Integrated engineering

Engineering tool integration for process industries

David Dobson, Robert Martinez

The design of a process plant is a daunting task. Numerous sensors and actuators need to be installed and connected, cables must be laid and cabinets wired. The instrumentation within the plant is specified and designed by different teams. Highly complex documentation is required to keep track of all this. It is essential that such documentation is updated as modifications are made during the lifecycle of the plant.

What is needed is powerful software that supports the designers in this complex process, improving flexibility and driving down costs while maintaining high levels of data quality and traceability. This is best achieved within a database. Rather than storing the finished documentation, for example, in the form of diagrams, the database holds the underpinning design information that enables the automatic generation of such documentation.

The engineering of a process plant starts with a conceptual design phase known as FEED (Front End Engineering and Design). In this phase, the description of the material flows through the equipment are defined. This is typically performed by an EPC (Engineer, Procure, Construct) Company. The EPC uses design tools to model the process layout in all dimensions and other tools to model the physical properties of the process, such as temperature and pressure. Once the overall design is complete the detail design and procurement processes can begin.

The project then enters the detailed engineering phase where the EPC produces piping and instrument diagrams (P&ID) using 2D computer-aided design software. Instrumentation engineers use design tools to specify the details of each sensor and actuator on the P&ID. In parallel, the control engineers develop the control strategy drawings which show how the devices need to work together in real time to control the process. The safety system undergoes a similar process resulting in the specification of cause and effect matrices to define the interlock logic.

The output of this phase is the starting point for ABB's own technical activities which, in the case of automation includes hardware engineering, application software, and Human Machine Interface (HMI). The control system engineers use the company's own programming and system configuration tools, such as those included with 800xA Engineering Studio. The main project deliverables for detailed automation and electrical engineering are shown on the right-hand side of 1.

Once designs are agreed, projects enter a manufacturing and testing phase, typically culminating in the Factory Acceptance Test (FAT) followed by shipment and installation including a Site Acceptance Test (SAT). After acceptance the system is handed over to the client for commissioning leading to operation and ongoing maintenance.

There are many variations of the above process. Functions such as telecoms, electrical systems and analytics are increasingly important and could be within ABB's scope of delivery.

All large projects have a common need to manage complexity. For a plant with tens of thousands of instruments, a huge volume of inter-related information must be managed. This information originates from diverse sources; from people working in separate teams; in separate companies, often on separate continents; each with their own set of specialized tools.

The engineering challenge 1: Globalisation of engineering

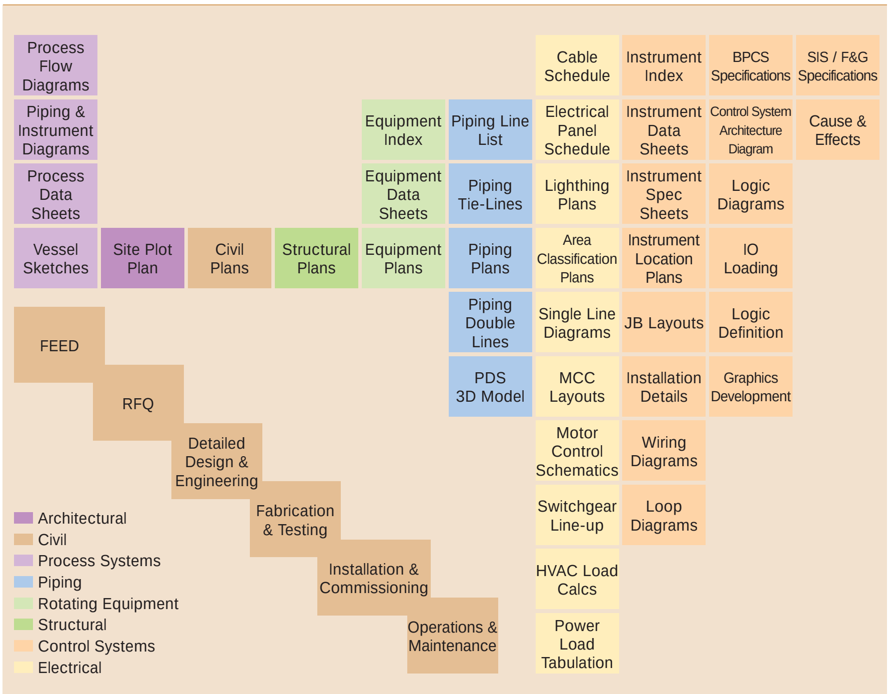
The traditional model of the project engineering lifecycle as described above is being challenged by the intense competitive pressures of globalization.

Shorter delivery schedules force project engineering partners to work in new ways and break the traditional linear engineering model in order to allow more tasks to be performed in parallel. Cost pressures force the project engineering partners to outsource more tasks to high-efficiency engineering centres. More stringent safety and environmental regulations are forcing project engineering partners to produce more and better documentation. More demanding customers insist on handover of a high-quality engineering database along with their process plant including systems to keep this data synchronized with plant changes so that the database stays "as-built".

Progress in IT is allowing project engineering partners to upgrade their own tools and add features to cope with these new challenges. A central prerequisite for this is the ability to exchange data with globally distributed teams, and to manage, with full traceability, the evolution of this data throughout the lifetime of the project. To support these requirements, engineering and design tools are becoming data- rather than document-oriented with the drawing document with rendered from this data. Data is also being increasingly standardized in neutral formats promoted by organizations such as the IEC (International Electrotechnical Commission).

As the world's largest process automation and electrical supplier, ABB is investing in tools, methods and standardisation strategies which are transforming the shared data from an engineering burden into a high-value asset

1 Plant engineering lifecycle phases and deliverables



for both project engineers and end-customers. The financial return from this effort is high as automation engineering typically accounts for half of the total control system package, and electrical engineering for more than one third of the total electrical package. Effective execution of engineering impacts on the project schedule, costs and on ABB's perceived capability to deliver such projects to a growing global market.

The engineering challenge 2: Delivering the digital asset

For end-customers, effective management of engineering information is vital for the safety and maintenance of the plant over its lifetime. For process industries, sources estimate that the value of well-managed electronic engineering data is approximately two percent of the total cost of the plant.

A large part of this engineering information is design data for tens of thousands of instruments and their input/output (I/O). For a process plant, instrumentation is about 10 percent of the capital expenditure (CAPEX) but about 20 percent of the operational expenditures (OPEX). Engineering companies eager to win contracts focus on reducing the former, but it is OPEX which most affects the operator's bottom line.

It should therefore be no surprise that end-customers are pushing for greater standardization and improved handling of process engineering information, as recommended by industry consultants ARC in a recent report 1.

The call for greater inter-operability and for vendor independence of engineering design data is a frequent request in many areas other than process design. In device communication, for example, the data handled is real-time instead of design data, but the underlying issues are the same. For example, vendors who acted early to embrace open fieldbus standards had a sales advantage As the technology opened the door for a range of new products and services such as asset management.

The engineering challenge 3: Integrate automation and instrumentation design

There are a number of instrumentation design software packages on the market. These packages attempt to centralize plant instrumentation design information so that it can be easily accessed, manipulated and updated, thus ensuring consistency across the different instrument tasks and deliverables. All such packages address the project lifecycle information requirements from early conceptual design and engineering to construction, maintenance and decommissioning. The commonly used packages include Intergraph's SmartPlant® Instrumentation (SPI) and Innotec's Comos® PT. Currently SmartPlant® Instrumentation (formerly INtools) has a dominant position worldwide, particularly with the major EPCs, while Comos PT's market is mainly European, but growing.

These packages use a database to hold all data related to the design of the instrumentation system – from the field instrument (sensor element or valve) through to the connection to the control system. This data is either obtained from other design sources e. g. P&IDs, or entered during the design process. Outputs from the system include instrument schedules; hook-up details for purchasing and installation; panel designs; cabling details and alarm data. All these are very relevant to ABB's project engineering processes. The data flows are summarized in 3.

2 Extract from an ARC insight document Oct.28, 2004

From an operations perspective, engineering & design tools coupled with information management solutions form the basis of lifecycle engineering. Having this data available greatly reduces plant downtime, improves plant performance, and assists in better plant revamp planning.

These packages may also have modules or interfaces that facilitate valve and orifice plate calculations. They enable significant parts of the control system to be automatically configured, allow the telecommunications system to be engineered and also enable interfacing with maintenance, calibration and purchasing systems.

ABB is working together with Intergraph and Innotec looking at ways of making instrumentation design data available to all the engineering partners and their systems. The three key technologies being used to achieve this are:

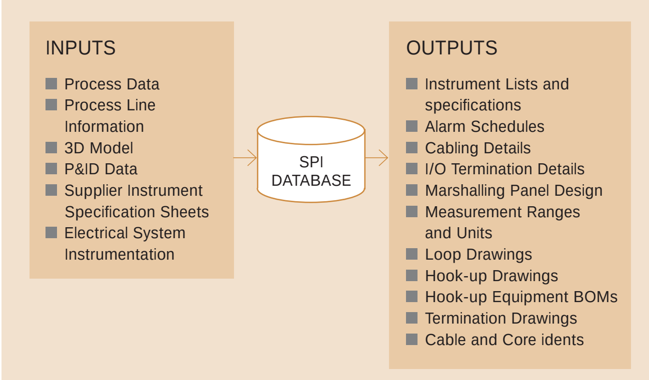
- Shared type-libraries and a mechanism for mapping between these types
- Vendor-neutral XML-based format for data exchange to preserve object relationships
- Web services communication for open transport between vendors' systems

The first result of these efforts is realized as a shared type-library for S800 and S900 I/O hardware and ABB's Process Engineering Tool Integration (PETI) application software, as discussed in the following sections.

Shared libraries: Accelerating hardware engineering

In order to help instrumentation and hardware design engineers to use the SPI package efficiently, a set of definition files has been developed by ABB to represent the most common 800xA hardware components. Once imported into SPI, these libraries can be used to create objects such as

3 Plant instrument engineering data inputs and outputs



I/O modules. The SPI user can drag and drop the desired I/O module type onto the project window. The field signals can then be allocated to the I/O channels and automatically cross-wired to the field terminals and IS barriers as required. Drawings may then be generated from the SPI system showing the correct termination numbers, terminal layout, cable and core numbering etc.

S800 and S900 I/O definition files are available for download by third parties from the Intergraph website, or for ABB users only, from ABB's internal SolutionBank.

The expanded SPI Reference Explorer folder in /4 shows some of the defined combinations of S800 I/O modules and termination units. The "My List" option allows a subset of I/O modules and bases to be defined for use on a particular project, thus aiding design standardization.

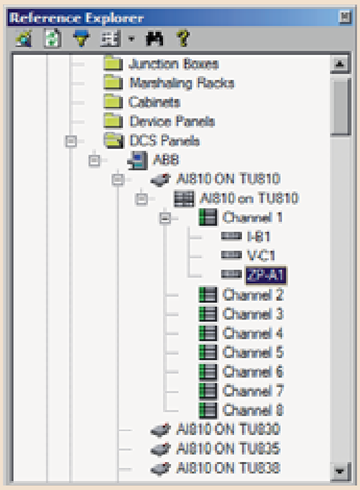
800xA has, from its inception, used the idea of type libraries to define frequently used objects within the automation project's applications. These libraries have been developed for a number of industrial sectors e.g., chemical and pharmaceutical, oil and gas, utilities and for common functional areas such as field devices, equipment modules and safety applications.

The extensive use of type-libraries is a key element in automating the generation of application objects which are based on information from the engineering database system used by the Instrumentation and Control System Hardware Engineers. ABB's Process Engineering Tool Integration (PETI) provides a mechanism to map interconnections between SPI instrument entities and the 800xA aspect object types. Instrument tags created in SPI are used to auto-create the corresponding objects within the 800xA control and functional structures. The SPI property is then used to set attribute values in 800xA. Once the object has been created, changes made to parameters during installation and commissioning can be automatically written back to the SPI database, maintaining this as the "master".

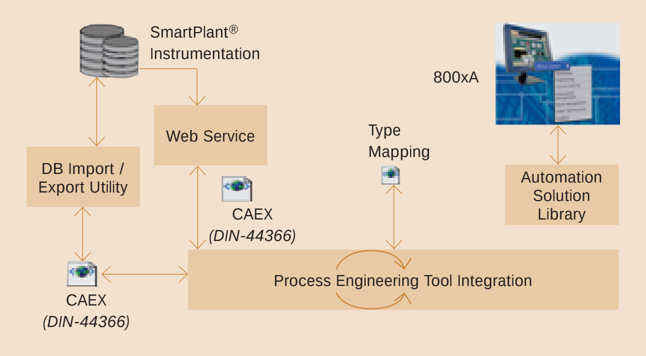
An open approach: Neutral format for data exchange and web services

The project engineering partners use a wide variety of tools with incompatible data representation. As these tool providers release new versions, formats from earlier versions become obsolete. Preserving the design data across tools and across the decades of a process plant's lifecycle is the motivation for using a standard format based on XML to represent design data. The CAEX standard XML-based format originated within ABB. It is now an approved DIN standard and currently under review by IEC. This ultra-flexible format is used within PETI to represent plant design data for bi-directional transport between the engineering system and 800xA, as shown in 5.

4 ABB S800 Hardware type library for SPI



5 Data Transport using CAEX between SmartPlant and 800xA



PETI offers two different ways to access the engineering database. A stand-alone import/export utility can be used by the EPC to export the data as a file for subsequent import by the control system engineer. Alternatively, a web service can be used to extract data and transfer it electronically. In either case the data is transferred in CAEX format.

Integrated Tools in Use: Experience from Projects

The PETI package has been used successfully on one recent chemical and pharmaceutical project in the UK, and is currently being used on several oil and gas projects in Norway and the UK.

UK ChemPharm and O&G

In the UK ChemPharm project, the ABB hardware design engineer worked within the EPC's offices using their SmartPlant® Instrumentation system to design the I/O and controller cabinetry supplied by ABB. The hardwired I/O system adopted was S900 and a significant amount of Foundation Fieldbus instrumentation was also used, particularly for control valves. The SPI was used to generate "strip" drawings, showing all terminations and interconnecting wiring and pneumatics. These were used in conjunction with externally-prepared standard panel designs to build the 12 panels required. The same documentation was used for inspection and testing. No other detailed design documentation was required.

6 shows one of the completed panels with examples of the SPI documentation used. A similar approach is now being used for two UK based oil and gas projects but with the ABB hardware design engineers based in the ABB offices and working on the EPC's SmartPlant® Instrumentation system. These systems will remotely use terminal server technology to maintain system security.

Norwegian oil and gas

BP has been supportive in the use of PETI on the Valhall project based in Norway and have guided ABB in extending PETI to support an online version of their alarm response manual (ARM). The ARM data is centralized in SPI but will be shared with operator graphic displays on ABB's 800xA system. PETI enables experienced operators and process engineers to view and, if the security level permits, modify alarm settings as a single shared dataset, allowing the master engineering database to be kept "as-built" throughout the lifetime of the plant.

6 Completed cabinet with an example of wiring diagrams automatically generated with PETI

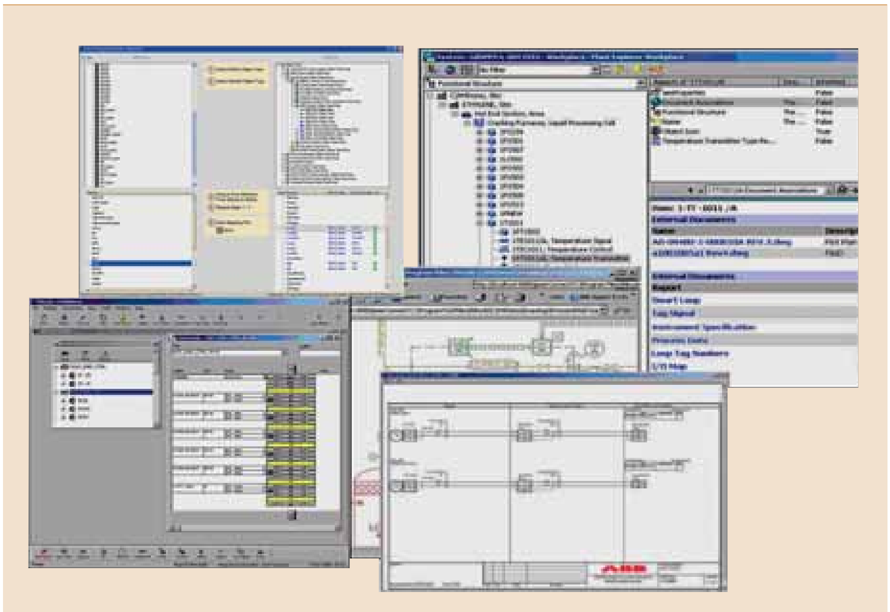
End-customers are also interested in the ability for 800xA operators to access SPI loop drawings, instrument specifications and other documents directly via the operator workplace. These documents, which are relevant to operations and maintenance functions, are rendered live from the SPI database server, where they can readily be maintained "as-built". Some examples of this 800xA Workplace integration are shown in the screenshots in 7.

One outcome of these projects has been a refinement of engineering work-flows between customer, EPC, ABB and other package suppliers. Early agreement between all parties on standards to be used for libraries and data transfer between systems is essential.

SmartPlant integration: An enabler for a main automation contractor

In some large contracts, the automation vendor has a expanded role typically known as "Main Automation Contractor" (MAC). In this role, ABB can be additionally responsible for the instrumentation scope, creating the instrument list from the received P&IDs and ensuring each instrument is fully specified and capable of fulfilling its process line function. A similar level of responsibility with respect to switchgear, cabling and the electrical instrumentation engineering applies if the electrical package is included within ABB's scope.

7 PETI screenshot (top left) and workplace integration of SPI with 800xA



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In addition to these engineering responsibilities come the added data management tasks related to purchasing, installation, commissioning and documenting all these devices.

The data integration approach described here is a key enabler for ABB in this strategic role. Instrument lists will no longer be issued to the MAC by the EPC. Effective execution requires that this interface be automated, and in addition end-customers will expect that a MAC contractor's database will be fully integrated with other design databases, for example P&IDs and 3D plant models. Use of SPI as the instrumentation and panel design tool will help minimize the risks of taking the MAC role. The SPI database has out-of-the-box synchronization with P&ID, Electrical and 3D design, and because of the PETI interface also with 800xA.

The systems businesses within ABB already function as system integrators. Using this new technology ABB can additionally develop the MAC role to become the data integrator. The engineering database system will deliver advantages for both the owner/operator and ABB during the plant lifecycle.

David Dobson
ABB UK Process Industries
St. Neots, UK
david.dobson@gb.abb.com

Robert Martinez
ABB Oil&Gas Strategic R&D
Billingstad, Norway
robert.martinez@no.abb.com