System Migration onto Standard SCADA Equipment in Power Stations

Cost-effective renewal of the SCADA level of legacy control and automation systems
Field report Grosskraftwerk Mannheim (GKM)

A 10 to 15 year time span - only a long service life for a block control system ensures high profitability. In reality, however, the individual components of the block control system have quite different life expectancies.

Process computers and operator stations on the process control level "age" faster than turbines and boilers - this goes without saying. But neither can they keep up with the lifetime of the plant automation equipment. "Aging" in this context is not so much the result of material wear and tear. It is rather due to the short innovation cycles of the components of the process control level. Extended functionality of computer hardware and visualization software, new ergonomic designs for user interfaces, and new concepts in the data exchange with other systems make it necessary to modernize the process control scheme long before the actual power station components are in need of replacement.

This need for modernization gives rise to two questions: Why not replace the existing operator control and monitoring system, which is usually proprietary equipment that has been specifically adapted to the power station industry, with commercial off-the-shelf SCADA equipment? The fact that in many cases the existing SCADA hardware has already been discontinued by the manufacturer gives this question new importance and urgency. And what if the balance tips in favor of such a standard system? How can it be connected with the existing plant automation equipment and the proprietary automation bus? How does one avoid the loss of the complex I/O addressing and structure parameters that contain an engineering investment of many years?

This article debates the pros and cons of using a standard SCADA system in a modernized process control scheme of a power station unit and examines the special conditions involved in connecting standard equipment to an existing proprietary automation platform. A practical example illustrates how a commercial off-the shelf system was introduced in the Mannheim power station called Grosskraftwerk Mannheim AG. All structure information from the old system was preserved while safely and consistently porting it to the new platform. Stringent adherence to power station standards and safety regulations is, of course, an absolute requirement that the new system must live up to even though it is based on a standard platform.

The primary goal in this modernization project is to increase efficiency by protecting past investments, preserving the current system while expanding its potential and enhancing overall plant performance.

Why invest in a new process control system?

Sooner or later, every utility owner will be confronted with this critical question. The power block's process equipment has not yet gone through its full life cycle, and the automation level "does its duty", causes no problems and offers all the functions required.
The same cannot be said for process computers and operator stations on the process visualization level. This equipment is usually out of date, does not allow open communication and is no longer in line with modern standards of efficient and ergonomic plant control. Moreover, maintenance costs shoot up, and obtaining spare part becomes increasingly difficult as many proprietary systems are discontinued by the manufacturer. The result: a growing risk of hardware failures and system standstill.

So, the operator control and monitoring system is due for modernization. Yet, this retrofitting must be achieved without intervention in the existing automation scheme , and -apart from the technical feasibility- the return on investment must always be kept in view.

So, you have decided for a new SCADA system! But how can it be done?

In the past, the process visualization level was based on proprietary equipment specifically adapted to the needs of the power station industry. With good reason, as only these systems were compliant with the stringent power station standards of safety, system stability and reliability. However, today these core specifications apply to other industries too and can be competently met by commercial off-the-shelf systems! So what is there to be said against using standard technology for the control and monitoring of power plant processes? Taking into consideration both options - standard system and proprietary system - there are three possible solutions for the renewal of the operator control and monitoring system:

1. The existing customized operator control system is replaced by a successor system of the same manufacturer.
2. Only the hardware platform of the operator process control level (the master computer and workstations) is replaced by standard hardware. After emulation to the new hardware, the existing proprietary system software is continued to be used.
3. An off-the-shelf SCADA system is introduced and connected to the existing proprietary automation system. All data, parameters and structure information of the legacy system are integrated by means of system migration.

Solution 1: Proprietary successor system

Proprietary solutions were characteristic for the power station industry in the past. Employing a successor product of the same manufacturer usually has the advantage of complete system compatibility. An inherent ponderousness with respect to modernization and extension of the functional scope, on the other hand, must be expected. System maintenance by the company's own personnel is often not possible.

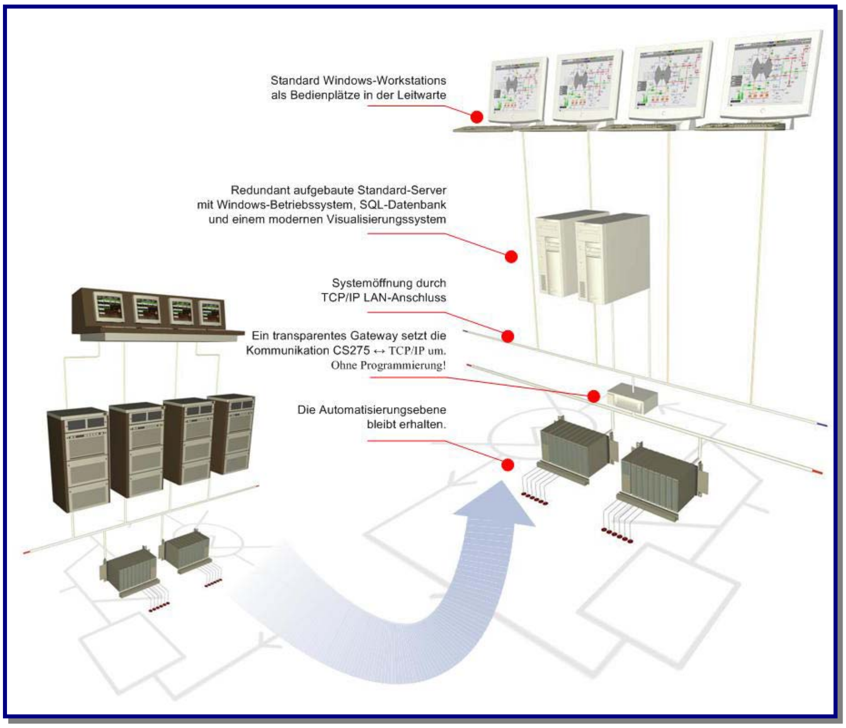

Figure 1 Connection of the new standard process visualization scheme to the proprietary automation technology

Solution 2: Hardware replacement through emulation

In this example it is possible to only replace the hardware components and keep the software because emulators are available for the existing process computers and their system software (Siemens SICOMP R30 and M80 with OS254, OS265, IS, MADAM S) and visual display units (DS078, COROS2000). Industrial servers with Windows operating systems replace the existing process computers; the peripheral equipment (terminal computers, monitors, printers) is replaced by non-proprietary standard hardware. The application software of the OS and IS systems continues to run without any modifications and restrictions on the Windows servers using a SICOMP emulator.
This solution offers various advantages:

- ✓ Open, expandable standard hardware and operating software architecture (Windows 2003/XP)
- ✓ Network connection based on the TCP/IP standard (LAN) and open system structure for the connection to the Windows world
- ✓ Substantial increase in performance

- ✓ Operators continue to use the well-proven and known application software
- ✓ The functionality of the application system remains unchanged
- ✓ The well-proven and known operator interface remains unchanged
- ✓ No tests of individual functions, no operator training
- ✓ The conversion risk is kept to a minimum (no programming, parameter assignment or operator errors)

A disadvantage is, however, that an extension of the functional scope must still be carried out in the "old" software, which could turn out to be increasingly difficult as expertise and support for the old system will surely no longer be available in the future.

Solution 3: Complete migration onto a standard system

Due to the short innovation cycles of the components of the process visualization level, open and expandable off-the-shelf technology is an obvious solution when plant modernization is due. A standard solution enables the utility owner to keep pace with the rapid advances on the IT sector and makes utility owners independent of special products and their often lengthy development times. And in view of the fact that today's standard systems are absolutely capable of meeting the stringent power station standards of safety, system stability and reliability, they can indeed be considered as an efficient solution for the modernization project.

Let us look at the pros and cons of a standard solution for the process visualization level in a power block:

A SCADA system based on standard technology

- ✓ uses commercial hardware and software components (Windows-based computers and components)
- ✓ offers a highly-available safety concept based on commercial redundant hardware and software components, RAID systems, SAN, etc.
- ✓ is manufacturer-independent, expandable and easy to maintain, in other words: future-proof
- ✓ can be adapted to changes in the structure and operation of the overall power plant system, by own in-house engineers
- ✓ provides open interfaces to the automation level (OPC), programming level (VB, C, VBScript) and database organization (SQL, ODBC,…)
- ✓ allows integration of the operator control and monitoring system in company-wide applications and the company IT system
- ✓ offers a state-of-the-art operator interface in line with modern ergonomic standards

In spite of this bundle of essential advantages, the cons should not be underestimated:

- × Complexity of the system integration: The data of the replaced systems must be ported to the new system without loss and free of errors.
- × Connection to the existing plant automation scheme: This is a proprietary system and usually communicates via a very special automation bus which quite often is not of the latest standard.

Assessment and decision

The possible solutions presented for the modernization of the process visualization level in block 3/4 of Mannheim Power Station (GKM) are assessed with respect to their suitability to reduce the service life costs without any compromise in system safety, availability and reliability. Looking only at the costs showed that the emulation of the existing OS and IS applications represented the most favourable solutions (solution 2). Migration onto an standard SCADA system (solution 3) was approximately twice as costly, and the conversion to the manufacturer´s successor system proved even twice as costly as solution 3.

Solution 1

- employment of a successor product recommended by the manufacturer - is rejected due to the fact that it is a proprietary product - and in spite of the fact that it allows a compatible conversion.

Solution 2

- emulation of the existing OS and IS application on Windows computers - is put on the short list due to its cost effectiveness, yet it is ruled out in the end. This is due to the fact that the planned functional extension must still be carried out in the "old software". Moreover, software maintenance by an "old hand" experienced in OS and IS systems might prove difficult in the future.

Solution 3

- introduction of a standard SCADA system based on Windows - turned out to be the most efficient utilization of the budget approved for the modernization project. The technological implementation with the two sticking points "Connection to the proprietary CS275 automation bus" and "Integration of the existing structure information" is based on a gateway black box and the CS275 ↔ TCP/IP telegram conversion (figure 1) on the one hand, and the "soft" system migration from OS/IS to the Windows platform on the other hand. Last but not least, the modernization project offers the welcomed opportunity to shape up the mimic diagrams of the process visualization system, bringing the operator interface in line with today's ergonomic standards.

Implementation in Mannheim Power Station, Blocks 3 and 4

The starting point

Grosskraftwerk Mannheim AG (GKM) was founded in 1921 as a joint venture power generating plant. Today, GKM is one of the largest and most modern coal-fired power plants in Germany. Blocks 3 and 4 went into operation in the years 1965 and 1970. Flue gas cleaning plants were installed in 1983 after the directive on the limitation of air pollutants from large combustion plants came into effect. Desulphurization and NO_2 removal plants were introduced in 1988.

Process automation in blocks 3 and 4 is based on Siemens' TELEPERM ME system, consisting of AS220EA programmable controllers on the plant level, the CS275 automation bus, the OS254 monitoring system, and the IS operator control and process information system (MADAM S) installed on SICOMP process computers.

Modernization steps

In order to preserve and secure the existing data stock when the SCADA system is modernized, the functions of the OS/IS systems to be replaced must be ported to a Windows-based computer system by means of sustained re-engineering and "soft" system migration. This means that thousands of I/O allocations must be safely and consistently transferred from the old system to the new system. Reprogramming or entering this information from scratch would inevitably entail a high error rate and considerable engineering expenditure. As the AS220EA equipment on the automation level shall continue to run unaffected by the modernization process, the new SCADA system must be enabled to communicate with the existing CS275 bus in both directions (figure 1).

Emulating and migrating the existing data stock

The method of "soft" migration is chosen, which means that the old visualization system continues to operate without interruption while it is being replaced step by step by the new SCADA system.
The first step is to emulate the OS/IS functions on a Windows computer. The "old" system then runs with its system software (Siemens operating system) and application software on a Windows computer using the SICOMP emulation tool M2000 - although without connection to the process. With this one-to-one emulation on the Windows platform, all structure information and I/O addressing of measuring values, analog and binary values, arithmetic values, control panels, graphs, messages, KKS allocations (KKS = German Designation System for Power Plants), etc. can then be migrated from the old systems to Windows files (figure 2). This data stock forms the basis for the migration database (SQL).

In this way, a complete database is generated through emulation and migration in which all of the original structure information is reprocessed for the new SCADA platform (figure 3). The variable values (also known as NOBI, typicals, and objects) displayed in the process screens are automatically linked with the variables in the database by means of KKS assignments. This method prevents input and logic operation errors that would inevitably occur if the data were transferred manually.

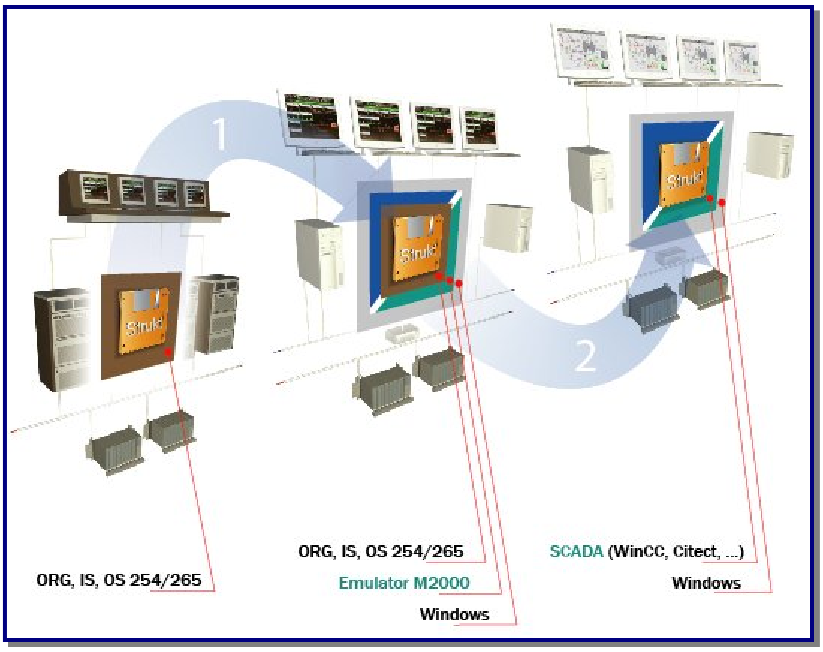

Figure 2 Emulation and migration of the existing data stock

Cleansing the data stock

A visualization system that has been running for a long time unfortunately develops its "own life". This means that inconsistencies between the data of the automation systems and the project data in the master computer of the visualization system become fixed over the years. To remedy such discrepancies in the forefront, prior to system migration, the data migrated from the process computers to the SQL database is logically and automatically compared with the programs of all automation systems. Incorrect parameters and data that is no longer used are corrected before the migrated system is put into operation. Quality -not quantity- is the hallmark of this method of data migration!

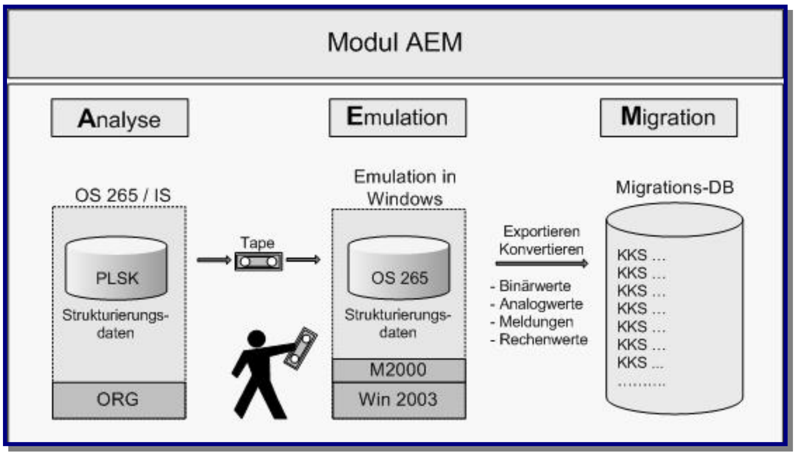

Figure 3 Generation of a migration database through emulation and migration

Connecting to the system bus

The existing CS275 bus is the interface between the process visualization level and the automation level. It connects the AS220EA automation devices with the visualization system.

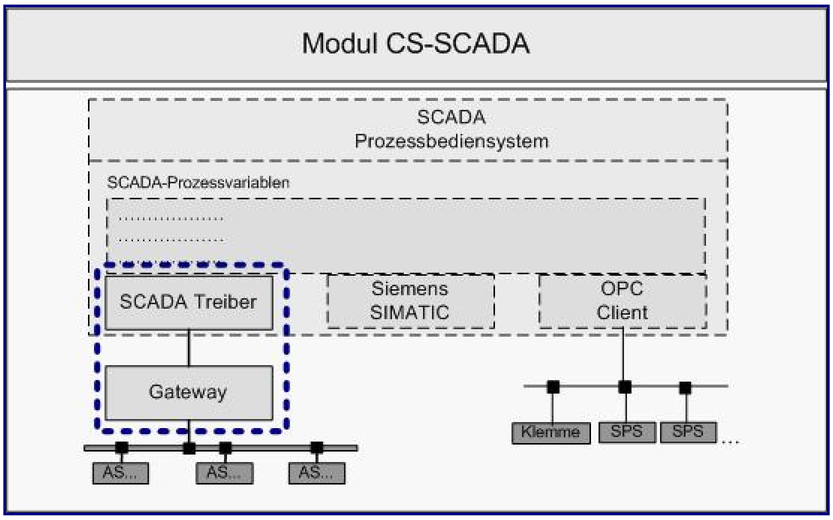

Figure 4

The connection of a commercial off-the-shelf SCADA system to a proprietary bus system is often problematic as the transmission methods and time behavior - usually not disclosed by the bus manufacturer- must be implemented at the bus interface. Also, the data and access structures of the "old" automation systems that are "tuned" to the TELEPERM M/ME system must be adapted to the access methods of the new SCADA system.

These tasks are implemented as follows.

The system bus with the AS220EA devices is connected to the new SCADA system by means of gateways. The gateway which is just an uncomplicated black box to the customer, converts the data traffic from the proprietary system bus to the TCP/IP standard protocol. Now the automation level is not only able to "talk" with the new SCADA system but is also furnished with an open, standard communication interface for the connection of other third-party systems based on the TCP/IP transmission standard (figure 4).

In the new Windows-based SCADA system, a driver converts the data and access structures of the AS220EA automation equipment to the structure of the new SCADA system. In the new SCADA system, the original AS220EA specifications are no longer relevant. This has the advantage that the project engineer who configures and "wires up" the I/O addressing in the new SCADA system sees the "old" AS220EA automation devices just like modern standard automation systems.

Creating new process screens

The process screens of the replaced visualization system have been running for about 15 years and do not comply with modern operator interface standards. Moreover, the functions for plant control and monitoring are based on the technological possibilities that were available at that time (i.e., limited graphical representation, screen resolution and color display, light pen instead of mouse device, etc.). The idea of migrating and keeping the old process screens to reduce costs is therefore rejected by the GKM personnel.

On the basis of the R&I plant scheme, an up-to-date visualization concept is worked out in close cooperation with the process control engineers and control room operators of GKM. This new scheme not only integrates today's ergonomic standards and visualization tools but also takes into account the vast practical experience and knowledge of the block operators. Essential criteria are an attractive design, improved and fast access to plant information as well as easy handling, always taking into account current power station standards and safety regulations (figure 5).

Automatic "wiring"

Visualization is based on WinCC, a standard system on a Windows platform. Owing to the previously migrated logic information and the generated migration database, the "wiring" of the variables into the process screens and the definition of the messages in the alarm system are largely automated procedures. With the help of an object wizard, plant-specific objects (formerly known as NOBI), such as motors, butterfly valves, control valves, setpoint generators, preselection, actuator drives, group control, etc., are inserted in the process diagrams by using drag-and-drop operation and automatically connected with the variables from the migration database. This automatic standard procedure for creating process screens is extremely efficient, helps to avoid errors and facilitates the subsequent commissioning considerably.

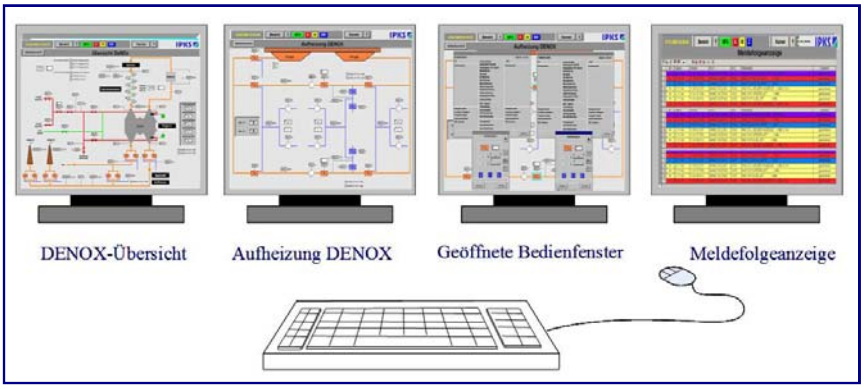

Figure 5 processhandling

Parallel operation and system bus load

The new SCADA scheme is installed in parallel to the existing OS/IS systems and put into operation one section after the other (REA, DENOX, boiler, auxiliary plants...). The bus load during commissioning is of special importance because the load on the older automation bus with its transfer rate of about 250,000 bits/s must at no time exceed the 50% mark for cyclic values. In spite of the temporary parallel operation of "old" and "new" during commissioning and the increased amount of displayed and updated process data on 12 screens in the control room, it is possible to keep the bus load always below the limit value without interrupting the running operation of the power plant.

Conclusions

Employing commercial off-the-shelf components, IPKS supplied and installed a turnkey plant for the GKM Mannheim power station block. The redundant master computers and data servers are highly available Windows servers (Fujitsu-Siemens). The plant´s processes are monitored and controlled on Windows workstations (Fujitsu-Siemens) comprising four screen each. The redundant fibre optics network based on the TCP/IP protocol comprises 3COM switches. Standard software products are used, such as Windows 2003 Server and Windows XP for the operating systems, MS SQL Server for the database, and SIMATIC WinCC for the process visualization system. All components of the new control infrastructure are continuously additional monitored; faults are recorded by the alarm system and indicated in the control room.

The time schedule of eight months – from the award of contract to the go-live phase set for March 2005 – was kept as initially planned and without any extra work required.

Time and effort spent on training could be kept to a minimum as the GKM engineers, technicians and plant operators service personnel possess sufficient knowledge on the standard technology used. With the design of the new operator interface, IPKS focused on compatibility and similar “look & feel” to the other existing operator control concepts so that the power station operators quickly felt at ease with the new system.

All migration, installation and commissioning work as well as the gradual transition from parallel operation to the productive stage were completed without interrupting the running operation of the power plant.

At the basis for this smooth and trouble free project implementation was the excellent cooperation between the utility owner and the supplier.

In the course of a first expansion, GKM connected approximately 300 recorder values to the new operator control and monitoring system using standard control equipment and the TCP/IP local area network. Provided GKM has sufficient capacities, it can carry out all future system expansions and modifications without external assistance.

Prospects

"Open and competitive" – this is how the electricity market has been presenting itself since its liberalization at the end of the nineties. Today's cost burdens force utility owners to increase operational efficiency while ensuring safe and sustained energy supply. Weighing up between the protection of past investments and preservation of the current system and the possibility of utilizing the advantages of today's information technology is a first step in this direction. This must not be a contradiction!

Different lifetimes of the power plant's automation equipment and process control and visualization equipment force utility owners to renew the technology of the visualization system while at the same time keeping the automation equipment running for some more years. Modernization of the visualization scheme therefore requires the connection of new hardware, software and bus technology to the proprietary automation technology.

The possibility of consistently migrating the complete data stock of the legacy system to today's Windows platforms smoothes the way for the use of commercial off-the-shelf visualization systems. These systems not only provide an open system structure based on standard operating systems, but also ensure full compliance with the stringent power station standards of safety, system stability and reliability.

The employment of standard technology offers additional economical benefits:

- ✓ Easy expansion of the functional scope by the company's own engineering staff
- ✓ Easy connection to other systems for decreed data evaluation and reporting
- ✓ Uniform administration, maintenance and system expansion due to the use of identical standard computers for all areas of the power plant
- ✓ Reduced administration and modification costs
- ✓ Reduced training costs for operating and maintenance personnel
- ✓ Reduced hardware costs due to the use of standard interfaces (this also applies to mixed configurations)
- ✓ Easy integration of new control technology developments and standards

With the use of a standard visualization system and the "soft" migration of the existing data stock, the process control level of the power station block is based on standard technology and thus directly benefits from new developments in information technology. Individual components and functions can be replaced and expanded at any time within the life cycle - always with the best technology that is available today.

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