Prejob briefing using process data and tagout / line-up data on 2D drawings

DIONIS François[1], RIBIERE Alain[2], and AUBIN Renaud[3]

1. EDF/R&D, STEP Department, 78401 Chatou, France, (francois.dionis@edf.fr)
2. EDF/R&D, STEP Department, 78401 Chatou, France, (alain.ribieres@edf.fr)
3. EDF/R&D, STEP Department, 78401 Chatou, France, (renaud.aubin@edf.fr)

Abstract: A research project is ongoing at Électricite de France (EDF) to provide advanced aids for plant operation and maintenance, trying to bridge the gap of plant knowledge between its designing and operation. This paper presents the basic concept to merge multiple sources of data on the same 2D CAD drawings for power plant operation. Also introduced are the software tools thus far developed and tested to apply for plant workers to conduct on prejob briefing by using process data and tagout / line-up data on 2D drawings. The development and application of the tools has been rapidly advancing with the cooperation between EDF R&D team and plant personnel.
Keyword: prejob briefing; process data; tagout; 2D drawing; database

1 Introduction

Today, 2D CAD technology has been commonly used in various processes of designing the nuclear power plants with its extended functionalities to realize multiple links with databases and 3D tools. But paper drawings and documents have been still commonly used for the area of plant maintenance. Therefore, Électricité de France (EDF) initiated modernizing the IT system for operation management as an advanced computerized support for operation and maintenance activities.

In 2008 EDF has launched on an important project to modernize its IT system for operation management, with strong motivation that the major components such as document management, maintenance database, operation database and CAD chain should be modernized. Within the framework of this project, the Power Generation Division of EDF had asked the R&D Division to propose new modern concepts and tools to get benefits from the significant investments. Then, the authors' R&D Division had proposed a method of using 2D CAD technologies for bridging from plant design to its operation and further for linking between operation and maintenance.

This is a new way of describing and performing plant procedures, line-ups, tagouts and prejob briefing for plant operation or outage, to replace traditional "table vision" (*i.e.*, look up various paper tables in papers to conduct various operation activities). The main goal of the authors' proposal was to afford all the members of the operation teams with the ability of better understanding the content of the operation documents that describe their activities.

Toward this direction, the authors first worked at modernizing the 2D CAD chain which was dedicated to the application for the designing nuclear reactors, and then they continued to propose new tools which look like "Google Map" vision for plant operation activities [1-5].

This paper presents the summaries of the authors' research project results until now, which tries to bridge the gap between the areas of design and operation by using the same 2D technology for the both areas, with the aim of providing advanced aids for plant operation and maintenance.

2 CAD Drawings

2.1 Existing drawings versus new drawings

In a majority of nuclear power plants, many CAD drawings such as piping and instrumentation diagram (P&ID), electrical diagrams, mechanical drawings and so on, are now difficult to modify, due to the obsolescence of their using support software systems. At this point, a difficult question arises: Should we convert the existing CAD drawings to new formats or should we redevelop new sets of CAD drawings to reach standards? The answer to this question depends mainly on the following criteria: (i) What is

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the format of the existing CAD drawings such as for P&ID, Electrical, diagrams and so on? and (ii) Is it more economical to convert or update the existing drawings than to redevelop new CAD drawings? For this question, you can choose either of the both.

2.2 A generic 2D CAD format developed by EDF

Rather than transferring existing 2D CAD drawings directly into new software, they at EDF decided to first replace a part of the existing out-of-date CAD system with a more up-to-date open system which is called 2D NGC Kernel at EDF, by the way as shown in the diagram in Fig. 1. The Engineering Division of EDF has thus opted to re-use existing CAD drawings and to import them into the new software solution. Wherein the employed new format is a free XML format which is called NGC ("Noyau Générique de CAO " in French or "Generic CAD Kernel" in English).

The structure of an XML NGC file is composed of two sections as below:

- The first section includes the definition of the business objects and all their relationships, for example the pipes and the valves as well as the link between the both, and
- The second section includes the definition of the graphical elements (primitives) representing the visible part of the drawings (curves, lines, and so on).

This format is completely generic and therefore independent of any CAD software you use. With XML transformations or file format transformations, it is also possible to recover specific drawings and export them to a "kind-of" NGC format. Therefore, the developed concept is not only applicable within EDF but also valid in other companies which use commercially available CAD software formats.

The advantage of the EDF approach lies in that the solution is very generic and independent of any type of drawings such as P&ID, mechanical, electrical, Instrumentation and Control (I&C), *etc.*, and of any type of format. This makes the solution more adaptable to different types of business and also more economical than other method.

The graphical editor at the base of the architecture is AutoCAD, which can also export the drawings in standard formats if needed. And in the long-term perspective, AutoCAD can be easily replaced by another edition of software without significant modification of the CAD architecture.

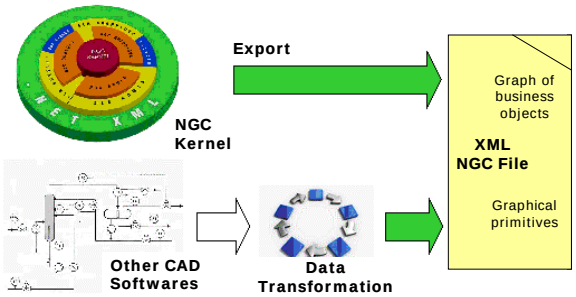

Fig. 1 Conversion to a generic 2D CAD format.

3 Links between CAD business objects and other sources of data

3.1 Business objects are central

The word "business object" here means any target of operation and maintenance work at nuclear power plant. With the usage of NGC format in the IT system for operation and maintenance, each business object in the IT system now becomes a part of the drawings, and it can be linked to an operation database such as Shift Operations Management System (eSOMS), Maximo, or Asset Suite. Those databases dedicated to operation and/or maintenance are called EAM (Enterprise Asset Management) solutions. And any business object can be also linked to various process data provided by the I&C system.

As first example of business object, take a valve, a switch, a pump, a pipe, *etc.* Each of them is not only displayed on CAD drawings as an object but also displayed in the database as a record, and the both are linked with each other. The link between the CAD world and the database world can be easily established.

As second example, take each process data provided by the I&C system. It is also a kind of business object. Then it becomes possible to connect a certain object in the CAD drawings with a certain process data directly and automatically. This is the case for P&ID diagrams, for electrical, mechanical or I&C drawings.

3.2 Overview of the architecture

In order to easily promote new operation tools by using 2D drawing and operation data, a specific software architecture has been developed by

EDF/R&D. An open architecture for linking 2D CAD files to multiple sources of data is shown in Fig.2, where the basic idea is to allow end users to interact graphically with operation and maintenance data, and to access different sources of data such as EAM, process data, outage schedule, *etc*. In Fig.2, the foundation of this architecture is Graphical Enhancement Library (GEL) which is the baseline of generic functions such as NGC transformation, highlight of business object, *etc*.

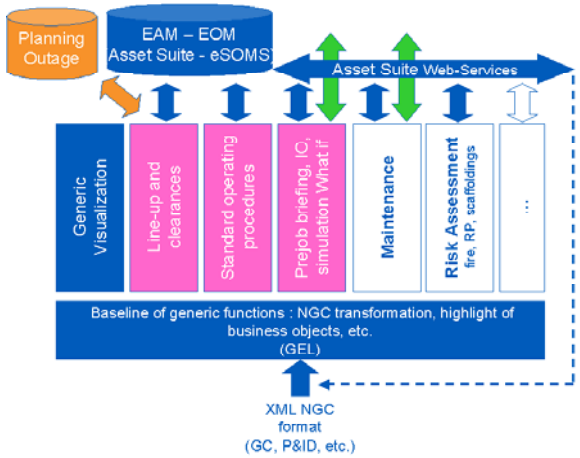

Fig. 2 An open architecture for linking 2D CAD files to multiple sources of data.

The GEL provides several common services as listed below to the final applications;

- reads XML NGC files,
- transforms the XML files into Scalable Vector Graphics (SVG) format for visualization,
- transforms the XML files into a graph of business objects,
- permits visualization,
- permits interaction with graphical primitives to reach business objects,
- offers a set of primitives for graphical enhancement, and
- enables users to export enhanced drawings (image file, SVG, PDF).

In Fig.2, each application based on GEL has to manage its interactions with data input or outputs. For example, the alignment procedures and clearances module (Tagout) manages its interface with an EAM (or with any other potential source of data), and with a 2D documents server.

The first application developed and industrialized by EDF on the basis of GEL, was a generic module of drawing visualization. It has been already used for visualizing the drawings of P&ID and plant room layout.

This module has been updated with the GEL technology so that it can access alignment procedures and clearance data and then show the position of the equipments over the P&ID drawing.

Based on the same idea, additional application has been developed for the enhancement of plant room drawings for radioactive protection, maintenance, risks management, *etc*.

4 Tagouts and alignments preparation on drawings

An important area of system improvement as illustrated in Fig.2 is to endow the system ability to view or modify various operation and/or maintenance processes such as alignment checklists, clearances, radiations zones, scaffoldings, chemical risks, *etc*., directly on 2D drawings.

Plant operation and/or maintenance data such as work orders, tag out, *etc*., are generally stored and managed in an EAM database. The 2D “plug in” developed on GEL enables to view and/or modify the operation/maintenance data (at each steps of the workflow) from the EAM using the 2D drawing.

For the demonstration that the proposed system concept is feasible, the EDF R&D team has developed a prototype system that enables users to graphically modify alignment checklists or tagout created in Asset Suite or eSOMS directly from a drawing. From Asset Suite or eSOMS, the user can directly access and display a graphical representation of the tagout or alignment checklist about position of valves, state of pumps, state of flows, *etc*. Once displayed graphically, then tagout or checklist can be modified directly onto the drawing. Once it is done, then user can return to Asset Suite or eSOMS. Further any modifications made on the drawing are automatically transferred to Asset Suite or eSOMS.

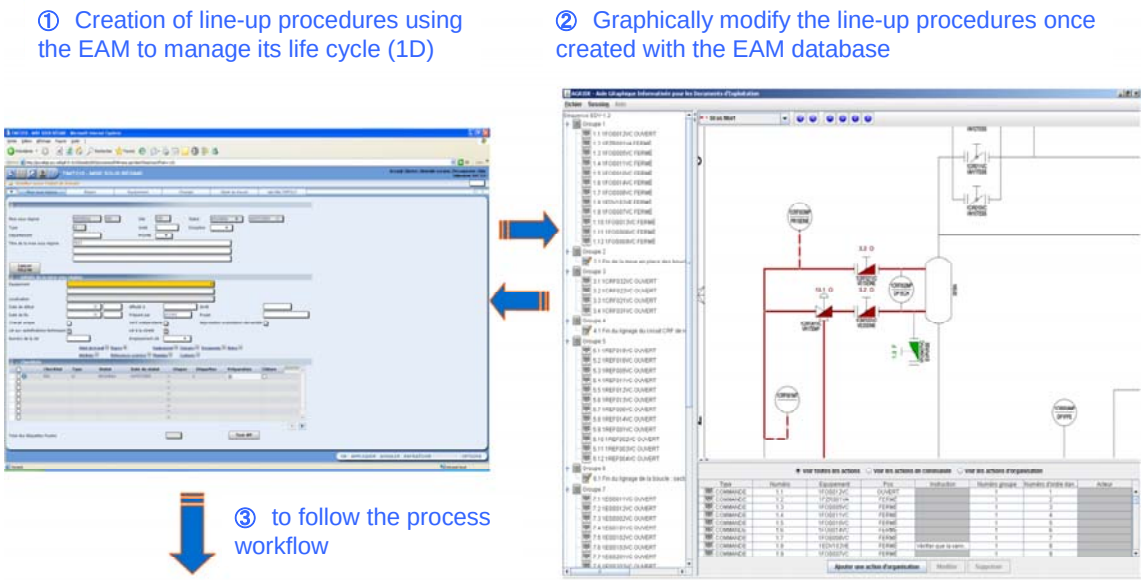

Fig. 3 Graphical way to modify operation documents.

Figure 3 shows how a user can switch from Asset Suite to the drawing by using a system function of "graphical plug-in". Wherein an online help option will guide the user on how to use the 2D drawing interface as well as to understand the type of data required.

This application allows the setting of the position of equipments, highlighting the involved pipes, drawing temporary pipes, adding comments, *etc*., in order to prepare for line-up procedures, clearances, or normal operation procedures. It also provides additional features such as proposal of the "clearance bubble", reversal of the alignment procedures, grouping of actions, ordering of actions to perform, definition of the actor (field operator, clearances officer, operator) who will perform the action, *etc*. Standard helps such as navigation through drawings, search of equipments, copy and paste of documents, generation of paper procedures, print of enhanced drawings, *etc*. are also available.

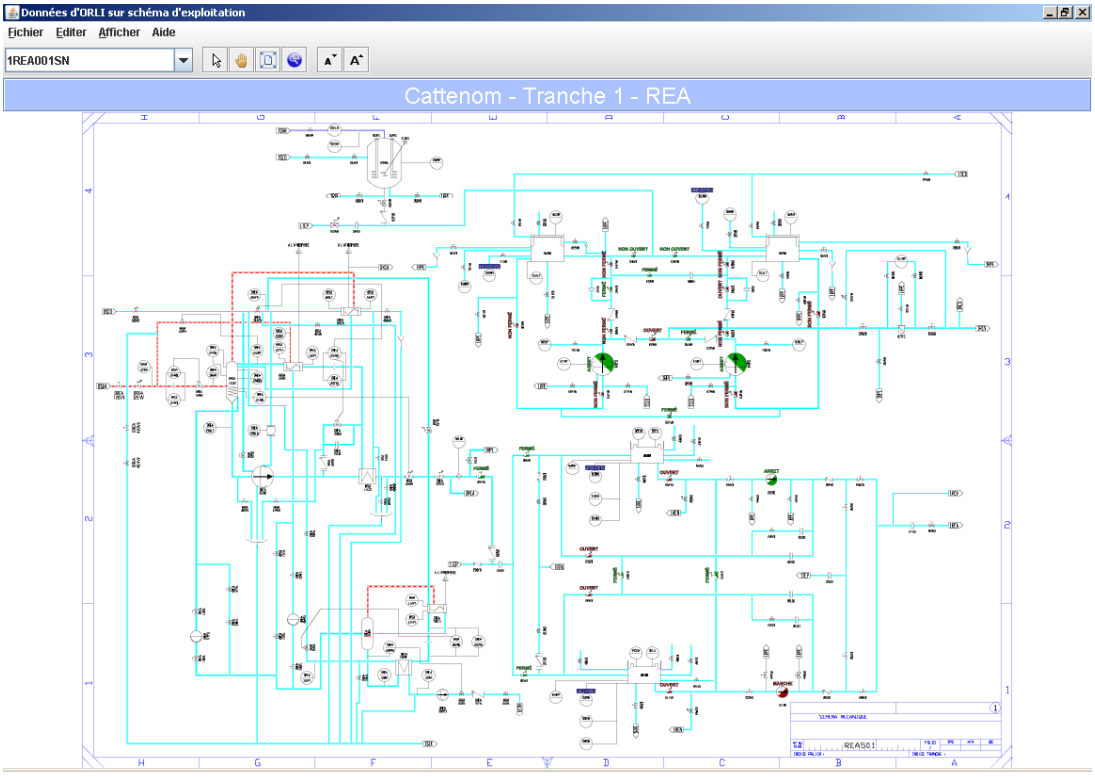

Fig. 4 Indication of process data on P&ID.

5 Process data visualization on P&ID

Once the clearances and the alignments have been prepared on P&ID, it is very useful to check whether or not the state of plant is really compliant with them just prior to performing the required actions in the field. To do this, the EDF R&D team hit upon the idea to show on the P&ID the change of information from (i) the state of equipments to be prepared, to (ii) the real state of the plant provided by the I&C system. (See Fig. 4) Thus, it becomes easy to detect any potential discrepancy on the same drawing.

Process data can be either analog values or logical values. The analog values are directly presented above the sensors in tags. (See Fig. 5) The tags can be moved by the user, in order to avoid being hidden information on the drawing.

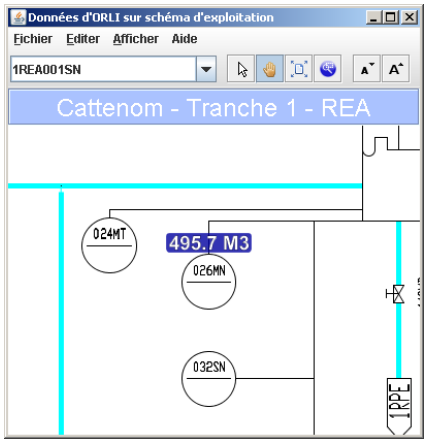

Fig. 5 Indication of analog values 495.7 m^3.

The logical values change the appearance of the monitored equipments, by the same way as the preparation of operation documents. (See Fig. 6)

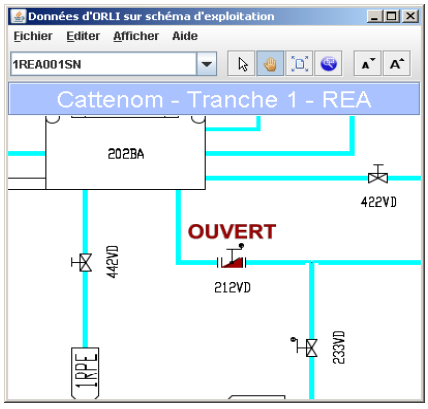

Fig. 6 Indication of logical values.
("OUVERT" means "OPEN" in English)

For each process value, it is possible to have access to more information.

Additional features are provided such as access to data history for each value or comparison between different power plants, for example, in order to optimize the process. (See Fig. 7)

The process data shown by the application can be filtered by type, elementary system or directly selected from a list of available values.

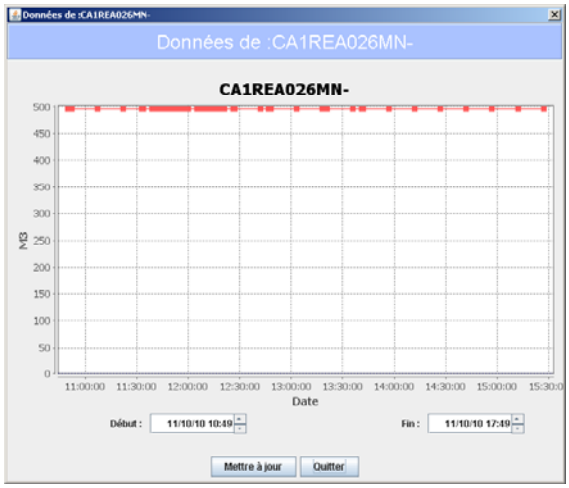

Fig.7 Direct access to time history of a parameter.

6 Rapid application design method

The software architecture concept, modules and tools as mentioned in the preceding chapters 2 to 5 has been developed and tested to apply for the support of operation and maintenance workers for prejob briefing using process data and tagout / line-up data on 2D drawings. The development and application of the tools has been rapidly advancing with the cooperation between the developer (EDF R&D team) and end users (plant personnel).

6.1 The working with end users

The first R&D prototype has been developed in EDF R&D lab in Chatou (Paris) over a period of about six months, during when continuous improvement had been made based on the feedback of end user testing. Clearance managers as well as field operators had used the prototype for the testing. After the testing period, it was decided to move the prototype to one site and see how it would perform under real conditions. The Penly Nuclear Power Plant (1300 MW PWR) near Dieppe (North of France) was selected as the pilot project. Today the prototype has been deployed and is being used by the personnel of

Penly plant (mostly clearance managers and field operators) to create, modify, visualize clearances and alignment checklist using the graphical interface. Alignment checklists have been graphically created for eight elementary systems. The module dedicated to process data visualization has been in testing at Penly plant.

6.2 The working with the software supplier

During afore-mentioned field test of the developed system, an important effort has been made to standardize the data exchange interface between the R&D prototype and the Ventyx software, in order to be able to interact with both the Ventyx EAM (Asset Suite Tagout) and EOM (eSOMS Checklist) solutions. Web Services have been developed and used with the Asset Suite. However, the interface with eSOMS is based on an XML file. The authors of this paper expect to reuse the Asset Suite Web Services in future development of the Web Version of the eSOMS interface.

The development and improvement of the prototype has been still continuing. Additional interfaces are currently being developed that will bring together clearances and alignment checklist into one graphical view. Using Asset Suite, all conflicts will be resolved and a final validation will be performed by using the graphical visualization.

7 Conclusion

A research project is ongoing at Électricité de France (EDF) to provide advanced aids for the staffs of plant operation and maintenance trying to bridge the gap of plant knowledge between its designing and operation. The basic concept employed in this project was to merge multiple sources of data on the same 2D CAD drawings for power plant operation. The software tools have been developed and tested to apply for plant workers to conduct on prejob briefing by using process data and tagout / line-up data on 2D drawings. Since the beginning of the IT system modernization of the nuclear fleet, the generic NGC technology has been industrialized, and it is now used for mechanical drawings, 2D room drawings and PLC programming for 1300 MW reactor.

The GEL library has also been used for developing new visualization tools for radioactivity or alignment procedures, in interaction with the operation database. In these two cases, the concept of operation “Google Map” has been implemented.

Today, the project continues in the Penly 1300 MW plant, with the development of a new NGC application for mechanical plant functional drawings (PFD), and new GEL tools for clearances and alignment procedures design, in accordance with the outage schedule.

Acknowledgments

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Nomenclatures

EAM	Enterprise Asset Management
EOM	Enterprise Operations Management
eSOMS	Shift Operations Management System
GEL	Graphical Enhancement Library
I&C	Instrumentation and Control
NGC	Noyau Générique de CAO (Generic CAD Kernel)
P & ID	Piping & Instrumentation Diagram
PLC	Programmable Logic Controller
SVC	Scalable Vector Graphics

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