Videowall Information Design: useless and useful applications

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Abstract

Recent trends in control room design show an increase in the application of large screen presentations of process information. In addition to the standard screens on the operators' station, the control room is equipped with one or more videowalls or large sized (> 40") screens, displaying a summary of the process being supervised. Often these overview displays look impressive and sophisticated. They surely contribute to a high tech appearance of the control room. Further consideration may reveal that an overview display is a costly, often quite useless addition to the standard desktop work stations. This article considers the ergonomic perspective, presenting the most commonly found traps and pitfalls.
Subsequently recent views on human perception, memory characteristics and information processing are used to develop an ergonomic design philosophy, which can serve as a basis for an appropriate and useful application of overview displays. The article describes two case studies concerning practical implementation of ergonomic overview display design principles. These examples include a two-operator control room for supervising offshore natural gas production and a three-operator control room in a chloride electrolysis plant.

Keywords: control room, human computer interaction, information design, design study, engineering project

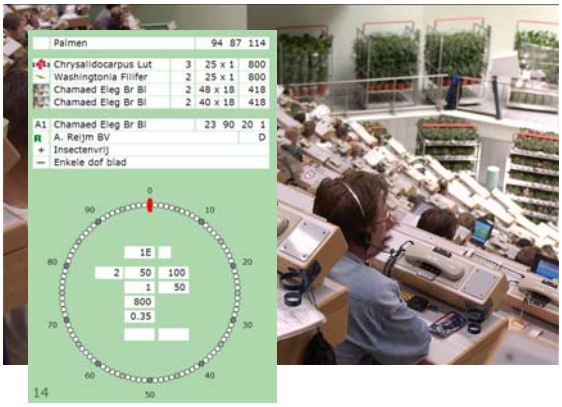
1. Introduction

Modern control rooms are often equipped with videowall systems. Videowalls are used to show process displays, video images and other information, at a central position, on a large scale format. A videowall seems to be an ideal system to provide process operators with a global overview on their area of control. However, sometimes overview information can be displayed just as well on a much less expensive desktop screen.

This paper aims to analyse the specific characteristics of overview information, and to point out in which situations videowall presentation is an appropriate choice. The results are primarily based on practical experiences. The authors are ergonomists with a technical background. Our main professional activity is to design controls rooms and control room information.

We are often consulted on the purchase of large screen presentation systems. The size of the control room often determines the most suitable technology, with the best quality/price ratio.
For a small one or two operator control room, a large sized flat panel display often suffices. Large flat panel displays have been developed as television screens, and they are relatively low priced because of the high production volumes. Large flat panel television screens offer superior display quality. For control room purposes, LCD (TFT) is the preferred technology. Alternatively plasma screens could be used, but plasma technology is not suitable for continuous presentation of still images, causing irreversible burn-in effects.
The size of large flat panel screens is limited (typical size 90 x 55 cm). This may be a disadvantage in comparison with other systems. The screens can be tiled to create a larger display area, but the edges of the screens remain visible.

'Rear projection' is an alternative technology based on standard display modules (typical size 140 x 100 cm). A built in beamer projects an image on the rear side of the module screen. Modules can be tiled almost seamless and provide a good image quality, depending on the type of beamer used, as well as optical features of the system. Because very large screens can be built, these systems are particularly suitable for larger control rooms. However, they are also relatively expensive.
An additional advantage of tiled systems is that the overall resolution of the videowall equals the sum of the resolution of the individual modules. This characteristic can be advantageous when the videowall must be viewed from short as well as long distances.
For very large control rooms beamer technology is an appropriate choice. The picture below shows an example of a large dealing room for auction of houseplants. About 700 users focus alternately on roll containers with products and beamer projected displays.



Beamers can display information at large sizes, but in combination with reflection based projection screens, limited luminance and contrast levels can be achieved. In this example users require a good impression of the product quality. Therefore a luminance level of 800 Lux is maintained. Indirect reflections create a high ambient light level. The contrasts in the display design must be maximised to pure black on pure white to ensure sufficient legibility. Disadvantage of beamer technology is the relatively short lifespan of the expensive lamps (3 to 4 months).

2. Overview information and detail information

In process supervision tasks two types of information can be distinguished. The operator constantly needs information providing a complete but global overview on the status of his entire work area (*overview information*). At the same time he also requires detailed information about a smaller area of interest, particularly at non-normal situations (*detail information*).

Is it possible to use overview information and detail information simultaneously?
Usually the operator will focus on detailed information concerning a small part of the process, for example one process unit. Doing so, he also tries to maintain a status overview about his entire work area [1].
Conventional instrument panels and modern large screen overview displays provide a "spatial coding" of information [2]. The location itself of a variable on the display helps the user to identify its meaning. It is difficult to perceive detailed information and overview information simultaneously. Every now and then looking at the overview may be a valid alternative, assuming it is possible to display overview data in such a format, that a quick scan suffices to obtain the required status information [3]. This principle implies:

- A quick and easy access to overview information . Information should be continuously available and no navigational control actions should be required. This means that overview information should be displayed *permanently* on a *fixed* (predictable) *location*. (spatial coding, [2]).
- Overview information should not distract the operator from performing the tasks concerning the detailed information. Therefore, overview information should not be displayed in the primary field of vision. [4]
- Overview information should be concise : a summary of the most important status indicators, which can be perceived in one quick glance.

When overview information is designed and displayed according to these characteristics, operators get access to detailed information on the desktop screens, which are in his primary field of vision. Additionally, a fixed selection of overview information is displayed in the secondary field of vision, either on a desktop screen, either on a videowall.

Desktop display or videowall display?
When a control room suits just one operator, displaying overview information on a desktop screen is usually the best option. Since there is a linear relation between viewing distance and object size [5], a large videowall at a distance of several meters may project the same image on the operators eye as a much smaller representation of the same information on a desktop screen. However, alternately focussing on distant and

nearby information will require frequent accommodation of the operators eye.
In a multiple operator control room a videowall is a more appropriate choice, although the spatial arrangement of consoles is somewhat restricted, since all operators must have a clear view on the videowall.
Specific advantages of videowalls are:

- All operators are able to see the information at the same time, discussing it and pointing out areas of interest.
- Monitoring of the overview information is not restricted to the console area. This can be convenient when operators also perform tasks elsewhere in the control room, such as permit handling at a permit counter.
- When operators share the same overview information, it has to be displayed only once on the videowall, thus reducing the amount of screens required on each desktop .
- A videowall certainly contributes to a 'high tech' appearance. Obviously this is not an ergonomic argument, but according to the authors experience, this consideration is often a crucial decision factor.

The first argument in the list may have a psychological effect of an improved 'sense of control', because the risk that one fails to notice relevant information will diminish when other operators look at the videowall as well. However the assumption that colleagues monitor the overview information may not be always correct.

3. Traps and pitfalls

Although sometimes aesthetic arguments prevail over functional arguments, a videowall generally contributes to the quality of the control room, when an appropriate selection of information is displayed. The most common traps and pitfalls are:

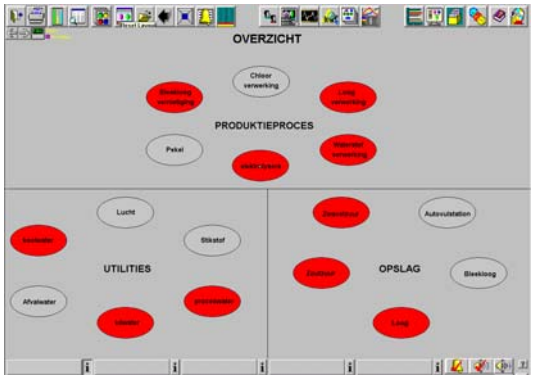
- Too much emphasis on static information instead of dynamic information;
- Too much emphasis on structure instead of content;
- Switching between displays;
- Character sizes too small.

Too much emphasis on static information instead of dynamic information.
Process displays consist of static information elements like process schemes, piping, labels, engineering units, and dynamic information elements like process values, valve positions and set points.

Essentially the operator is interested in the dynamic information. This type of data will inform the operator on the status of the process. Static information is necessary to add structural context, and it clarifies the meaning of the dynamic values.
When a process display is examined frequently, a learning effect will occur with regard to the static information. After some time the operator knows exactly where to locate a certain information element. Because of this learning effect, the amount of static information can be reduced when the display is watched more frequently.

The example above shows a typical videowall set-up. The predominant type of information on this display is a static map, containing geographical details. It will be hard to distinguish the dynamic information clearly, because of the very detailed static context.

Too much emphasis on structure instead of content
'Overview' is not identical to 'structure'. Process displays are usually arranged in a hierarchical structure. It is tempting to show the top level display on the videowall. Unfortunately these top level displays typically contain mainly static information.



In this example a process plant is divided in 17 units, represented by large oval dots. When a process value reaches a warning level, its unit dot will change to a

bright red colour, to alert the operator. Since each dot represents a large number of process values, the dots are mostly red coloured. Therefore it does not give the operator a clear overview on the overall process status.

Switching between displays
The 'learning effect' as described earlier, will only occur when a process display is shown permanently. This implies that overview displays may never be substituted by other displays or covered by overlay windows, particularly when several operators share the same information. When one operator can change the arrangement of the information without informing his colleagues, misperception and wrong interpretation can be expected.

Character sizes too small
There is a linear relation between viewing distance and character size. So when the distance to the videowall is 4x the distance to the desktop screen, the size of the characters needs to be also 4x the size of the desktop character size. In accordance to the authors experience this simple rule is often neglected. In the next example the line structure is clearly visible. However, the character size is much too small, resulting in poor legibility.

4. Ergonomic principles

An overview display is basically a standard process display. The designer can use the same guidelines that apply for common process displays, as for example given in [1]. These guidelines aim to reduce the perceptual load to a minimum. An important rule is to present information as simple as possible, within the constraints of the operators task. 'Consistency' is another important rule. Perception and interpretation can be made easier when information is always presented in the same way.
Some aspects of overview displays require different guidelines. Overview displays are usually looked at more frequently (typical sample rate 2 to 3 times per minute) during a much shorter period (few seconds). This will result in a learning effect on topology (where to find a certain process value) and on static context information (what is the meaning of a certain process value). After some time topology and context information are copied to the operators' memory. Eventually the operator won't read the static, well known information like labels and engineering units at all [5]. For this reason overview displays can be designed with a minimum amount of static information.

Overview displays are not only used for an overall process status, but also for quick access to specific process values. If one knows exactly where a particular item can be found, the localisation process will be quick and effective. It is not necessary to add much context information like labels, borders and other hints to determine the exact location of the desired information, once the operator knows where to find it.

When the operator does not need to focus on the static context, the designer can use the free space to provide extra dynamic information. For this reason overview displays may have a much higher dynamic information density than standard process displays.

5. Design guidelines for overview displays

This paragraph gives some practical design guidelines for overview displays. These guidelines apply both to desktop and videowall presentation.

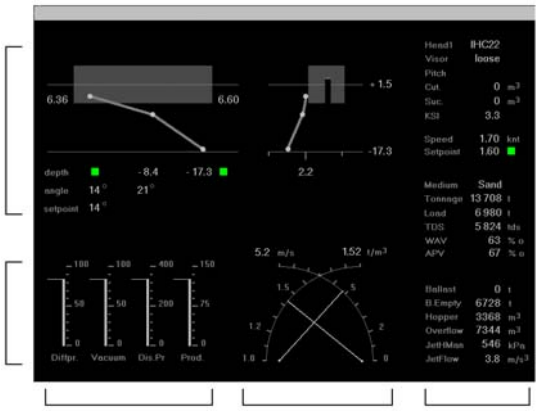
Decide on the amount of the display area needed
There are no strict rules for determination of the exact amount of display area. The operator should be able to overlook the information in one quick glance, possibly moving his head, but without moving his chair. Practical applications reveal that the optimal area size corresponds with one or two desktop screens. Three screens can be regarded as a maximum. This guideline applies to standard desktop screens, in combination with a viewing distance of 80 to 90 cm. For videowall applications, the size can easily be derived through linear extrapolation.

Decide on a set of key performance indicators
Find a comprehensive selection of independent information elements to show on the overview display: called Key Performance Indicators (KPI). A well considered combination of KPI values should give the operator the required status overview. When mainly numerical information is used, arranged in a spatial structure like a table, showing up to 200 parameters on

one overview display should be no problem.

Code information as simple as possible
Showing information as simple as possible requires the lowest amount of perceptual load and is therefore the most desirable option. When a binary status is to be shown, a simple checkmark, dot or coloured square will suffice. If more detail is required a qualitative presentation should be considered (for instance a bar indicator). Quantitative representation by texts and numbers is the appropriate choice when even more details are needed.

Organise information in blocks and tables
Minimal amount of labeling is required when related information is clustered in spatial separated blocks.



Use quick-scan principles
Try to code information in such way that abnormal values are easily distinguishable. One way to achieve this is to use a neutral grey colour for all process values functioning within normal operational limits, and a yellow or red colour to emphasize an abnormal value.

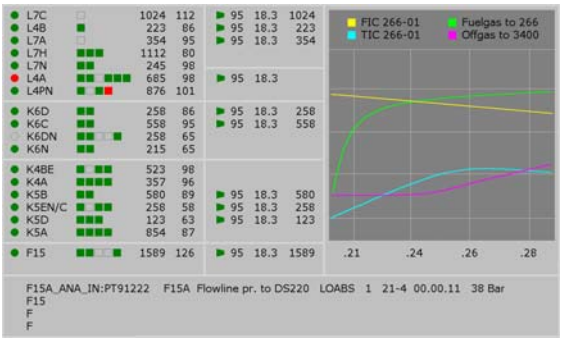
Abstract and simplify presentation
An even more compact presentation can be achieved by using tailor made symbols, representing process modes or equipment. Obviously the operator has to learn the meaning of these symbols by heart. This is acceptable, since an overview display is consulted frequently.

Choose appriopriate fonts and font sizes
For overview displays (both desktop and videowall) the same font guidelines apply as for standard process displays. In case of dynamic information, a ratio of 1:200 should be maintained for font size (capital height) and viewing distance. For static information a slightly smaller font size is acceptable (up to 1:250) [1].
Overview information is often viewed at a horizontal angle. To achieve a good legibility a relatively wide font is preferable. The MS Windows operating system offers some useful fonts, like the font family 'Verdana'. Sometimes the operating system provides advanced character reproduction functions, like anti-aliasing. This will smooth the uneven round and diagonal edges and significantly improves the image quality of fonts. ClearType fonts are aviailable since the introduction of Windows XP, providing improved font quality in combination with flat panel displays. This technology is based on subpixel anti-aliasing algorithms [6].

6. Cases

Recently the authors worked on several projects comprehending design of overview displays. This paragraph shows a small selection:

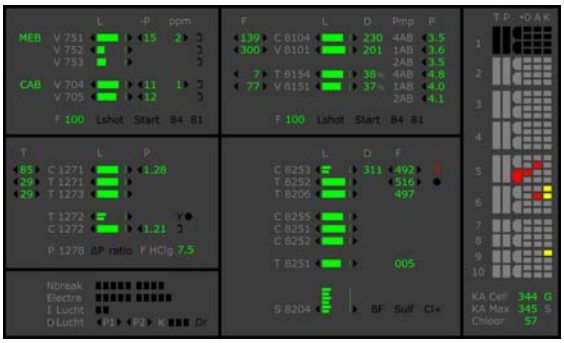
Case 1: Offshore natural gas production
Two operators control 18 offshore gas production assets. Each operator uses 4 desktop screens. One wall-mounted 40" widescreen TFT, serving both operator workplaces, is positioned at a viewing distance of 2.5m, showing the following image:



The left side of the display contains a table. Each production unit is represented by one row in the table, showing communication status, gas well status and main production flow and pressure values.
Interesting is the fact that no column headers are shown. Initially the labels were written on a piece of self adhesive tape and positioned on the top edge of the screen. After two days every operator knew the meaning of the columns by heart and the tape strip could be removed.
In supervision of gas production operators anticipate on non-normal situations by monitoring pressure developments. For this reason the rightmost part of the

display is reserved for trend information.

Case 2: Electrolysis
The following image shows an overview display for a chloride electrolysis plant. The image is displayed on a 40" TFT screen.
This overview display has a dark background to maintain consistency with the other process displays. Typical for this display is the high abstraction level of the information presentation.



The right side of the display shows a matrix of 128 small blocks, each identifying an crucial element in de electrolyser setup. At normal process conditions all blocks are evenly grey coloured. Yellow, orange and red coloured blocks indicate malfunction of one or more systems. The matrix covers a relatively small area of the display, but the pattern of coloured blocks informs the operator efficiently about the current status of many devices.The following example shows a detail of the screen. In some units it is essential to know if the vessels get sufficient recirculation flow. To save space on the display, the circulation is not indicated by a numerical flow value, but by a specially designed symbol, which colour will change to red when the value gets too low.
In this display colour coding is used exclusively to indicate the status of process values and equipment. An evenly green appearance means 'everything OK'. Deviating values are clearly indicated by a contrasting red colour, allowing fast recognition (quickscan).

7. Conclusions

Overview displays are useful to show the operator a concise image of the overall process status, by one quick scan of the information. The same guidelines applying to standard process displays also count for overview information displays. However, overview displays may have a relatively high information density and relatively few static information elements.
Overview displays can be shown on both desktop screens and videowalls. Videowalls are a good choice when the controlroom is manned by several operators, using of the same information at the same time, particulary when the overview display is used as an consultation aid.
Videowall presentation can be realised by several technologies. The appriopriate system choice is often determined by the size of the control room and the number of operators.

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