IT'S TIME TO CONSIDER HUMAN FACTORS IN Alarm MANAGEMENT

Photos courtesy of Nova Chemicals.

Ian Nimmo,
User Centered Design Services, LLC

Implement these procedures to consider human factors, not simply human error, in control-room architecture and reduce the chance for incidents in the plant.

An abnormal situation is defined as "any time an operator needs to manually intervene," according to the ASM Consortium (www.mycontrolroom.com/asmconsortium.htm). Manual intervention is generally prompted by receiving an alarm, or often multiple alarms in the control room. Abnormal situation management (ASM), however, involves more than just keeping alarm management manageable. ASM must be addressed properly and made a priority by upper management *(1)*, and an appropriate training program must be put in place *(2)*.

Still, a new approach to safety is needed concerning ASM. This approach should break the traditional barriers of people, organizations and culture, and put the control engineer in the driver's seat again for performance improvements that optimize not just control algorithms, but also people and the way they interface with technology. This means integrating human factors into ASM.

Human factors and organizational accidents

While many books and articles have been published on process-plant safety, incidents and near misses still continue, and engineers keep making the same mistakes over again. A major reason is that companies do not have the mechanisms to pass on accumulated knowledge to the next generation. Newer employees must learn by making the same mistakes were previously. This is what engineers call loss of corporate knowledge.

Studies done by the ASM Consortium, AIChE, the American Petroleum Institute, the American Chemistry Council and similar organizations have concluded that 80% of the catastrophes are linked to human error. Figure 1 represents the findings of 18 studies undertaken by the author, plus information taken from published databases. The chart shows that only 40% of incidents are caused by people. What the chart does not show is the root causes of all incidents. When the root causes of the categories "Equipment" and "Process" are considered, 80% of all incidents are due to human error.

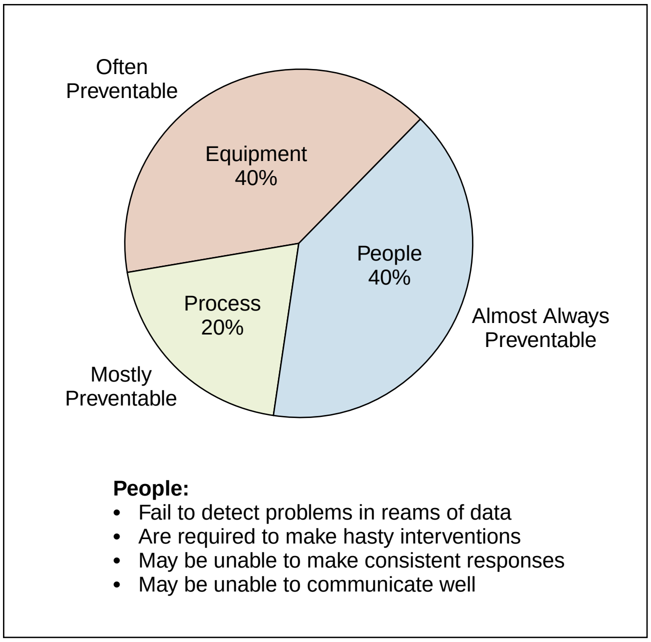


Figure 1. About four-fifths of plant catastrophes are linked to human error once the root causes of incidents are considered, not just looking at the incidents themselves.

The research also shows that such error affects production output, quality and efficiency. The ASM Consortium measured sites with lost opportunity figures in the 3–12% range. The data emphasized the role that people and people systems (*i.e.*, management policies and attitudes) play in contributing to these losses — from simple mistakes such as opening the wrong valve, to poor response times in interceding when events are detected. Sometimes, this is simply caused by poor situation awareness due to distractions in the control room. Improved profitability and reduced fixed costs can be achieved by paying attention to human factors.

Taking a new approach to safety

Human-factors studies emphasize human error, but not as a means to assign blame. The goal is to find the reason why errors are made.

Traditional safety approaches focus on modifying workers' behavior. When an incident occurs, the most common thing to do is to investigate what employees did or did not do. Were they following management systems? Were they paying attention? Did they perform their tasks in the correct order? This approach often blames the individuals and seeks a solution such that, after punishment, the workers will work in a safer manner.

Human-factors evaluation takes a different view. Instead of looking only at individual behavior, this methodology looks at what made the error possible. It tries to identify and eliminate "error-likely" situations by studying the whole operation, then seeking ways to remove weaknesses.

This approach reduces human error by changing the workplace — and sometimes worker behavior. There are situations when operator error is likely or even inevitable, given the way the system is set up. The whole system must be examined to find out why an error occurred and how to eliminate it in the future. The challenge is to do everything possible to eliminate the weaknesses before an error occurs. This ideal means being diligent in considering human factors during design, procurement, installation, operations and maintenance. Hence, the vision here is to engage the entire production organization in improving reliability, performance and quality.

The human-factors approach involves considering many aspects of safety and plant operation. For example, this method should include these factors when performing a process hazard analysis, when undertaking a root-cause investigation, when evaluating operating procedures, and so on. This article will cover only the management of change (MOC) of people, owing to space limitations. How can a site ensure that it has enough process operators with the correct skills and knowledge, ready and prepared to deal with hazardous scenarios?

In December 1998, after several refinery accidents, Contra Costa County, CA passed a new industrial safety ordinance *(3)*. This law requires refineries, and some other industries in the county, to develop new safety plans. The plans help to prevent accidental releases of hazardous materials into the community, and also promote worker safety. These safety plans departed from the traditional safety approach, such as EPA's Risk Management Program, and assumed a new approach, that is, focusing on human factors *(3)*. The law affects two critical areas that have been sadly neglected by designers and they are the human workplace, especially the control room, and people, and the role they play, and how they interface with the environment and technology. The regulation actually calls for comprehensive management of change (MOC) policy for people or organizational changes.

In parallel, in the U.K., the Hazardous Installations Directorate (HID) of the Health & Safety Executive (H&SE) passed a regulation to effectively implement a comprehensive MOC policy for people or organization changes *(4)*. The staffing methodology is based on an assessment framework developed by Entec, a London-based consulting firm.

Along with the new regulation is a comprehensive structured assessment methodology that systematically covers all relevant issues and will help to prevent overlooking potential problems in process operation staffing arrangements when changes are made. The approach presented here is based on the same principles as both the Contra Costa regulation and the one put together by the H&SE based on Entec's work.

Control-room staffing studies help to rationalize plant staffing based on current and future automation, the plant's operating philosophy, and hiring and training practices. The H&SE framework aims to systematically cover all of the relevant issues and to prevent the overlooking of potential problems in process-operation staffing arrangements.

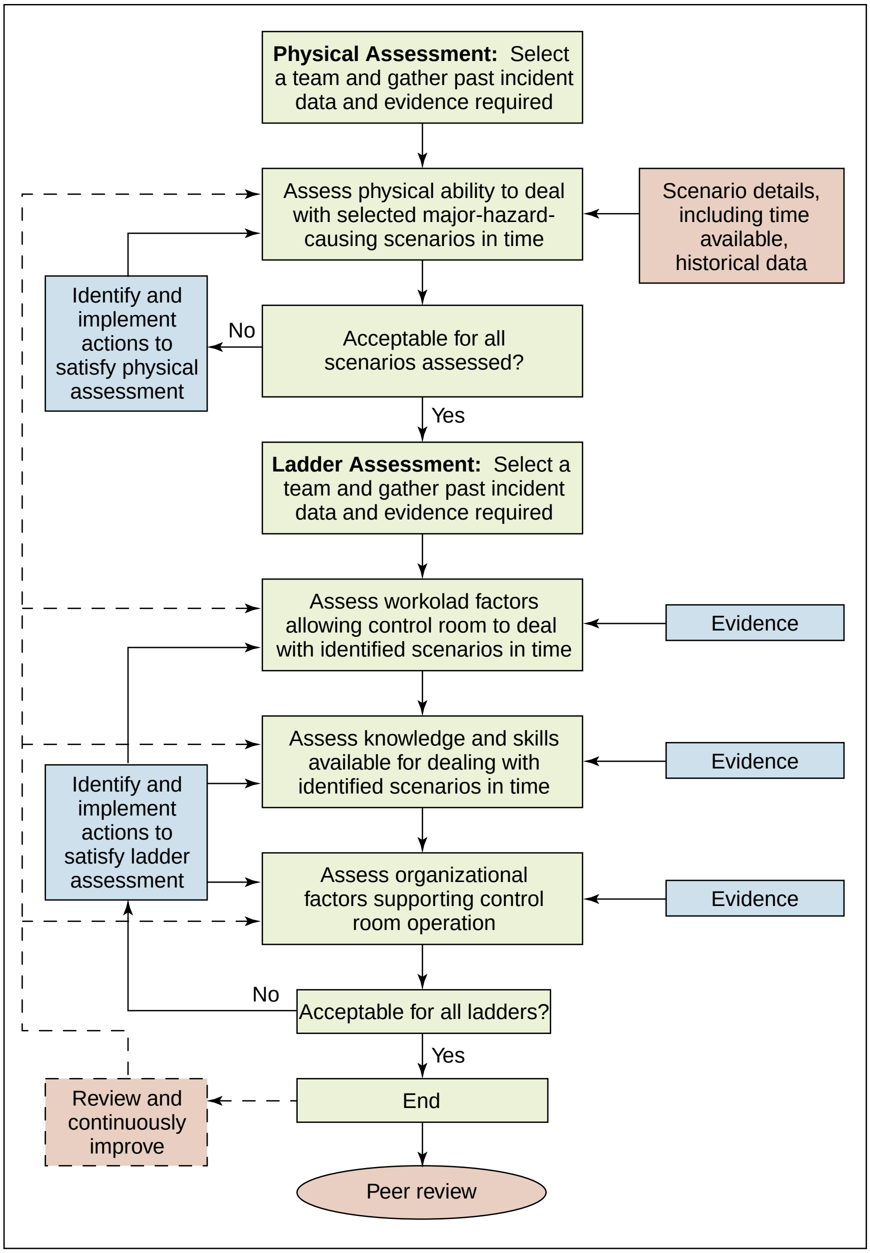
While control-modernization projects often afford an opportunity to reduce control-room staffing, such changes cannot be undertaken without caution. For example, reductions in staffing levels could affect the ability of a site to control abnormal and emergency conditions; and staffing cuts may also have a negative effect on the performance of the staff by affecting the workload, fatigue, etc.

Because of these concerns, organizations need a practical method to assess their existing staffing levels and the impact on safety of any reductions in the operations staff.

Assessing staffing levels

The staffing assessment presented here concentrates on the personnel requirements for responding to hazardous incidents. Specifically, it is concerned with how staffing affects the reliability and timeliness of detecting incidents, diagnosing them and recovering the plant to a safe state.

The method highlights when too few persons are being used to control a process. The assessment is not designed to calculate a minimum or optimum number of staff. If a site finds that its staffing arrangements "fail" the assessment, then it is not necessarily the case that staff numbers must be increased. Other options may be available, such as improving user interfaces, event detection, alarm or trip systems, training or procedures.



■ Figure 2. Staffing assessment considers performance in a range of scenarios, and management practices and cultural attributes.

The assessment is conducted in two parts. The first is a physical assessment of performance in a range of scenarios; the second is a ladder assessment of the management and cultural attributes underlying the control of operations (Figure 2).

Physical assessment

This assessment is completed for a range of scenarios, which should include examples of:

• worst-case scenarios requiring implementation of an off-site emergency plan

• incidents that might escalate without intervention, but remain on-site

• lesser incidents that require action to prevent the process from becoming unsafe.

The engineer must consider whether it is necessary to assess such scenarios during the day vs. night, or during the week vs. weekends, if staffing arrangements vary over these various times. The scenarios must be defined in sufficient detail and rely upon relevant historical data, so that they can be assessed properly. Evidence of reliability is required, such as from simulation exercises, equipment-reliability records and incident reports.

The physical assessment evaluates the plant's staffing arrangements against six principles:

1. There should be continuous supervision of the process by skilled operators, *i.e.*, they should be able to gather information and intervene when required.

2. Distractions that could hinder problem detection should be minimized. These include answering phones, talking to people in the control room, performing administrative tasks and handling nuisance alarms.

3. Additional information required for diagnosis and recovery should be accessible, correct and intelligible.

4. Communication links between the control room and the field should be reliable. For example, backup communication hardware that is not vulnerable to common-cause failure should be provided where necessary. Examples of procedures to ensure reliability include preventive maintenance routines and regular operation of backup equipment.

5. The staff required to assist in diagnosis and recovery should be available with sufficient time to attend, when required.

6. Distractions that could hinder the recovery of the plant to a safe state should be avoided. Necessary but time-consuming tasks should be allocated to non-operating staff. Examples include summoning emergency services or communicating with site security.

The bottom line is that the physical assessment is concerned with determining if it is possible to detect, diagnose and recover from scenarios that could lead to major hazards in the plant. The assessment provides a yes/no response to the feasibility of physically dealing with each scenario in sufficient time.

Table 1. Example ladder for training and development assess both individual and organizational factors.

Grade	Description
A	Process/procedure/staffing changes are assessed for the required changes to operator training and development programs. Training and assessment are provided, and the success of the change is reviewed after implementation.
B	All control room (CR) operators receive simulator or desktop exercise training and assessment on major-hazard scenarios on a regular basis as part of a structured training and development program.
C	There is a minimum requirement for a covering operator to ensure sufficient familiarity, based on time per month spent as a CR operator. Covering-operator training and development programs incorporate this requirement.
D	Each CR operator has a training and development plan that progresses through structured, assessed skill steps, combining work experience and paper-based learning and training sessions. Training needs are identified and reviewed regularly, and actions are taken to fulfill needs.
W	All CR operators receive refresher training and assessment on major-hazard-scenario procedures on a regular, formal basis.
X	New operators receive full, formal induction training followed by assessment on the process during normal operation and major-hazard scenarios.
Y	There is an initial run-through of major-hazard-scenario procedures by peers.
Z	There is no evidence of a structured training and development program for CR operators. Initial training is informally by peers.

Table 2. An example ladder for roles and responsibilities — a ladder is a behaviorally anchored rating scale that provides pass/fail measures.

Grade	Description
A	Prior to any proposed change to equipment or procedures, the core competencies required for the operations team are reviewed and any new such competencies required after the change are introduced.
B	The operations teams are selected and then trained on the basis of the identified core competencies. Operator development is assessed against these criteria.
C	There is a management control in place to ensure that the core competencies required for the operations teams are retained during any staffing changes.
V	Additional roles, such as providing first aid or being a part of a search-and-rescue team, are taken into account when assessing the operations team's ability to cope with normal and emergency situations.
W	Roles and responsibilities within the operations team are clearly defined so that each individual knows his/her allocated tasks and responsibilities during normal and emergency situations.
X	A structured approach is used to identify the team's required competencies.
Y	There is a general job description for each member of the operations team.
Z	There is no definition of team roles and responsibilities. There is no identification of core competencies.

Ladder assessment

Individual and organizational factors are assessed using ladders. There are ten ladders in total, and these are organized into three different areas:

Individual factors (workload):

1. Situational awareness — This rates the quality of knowledge on current and near-future situations. Is it possible to carry out all of the required monitoring checks in the time available? Tasks looked at include short-term disturbances, such as writing work permits. Also covered are shift handover and monitoring conditions over a week, and re-familiarization after long breaks.

2. Teamwork — Is there a support staff available, possibly from outside of the control room, to assist when there is above-normal activity? This is the role of outside operators. Are the roles and procedures defined?

3. Alertness and fatigue — Use of health programs to monitor the possible symptoms of stress via measurement. The techniques include using questionnaires, monitoring absenteeism, identifying shift patterns that rotate in reverse rather than forward, and noting shift-pattern effects on operator fatigue. The sickness rate among operators may indicate problems, as well. The assessment also considers the effects of lighting and temperature on operator alertness.

Individual factors (knowledge and skills):

4. Training and development (Table 1) — How is this done for new operators and to refresh existing ones, particularly for major-hazard scenarios?

5. Roles and responsibilities (Table 2) — Are these clearly defined? Is the team composition defined and based on a structured assessment? Are the roles and responsibilities reviewed to ensure that core competencies are maintained before a possible change is made?

6. Willingness to act — This measures the extent to which operator actions can be influenced by factors such as cost and environment, over safety concerns.

Organizational factors:

7. Management of operating procedures — How good is the system for updating procedures, and for validating and implementing them (including training)?

8. Management of change (MOC) — Evaluates the use of transitional techniques to ease the change, whether it is in people, technology or procedures. MOC is also applied to determine the extent of training when changes are needed, as identified by the MOC process. After a change is made, checks should be in place to review its effects.

9. Continuous improvement of control room safety — Techniques expected for continuous improvement include: monitoring of product quality; appraisal of operator performance to promote continuous improvement; and use of on-site and off-site historical incidents to improve performance.

10. Management of safety — How strong is the site policy? How are historical data used to improve performance? How is the workforce involved in managing safety?

Each of the ten ladders is essentially a behaviorally anchored rating scale that provides observable measures and either passing or failing grades. Next, consideration is given to eliminating unacceptable risks.

Assessment output

This method identifies areas of unacceptable risk in process-operation staffing arrangements and provides target areas for improvement actions. Typical output actions include:

• Evaluating costs and benefits of the identified improvement options.

• Further investigation, such as determining the reliability of equipment, more-closely analyzing critical tasks, and checking assumptions about the behavior of leaks.

• Consulting with a human factors expert on key judgments.

The output from the method is an action plan for each assessed element. The priority for improvement actions is:

1. Those required to ensure the reliability of the operations team; they are physically capable of detecting, diagnosing and recovering from scenarios.

2. Those necessary to move the staffing arrangements above the acceptable line on all ladder elements. (Shown as the bottom area in Tables 1 and 2.)

3. Those required to continuously improve the staffing arrangements to meet the best practices. Here, the references are to those persons that fall short of the target line or those that are impacted by a change. The main comparison is done by doing the assessment before the change and then again with the changes in mind.

Practical application

The staffing assessment should be conducted similarly to the way other process safety assessments are carried out. This means using such techniques as hazard and operability (HAZOP) analyses or risk assessments that support a safety case.

The assessment of a defined production area should be coordinated and facilitated by one person who is technically capable and is experienced in applying hazard-identification and risk-assessment methods. This role is similar to that of a HAZOP chairperson.

In addition, the assessment team should consist of:

• Control room operators, both experienced and inexperienced, plus members from different shift teams.

• Staff that would assist during incidents, perhaps in giving technical advice to operators or with tasks such as answering phones.

• Managers or administrators knowledgeable about operating procedures, control system configurations, process behavior, equipment and system reliability, and safety (including risk assessments and criteria).

• Teams may also require assistance from specialists in human factors.

When to apply the method

It is good practice to apply the method in full and to review and reapply it periodically. This is determined by the plant so as to reflect what happens in real life there, in terms of projects and economic changes to staffing. Changes in staffing arrangements (or other changes affecting the response to emergency or upset conditions) should be evaluated prior to implementation. Any change that could alter the ladder rating is considered to be a change in the staffing arrangement. A guiding principle is that changes should not lead to a reduction in the assessment rating.

The procedure for analyzing proposed changes is:

1. Produce an up-to-date baseline assessment of the existing arrangements.

2. Define the proposed change and evaluate it using the assessment method, modifying the plans until an equal or better rating is achieved.

3. Reassess the arrangements at a suitable time after implementation (within six months).

Benefits of the method

Using the methodology developed by Entec and the H&SE, this method was later built into the ASM Best Practices. The staffing methodology was not available during that time or it would have been done, as we are doing on all new projects.

The comments from the participants of the original studies indicate that the method: brings staffing issues into the open; enables the adequacy of staffing arrangements to be gauged and assesses the impact of staffing changes, particularly reductions; is practical, useable and intelligible to inspectors and duty holders (*i.e.,* those managers on-site who have responsibility for the people, and their roles and responsibilities). Finally, the method is robust and resists manipulation and massaging of its output.

Now, consider how to design the workspace to optimize both people and the technology used.

Control building location

The location of a control building can significantly impact the operating team's performance. The trick is to understand whether there is a requirement for a strong collaborative structure — *i.e.,* the unit console operators talking and working together with other unit console operators — as well as the quality and reliability of remote communications. The question comes down to: Whom is it more important to have face-to-face communications with? Other field operators on the same unit, or other console operators on an adjacent unit that may impact control through feed or utility relationships among units?

Often, there is not a simple answer to this question. An example of this complexity arose in locating the control room for a Nova Chemicals ethylene project. Nova was going to add a new ethylene plant to a site that already had three up-and-running ethylene units. A method was developed for deciding on the location for the control building. The decision was more complex than just selecting a space on a map, and considered whether the control rooms for all three existing ethylene plants and the new one should be consolidated into a single building. The decision method also looked at whether other control units on-site should be consolidated into a centralized control building, as well as what the benefits of doing this would be. Nova further evaluated what impact a consolidated control room would have on operations.

The project team initially undertook a literature search to identify the existing industry standards, issues and benefits. The team identified a draft ISO standard, "Ergonomic Design of Control Centers, Parts 1-3," No. 11064 (from the International Organization for Standardization, Geneva, Switzerland) that served as a good basis for a design methodology, although it did not address the control building location. The only path forward was to follow sound engineering practices of project management, identify opportunities and review possible problems.

Multi-disciplinary teams met and brainstormed alternative control building solutions, evaluating the strengths and weaknesses of each of the proposed alternatives. Each solution was evaluated in four key areas — cost, impact on people, safety and business opportunities or issues.

Three solutions were considered: a centralized control building located remotely; a centralized control building within battery limits; and individual, distributed-control buildings.

Initially, the team had expected to recommend the first option (the remote location), although individually, each team member had his or her own preconceived idea of what the best solution would ultimately look like. The great value of performing the evaluation together was that the team achieved a shared vision for the ultimate solution. This vision included coming to a clear understanding of why compromises had to be made, and what had to be done to strengthen the weaknesses with the chosen solution.

The team did a good job of identifying the real costs for the project. For example, estimating the costs of building a remote centralized control building included those costs for constructing a local building for field operators and a safe haven for maintenance personnel and contractors. A centralized control room would have different capital costs, depending upon whether it was built remotely or within battery limits. The latter would require a blast-resistant structure, while a remote structure would require additional buildings to be constructed within the battery limits. The evaluation also considered any demolition costs, such as those for moving existing piping and equipment.

In evaluating the impact that the various options would have on personnel, the team focused on communication, collaboration, team activities, distractions, delays, reliance on technology, staffing levels and placement of expertise.

In evaluating each alternative for safety, the team considered possible exposure to hazards. It was argued that the closer the building were to the unit, the more effective the occupants would be in operating and maintaining the plant. This is because they would be closer to the hardware they manage and the people with whom they interact most often. Further, there seems to be a lessened risk of an accident, due to better communication among key groups.

On the other hand, the closer the control room operators were to the unit, the greater the risk they would run of suffering the consequences of an incident, should one occur.

To balance these hazards, consideration must be given to the protection afforded to people by the buildings they occupy. The closer to the hazards, the more protection the buildings must provide, hence, the more they will cost.

Business opportunities, such as optimization and speed of response to change, must be weighed against poor performance due to communication breakdowns, lack of teamwork, and loss of knowledge and expertise.

Based on the evaluation, the team selected individual control buildings for this site. (See the lead photos.) This solution was more expensive, but had a larger positive impact on people, since several of the complex's units were batch processes that required close collaboration between field and console operations. The individual ethylene plants had no strong requirements for improved communications among each other, other than the existing solutions, such as computer monitoring of other units by a single unit, and use of telephones and radios.

In fact, a best practice was identified in the way Nova operators work together during disturbances and how they rehearse potential scenarios after an event. Most operators deal with a disturbance, and when it is over, they go back to reading a paper or put their feet up and wait for the next alarm.

At Nova, they handle the disturbance, then all the operators come into the control room to review what was done and what potentially could happen if the problem were not fully resolved. A plan is prepared to handle any future disturbance or event.

(Note that best practices were identified by the ASM program through many site studies at each of the member company sites, identifying and comparing practices across companies, and then the consortium members agreed which were the best ones. The consortium developed a white-paper called "Effective Operating Practices" that summarizes the main ones.)

The team felt that this solution provided a better business opportunity for several reasons: individuals would focus on the business; security would be improved; employees would feel an increased ownership of problems; there would be less interference and confusion; and there would be less impact from common-mode failures.

Control building design

This initial project established a new way of carrying out control building projects that is used successfully at Nova. The first critical step is creating a shared vision for the control building and how it will operate. The activities in this step include:

1. Interview a cross-section of management, engineering and operations personnel, usually over a one-week period.
2. Review the current operating practices and opportunities to implement the company's best practices.
3. Analyze the building location, based on cost, people implications, a safety-related risk assessment that considers API RP 752 ("Management of Hazards Associated with Location of Process Plant Buildings, CMA Manager's Guide" *(4)*), and the business case.
4. Review the impact of the project and its alternatives on people and the organization.
5. Develop an order-of-magnitude cost for each of the alternatives, based on the building type and square footage.
6. Identify the benefits and project risks of various alternatives.
7. Develop a list of recommendations covering priorities and ways of achieving long- and short-term goals that meet the shared vision.

Once the shared vision is created, the work of the detailed control building design can commence. Design begins with the operator and works outward. The major activities include:

- Completing a task analysis for present and future jobs, especially when remote centralized solutions are implemented. Key issues include whether rotation is required between jobs and whether the field operators will become equipment specialists, once the new control room is up and functioning.
- Clearly documenting the form and function of the current human/machine interface. What information does the operator need? When does he or she need it, and how and where will it be gotten? Which tasks will be done manually and which will be done by automation?
- Developing a functional specification that includes console layouts and room adjacencies and priorities.
- Detailing a control-building design specification that encompasses the mechanical systems (heating, ventilation and air conditioning (HVAC), security, lighting, communications, including operator log books, telephones, video conferencing, large overview screens, and all other aspects of the building's operation). The greatest benefit of using an experienced control room architect will be found in the development of the detailed design.

Selecting an architect and builder

The selection of the control room architect and the builder can affect the functional use of the building. Architects not only carry out the building design, but also function as project managers to coordinate the work of different disciplines that create the building. The architect is in charge of structural, HVAC, acoustic and lighting engineers, CAD operators, and interior designers. This sounds good, but some architectural firms that properly design the control-room structure may lack the needed the project management expertise to meet a company's standard, and their ability to understand and satisfy the functional requirements is almost impossible, based on their perception of chemical plants.

Since architects often are the project managers as well, the engineer must select a firm with the right people and experience to avoid problems in the final product. Such problems can affect the performance of the control room operators. For example, the acoustics may be so poor that the operators cannot hear themselves think when audible alarms start to proliferate, radio noise escalates and conversations become loud and stressful.

Lessons learned on the Nova project

Although the draft ISO standard (11064) did not explain how to do the job, it did provide clues. Section 1 (of six) states that the most important step is to get a shared vision and involve all relevant employees. Past experience carrying out this type of activity reveals that the team must get senior management's view of the current situation and extract a challenging vision for the unit, initially for the next five years and then for 20 years. Interviews with other managers, project staff, and other employees identified how well (or poorly) they shared the management vision and how well management understands whether the policy matches the corporate culture.

Interviews with users of the building, such as engineers, managers and supervisors, identified how they interface with the process and the primary users of the building — the operators. The control room operators were not always able to articulate what the future looks like, but they know what works and what does not in the existing environment. Also, they have insight into what will and will not work in a new solution.

It is more efficient and productive to interview managers individually for an hour and spend a good part of a shift in the control room with operators, observing and asking casual questions, as well as getting their buy-in on a potential solution. The operators were told that the design process is iterative, whereby the design was refined by many reviews with the multi-disciplinary team until each person in the control room during all the shifts understood why something was proposed and why some ideas were rejected.

Creating a shared vision also helps to understand: how people do their jobs currently and how they may do them in the future; to whom they need to be adjacent; with whom they have loose communications or collaborations; and which support functions are the most important to place as close as possible to the control room. The information gathered identified whether the operators need to see each other's screens, whether they should always have eye contact, how much verbal communication is required, and what shared facilities are subject to common-mode failures. The aim was to understand the working patterns, whether people get information from other operator's screens, or whether the dependence is on the operator having face-to-face communication to relay a problem. There may be a strong reliance on phones or radios, and the impact of a common-mode failure in the control room had to be determined. In a worst case scenario, the operators may lose phones, radios and computers, which has happened in major incidents in the last five years.

How and when are people segregated to avoid disturbances, such as issuing permits at the beginning of a day and closing them at the end of the day? How is traffic controlled in the building? How will the design allow viewing, yet isolate disturbances and noise?

Once this information is collected, a console layout can be developed, based on communications and collaboration; a control room layout can be created, based on the operators' need for information; and, finally, the entire control building can be laid out, based on priority adjacencies (for example, which is most important, the rest room, the kitchen, the conference room, the supervisor's office, the engineering workstation, etc.?).

The Nova project successfully maintained one-on-one communication and collaboration between the field operators and console operators, and, at the same time, kept the traffic flow to a part of the building that was away from where console operators were working. This was done by creating a separate field/operator work area.

Further, the project was set up such that supervisors and managers had a place where they could observe how the team was progressing, without crowding the operator. The application development engineers were able to work in isolation, but still be close to observe and communicate with operators during the testing and commissioning of new software applications.

The other turn that the project took was that Nova had a vision for providing tools for operators on 12-h shifts to maintain vigilance and deal with sleep deprivation in the transition from the day shift to the night shift. Nova had developed a loss-prevention standard that would support the healthy-body/healthy-mind attitude. For example, an operator often struggles to stay awake because his or her body is physically saying that it should be asleep and, at the same time, not much activity is going on because the process is running smoothly and is not disturbed. As a solution, Nova invested in an exercise room for operators to use during quite periods and scheduled breaks.

The company also established "Rest Recovery" rooms (nap rooms) in which an operator with a sleep problem can obtain permission to take a 40-min nap, as long as the plant monitoring is covered, and the need is genuine and approved by the team of operators. During the nap, the operator does not get into the full sleep cycle. He or she sits in a recliner and is able to fall into the first few of stages of non-REM sleep, thus being fit for over 11 hours of productive shift work, rather than being slow to respond and sluggish for the whole shift. Nova also invested in dynamic circadian lighting systems to help operators adjust to night work.

This control building is also unique because it has a maintenance block and a small administrative office associated with it, due to the extreme winter conditions in that part of Canada. This impacts traffic flow, parking, noise and available adjacencies.

In all, the methodology produced an outstanding building. But the building was not the only good thing to emerge from this project. The design process identified other opportunities for business advantages. The building was designed to ensure that the operators and other personnel have good situation awareness, which is also reflected in the console design and the use of custom consoles to meet the needs of the operators. The information presented at the consoles is optimized and designed to meet best practices.

After reviewing the best of the best alarm management and graphic displays, Nova Chemicals synergized the work of these companies with the ASM Consortium guidelines and developed a state-of-the-art alarm management system, which was not done as a one-off, that is, something that is done once at the beginning of the project and is never updated. What was done for Nova is something that will be used on all future projects and will be used throughout the life cycle of the plant. Nova developed a company loss-prevention standard that reflected the work of EEMUA's "Alarm Management Guidelines" and the IEC 1508 standard, among others. Plus, there was input from other ASM Consortium members. EEMUA is a U.K. organization of manufacturers that writes recommended practices for industry. EEMUA was formed in 1983 to "reduce costs and improve safety by sharing experience and expertise, and by promotion of distinct engineering users interests" (www.eemua.co.uk/index2.htm).

A long-standing issue in control rooms is poor design of displays. Therefore, Nova addressed the navigation of information and the quality of the displays, based on ergonomic and human-factors standards identified by the ASM Consortium and work that Nova commissioned.

Nova's success has prompted the ASM Consortium to sponsor a project to measure the benefits of the features implemented at this site. The basic methodology confirmed that a shared vision is important and that a feasibility study has to be done first. CEP

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IAN NIMMO is president and a founder of User Centered Design Services (40218 N. Integrity Trail, Anthem, AZ 85086; Phone: (623) 764-0486; Fax: (623) 551-4018; E-mail: inimmo@mycontrolroom.com: Website www.mycontrolroom.com), an ASM Consortium affiliate member and an ASM service provider. Nimmo served for 10 years as a senior engineering fellow and a founder and program director for the ASM Consortium for Honeywell Industrial Automation & Control (Phoenix). Before joining Honeywell, he worked for 25 years as an electrical designer, instrument/electrical engineer, and computer applications manager for Imperial Chemical Industries in the U.K. Nimmo has specialized in computer-control safety for seven years, and has extensive experience in batch control and continuous operations. He developed the control-hazard operability methodology (ChazOp) during his time at ICI, and has written over 100 papers and contributed to several books on the subject. He studied electrical and electronic engineering at Teeside (U.K.) Univ. He is a member of IEEE, and a senior member of ISA.