train applications.

Another unique selling point of PROFINET is its use of "proxies." A proxy is a "black box" interface that allows existing automation networks such as PROFIBUS and others to be connected to PROFINET. This means that existing automation equipment does not have to be obsoleted when a PROFINET system is installed. Hence, existing investments are protected and migration to an Ethernet future is simple. And since a proxy has been defined for PROFIBUS PA, it

PROFINET



PROFINET is based on Ethernet-TCP/IP and supplements the well-proven PROFIBUS technology for applications requiring higher performance levels for data communication and the use of industrial IT functions. PROFINET builds on the well-proven function model of PROFIBUS DP and uses Fast Ethernet technology as the physical transmission medium. The system is customized for fast transmission of I/O data, while offering the ability to transmit demand data and parameters as well as IT functions. Existing expertise on PROFIBUS DP can continue to be used. As for PROFIBUS DP, a device description is used to integrate the distributed field devices into the configuration tool for PROFINET IO. The device manufacturer describes the properties of the field device (PROFINET IO device) in a GSD file. The I/O signals of the field devices are read into the PLC cyclically, processed there, and then output again to the field devices. In contrast to the master-slave mode of PROFIBUS, PROFINET IO uses a provider-consumer model that supports communication relationships between Ethernet nodes with equal rights. An important feature of this model is that the provider sends its data without a request from the communication partner. In addition to the cyclic user data exchange, PROFINET offers additional features for transmission of diagnostics, assigned parameters, and alarms.

also means that process automation applications as well as discrete applications are readily deployable with PROFINET. And, remember, the PROFIdrive and PROFIsafe Profiles both work equally well with both PROFIBUS and PROFINET.

Thus, unlike all other Ethernet-based systems, PROFINET is able to cover the entire performance range of industrial automation today.

Minimum time in real time

With PROFINET the bar is raised in other ways too. Typically, three application "domains" need to be covered by an Ethernet-based solution: The first is when messages have to be communicated horizontally between controllers, or vertically into higher-level IT systems. This requires response times in the range of 10 to 100ms, which PROFINET easily handles using standard Ethernet. For most discrete control applications however, response times of between 5 and 10ms are needed, and this is accomplished using an optimized Ethernet communication channel in which unnecessary IT protocol "layers" are omitted. In this way the performance needed for "realtime" control is achieved while maintaining full compatibility with Ethernet.

The third, and most difficult, automation domain for an Ethernet solution to support is that of motion control (drives). Here, the communication system has a critical role since update times of less than 1ms are required, usually with a variance of less than 1µs. This level of "determinism" is well outside the scope of office Ethernet so enhancements are needed. PROFINET does this using additional hardware (ASIC) support, again without detriment to the underlying Ethernet.

It's important to note that all three PROFINET application domains retain full compatibility with the Ethernet Standard. And, they can be used simultaneously on the network according to needs.

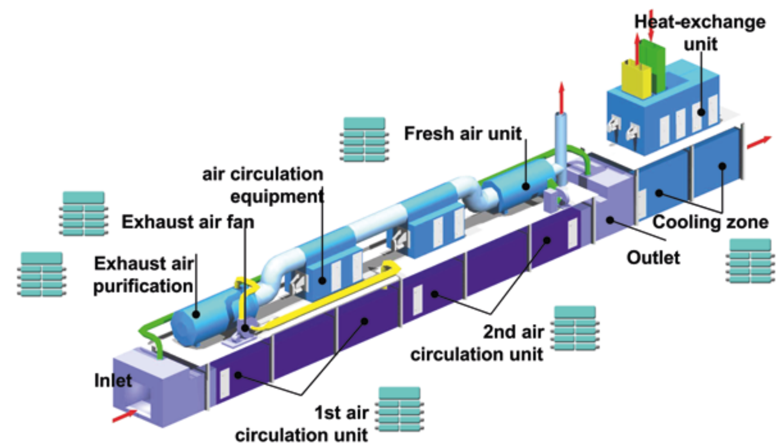
Best practices with PROFINET

The practical significance of the AIDA commitment to PROFINET was revealed at Volkswagen in Wolfsburg, Germany, just to mention one example. This site had already gained experience with PROFINET and at the time of the AIDA commitment in 2004, it was already known what could be achieved.

Following successful testing in a pilot plant operated by Dürr, the first production facility at Volkswagen in Wolfsburg was commissioned in March 2002. Over 60 independent, intelligent devices were networked over PROFIBUS and Ethernet. In this project, the communication relationships were configured 100% graphically. The modular approach resulted in significant savings for engineering and commissioning. Since March 2002, the facility has been used to produce bodies for the Golf and other models. The availability of the plant, which operates 3 shifts, was ensured at all times.

PROFINET also demonstrated its capabilities in other sectors. For example, Imperial Tufting Company (ITC), one of the largest manufacturers of tufted and printed carpeting, is using PROFINET to

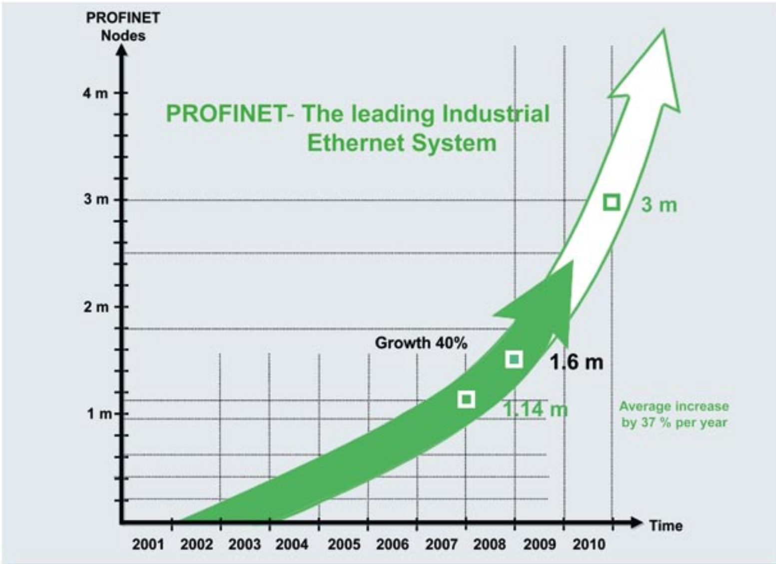
In 2002 Volkswagen started a production plant with PROFINET



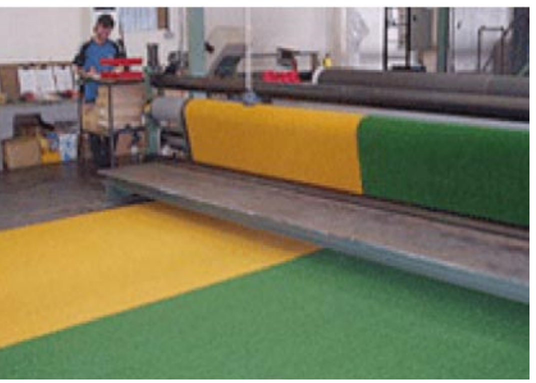
Schematic representation of use of PROFINET on a continuous-flow dryer of a Dürr painting system at Volkswagen

The approach of including all industrial sectors makes PROFINET, with more than 2 million installed nodes and the most dynamic growth among all its competitors, the leading solution today for Ethernet.

Dr. Peter Wenzel, Executive Director of PNO



Carpet production at ITC



exchange data with the connected I/O for activating and controlling their wells and pumps. The existing Ethernet infrastructure is used to support the PROFINET application.

The Manager for Electrical Engineering and Electrical Systems at ITC is enthusiastic about the PROFINET system: "Simple programming and configuration over the office network convinced us." The entire water catchment facility at ITC was controlled by a master PLC and 12 slave controllers, each of which activates and monitors several wells. All slave controllers exchange their I/O data with the master PLC. The pumps connected to the network are activated via various input signals, such as the water level in the tanks, a faulty signal, a sudden pressure drop in the pipe, or other alarms. This control solution ensures that faults are immediately detected in the slave

controller and forwarded to the master PLC. This is connected to a PC that automatically informs maintenance personnel about any maintenance need, either by e-mail or GSM modem via SMS. The entire network is displayed on the PC.

PROFINET in everyday life

The manner in which PROFINET now affects everyday life is revealed by the example of an automated beverage shop. This new shopping solution has been set up by the Staake company in Braunschweig, Germany, is setting new benchmarks. At "Drink Drive 24," it takes less than four minutes to purchase four cases of beverages. Customers drives directly in front of a covered service location and order the desired merchandise using a terminal similar to an ATM machine. The order is automatically filled and an extendible shuttle places it directly in front of the trunk of the vehicle at an ergonomic height.

Thus, modern control and communication technology with comprehensive diagnostics, combined with simple, robust, and low-wear mechanics, enable a convenient option for purchasing beverages, regardless of the day of the week or time. A test facility was built in advance and subjected to comprehensive testing. In addition, simulations similar to those performed by the automotive industry were carried out to confirm the strategies. Thus, it was possible to proceed with implementation of the first "Drink Drive 24" with minimal risk.

The preplanning and testing paid off. Only four months were needed to complete the first facility, including steelwork, electrical equipment installation, commissioning, and handover to the customer. An availability of over 98.5% was achieved from the start. Inside the building is a storage system with an extremely high packing density. Up to 15,000 beverage cases are accommodated in an area measuring only 6 m x 33 m and 7.5 m high. One order picker

Thanks to PROFINET: fully automated beverage shop in Braunschweig

A view of the fully automated beverage shop made by Staake is responsible for filling the order, while a second replenishes the stock. The facility is equipped with three pick-up points and can serve approximately 50 customers per hour at an average of four cases per order. Beverage cases as well as PET bottles can be returned to the empties collection point. All communication at the "Drink Drive 24" facility is implemented using PROFINET. In this way, the facility is following the trend of using Ethernet at all levels of automation.

Market leader in Ethernet-based industrial communication

Volkswagen, ITC and Staake are only three examples out of many applications in which PROFINET has proven itself. The comprehensive range of services of PROFINET – along with effective marketing – has led to rapid market success. "Ethernet is definitely a topic for the future," says Prof. Dr. Klaus Bender. The inclusion of Ethernet in automation will accelerate greatly in the next few years, since consistent use of Ethernet in the field area offers machine building and plant construction operators the potential to significantly lower their planning, commissioning and maintenance costs.

The effect of PROFINET can already be felt. A few numbers: today, more than 1000 member companies around the world stand behind PROFINET; while the "first" 1.1 million nodes were installed by 2007, the total grew to more than 2 million by the end of 2009; this corresponds to 40 percent growth. The numbers show that PROFINET has succeeded in establishing itself as the market leader for Ethernet-based industrial communication.

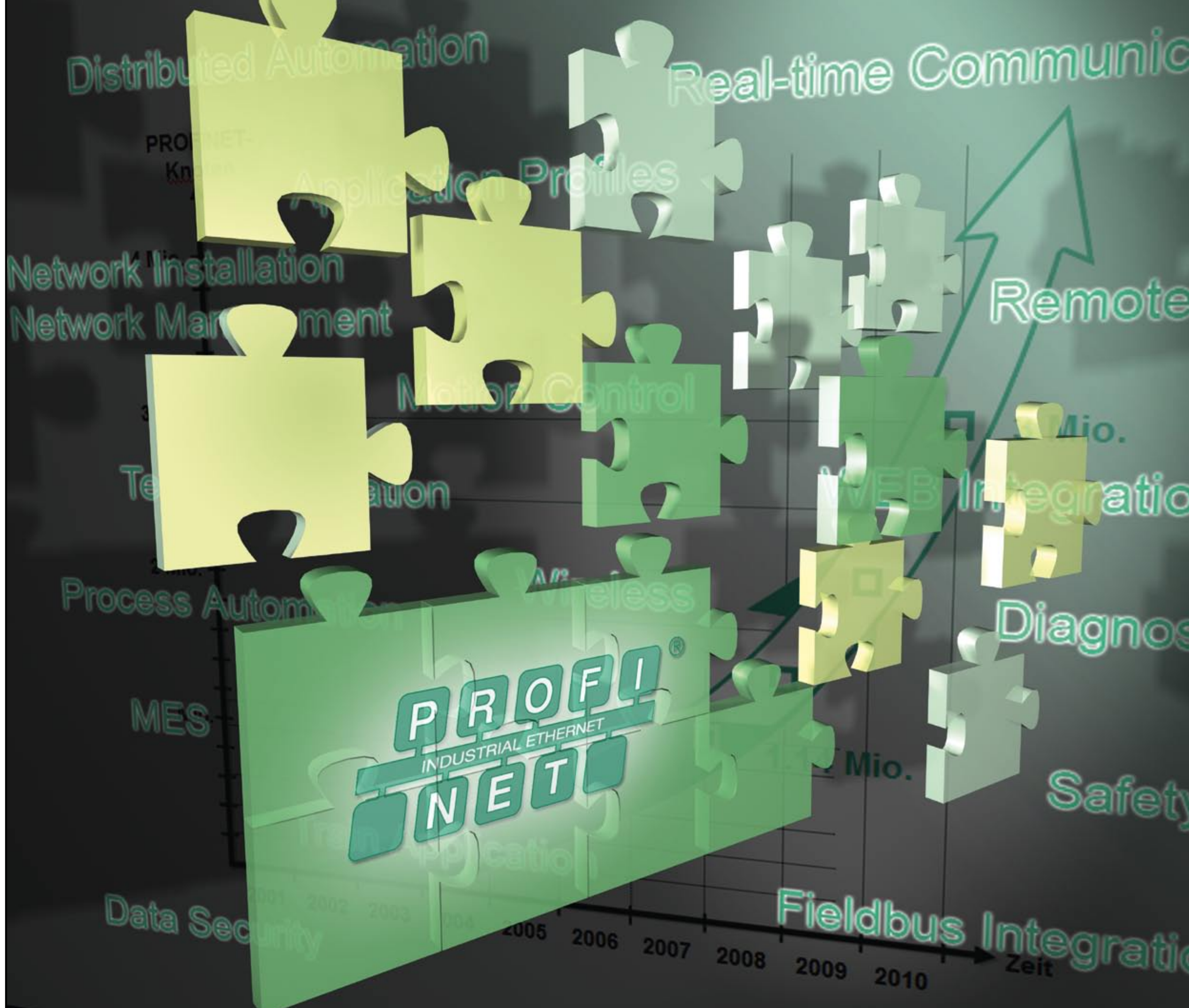


Image photo for PROFINET

Success sets the course

20 years of PROFIBUS – and the progress continues. Buoyed by the success and motivated by the high degree of acceptance by users, participants in Working Groups continue to take on new challenges, searching for real-world solutions to furnish manufacturers with intelligent solutions for better, safer, and more cost-effective automation. When interviewed, the three members of the Board of Directors, Prof. Dr. Klaus Bender, Jörg Freitag and Klaus-Peter Lindner named the most important tasks in the future.

"There is no other network with so much positive energy, where people are constantly endeavoring to find a good solution for everyone," said Jörg Freitag in describing the special environment of PI. This statement underlines the healthy position of PROFIBUS, and is backed by the number of members, the number of installed nodes, the related economic value (which, estimates suggest, run to a two-digit billion euro amount), and the global reach of the RPAs.

The push to take on and advance new technologies has prevailed throughout the history of the PNO. As Prof. Dr. Klaus Bender recalled: "It was not a matter of throwing just any specification on the market, but rather of finding a fast, cost-effective, and workable solution that satisfied everyone." This guiding principle is valid to this day. Whether pigment or automobile manufacturer, brewery or drive specialist, research institute or control system manufacturer, corporate group or startup company – everyone finds a home at PI.

"What other user organization can point to 30 million components with a fieldbus interface?" asks Prof. Dr. Bender with pride. He cautions against underestimating this base. "Many users are oblivious to the size of this treasure trove and the expertise and experience it's based on," he says.

Users are currently benefiting from the wide dissemination of PROFIBUS, the systematic quality assurance and a certification program that offers unequaled opportunities. "Success is our driver," says Klaus-Peter Lindner in describing the motivation for the work of PI. "We actively take on new technologies." Among the pluses is that PI has never shied away from implementing new topics, be it IO-Link in the field or the expansion of PROFINET. By so doing, these new technologies benefit from the experience and maturity of PROFIBUS. The result is seen particularly with PROFINET, which is virtually unrivaled among Industrial Ethernet technologies.

Publicizing benefits

One of the highest priority goals of the Board of Directors is to highlight the benefits to users and to focus the work of PI around these benefits. "We must continue to intensify our efforts to incorporate users, whether machine builders or plant constructors, and convince them that PROFIBUS is a fully developed technology," affirmed Lindner. It makes no difference whether the user is an experienced PROFIBUS user or comes from a sector that still has limited experience with fieldbuses - such as laboratories, the semiconductor industry, or train applications.

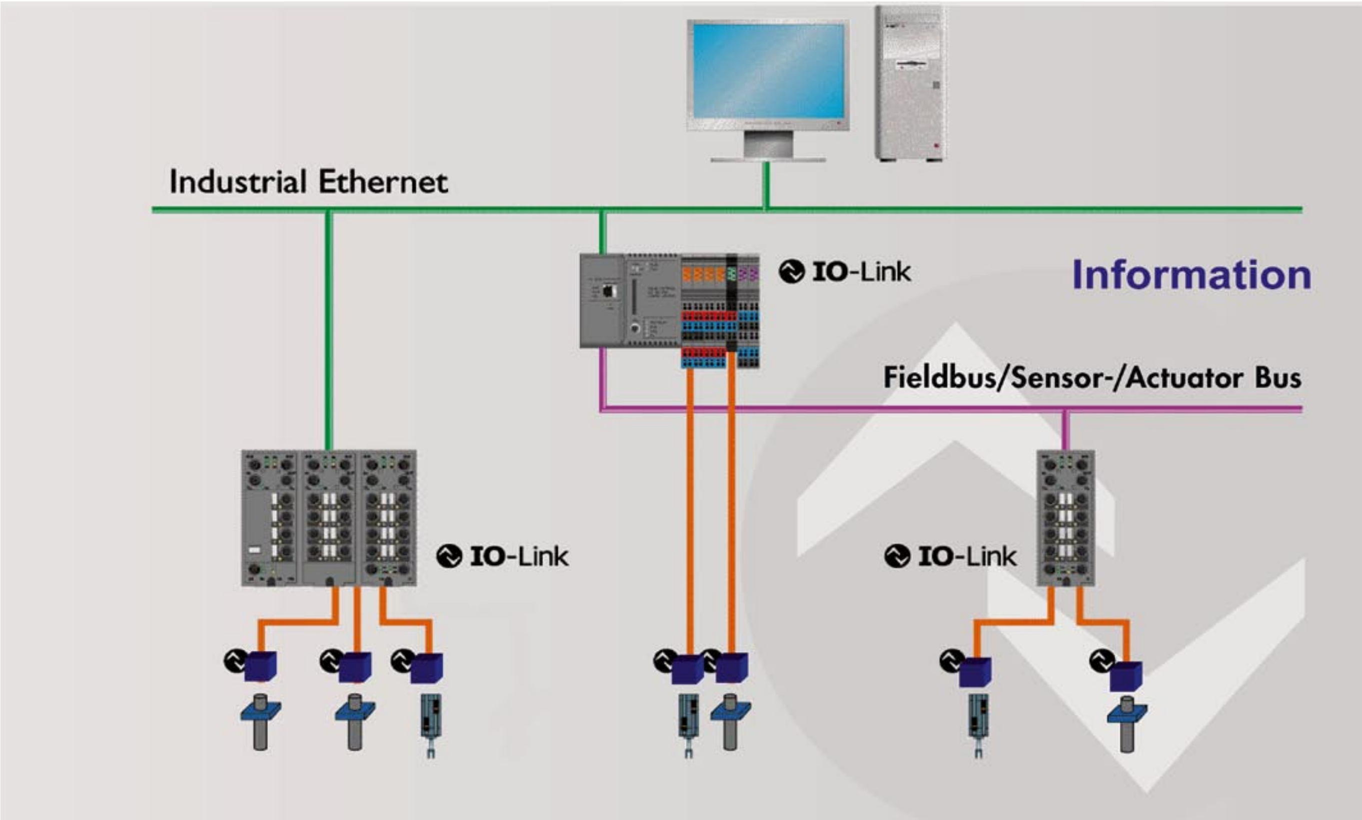
Image photo for IO-LINK

This means not only mastering technological tasks, as Freitag explains: "Many manufacturers, especially small and medium-sized companies, are showing a greater interest in our services." RPAs already offer a broad program of workshops, road shows, and conferences. This includes well-grounded technical consultation through the Competence Centers and workshops for users. These services are constantly expanded and optimized to suit changing market conditions. Particular interest is focused on newer topics, such as IO-Link and PROFINET.

Information from the last few meters

There are any number of exciting technology topics that PI will tackle in the next few years. While tasks may differ according to the industry and subject areas, everyone is in agreement that they want to work together to define innovative solutions. New challenges will be tackled energetically in line with this objective.

One example of this is IO-Link, which provides an open method of communication below a fieldbus or Ethernet, to cover the final



With IO-LINK, communication is managed as far as the sensor, thus bringing the last few meters of an automation system into the digital network.

few meters in the field. IO-Link is optimized for a new generation of low cost "intelligent" sensors and actuators now coming on stream in machine building. Thanks to microprocessor technology, these dazzle with ever smaller housings and greater performance, with rich parameterization and configuration potential, more precise adjustments, and expanded diagnostic information. Communications take place digitally, although wired connections remain point-to-point.

Most users cannot fully take advantage of these capabilities because a suitable method has not been available for communicating data to and from higher level automation systems. With IO-Link – it's an increasingly important element in the information chain, according to Prof. Dr. Bender – this is now possible.

The IO-Link interface enables parametric, diagnostic and switching data from the lowest level devices, to be exchanged directly with the fieldbus or Ethernet network. As a result, it is finally possible to integrate the last few meters of field device connection into a consistent digital communication solution.

Prof. Dr. Bender is convinced that "more and more sensors will be added in production automation." PI is active in supporting the IO-Link Consortium and Bender is certain that it will remain active in any new tasks that result from the use of IO-Link in production automation.

Open engineering

New possibilities are also opening up for engineering - the configuration and parameterization of field devices - in production automation. Open engineering solutions are propagating fast in the process industries, and are these are now becoming of interest to production automation, where proprietary systems currently dominate.

The initial demand is from hybrid applications (process and discrete processes running together), but Prof. Dr. Bender is convinced that other industries will also register interest. Here, new solutions could benefit from PI's experience in terms of standardization. In the end, the engineering tasks are similar, regardless of whether they involve IO-Link sensors, field device nodes, or PROFINET networks.

"It is a powerful challenge to enable engineering functionality for many systems from many manufacturers, and still keep it open," acknowledges Prof. Dr. Bender. "Only a well-managed user association working collaboratively can solve such challenges."

Intelligent troubleshooting and predictive maintenance

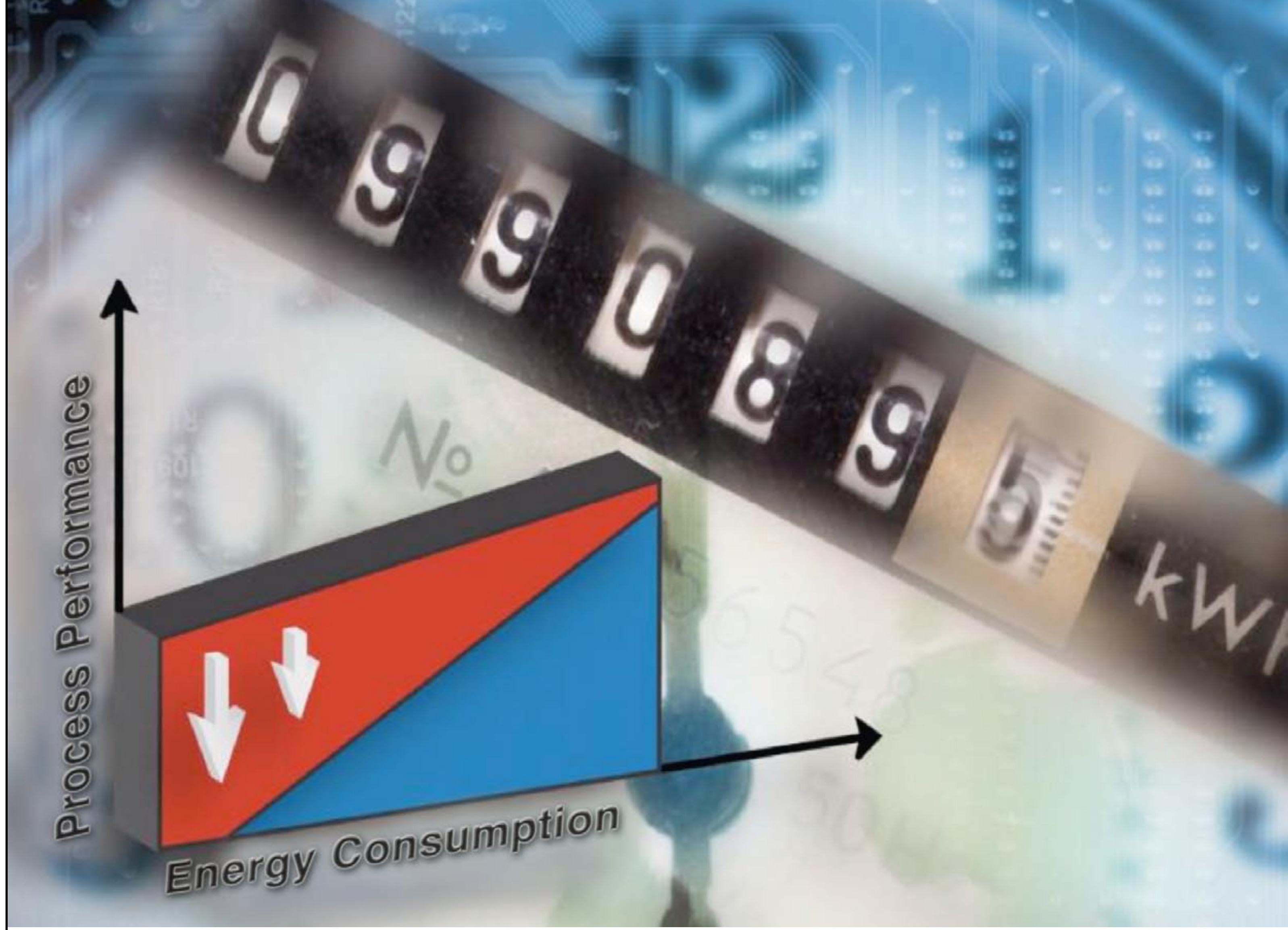
Another example of intelligent use of the information from field devices is in the area of diagnostics. “We are well-positioned and are offering field-tested solutions,” states Freitag. As an example, he notes the latest topology display available for PROFINET.“ A network graphic is generated automatically based on the detection of neighborhood relationships. Any changes are displayed immediately too, he explains. “In the past, for example, it was not a simple task to show a device replacement on screen. PROFINET now makes this possible.” Other emphasis is on the standardization of diagnostic and status messages, similar to those described in NAMUR Recommendation NE 107.

Energy savings taken seriously

Hardly any topic has received so much discussion recently as that of energy saving. In automation, the need is clear, though the actuality is sobering. As Freitag remarks: “There has been a lot of talk, but an open, industry-wide, solution is missing.”

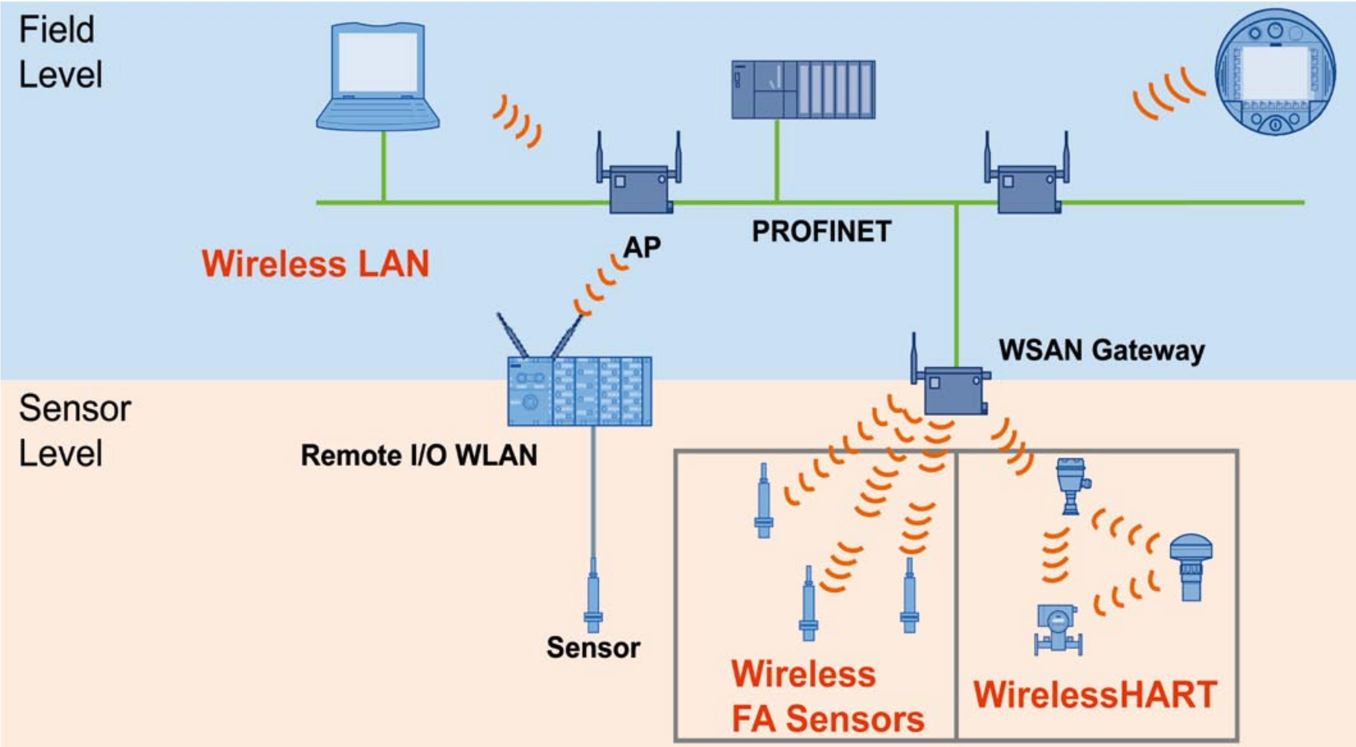
All the more noteworthy then is the preparatory work of PI in response to an idea of the automotive industry. “PI cannot develop energy-saving components,” conceded Freitag, “but it can provide the communication infrastructure so that energy savings become possible.”

It is not satisfactory to simply shut down equipment at the weekend. PI wants to do more. “It can be profitable to selectively switch off smaller components, such as lasers, or even individual plant sections, during production gaps. For example, switching off lasers for just 30 seconds can be profitable over the long-term,” states Freitag.



The PROFIenergy Profile provides the infrastructure for energy-saving communication

In response, PI is developing a vendor-neutral energy savings Profile called PROFIenergy, which will become a standardized interface for data exchange between a controller and its subprocesses. The Profile can be integrated into individual components (e.g., robots, lasers, operator computer, or drive controllers) so that no new hardware is needed. Users are welcoming the initiative because it is vendor-neutral.



When wireless is used, the question of coexistence of systems among one another is of special significance

Wireless connection to the world

Although wireless is still in its infancy, Freitag believes it will lead to massive changes for users. One major goal of PI is to develop a common interface to allow end users to access wireless technologies more easily. "We are collaborating closely with the WCT (Wireless Cooperation Team) and have agreed to standardize on WirelessHART in process automation," indicated Freitag, in describing the first visible results. PI is now focused on developing a specification for wireless-based sensors and actuators in production automation. The issue of coexistence of systems among one another and on the LAN is of special significance here. The specification is scheduled for completion in 2009.

Safe in the future too

The proportion of HART devices in the process industry remains very high (more than 80%). But, in the long run, analog technology cannot be adequate for the complex tasks of the process industry. Equipment utilization is greater, processes are more expensive, and products are more specific. At the same time, raw material and energy costs are rising while the number of qualified employees available is reducing.

Only intelligent field devices can manage this balancing act but the key to successful fieldbus migration will be the ease with which device integration can be handled. "It is still difficult to connect a device to a control system. There are simply too many options, when you consider FDT, EDDL, or now FDI," acknowledges Klaus-Peter Lindner. "PI takes these issues very seriously." With the introduction of PROFIBUS PA Profile V3.02 last year, PI has already taken a crucial step forward. "We must capitalize on this success," says Lindner. "We must make it easier for users of 4-20 mA technology to migrate to the wider possibilities of digital technologies."

Once fieldbus is more widely established in the process industry sector, Lindner sees additional tasks: "Reliability and availability are keywords in the process industry. Therefore, greater use of fieldbuses requires that our to-do list includes topics such as bus self-diagnostics and certification of network components such as couplers and links," he says.

Lindner ventures to go even one step further: "In 20 years both PROFINET and PROFIsafe will be established in process automation."« This sector has many safety requirements that have been dealt with up to now with simple solutions, such as leakage monitoring on tanks. "I am convinced that increasing environmental protection requirements will make intelligent solutions like PROFIsafe a necessity," he says. In order to identify which solutions will be needed, an investigation is already underway.

At home worldwide in all sectors

Whether for the production industry or process industry, any attempt to establish Standards in the market is bound to fail without an international outlook. The well-established network of PROFIBUS and PROFINET experts in the RPAs, PI Test Labs for certification, PI Competence Centers, and PI Training Centers today guarantees high-quality support for dissemination and use of the technologies. "That is unique, and we are years ahead of other organizations in that regard," states Freitag confidently.

He attributes this to the excellent team spirit of participants. "Although our competitors are also working collaboratively, it is clear to everyone how important the work of PI is." He sees this as a strong argument for further expansion of the PI network. There is a spirit of optimism in India, where an RPA and a PI Competence Center are currently being established. Freitag foresees an intensification of activities in South America too.

Outlook

"We as PI must set the course and always stay one step ahead of the competition," states Prof. Dr. Bender in describing the goals of PI. "In so doing it is important not only to be knowledgeable but also to offer far-reaching solutions. Thus, in ten years, we see ourselves not just as representatives of PROFIBUS and PROFINET but also as an umbrella for other technologies, perhaps because they are not yet represented by an organization or, perhaps, because current organizations do not have the strength of PI."

For example, it is possible to see consolidation in the area of Ethernet on the horizon. PI is gearing up to retain technology leadership here and expand its market share. "Even new technologies have a chance with us, and we will give them a home," says Lindner in describing his vision for the future of PNO and PI.

There is a deliberate decision to not just rely on our own strengths but rather to forge strong contacts with users and other technology organizations. Lindner is convinced that: "Over the long-term, there will be even closer collaboration with other organizations, and key technologies will be advanced collectively."

Already today PI is relying on cooperation with groups like the EDDL Cooperation Team (ECT), the Wireless Cooperation Team (WCT), the FDT Group, FF (Fieldbus Foundation), HCF (Hart Communications Foundation), and the OPC Foundation (OPCF). The goal is the specification and subsequent dissemination of consistent functionalities and standards. "In hard economic times such as now, it is not a matter of working against one another, but rather of establishing stronger working relationships," affirms Freitag in conclusion.

Milestones

1985	Queisser Report on promotion of information technology is issued on behalf of the German Federal Government
7/29/1987	‘Fieldbus’ project master plan is developed and supported by 18 partners. Total estimated expense: DM 18.5 million
9/1/1987	Start of joint “Fieldbus’ project
1/29/1988	PROFIBUS logo is adopted
9/27/1988	Eduard Hofmann proposes establishment of a PROFIBUS User Organization (PNO)
11/13/1989	Decision in favor of establishing the PNO
12/11/1989	Establishment of PNO (in VDE offices in Frankfurt, Germany)
12/31/1989	Conclusion of joint project
3/27/1990	First General Meeting of the PNO
1991	PROFIBUS becomes DIN standard 19245 (Parts 1 and 2)
1992	Establishment of first RPA in Switzerland
	Establishment of PI Test Labs; certification for PROFINET FMS established

1993	Establishment of France PROFIBUS user organization, PROFIBUS i Sverige, The PROFIBUS Group UK
	PROFIBUS DP becomes DIN standard 19245 (Part 3)
1994	Establishment of PROFIBUS Trade Organization USA, RPA Belgium, PROFIBUS Nederland, PROFIBUS Network Italia, PROFIBUS User Organization Southern Africa
	Certification for PROFIBUS DP is established
1995	Adoption of PROFIBUS PA Profile for use in process automation
	PROFIBUS becomes the market leader in Europe
	Establishment of RPA Australia and New Zealand, PROFIBUS Finland, PROFIBUS User Organization Russia
	Pooling of all RPAs under the international umbrella organization PROFIBUS International (PI), initial meeting is held on November 1, 1995 in Dusseldorf
1996	Establishment of Associação PROFIBUS Brazil, PROFIBUS User Organization Norway
	PROFIBUS becomes a European standard (EN 50170)
1997	PROFIdrive published
	1 million PROFIBUS devices installed
	Establishment of Chinese PROFIBUS User Organization, Japanese PROFIBUS Association, PROFIBUS Association South East Asia

1998	Profile for PA devices is published
	Establishment of PROFIBUS Association Czech Republic and PROFIBUS Denmark
	Shell AG becomes the 200th member of the PNO
1999	PROFIsafe is published and presented at the Hanover Fair
	Establishment of Irish PROFIBUS User Group, Korea PROFIBUS Organization
	Establishment of first PI Competence Center
2000	Establishment of PROFIBUS Slovakia
	CERN becomes the 1000th member of the PI
2001	PROFINET CBA is published and presented at the Hanover Fair
2002	PROFIBUS DP-V2 and PROFINET CBA becomes part of the international standard IEC 61158/IEC 61784
	Certification for PROFINET is established
	First PROFINET Competence Center and Test Lab is established
	Establishment of PROFIBUS Thai Association
2003	Certification for PROFIsafe is established
	10 million PROFIBUS devices installed
	PROFINET IO published

2004	Establishment of PROFIBUS Polska
	PROFINET Marketing Working Groups are started in Japan and the United States
	PROFINET IO with IRT is published
	AIDA commits to PROFINET
	Certification for PROFIdrive is established
	1000th PROFIBUS certificate is issued to Phoenix Contact
2005	15 million PROFIBUS devices installed
	PROFIdrive and PROFIsafe are published for PROFIBUS and PROFINET
2006	Name is expanded to PROFIBUS & PROFINET International
	Establishment of PI Training Center
	Activities are started on PROFINET for PA
2007	IO-LINK specification is published
	PROFIsafe becomes an international standard (IEC 61784-3-3)
	1 million PROFINET and 20 million PROFIBUS devices installed
	Activities started on FDI
	PROFIdrive becomes international standard IEC 61800-7
	Establishment of RPA Middle-East (Dubai)

2008	Work is started on wireless for sensors and actuators
	Profile 3.02 for PA devices is published
2009	Work is started on energy efficiency profile PROFIenergy
	2 million PROFINET devices and 30 million PROFIBUS devices installed
	Establishment of RPA India

Appendix

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