Abnormal Situation Awareness

The Need for Good Situation Awareness

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Centralized control rooms have been popular since the early 80's. However, the initial ones made a few mistakes, and we have learned from.

Overview

The goal in designing a control room is to create a work environment that promotes high levels of vigilance and situation awareness. Operators are vigilant when they are alert and prepared to act. They have a high level of situation awareness when they have an accurate perception of the current condition of the process and equipment, and an accurate understanding of the meaning of various trends and key performance indicators.

However, rather than making a conscious decision about how their control rooms will function, many plants have evolved their operating philosophy over many years. During this time they have been impacted by regulations, changing workforce requirements, worldwide business competition, and other local conditions, including union agreements, past leadership decisions, and the demographics of the workforce.

Many companies have addressed these issues with investment in technology, management systems, workforce training, and new organizational structures (sometimes including union agreements seeking workforce flexibility and changing roles and responsibilities. Included in these trends we often find construction or refurbishment of control rooms.

Some companies have experienced failures during these changes and have experienced an increase in incidents and accidents, falling morale, and difficulties in recruiting certain positions such as dedicated console operator in large centralized control buildings.

The common failures can be categorized into 4 main areas:

I. Poor (stress creating) work environments
II. Poor situation awareness
III. Poor communications practices
IV. Inadequate implementation of management systems

Poor (stress creating) Work Environments

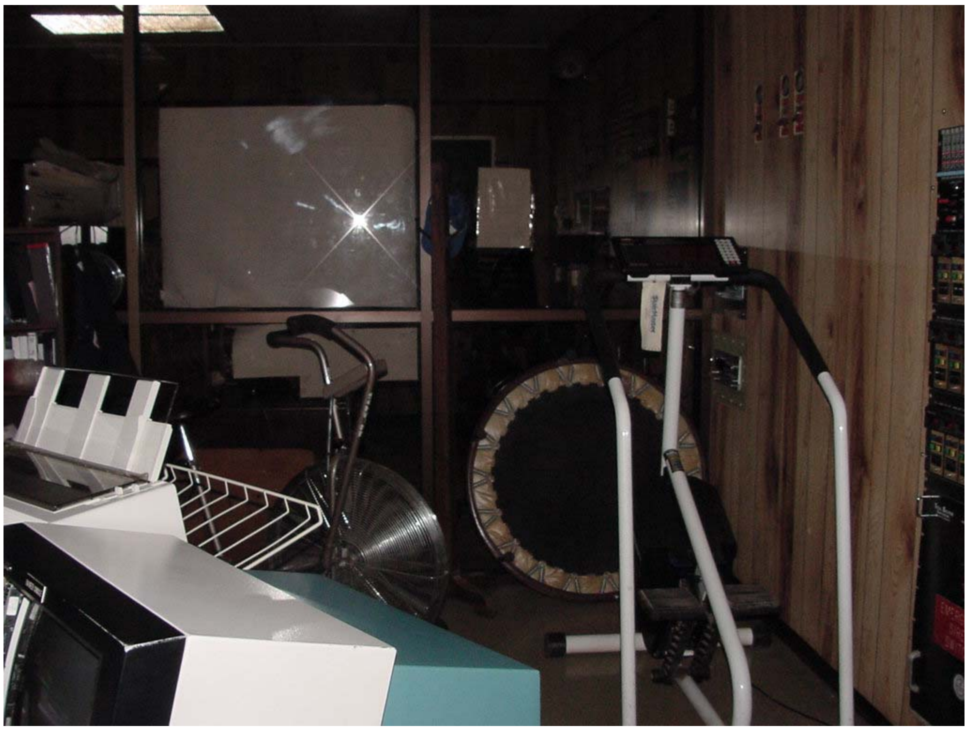
Poor working environments have been associated with control room design, some as a result of evolving an existing 1950's control room designed for long panel displays and modified for computer control with the introduction of DCS. These buildings are characterized by cramped conditions, inadequate lighting – often turned down very low or off due to reflections in computer displays and contrast issues due to the use of dark screen backgrounds against light walls.

Alternatively, some companies moved the console operator out of the buildings leaving just field operators in these buildings. The console operators were moved into a centralized building with console operators from other units of the plant. These buildings were characterized by being large impersonal buildings again with poor lighting, poor heating and ventilation systems, poor acoustic qualities, and poor people movement in the buildings.

Several incidents in the industry have been attributed to human error. When we look at human reliability we discover that, on a good day, just the environment they have to work in stresses the operator. We discover that headaches, eye strain and sleep related problems are common place due to inadequate lighting, poor air conditioning and bad air quality, poorly maintained buildings with dirty inadequate conditions, and constant noise from loud panel alarms and radio communications—conditions made worse by poor arrangements of consoles, lack of separation between units, and poor radio systems.

The workstation is often designed for one specific task—interfacing with the DCS—and has no allowance for other duties such as report writing or training, and few or inadequate facilities for using and storing manuals and communication equipment.

We discover also that operators are equipped with broken or patched chairs that were never designed for 24-hour operations and no rest recovery strategies. Some operators find ways of taking a break or getting some exercise but few have had this designed into their environment.



Distractions are one of the most common environmental impacts for operators. These include poor people flow through the building (traffic); engineers and manager's congregating in the control room and laughing and joking during intense periods of diagnosing and correcting problems; undisciplined telephone traffic; maintenance people wanting permits or advice; equipment noise; doors opening and daylight illuminating a dark control room; heavy blast resistant doors banging; alarms sounding; other operators talking on the radio; PA systems filling the control room with conversations; and maintenance activities in the control room such as trip and alarm testing, etc.

Poor Situation Awareness

Having good situation awareness means that the operator has an accurate perception of the current condition of the process and equipment, and an accurate understanding of the meaning of various trends in the unit.

The most common issue raised by operators and supervisors around the world is the loss of the big picture, when a company evolves to computer control rather than the panel mounted instruments.

This complaint is echoed by the findings of the Health and Safety Executive in their report on the explosion and fires at the Texaco Refinery in Milford Haven.

Poor graphic display navigation techniques can limit an operator's ability to find information. Having to build trends on demand, limits the operator's ability to get information in a timely manner. Hardware failures are also a source of loss of information, as are operator overload due to poor alarm management practices, poor design of graphic displays (especially over-populated and congested displays) and no common user interface between alternate systems such as emergency alarms, safety instrumented systems, reliability monitoring systems, process safety information systems, and Information Technology systems that support email and reports.

We have also witnessed poor acceptance of User Interface designs and operator's migration back to individual controller loops, using faceplates and group displays. Operators find this a fast way to navigate compared to some of the poor implementations of level 3 graphics. They memorize large number of controller groups; however, this technique is responsible for many of the problems with poor situation awareness.

Cocooning is another common problem—before the operators moved away from the process they could hear tell-tale noises, they could look outside and see what was happening or they could communicate face-to-face and get non-verbal cues from other people in the form of gestures or expressions which could confirm relevance or importance of information. The human has a range of sensors and the more of them we can use, the better the quality of our decisions. Limiting human sensors to 1 or 2 (sight and sound) is putting the human at a disadvantage.

Poor communications practices

Communication takes many forms in today's busy control rooms. What is clear is that we have introduced new and challenging problems that were not there a few years ago. As console operators are separated from field operators, a new challenge for communications is presented to a company and a new working relationship and culture is established.

In the days when operators were together important communications were done face-to-face when possible. This was achievable because distance between workplaces was small and if necessary the panel operator could also go out into the field. Supervisors often acted as a link between two operators and relayed information.

Today this exchange relies on radios; unfortunately they are not always reliable due to blind spots, battery issues, and poor or incorrect installation, or maintenance issues. Because of these issues operators like to have an alternative such as phones or a PA system such as the Gaitronics system that allows an operator to call on the PA and have the other person pick-up a phone and talk one-on-one.

We also note that control rooms don't adhere to a practice common in other industries that practice a radio protocol with call signs and word identifiers such as "A" for apple, etc. This protocol can enhance communications especially during bad weather or other noise interference.

Console adjacency is critical for good communications and business optimization in a centralized control room. The guidelines identified in the ISO 11064 standard for ergonomic design of control buildings is a useful guide to understanding the communications needs based on face-to-face communication, information sharing, display sharing or collaboration, note passing, etc. However, putting console operators in the same room does not improve communications; in fact we have discovered that if not designed correctly console adjacencies can actually hinder important communications. Having people in the same room facilitates good communications but breaking cultural barriers and establishing team working are a management driven solution.

Phones can be a blessing and a curse; generally the control room has two phone systems, an internal phone for internal communications, and, an external phone with access to the outside. We find that console operators get calls for secondary users of control building and end up taking messages or tracking down Supervisors, Engineers and Managers.

Phones should be surveyed and non-essential calls into the control room should be restricted, operators are not paid to be switchboard attendants or secretaries. It can be an enormous distraction during an upset as other units are often calling in to find out what is going on. Procedures should be in place to remove the burden of un-important calls during an upset, or re-directing important calls to an available helper such as an adjacent console operator.

Essential lines of communication between non consolidated control buildings is extremely important and should not have to rely on phones alone. The big question that needs to be communicated is what are we dealing with, who is affected and what is our estimated time to repair. Can the situation get worse? What is the probability?

This communication is something that can be handled by someone else, not the operator fighting the fire, a Supervisor or adjacent operator may be available to help. The phone may not be the best way to communicate this information, plus operators on an effected unit can be trained to look up information on-line about upstream or downstream unit's condition. We have identified that having a single resource in a single consolidated control room that is in charge and calling the shots and managing the communications is an effective practice.

Email is the mechanism chosen by management to transmit important organizational or strategic information to the workforce. It is often the delivery mechanism for Management of Change, Night work orders and job requests. The delivery is unstructured and mixed with junk mail with no means of prioritizing mail messages. This leads to problems when shift workers return to the workplace after many days off.

Meetings are also a valuable way the operations team communicates. In the days when we had one control room, everyone used to crowd into the building to hear what other people were doing or planning to do. They got updated information on equipment status and this enabled them to have good situation awareness. When the control room moved, so did the meeting and the console operator became less informed and this limited their ability to put data together into information.

One of the biggest losses with new remote centralized control rooms is the supervisor's ability to be in two places at the same time. Active leg work and nimble supervisors used to run between work areas as needs arose but today with greater distances, supervisors support the field more and the console operator is often left without support. During this time trainers and engineers can provide more support. The supervisor often chooses to support the field as that is where the weakest link is, the newest and most unskilled person, the rookie.

The rookie often can't find equipment or is not familiar enough to know what to do. They need training manuals and procedures, which often are not available 100' up a tower. The supervisor provides the mentoring required to get the rookies through unfamiliar territory.

We find that shift-handover communication is not designed. When we ask manager's and engineers if they have ever defined or demonstrated what is a good handover, what support documentation such as trends, logs and reports should contain, we find that they have never thought about it, even though they may not be satisfied with current handover practices.

Our industry has evolved this practice. There is no discipline or reinforcement of good quality and thorough handover by management. This leads to breakdowns in shift handover, lost information and poor situation awareness.

As we evolve our Abnormal Situation Management® [1] practices we will need to vastly improve this practice as the information collected and reviewed during a shift will be crucial to the techniques used to anticipate or predict an event.

Other critical communication to consider in control room design and operation are the extra ones that take place during a startup. These include extra laboratory samples. Is the information available on-line? Does the plant have a LIM system? Does a field operator take and analyze the sample? How is this information communicated, by phone, fax, or on-line? Who needs this information and how is it used?

Procedure management is also dependent on good communications and in the earlier days of the plant's life people used to meet face-to-face to review and schedule

[1] Abnormal Situation Management is a Registered Trade Mark of Honeywell

the procedure activities. The panel or console operator would monitor progress checking of actions done by teammates and ensuring critical steps were not missed.

In today's environment this tracking is limited by radio traffic, the quality of that communication, and the number of other people fighting for airtime. This is often strengthened by the use of a PA system but may in the future benefit from hand-held browser interface technology.

The ASM® Consortium have recently developed new guidelines for Effective Procedural Practices which covers design of and implementation of procedures and how to get knowledge transfer from them.

Inadequate implementation of management systems

By management systems we mean things like training, procedures, permit issue, management of change, incident reporting and investigation, shift handover, shift rotation, shift cover and overtime. These are management policies and procedures that determine good, consistent working practices.

Training is a challenge to every company especially as its foundation on a site dates from a previous technology and different work culture.

Most companies try to comply with statutes but find that they don't have the facilities, the resources or the time available to do training the way we did 20 years ago. Training is now done very differently if done correctly; it is more formal, it is based on clear roles and responsibilities, and it has some form of competency model that identifies the characteristics of the job and the skills and knowledge to be successful in that job, Mentoring is not the role of the supervisor but everybody involved in a team based work process.[2]

[2]Tackle Abnormal Situation Management with Better Training Ian Nimmo & Peter Bullemer also Operator Training Strategy: Design the Work Environment for Continuous Learning? Peter Bullemer Honeywell Technology Center and Ian Nimmo Honeywell Industrial Automation Control September 29,1997

Now that simulator technology is available at affordable and cost effective rates it is becoming the main training tool of choice.

Procedures are a formal requirement by law but the law only addresses having them, not using them. The first secret in determining the level of detail and how a procedure will be used is to establish the frequency the operator will practice it, how similar jobs are, what the risks are, and are they clearly identified.

Consider a balance between what can and is done from memory. What needs to be done by memory prompts such as checklists and sign-off sheets? Both styles exist, but one is based on training and familiarity and is informal, the other is abase on training and using checklists and procedures. In some circles the informal style is considered foolish and open to human error. The tie between procedures and training has always been there but not as formally as it is today.

Today's training simulators and on-line procedure delivery can be a significant advantage if applied correctly. But they can also be a burden if not done effectively. There is nothing worse than watching an operator using a badly designed pc database to retrieve a simple procedure that could have been found in minutes in book form.

Often this is because they cannot navigate the system to get the data or retrieval time is greater than the job requirements.

We know that near miss or near-hit information is often not recorded because of the close correlation to human error. We know that the error rate is very high and is related to vigilance issues, distractions, and stress/time constraints.

Some companies use a buddy system to do work during error likely times such as 2:30am. They have a no name, no punishment anonymous reporting system that allows them to address a workmate's behavior and also record the failure type.

Permit issue can be a main source of distractions in a control room especially if maintenance and contract staff invade the control room and wait for an operator to be free to deal with them. We have witnessed plants that allow maintenance personnel to sit at the console, and, in some cases on the console, while waiting for an inside/outside operator to handle a problem and be available to issue a permit.

This practice is not desirable and if permit issue is to be practiced within the control building it should be designed to ensure good traffic flow through the building limiting it to the nearest plant doorway entrance and never into the control room.

This is often achieved using permit desks isolating people into a corridor or a window. Industrial practice has determined that the person issuing the permit, must go out to the workplace and inspect, inform and instruct all participants working on the job during permit issue and closure. This is done in the field normally at a local field operator shelter or permit shack.

Management of Change has been legislated and practiced for at least 10 years here in the USA; however, a new definition of MOC for people has recently been added and defined similar to the UK. Any change to one of the following categories would require a formal MOC for people or staffing assessment:-

- Operator positions may be consolidated
- Self-directed work teams may be established
- Supervisory positions may be eliminated
- The span of control for supervisors or other managers may be increased
- Maintenance (craft) assignments may be revised, or multi-craft teams established
- Manager positions may be reduced and areas of responsibility changed
- Technical and quality assurance assignments may be revised
- Safety and health positions may be eliminated

As a result, many traditional roles and responsibilities may change, affecting the manner in which work is done and by whom, and the system of checks and balances that have evolved within a plant's culture. These changes in roles and responsibilities may affect formal and informal work processes and procedures, such as:-

- Safety and health management systems
- Operating procedures
- Safe work authorization and permitting
- Special work authorizations (hot work, confined space, lockout/tagout, hot tapping, flare entry)
- Safety and health training needed or delivered
- Emergency response capability
- Undocumented or informal safety cultures, practices, and norms

I. Good Practices and Industry Standards

Control Room Operating Practices

An effective control room operating philosophy begins with a conscious set of decisions and actions that result in a complete organizational commitment to the development and continuous improvement of systems that support excellence in operational practice, and employee adherence to those systems. In our experience, these systems must ensure that:

- Management's communications of goals, processes, and status is effective and comprehensive,
- Employees' knowledge and skill are continuously and appropriately enhanced,
- Employees work in a supportive culture, and in an appropriate and safe environment,
- Management seeks opportunities to innovate and apply technologies to continuously improve
- The change that results from continuous improvement is well managed.

An effective control room operating philosophy includes six practice areas, which are briefly described below:-

- Situation Awareness
- User Interface Design
- Alarm Management Practices

- Operating Posture
- Training
- Communications

Situation Awareness

Situation Awareness as the name implies is the ability of the operator to be aware of the systems in their operating environment. They consist of the DCS Control and Instrumentation system that provides feedback to the console operator on the plant equipment, the process variables, and the instrumentation system.

The interface is usually via DCS graphics so the design of the User Interface is critical to successful awareness. The second system is communication with the unit field operators who are the eyes, ears and hands of the console operator.

Communication is usually via radio, phone and sometimes face-to-face. It is important that the tools used are reliable, free from distortion and that the operators are trained on radio protocols and team building techniques so as to be aware of the needs of the team and not just personal goals.

The third system involves understanding what is happening on connected units or utility suppliers. This is achieved via monitoring their DCS data through DCS screens or Large Off-Workstations in the control room. Information is sometimes collected casually through overhearing radio conversations or discussion with supervisors, but ideally one-on-one between the operators.

The fourth system is business information which consists of laboratory results of sampling, management communications through emails describing plant changes, operating targets and potential problems. This is normally delivered electronically through a pc located on the operating console but may be re-inforced by line supervision.

Framework for Human Intervention Activities

A number of authors have developed models, to describe supervisory control[3]. This discussion is organized around a framework that simplifies the number of stages used to describe cognitive behavior underlying intervention activities. Figure 1 (based on a model proposed by the Chemical Manufacturers Association) is a simple loop diagram that describes stages of processing within the operations team.

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[3]Most notably, Jens Rasmussen, Tom Sheridan, and David Woods. Note that these models are intended to be descriptive only, and are in no way intended to be prescriptive.

The framework depicted in Figure 1 outlines distinct intervention activities that occur during an abnormal situation.

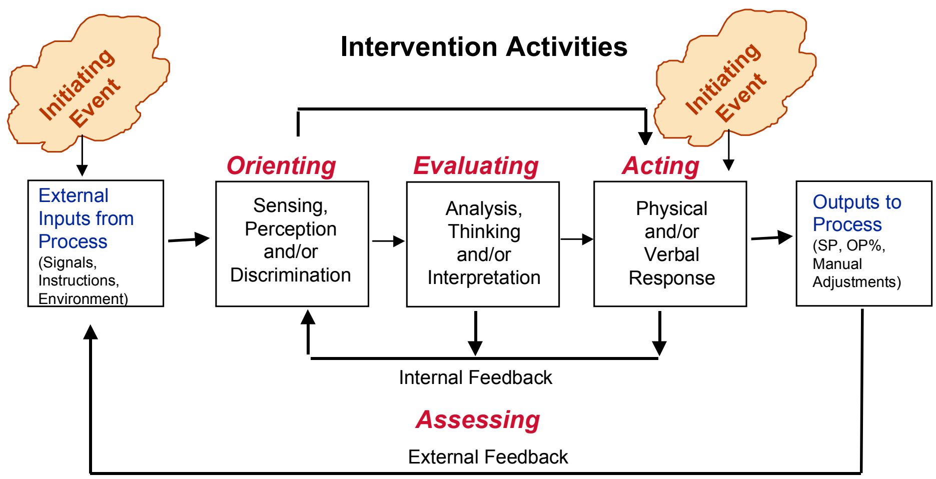


Figure 1 Intervention activities during an abnormal situation

The left side of the figure represents the occurrence of an external event that initiates a process upset. The operations team and/or technical team then will act to stabilize the process. The four stages of operations team intervention activity are:-

Orienting—Sensing, Perception, and/or Discrimination;

Evaluating—Information Processing (thinking and/or interpretation);

Acting—Physical and/or Verbal Response; and

Assessing—Information Processing (thinking and/or interpretation).

The first stage—that of Orienting—involves perceptual discrimination of an anomaly in the process. This can happen by a number of means. Typically, an alarm in the process control system, or an alarm or trip in the safety shutdown system may direct the operations team's attention to a specific point in the process. Alternatively, the operations team may be monitoring the process using schematics (with value readouts) or trends, and determine that an anomalous condition exists. Finally, an extensible indicator such as size of flame in the flare or sound of an emergency relief valve alerts the plant personnel to a problem.

In the Evaluating stage, the operations and/or technical support team develops hypotheses regarding the cause of any anomalous operating conditions. As denoted by the solid line that goes directly from the Orienting to the Acting stages of processing, an individual may be so well rehearsed for certain response conditions that it may appear that this intermediate stage of processing is skipped.

In the third stage—that of Acting—the operations and/or technical support team must take some form of compensatory or corrective action. This may entail the use of the automated control system, or the assistance of plant maintenance personnel. The indication of an initiating event following the acting phase illustrates the possibility that an inappropriate action by the operations team can initiate or escalate disturbances. Not all action taken is corrective (e.g., reestablishing a stable process by manipulating process parameters). Sometimes the operations team may perform hypothesis-testing actions to determine if the supposed problem is in fact real.

The final stage, Assessing, leads to the iterative nature of active control (action – observe / action – observe) is represented by the internal feedback loop connecting the blocks at the bottom of the diagram. When operations and/or technical support are satisfied that the process has stabilized, the operator can resume supervisory control. However, additional analysis and evaluation may continue to try to restore the system to normal production levels and prevent future occurrences.

Intervention Event Sequence

There are several points in the sequence of intervention activities that can lead to success or failure of human intervention. As claimed in the previous discussion, there are three basic component activities comprising human intervention in managing abnormal situations.

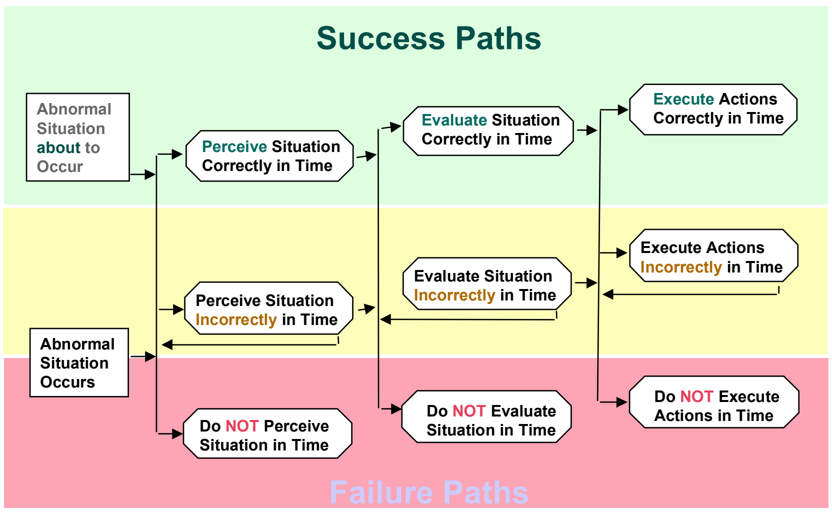


Figure 2 Activity paths involved in an abnormal situation

In Figure 2 above[4], these activities are shown in sequence illustrating the impact of correct or incorrect actions at each phase. Moreover, success depends not only on the accuracy of the individual activity, but also on the timeliness of its completion.

[4]This figure is based on original concepts created by Ken Emigholz of ExxonMobil.

Table 1 below is provided to aid the reader in understanding the potential external contributors to human intervention failures. The success or failure of the individual activities is influenced to a large extent by limitations in the information display and device support of the console work environment.

Orienting	Evaluating	Acting	Assessing	All Stages
Information overload	Inconsistent information	Inadequate procedures	Lack “big picture” view	Insufficient time
Inappropriate detail	Inaccurate information	Complex procedures	Inaccurate information	Insufficient training
Navigation problems	Inappropriate detail	Lack of instructions or checklists	Inadequate information	Inaccurate training
Distracting environment	Lack of knowledge	Lack of experience	Failure to track practices	Insufficient people resources
Missing information	Poor information accessibility		Failure to check assumptions	Communications

Table 1 Potential contributions to human intervention failures

User Interface Design

Schematic Design Methodology

We provide an overview of our methodology and describe the benefits of following our approach as well as provide a typical consequence if a key step is skipped.

How we approach graphics development

There are fundamental differences between our approach to graphics development and the approaches employed by graphics implementation providers. Our approach is firmly based on Human Factors design principles and involves more than simply passing P&IDs to the graphics provider for implementation. Our methodology contains the following nine key steps, with the end goal of providing simple, coherent and usable graphics to the client that will enhance operator performance.

1. Define Information Requirements

2. Create a Graphics Style Guide
3. Create Display Sketches
4. Conduct Operations Design Review
5. Conduct Implementation Design Review
6. Revise and Document Display Design
7. Conduct Quality Control of Implementation
8. Evaluate Usability Using Operators in a Simulation/scenario-based Approach
9. Enhance Display Design

Define Information Requirements:

This step is the key to our approach and is, in the end, what helps to set our designs apart. In this phase of the design process, we aim to understand the system being run, to the point of knowing what equipment and which phases of operation are sources of difficulty for operations teams.

We spend time interviewing operators to understand the environment and the issues they face as well as conduct interviews with engineering and support staff to complete the operations picture.

The result of the interviews is a firm understanding of the key operational relationships that reveal the dynamics of the system being operated, as well as the practical issues facing operations on a daily basis. The information obtained in these interviews provides the content required in the operating graphics. This allows us to design graphics for operators that provide the right information at the right time.

Understanding the content required of a graphic display is a fundamental design component that is often either completely overlooked or casually attempted, resulting in graphics that are not useful to operations and, in some cases, the graphics pages are completely ignored.

Create a Graphics Style Guide:

The purpose of the document is to provide guidance that will define the user interface and enable consistent presentation of information, which will improve the overall performance of the operator with the DCS system. A style guide is written to support the technical, operational and cultural requirements of the plant.

Topics may include: workspace management, the use of color, text sizes, line styles, equipment characteristics and the presentation of alarms. This is extremely important in Centralized Control Rooms and allows operator cross training of areas.

When this step has been overlooked, the result is a set of graphics pages that are not cohesive and are full of inconsistencies, ultimately leading to degraded operator performance.

Using a Graphics Object Library

The development of graphics is simplified by using a Graphics Object Library, which ensures consistency in the design and ease of use for operators doing complex cognitive tasks.

Some of the objects are simple and are provided to complete the object library set using the style of graphics we recommend from a human factors and cognitive processing perspective.

Other objects are more complex but are designed to provide the operators with all the critical information at a glance, thus improving their ability to process large amounts of information more effectively. These objects are valuable tools for normal operations as well as during upset or abnormal situations.

We have also found that by implementing these objects in the context of graphics specifically designed to support the tasks as well as the system, the overall number of graphics pages required has been significantly reduced.

The operators are still provided with the data and information they need, but are not required to call up several graphics pages to see the complete picture.

Object Libraries may be obtained with the DCS Control System, developed by the user or they maybe obtained from a third party graphics developer, they come in two forms a Visio/PDF specification or as a Visual Basic Code, Active X Controls. We provide both of these and they are designed to be application specific and ASM® Compliant.

Create Display Sketches:

Our design team has been formally educated in Human Factors engineering that allows us to turn the information requirements gathered in the first phase of our approach into graphics designs that are intuitive to operations staff. We achieve this end goal by incorporating graphics concepts that support the way people perceive and process information. Understanding and aiding human limitations related to information perception and processing in abnormal situations, frees up the operator's mental resources that can be better put towards recovery tasks.

It is for these reasons that our graphics take on a form that is atypical of P&ID graphics pages. We make minimal use of digital values and maximize the use of graphics that aid pattern matching so that operators can make quick determinations about the state of a system without taxing their memory resources.

At first glance, our graphics designs might seem odd because they are different. A second glance reveals their useful and intuitive design. Part and parcel to our design philosophy is providing graphics within a structured hierarchy to aid an operator when solving a problem.

Our hierarchy consists of four levels of graphics, which we have labeled Type 1 to Type 4. Figure 4 below is a graphical representation of the hierarchy for your convenience.

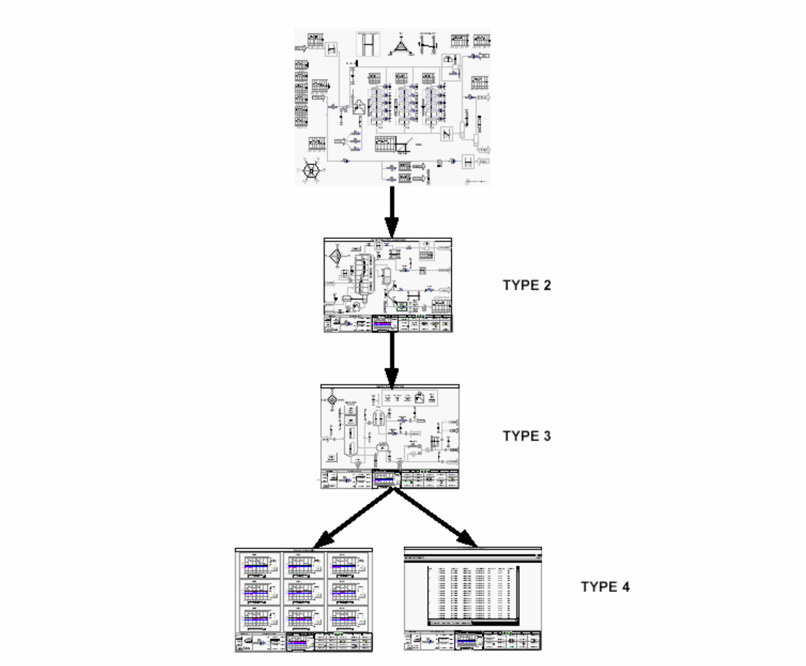


Figure 1: Example of the display hierarchy employed in our methodology

Humans have very definite, ingrained, steps to solving a problem. First they attempt to look at the bigger picture and then they drill down to the part of the process that is the source of the problem. Unfortunately, the bigger picture was lost when the panel board was replaced with the various incarnations of the DCS.

In our design scheme, we endeavor to return the bigger picture to the control room in the form of overview displays that provide key information to the operator related to their entire span of control. The overview, or Type 1, displays reside in the top level of the hierarchy below.

The area, or facility, overviews form the basis of the Type 2 displays. The purpose of the Type 2 display is to provide the operator with a means of quickly determining the health of a major system within their span of control. In addition, we provide dedicated task oriented displays at this level of the graphics hierarchy to allow operations to quickly detect, diagnose and recover from a pending situation.

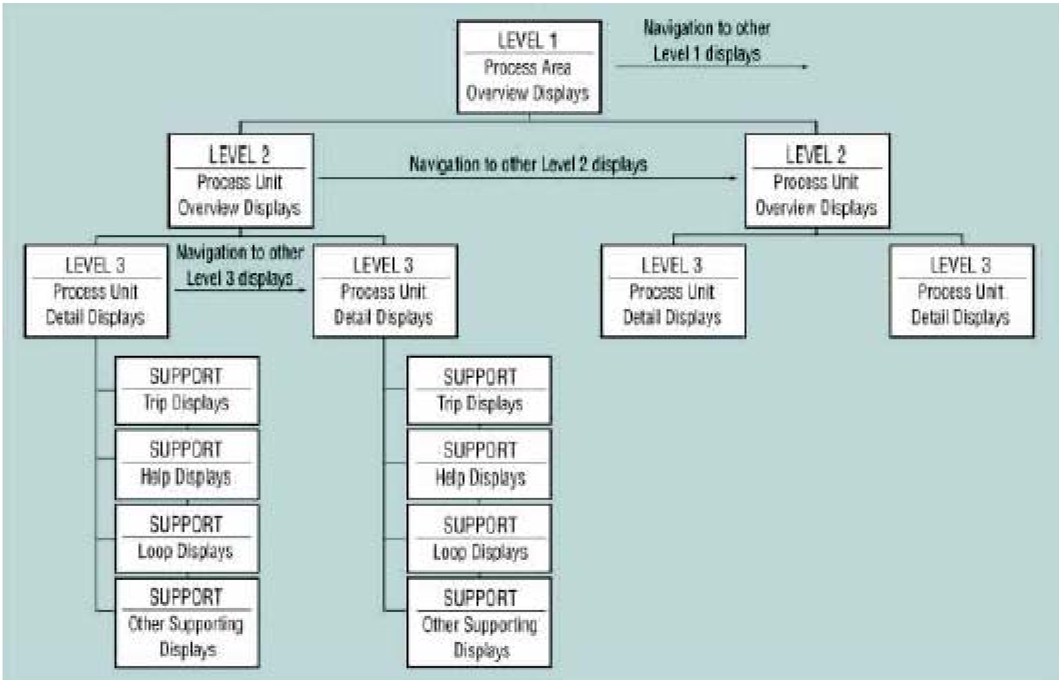
The necessity for the number of task displays is directly a result of the phase 1 Information Requirements analysis that we perform. Examples of task-oriented Type 2 displays include, but are not limited to, start-up and shutdown displays.

Almost all graphics, that are implemented in refineries worldwide, reside in our third level of the display hierarchy, referred to as Type 3 displays.

The purpose of Type 3 displays is to provide detailed information not displayed on the Type 2 displays. Type 3 screens are detailed process displays that provide detailed views of sub units, equipment, related controls and indications.

These displays should be used for routine operations, such as switching of pumps, starting blowers, opening drain valves and so forth. Type 3 displays will also be used for detailed diagnostics in interventions that are not time critical.

The last type of display within our hierarchy is the Type 4 display. The main purpose of Type 4 displays will be to provide additional, or miscellaneous, information that will be useful for operating a particular section or piece of equipment within a unit. Type 4 displays do not contain control functions. Typical examples of Type 4 displays include: Alarm summary display; Procedure and Help displays; Trend displays and System diagnostics.



Conduct Operations Design Review:

The purpose of this phase is to review the initial design sketches with operations to ensure the validity of the design, to begin to obtain operator buy-in to the graphics and to obtain operations comments that will begin to finish the design. If this phase of the process is overlooked, the result is incomplete graphics that may be incorrect. The overall performance of the graphics, operator ownership and familiarization are greatly enhanced during this step.

Conduct Implementation Design Review:

In this step, the graphics that have been reviewed by operations representatives are then passed onto the implementation team to determine if there are any potential implementation issues with the designs. It is a checkpoint in the process that ensures the most efficient design-to-implementation process as it limits the amount of artistic liberty employed by implementation team. Any implementation issues that result in redesign are most effectively handled at this point in the process and therefore minimize the cost and effort related to re-work on graphics.

Evaluate Usability Using Operators in Simulation/Scenario-based Approach:

Once the graphics have been implemented in the system, they are evaluated as a group in certain key mocked-up situations that provide a final source of feedback into the design. This is performed with real operators performing relevant tasks with the system they will be operating, thereby affording observation of issues with the interface that even the operators might not be aware that they are having. The cohesiveness of the graphics as a whole, when performing routine tasks or recovering from abnormal situations, is assessed and any necessary adjustments to the graphics are determined.

Enhance Display Design:

This is the final step in our process and it serves as a point at which any minor adjustments determined by the above evaluation phase are made as well as all documentation, such as the design specification and associated training materials, is finalized.

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