Control Centre: Layout and Location Design

E. Johan Hendrikse, Paragon Engineering Services
and Denise B McCafferty, American Bureau of Shipping
Houston, Texas

Presented in the Proceedings of IBC's 14th event in the Series on Safe and Reliable Control Rooms

Introduction

Over the last two decades or more, developments in information processing and communication technology, as well as demands for safer, more reliable, and efficient operations have led to the concentration and centralization of supervisory control in most process-related facilities. This has led to a major increase in the establishment of centralized control centres. Not withstanding these developments, the operator has retained a critical role in monitoring and supervising these complex automated systems. As the scale of automated solutions has grown, so have the consequences of equipment and human failures.

The job of the operator can at times be very demanding. The consequences resulting from inappropriate operator action in control rooms, i.e., acts of omission, commission, timing, sequence, etc., can be potentially disastrous. As a result, Human Factors or Ergonomics is being applied more frequently during the design of control centres with the view toward eliminating or minimizing the potential for human error and enhancing the effectiveness and efficiency with which human work is carried out.

There are now an increasing number of National/European and International statutory directives or guidelines available on the Human Factors/Ergonomics of Control Centres. An example of one of these references is ISO 11064: Ergonomic Design of Control Centres. In Part 1 it provides the principles for the design of control centres, whilst Part 3 provides the principles for control suite layout. The purpose of this paper is to briefly highlight some particular aspects of layout and location design based on both Part 1 and 3. The paper will discuss both conceptual and detail design. It will stress those factors that we have found to be of particular importance during the design of onshore and offshore control rooms/rooms in the oil and gas industry.

Designing for All the End Users

A fully functional control centre, i.e., one that is designed to be “Fit for Purpose”, must satisfy the operational requirements of all end users. A functional analysis (function analysis and description) should be performed and documented in order to determine the needs of all the end users above and beyond the pure functional performance requirements of the system. The functional analysis should include all anticipated modes for all the expected end users of the controlled system:

- Steady state operation
- Normal transient operation (start-up, shut-down)
- Emergency/abnormal operation†
- Maintenance (scheduled or unscheduled)†

† Note: Greater end-user involvement is often required for defining end-user needs for emergency operations and maintenance than for the normal steady state ones.

While the operator(s) and even maintainers of a system may be the primary end users, it is important that all potential users be defined. During some recent projects, the potential system end users were both an LNG terminal and for an offshore installation were defined. In both cases, the end users were found to be quite numerous and varied both in terms of job function and technical background. A larger number of users were...
defined than was originally expected. Table 1 provides a List of System End Users for an LNG Terminal, while Table 2 gives List of System End Users for an Offshore Installation.

**Table 1: List of System End Users for an LNG Terminal**

<table>
<thead>
<tr>
<th>Title</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Supervisor/Trainer Marine Supervisors</td>
<td>Marine Supervisors</td>
</tr>
<tr>
<td>Control Room Operators Marine Superintendents</td>
<td>Asset Manager</td>
</tr>
<tr>
<td>Field operators</td>
<td>Terminal Director</td>
</tr>
<tr>
<td>Reliability Engineers</td>
<td>Logistics/Transport</td>
</tr>
<tr>
<td>Senior Technicians – Mechanical</td>
<td>Security Officers</td>
</tr>
<tr>
<td>Mechanical Support</td>
<td>Contract Support</td>
</tr>
<tr>
<td>Senior Technicians – Electrical / Instruments (E&amp;I)</td>
<td>Business Services Manager</td>
</tr>
<tr>
<td>E&amp;I Support</td>
<td>Human Resources Officer</td>
</tr>
<tr>
<td>E&amp;I Supervisors</td>
<td>Finance Officer</td>
</tr>
<tr>
<td>Material Controller (Warehouse)</td>
<td>Administrative Officer</td>
</tr>
<tr>
<td>Fire, Safety and Security Advisor</td>
<td>Administrative Staff</td>
</tr>
<tr>
<td>Information Technology Focal Point</td>
<td>Canteen operations/catering</td>
</tr>
<tr>
<td>QHSE Manager</td>
<td>Administrative Staff</td>
</tr>
</tbody>
</table>

**Table 2: List of System End Users for an Offshore Installation**

<table>
<thead>
<tr>
<th>Title</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Supervisor/Trainer Operations Engineer</td>
<td>DCS Administrator</td>
</tr>
<tr>
<td>Control Room Operator (Process)</td>
<td>Safety Officer</td>
</tr>
<tr>
<td>Deck Operators</td>
<td>Fast Response Task Force</td>
</tr>
<tr>
<td>Ballast Control Operator (Marine)</td>
<td>Search and Rescue/Fire Fighting Team</td>
</tr>
<tr>
<td>Senior Technicians – Electrical / Instruments (E&amp;I)</td>
<td>Fast Rescue Boat Task force</td>
</tr>
<tr>
<td>E&amp;I Support</td>
<td>Medic</td>
</tr>
<tr>
<td>E&amp;I Support</td>
<td>Helicopter Landing Officer</td>
</tr>
<tr>
<td>Senior Technicians - Mechanical</td>
<td>Catering Staff</td>
</tr>
<tr>
<td>Mechanical Support</td>
<td>Planner</td>
</tr>
<tr>
<td>Production Team Leader</td>
<td>Platform Clerk</td>
</tr>
<tr>
<td>Maintenance Team Leader</td>
<td></td>
</tr>
<tr>
<td>Barge/Marine Supervisor</td>
<td></td>
</tr>
<tr>
<td>Offshore Installation Manager (OIM)</td>
<td></td>
</tr>
<tr>
<td>Subsea Team Leader</td>
<td></td>
</tr>
</tbody>
</table>

After defining potential end users, it is necessary to determine the potential operational links or interface relationships between all of the physical functional areas of the facility and the end users. This is done in order to accommodate these links during the development of conceptual layouts for areas where an end user will reside, for example, the control room. Table 3 below provides an example of the main functions of the spaces inside a control centre and their interrelationship (high (H), medium (M), low (L) or none) as rated by the end users.
Table 3: Interface Relationship Matrix for Control Room Building

<table>
<thead>
<tr>
<th>Function</th>
<th>Area (sq.m.)</th>
<th>Control Room</th>
<th>Eng. Room</th>
<th>Training Rm</th>
<th>Supervisor Rm</th>
<th>Permit Room</th>
<th>Technical Rm</th>
<th>UPS Room</th>
<th>Battery Room</th>
<th>Laboratory</th>
<th>Chemical Store</th>
<th>HVAC Room</th>
<th>Cafeteria</th>
<th>Restrooms</th>
<th>Janitor</th>
<th>Store</th>
<th>Visitors Ent.</th>
<th>Walkways</th>
<th>Airtlock</th>
<th>Waiting Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Room</td>
<td>104</td>
<td>H L M M M</td>
<td>L H H</td>
<td>L L L L</td>
<td>L H H H H</td>
<td>M L L M M L</td>
<td>L L L L M</td>
<td>L M L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td></td>
</tr>
<tr>
<td>Eng. Room</td>
<td>23</td>
<td>L H H H M</td>
<td>M L L L</td>
<td>M M L L L L</td>
<td>M L L L L L L</td>
<td>M M M M L L</td>
<td>M L L L L L</td>
<td>M M L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train/Meet Rm</td>
<td>34</td>
<td>M L L L L L</td>
<td>H M M M H M</td>
<td>L L L L L L</td>
<td>L L L L L L L</td>
<td>L L L L L L</td>
<td>M M M M M M</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supervisor Rm</td>
<td>12</td>
<td>H M L L M</td>
<td>M L L L</td>
<td>M M L L L L</td>
<td>L L L L L L L</td>
<td>M M M M L L</td>
<td>M L L L L L</td>
<td>M M L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L</td>
<td>L L L L L L</td>
<td>L L L L L L</td>
<td>L L L L</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Once links and interfaces are defined and prioritised, it is helpful to conduct link analyses to begin the process of determining potential locations and layouts. A Link Analysis is typically performed to optimise the layout based on the interface relationship determined for the various end users. An example of the result of such a Link Analysis is depicted in Figure 1 for an onshore control room and in Figure 2 for a control room on a Floating and Production Facility Offshore (FPSO):

**Figure 1: Link Analysis for Control Room Building**
Figure 2: Link Analysis for Control Room on a FPSO Analysis for Control Room on a FPSO
What Does It Control and What Are The Risks?

Decisions made about control system and control centre design significantly affect the nature of operations tasks themselves, as well as the effectiveness and efficiency with which the tasks are carried out. For example, a control centre is far more than just a human-machine interface where equipment is being monitored and controlled in a closed loop system. The control centre may also have to function as the following:

- A communications and visitor centre
- Must be suitable for 24-hour, 7 days a week operation in 12 hour shifts
- The main training facility for operators
- An Emergency Response Centre
- A Control Application Development Centre used in the definition, design, testing and maintenance of software applications

Apart from those functions, the primary purpose of a control room within a control centre is to monitor and control plant processes. This requires usually requires some level of system automation. The paradox of automation is that it leads to more sophisticated computer and sometimes work processes. More sophisticated processes in turn lead to more opportunities for “human error”. We then attempt to mitigate the increasing errors with still more automation and when things go wrong, people have difficulty intervening to correct the problem. Some of the critical issues that can increase the risks associated with control/monitor tasks may include the following:

- Limited understanding amongst all involved of what the cause or source of the incident is at the time of the event
- No shared understanding of the impact of their decisions/actions by all at the time of the incident
- A lack of human-systems integration caused by the lack of consideration of the strengths and shortcomings of contemporary equipment design, humans, and past design experience and performance during the allocation of functions process
- Inadequate communication
- Tendency to design just for normal situations
- Skeletal engineering/technical support
- Ineffective training methods
- Over dependence upon operating procedures
- Poorly defined selection criteria resulting in personnel with low competency and skill levels needed for the task at hand

The risks associated with control rooms inside hazardous plant areas or on offshore installations are furthermore managed through consideration of where the building is to be sited or located to reduce the risk as far as reasonable practicable. The control centre location though is most often determined by factors which are not specifically governed by Human Factors Engineering philosophy, such as safety, wind direction, desired free space around the building, potential for future expansion and the number of plants/units to be controlled from the control room. Locating the control centre near or inside the plant obviously brings it within close contact of the plant and the hazards associated with the process. It will result though in short walking or cycling distances but the civil costs are generally high for blast-resistant buildings ($200/sq. ft. - $350/sq. ft.) Locating the building further from the plant results in less noise, less odour, a greater feeling of safety and the civil cost is less ($160/sq. ft. - $200/sq. ft.) Functional requirements and interrelationship activities as already mentioned play an important role in determining where the building will be sited. Other factors to take into consideration include the standoff distance required to protect personnel from a blast as well as the orientation of building entrances away from the source of the explosion. Non-process related hazards might include groundwater, flooding, soil conditions and potential seismic activities in the area.
How Much Space?

After confirmation of all needs and requirements of the end users, determination of the areas where the various functions will take place, any special physical requirements or constraints and the various interrelationships of each, it is necessary to determine how much space is required for each user and in which areas. Some of the areas where functions may be undertaken by the various users are as follows:

- Control room
- Conference or meeting room
- Equipment room
- Offices
- Maintenance room
- Clean and dirty break/relaxation room
- Sanitary facilities
- Exercise and an alertness recovery room
- Kitchen and eating area
- Locker room and toilets
- Library for manuals and “As-built” drawings
- Instrument workshop
- Visitors gallery

The first task to be undertaken to determine space requirements is how much usable space is need in an area such as a control centre. The next step will be to identify the furniture and equipment to be accommodated. Next determine the operational links that need to be provided among items to be housed within the control centre including the personnel. Finally specify circulation requirements for staff and visitors as well as the maintenance access requirements. Some of the furniture or equipment to be considered in a particular control centre layout may include:

- Console and/or individual workstations
- Communication equipment
- Equipment racks
- Shared off-workstation displays
- Storage both on the workstation and off the workstation
- Notice and marker boards
- Desks, file cabinets, bookcases, etc.
- Printers, copying machines, etc.
- Entrances and exits.

In order to develop the functional design specification for the workstation layout and workstation dimensions, the following tasks should be conducted:

- Analyse and clarify the tasks to be undertaken at each workstation (operation and maintenance)
- Identify the necessary functional elements to the workstation
- Develop workstation layout and dimensions.

All ergonomic requirements associated with the workstation layout should be considered such as controls, displays/monitors, writing space, communication devices, seating. The workstation should offer some elements of adjustability if customarily used by differently sized operators. Room and control workstation layout dimensions and features for which peoples sizes (anthropometric dimensions) are relevant, e.g., lateral workspace per workstation, seated view over workstations, must take account of the range of operators for which these items are being provided. Numerous Ergonomics and other reference exist containing dimensional data which can be used by designers for determining the space requirements inside control rooms e.g., ASTM F1166-2000, ABS Guidance Notes for the Application of Ergonomics to Marine Systems and ABS Guide for Crew Habitability on Offshore Installations. Examples of some basic physical (based on USA Anthropometric data) and visual workspace requirements that were considered during a control room design include:
Physical Workspace
- Work surface Height – 29 inches max on top and 26.5 inches as minimum below
- Leg room must be minimum of 30 inches in width and 18 inches in depth
- Individual operator workspace must be no less than 30 inches wide
- Frequently used controls and input devices should be located within a radius of 16 inches.
- Infrequently used controls and input devices should be within a radius of 28 inches

Visual Workspace
- Viewing distance to monitors/screens should be between 25 and 32 inches for an upper case character height of no less than 0.14 inch (3.6 mm), which is equivalent to a 10-point font size with a preference for 0.17 inches (0.42 mm) or a 12-point font size. For larger viewing distance the character height (minimum of 20 minutes of arc) should be increased. Character height in mm can be determined by 0.0058 times the distance in mm from the eye position to the character/symbol.
- Vertical location of the primary viewing area of the screen/monitor should be between 15 and 50 degrees below the horizontal.
- Height of console/workstation for vision over the top when seated is maximum 46 inches from the standing surface.
- Monitor/Screen orientation should be perpendicular to the operator’s line of sight.
- Viewing angle – the total left-to-right viewing angle for head and eye rotation should not exceed 190 degrees.
- Screen/monitor usage- A set of maximum of two to four screens should be allocated to each operator. An operator can only and will use one screen as his main interface and refer to one or two others. (Bransby and Jenkinson, 1998, report the witnessing of two actual plant upsets as follows “It appeared on both plants that the operator was using just one VDU and flicking quite quickly between the graphics. They did not appear to use their second VDU very much and one of the graphics that the B operator brought up quite a few times was on permanent display on the next screen – but he seemed to find it preferable to bring it up on the screen in front of him rather than glance across to the other one.” This is the design intention of VDU based systems and it is interesting to see this evidence of operators using the system this way.)
- There are possible negative effects on operator and system performance if excess screens/monitors are present. A two-fold effect is possible: (1) display designers might feel compelled to “spread out” the display system to accommodate all the screens/monitors (Note: information systems should be ‘compact’) and/or (2) the operators will feel that all the screens/monitors should be used in solving a problem (a common characteristic of problem solving is assuming all available information is relevant, and people actually do better in processing information from a single source). Another related problem is based in signal detection theory: extra, unnecessary screens/monitors add noise to the information environment, thereby decreasing the ability of the operator to find the information they need.
- Tiered screens offer viewing angles that normally exceed the recommend viewing angles. Anecdotal experience suggests that the upper tiered screens are not used by operators during upsets and do not appear to offer any particular advantage. They may be of greater use to ancillary staff standing behind the seated operator but this practice of having people stand behind the operator during upsets is not recommended because it leads to distraction and the increased risk of human error and the additional stress of a supervisor watching over the shoulder. Users wearing bifocals find the upper screen difficult to view. Upper tier screens prevent the wall behind the screens from being used for any off-workstation displays.

According to ISO 11064-3 there are ergonomic benefits in varying postures during periods of work. Whenever practicable it is recommended that workstation layouts and work regimes allow operators to change their posture at the control workstation and to move from their workstations from time to time, this may be achieved by locating some off-workstation equipment at a distance from the main operating positions. At no time however should this interfere with primary control duties or be undertaken as part of a time-critical activity.
Developing the Functional Specification

The results of the functional analysis that have been briefly discussed in the previous sections should typically be captured in the Functional Specification. ISO 11064-1 defines a Functional Specification as a “Description, resulting from the functional analysis, of what the control centre is to be in terms of its functions, support of users and equipment within it, relationships with external systems, and physical and environmental attributes”. The focus here being functions i.e., “What” is needed rather than “How” it is to be achieved. These functional requirements will form the basis for the Design Specification that addresses the “How”. The Design Specification is defined in ISO 11064-1 as a “Detailed description of features of the control suite including room arrangements, equipment, workstation displays, and operator consoles that make possible the development, procurement, and construction of control rooms to satisfy the centre’s overall functional requirements.” These requirements will be used as the basis for the verification and validation process to ensure that the final design conforms to the end-user needs.

The various functional entities and interrelationships to be addressed as well as some functional space requirements have been discussed in the previous sections. Provided below are examples of some additional physical and environmental attributes summarized from ISO 11064-3 that have been found to be valuable in trying to ensure a control centre that fulfils the end-user requirements and minimizes the potential for “human error”.

**General**

- The layout for a control centre staffed by more than one person should optimise team working opportunities and social interaction for personnel without noise distracting task activities at adjacent workstations. The layout should allow direct verbal communication between personnel, but avoid excessively short separations between people.
- The information on off-workstation (projected) displays should be easy to see and be readable by all those needing access to them. The information on all parts of these screens should be visible for personnel from their normal operating positions or from the site from which the information displayed will be acted upon.
- Circulation of control room operators, supervisors, technical support and maintenance staff as well as visitors should be achieved with the minimum disruption.
- The control room should allow for expansion.
- Where it is anticipated that supervisory positions will give rise to additional circulation from outside the control room it is recommended that this workstation be located close to the main entrance.
- The control room and operating workstations should have a means of restricting thoroughfare access.
- Room layout should be based on an agreed set of principles based on a high-level task analysis. This will need to be considered when determining the number of display monitors/screens at each workstation as well as providing redundancy of equipment.
- Entrances/exits (excluding fire exits) should not form part of the working or peripheral visual fields of operators/supervisors.
- There are substantial ergonomic benefits where operators are required to move from their seated position from time to time and avoid remaining in the same fixed posture over long periods of time during a shift. The location of alarm and other printers away from the workstations so as to force operators to walk to them could serve this purpose. Under no circumstances should this activity interfere with primary control duties or be required as part of a critical time function.

**Architectural/Building Considerations**

- It is recommended that a view of the outside be provided if possible. If not some form of visual relief such as scenic posters should be provided.
- Lighting levels should be task dependent, adjustable and minimize discomfort glare.
- External noise is an irritant and can result in the loss of essential verbal information in emergency situations. Consideration should be given at an early stage to traffic, air conditioning systems and other sources of potential unwanted sound. Noise levels should not exceed 55dB(A).
The selection and allocation of space for and within the control room should be based on usable area and not gross area. As a guide an allocation of 108 – 161 sq. feet per operator has been found to be satisfactory. This space provision is based on the use of “usable” or open area.

It is recognized that certain shapes of rooms are more likely to concentrate noise that may be distracting or lead to speech intelligibility problems. Such rooms include hexagonal and circular configurations. Sound dampening/attenuation materials should be incorporated in the design of these shaped configurations.

Control rooms with a single finished floor height offer the maximum flexibility for future change and for the movement of equipment and personnel.

Obstructions and structural features, such as pillars, and of awkward corners within the control room must be avoided in order to maximize usable space and avoid visual obstructions.

Access to building services and service ducts should be from outside the control room.

If possible the public/visitor viewing area should be designed so that control room personnel do not feel that they are there for the entertainment of visitors.

**Workstation Arrangements**

- Workstation arrangements must take account of operations under both normal and emergency conditions.
- Ventilation ducts and grills should be placed to avoid drafts on personnel. Other recommended environmental requirements, include air temperature ranging between 68 and 82 degrees Fahrenheit (20 -26° C), with relative humidity between 40 – 60%. Fresh air should flow at a rate of 427 cubic inches (7 litres) per second per person throughout the control room and air velocities at operator workstations should not exceed 1.65 feet per second (0.5 m).
- Workstations should work equally well under high and low staffing levels.
- Workstation layouts should provide convenient storage and display of all necessary reference documentation and job aids that they normally require to access as part of their duties as well as items that may be required in emergencies. Where workstations are grouped together at a console, the minimum distances between adjacent positions should not result in individuals sitting within each others “intimate zones” or closer than 30 inches.
- When designing workstation layouts, attention should be paid to operator training requirements.
- Supervisory workstations must take into account the additional reference material that may be required to be stored, displayed and used at these positions.
- Layout should allow for additional access, circulation and storage around the supervisory workstation.
- Storage requirements should be classified and prioritised such that the most appropriate provisions can be made within the control room.

**Circulation & Maintenance**

- Adequate provision should be made during the design of the layout/arrangement so that control operations are not interrupted by either visual or auditory instructions made during general circulation.
- Particular care should be taken to provide adequate circulation areas where shift changeover is protracted and two shifts may be present at the same time.
- The layout of the control room should allow for easy and orderly evacuation of the room.
- Control room circulation routes should be arranged to avoid cross-circulation.
- Two-person passageway should be 48 – 54 inches.
- Fixed items should not be placed within 4 inches from the swept area of hinged doors.
- Rear access to workstations for maintenance is required with adequate clearance of 52 inches behind the workstation.
- Where gaps occur between items of equipment, or furniture, adequate clearances must be allowed for cleaning to be undertaken.
- It should be possible for all necessary cleaning to be undertaken without interruption to control room activities.
- An adequate number of power outlets should be provided which will enable cleaning appliances to be used without causing electrical interference or interfering with control room operations.
Special provisions may be required where food and other refreshments are consumed in the control room.

**Off-Workstation/Projected Displays**

- Where off-workstation/projected or shared displays need to be used on a regular or continual basis that preferred position is directly in front of the operator or such that eye-movements from workstation monitors to projected displays are minimized and are achieved by eye movement only. If displays have to be positioned at an angle, they should be such that all information can be reliably read, from the operator’s normal position, by a simple rotation of the control chair.
- Windows and entrances/exits should not be located within the same field of view as major off-workstation visual displays.
- Artificial room lighting should not interfere with the visibility of any sections of the off-workstation, shared visual display.
- Finishes around off-workstation, shared visual displays should be carefully controlled so as not to interfere with the visibility of parts of the shared display.

**Summary**

This paper has attempted to describe the factors that one should consider while determining location and layout of control centres. Since control centres may contain be multi-unit or house functions besides control and monitoring, one of the first steps discussed was the need to identify all functions expected to take place. Initially, these functions can be described in general terms with more explanation being added as the control room location and layout evolves. As control and monitoring functions are better defined, task analysis can be helpful to more closely specify what in necessary to support control centre staff and where various tasks should be performed. Link Analyses provide a means to examine and later optimise location and layout of various functions based on task requirements. Throughout the design process, risks must be considered. Such risks may relate to the design and location of the control centre or relate to the functions taking place or being controlled. Lastly, the results of analyses conducted as part of the control centre location and layout design activities, assumptions and decisions made throughout the location and layout process are normally documented in a functional specification. These will be the basis of the Control Centre (Detailed) Design Specification to be prepared later. The steps described in this paper relate to those described in ISO 11064: Ergonomics Design of Control Centres. This said the reader should note that Location and Layout are only one part of the process for designing such centres. As a result, the information in this paper should used in conjunction with others presented at this conference or those described in ISO and other specifications / guidelines.

**References**


