# ANNUNCIATION - BUILDING PRODUCT TEAM CAPABILITIES TO SUPPORT UTILITY OPERATIONAL IMPROVEMENT

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## ABSTRACT

The purpose of this paper is to describe an AECL initiative to enhance the capabilities to assist utilities with undertaking annunciation improvement. This initiative was undertaken to complement a recent annunciation product upgrade, and in anticipation of developing commercial opportunities to assist Canadian and foreign utilities with control room annunciation improvement.

Utilities are relying more and more on external engineering product and service providers to meet their plant support needs as they reduce in-house staffing to lower ongoing support costs. This evolving commercial environment places new demands on product and service providers, and provides new opportunities for increasing the proportion of product and service provider participation in plant improvement projects.

This paper outlines recent AECL experience in the annunciation product area. The paper discusses the rationale for product support capability improvement, discusses the approaches undertaken, describes lessons learned, and outlines a proposed utility support model for assisting with future annunciation improvements.

## BACKGROUND

Annunciation is a key plant information system that alerts Operations staff to important changes in plant processes and systems. Operational experience at nuclear stations worldwide has shown that many annunciation implementations do not provide the support needed by Operations staff in all plant situations as originally intended [1]. Problems with chronic nuisance alarm generation, and alarm flooding in upsets and outages, and indication of alarm importance independent of operational state are just a few of the common limitations identified by utilities with current annunciation implementations [2,3].

To address utility needs for annunciation improvement in CANDU plants, AECL in partnership with Canadian CANDU utilities undertook an annunciation improvement program in the early nineties under CANDU Owners Group sponsorship. The outcome of the four year research program was the development and simulator validation of alarm

processing and display, and information presentation techniques that provided practical and effective solutions to key operational deficiencies with earlier annunciation implementations [4]. Following the completion of the research program, AECL invested in a further six years of engineering development and product enhancement to bring the annunciation improvements and supporting system analysis and configuration tools to readiness for utility application [5]. This engineering development program was completed in 2002 and the first plant deployment of improved annunciation capabilities has been provided to the Qinshan plant in China.

The improved annunciation capabilities consist of a series of detection, information processing and presentation functions called the CANDU Annunciation Message List System (CAMLS). Key CAMLS features and their operational impacts include [6]:

- Central Alarm Display - Separation of Fault alarms (i.e., problems) and Status alarms (i.e., equipment feedback) into separate list displays removes the need for operations staff to mentally sort the alarm stream in real-time. Listing of Fault alarms by priority ensures that the most important problems are always visible.

- Determination of Operating Context - Continuous calculation of the plant-state enables alarms to be presented consistent with their operational relevance and importance. Three dimensions, reactor power level, heat-sink state, and turbine/generator state, are used in determining plant-state for annunciation purposes.

- Relevance Conditioning - Selective suppression of alarms irrelevant to the current operating goals, plant operating situation and equipment configuration substantially simplify operator alarm state interpretation and diagnosis. Conditioning factors can include plant-state, events or local process and equipment states.

- Dynamic Prioritization - The re-ordering of Fault alarms by priority as a function of plant operating context always ensures display of the most important aspects of the plant alarm state with changing operating conditions.

- Similar Alarm Coalescing - Replacement of several similar Fault alarms with a single summary Fault alarm effectively conveys the same alarm state information while reducing the number of displayed alarms.

- Functional Alarm Generation - New alarms to support higher-level interpretation of plant alarm state can be created based on the logical combination of process conditions and alarms.

- Audible Alerting and Acknowledgment - Audible alerts are only provided for new Fault alarms. Following operator silence, acknowledgment, or reset actions, subsequent audible alerts to new Fault alarms are suppressed for a selectable period. This approach reduces horn silence and alarm acknowledgment demands, and eliminates a current source of control room annoyance.

- Electronic Display of Alarm Response Information - Electronically linking displayed alarms with support information, such as alarm response procedures, simplifies control room staff access to response guidance. Control room staff can now focus on the primary alarm response tasks of interpretation and mitigation, rather than being delayed in the secondary task of manual response guidance access.

- User Configurable Alarm Views - Through a console-based annunciation display, operators can select and display locally, filtered views of the Fault, Status and Alarm History lists. With this capability, customized views of alarm information for a specific system or function can be configured to support operational tasks (e.g., heat sink management in outages, or safety system testing).

CAMLS is implemented as a group of software functions within the AECL Advanced Control Centre Information System (ACCIS) product. ACCIS is a generic display, monitoring and supervisory control system that has been developed to meet the evolving CANDU utility needs for better and expanded display, management and distribution of real-time plant information [5]. ACCIS is implemented using commercially available system software and hardware, and AECL-developed data management and presentation software. For retrofit applications, ACCIS can be configured to enhance the information presentation of DCC display and panel instrumentation in current CANDU plants. In new plant designs such as the Advanced CANDU Reactor 700, ACCIS will serve as the primary platform for control centre information display, as well as management and distribution of plant information outside the control centre environment.

## RATIONALE FOR PRODUCT SUPPORT ENHANCEMENT

Product support involves execution of a number of functions spanning initial system configuration and delivery, customer training, in-plant commissioning, and ongoing maintenance and enhancement during operational use. The success of these functions is primarily dependent on human resources and capable tools. Critical to successful product support delivery is a team with:

- Knowledge of customer needs and operational practices, and product capabilities,
- Skills in product configuration, commissioning, and customer training,
- Experience in application assessment and refinement, and
- Access to effective product configuration and maintenance tools.

Annunciation is a plant information system that requires extensive configuration prior to operational use. The configuration phase establishes alarm properties and relationships consistent with equipment design purpose and utility operational practices. To complete the configuration of an annunciation system, an implementation team must be knowledgeable in the following areas:

- Plant Operations - Knowledge of annunciation needs and usage in supporting plant operations in all operational states,

- Plant Systems Design - Knowledge of the design purpose and implementation aspects of individual alarms for each plant system, and

- Annunciation Application - Knowledge of annunciation configuration capabilities, principles and application practices.

During the original annunciation research program, AECL had developed staff with knowledge and skills in plant operations and annunciation application to complement their traditional plant system design expertise. In addition, AECL had continued refinement and extension of database tools to support CAMLS configuration and on-going maintenance.

As the completion of the annunciation engineering development program approached and utilities began expressing interest in embarking on annunciation improvement, AECL realized, that a transfer of plant operations and annunciation application knowledge and skills to a broader base of staff would be beneficial, in order to enhance annunciation product support and service capabilities.

## APPROACH

A program with the following elements was undertaken to broaden and enhance staff knowledge and skill development for annunciation product support purposes:

- Needs Assessment - Re-examination of the knowledge and skills required to support utility familiarization with product capabilities, initial product configuration, customer training and site commissioning was undertaken. These activities are expected to be the CAMLS product support focus for the next few years during initial utility deployments. The experience with the initial deployment of CAMLS annunciation capabilities at the Qinshan plant was reviewed to identify aspects of these product support activities that proved successful and those that require improvement.

- Staff Selection

  Staff were selected to strengthen CAMLS application depth and to broaden CAMLS awareness within AECL product application groups outside the product development team. A group of five AECL engineering staff from three groups were selected to receive CAMLS product support training. Three persons were members of the ACCIS product development team and thus were very familiar with CAMLS capabilities. Two persons were selected from other product development areas (i.e., system health monitoring and advanced control centres). Four of these persons had operational or commissioning experience with control room information systems from former projects.

- Training

  The product support training was organized into three segments as follows:

- Instruction - This training consisted of 3 1/2 days of group instruction in how annunciation is used to support plant operations, how CAMLS capabilities can be configured to support specific operational needs, and CAMLS alarm analysis and configuration methods.

- Analysis Practice - This training consisted of 2 to 3 days of individual self-application of CAMLS alarm analysis methods. Participants were assigned groups of alarms for fault/status categorization, prioritization by plant state, and definition of conditioning relationships applicable to plant upsets. Some alarms were assigned to two or more participants to encourage comparison and discussion of individual analysis decisions. An upset scenario from the Qinshan training simulator was used as the source of alarms for the analysis practice.

- Review - This training consisted of 1 1/2 days of group review and rationalization of individual alarm analysis results. An outcome of this review was the identification of several generic application principles for guiding development of plant specific CAMLS configurations on future projects. Analysts referred to the existing alarm response procedures as well as to design information such as the plant Functional and Operational Bases in determining the treatment of each alarm, in each operational context.

- Configuration Practice

  To reinforce CAMLS alarm analysis and configuration skills, the training participants developed a partial CAMLS configuration based on their alarm analyses from the training course. Analysis information from each participant was consolidated into a common database using the ACCIS Configuration and Alarm Analysis Tool. This database information was then used to configure an operational CAMLS system. Replay of the alarm stream for the Qinshan upset scenario enabled comparison of the alarm display behaviour between conventional DCC annunciation and the CAMLS configuration.

## LESSONS LEARNED

In undertaking this program the following lessons were learned:

- Alarm Inflation - With the shift to replacement of analog with digital instruments, and an increase in plant instrumentation, there has been an inflation of plant alarm sources. While many of these alarms improve equipment diagnostics, their numbers can further complicate operations staff understanding of alarm-state during commissioning, normal maneuvers, upsets, and outages. Additional screening criteria need to be established to provide guidance to designers on what alarms should and shouldn't be created for control room annunciation.

- Alarm Basis - The original basis for many alarms is no longer documented. A re-identification of the purpose and continued need for some alarms should be undertaken during future annunciation upgrade or new plant projects.

- Analyst Selection - Design staff can make relevant configuration decisions from an operational perspective once they understand and appreciate utility operational practices and needs.

- Team Consensus - The use of operational and application principles are useful in building application team consensus. Such a team consensus helps simplify and standardize design decisions across an annunciation configuration.

- Alarm Response Information - The availability of alarm response information is essential for analysts configuring a CAMLS application. For retrofit applications, this information is readily available. For new plants, response information from previous plants can serve as initial guidance for alarm system configuration decisions.

- Analysis Simplification - The analysis of plant alarms in support of a CAMLS configuration need not be undertaken on an individual alarm basis. Substantial opportunities for analysis simplification, standardization, and effort reduction are available when alarms are first grouped by common purpose.

- Configuration Tools - Application of database information tools can substantially simplify and minimize the effort required to define, manage and maintain alarm information specific to an annunciation configuration.

- Customer Training - Formal training of utility staff is required to support CAMLS application deployment and operational adoption. Training should incorporate the following components: operational usage and benefits, adjustments to operational practices, application configuration, simulator practice, and maintenance.

- Commissioning States - During commissioning, all alarm information is useful from a diagnostic perspective, however all plant systems may not be functional. In such instances, an annunciation system configured for plant operation may be less effective in supporting commissioning staff needs for alarm information. The definition of commissioning as well as plant operation configurations for the annunciation system may be considered in future applications.

- Configuration Review - Operations staff should be part of the review and refinement cycle for initial CAMLS configurations. Design staff can successfully undertake the bulk of configuration decisions, however the perspective of operations staff can be useful to confirm configuration soundness and identify opportunities for refinement.

- Cost Reduction - Initial configuration, long-term support, and product feature enhancement can be undertaken at less cost if utilities agree to some standardization of future annunciation configurations.

## UTILITY SUPPORT MODEL

As AECL and CANDU utilities introduce advanced control room operational support functionality like CAMLS annunciation, a generic model for deployment and long term support of the application and underlying software platform is required. Key performance criteria for the model are delivery of effective support at minimum cost, and long-term maintainability.

To support the Qinshan implementation of plant display and CAMLS annunciation, AECL considered a number of approaches, and concluded the most effective model is based on the following division of responsibilities:

- AECL maintains the ACCIS product, develops enhancements and delivers releases to meet customer needs. This includes managing the interface with the supplier of the underlying operating system and delivering operating system updates, and type-testing hardware.
- The customer utility manages implementation-specific set-up information and configuration data.

For example, AECL would manage requests for additional CAMLS alarm detection/conditioning logic and develop the required enhancements, and the utility would adjust the alarm configuration information (e.g., defining modes and tuning alarm priorities) to meet local operational requirements.

Given this division of responsibility, the challenge was to implement a support capability that allowed AECL and the customer utility to work together to maintain the ACCIS product and specific configurations over the long-term. Key requirements for the support capability include:

- Trouble report and change request management – AECL and the customer utility should have a common method for initiating, responding to, tracking and closing out change requests.

- Product-level configuration management – A configuration management capability must be available that allows the product baseline including a representative, generic configuration to evolve as necessary changes and enhancements are implemented, and implementation-specific product releases to be delivered to meet customer requirements.

- Implementation-specific configuration management – Although the customer is responsible for managing this information, it is essential that those responsible for maintaining the ACCIS product and customer-specific releases have access to typical configuration information to support system integration and ACCIS product (e.g., CAMLS) testing.

- Information exchange – To meet the needs identified above, AECL and the customer utilities need to share information. Doing this is contingent on having a secure method for exchanging information.

To meet these requirements for Qinshan, AECL extended the ACCIS product configuration management and change control capability using secure web technology. This allowed AECL and TQNPC to share the information required to allow AECL manage the ACCIS product baseline and TQNPC to manage the Qinshan-specific configuration.

Experience to date in supporting Qinshan shows that the adopted support model is very effective. AECL has been able to perform testing and troubleshooting remotely, and to deliver upgrades and enhancements electronically. TQNPC and AECL have been able to jointly manage trouble reports and change requests, and shared implementation-specific configuration information. This has significantly reduced the time and effort required to support the Qinshan implementation of ACCIS, and provides an excellent basis for supporting future implementations.

## SUMMARY

An improved control room annunciation capability is now available from AECL as a component of the ACCIS plant display system product.

This paper has outlined recent AECL experience in enhancing staff product support capabilities to meet evolving utility needs for annunciation improvement. The paper has also outlined AECL's vision for a utility support model for partnering with utilities in achieving successful deployment and operation of CAMLS annunciation and ACCIS plant display system improvements.

AECL looks forward to working with CANDU and other utilities to undertake annunciation improvements for the purpose of effecting plant operational improvements.

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