

## Plenary Discussion Notes – Session 5

### Display Design Concepts

The Plenary discussion on Display Design Concepts incorporated many different themes.

- One, which underlay many seemingly disparate comments, was that what should be shown on the screen depends at least as much on what the display is to be used for as it does on what data are to be displayed.
- Another underlying theme was that, regardless of the purpose of the display, it is essential to allow the user to maintain the context of what is displayed within the environment of the larger task.
- A third theme was that the best display, regardless of purpose and of the nature of the context, depends on who is using the display.

This summary elaborates on the way the different underlying themes were exposed in discussions of specific topics.

A pervasive issue in the display of geospatial data such as a quasi-realistic view of a battlespace, or the cityscape of an anti-terrorist operation, is whether the display should be from an egocentric or an exocentric viewpoint. Both show the terrain and objects in it as though the display user were looking at the actual terrain (probably augmented with symbology representing entities or status information). An egocentric display has the appearance that would be seen by a person acting within the terrain, whereas an exocentric display is more like the scene as it would be viewed by an observer viewing a miniature model. These statements hold true whether the display itself is 2D or 3D. An intermediate kind of display provides a viewpoint that allows a protagonist to be seen in the display, but links the movement of the viewpoint to that of the protagonist, as if the viewer were somewhere behind (and often above), rather than inside the protagonist or in a location independent of any protagonist.

The concept of a protagonist in a display is related to the effects of interaction. In a display that represents semi-realistically a 3-D terrain, an interactive user might choose to place the viewpoint within an actor in the display and control the movements of that actor. That would imply an egocentric display. A non-interactive user, however, might be presented with a map-like view or a distant view in which no one actor is preferred but the action is seen, so to speak, “theoscopically”.

When one is observing the real world, one is doing it from an egocentric, interactive viewpoint. Not only that, but what one observes is exclusively the present state of the visible surface of the world. The user of a display sees an interpreted world, in which some entities may be symbols that represent non-visible states such as temperature, wind speed, networks of influence, or any of the myriad things that one may deduce but cannot see in the real world.

Furthermore, the data on which these non-visible representations are based may be of varying staleness or uncertainty. A map might be based on old surveys, and show roads that pass over bridges since destroyed, or a symbol on a map might represent enemy armour, but the observer who provided the intelligence may not have known how much armour was in the formation. Or perhaps the observer noted that there was armour, but could not determine whether it was enemy or friendly.

Uncertainty could reside in the reliability of the data source, the quality of the observation, changes that might have occurred since the observation, the resolution of the representation on the display (or even of the display

itself), or even in the ability of the display user to interpret the display. This last possibility is important in the context of coalition (or even sometimes joint) operations, especially if the displays use symbology that is culturally specific. The display designer may be uncertain as to how the various intended users may interpret the display, and the user may be uncertain how the designer intended the display to be interpreted.

There was considerable discussion, but not much was resolved, in respect of how to represent on the screen the currency or the reliability or uncertainty of data. Several *ad hoc* representations were shown and criticized, but the main take-away lesson may be that if the data require a certain amount of screen real-estate and pixel value information, to represent the uncertainty of the data is likely to require appreciably more, and to contribute to the problem of clutter.

Fading the representation is a low-resolution and way of avoiding that problem to some extent, though rather unsatisfactory in most situations, since fading affects the visual salience of the data being represented, and to use fading to represent uncertainty precludes its use for representing other aspects of the data. The same applies to using colour, which often is used to represent qualitative distinctions among symbols (such as friendly, enemy, neutral, and unidentified — which last is actually a kind of source-based uncertainty in the data). Texture, which could be an indicator of the level of uncertainty, inherently takes visual space. Making symbols representing precise data be sharp-edged while making uncertain ones fuzzy seemed to have some merit, but only for a qualitative and limited assessment of uncertainty. No really effective solution was proposed during the discussion.

The representation of time was another issue raised. Time could be important in several ways. The evolution of a dynamic situation over time may convey information about its future development. Illustrating when different displayed data were obtained could be as important as illustrating the data themselves. Departures from regular rhythms might be significant, or it might be important for the user to know exactly when certain data were acquired or in what order certain events happened. An observation that armour was noted at point X ten minutes ago is potentially much more valuable than noting that armour was seen there last month. If the evolution of a dynamic display permits prediction, how should the predicted situation be displayed to differentiate it from, and relate it to, the current situation?

The words “relate it to” suggest the pervasive issue of contextual maintenance. Most displays represent only a small portion of what the user needs to know, and that small portion may make little sense when considered by itself. What makes the display useful is what it contributes to the larger mental picture formed by the user.

It is an everyday observation that one knows a route better if one drives it oneself than if one is driven over it as a passenger. The same holds true for display representation. If the user drives changes in the display in a natural way, the changed display will seem better integrated with the original than it would have, had the change been performed autonomously by the software. User interaction with the display is an important way to get around the limitation of screen real-estate. It helps the user maintain a picture that incorporates both the old display content and the new as an integrated whole.

There are several mechanisms that help the user maintain context through interaction. One class does it by maintaining continuity during a change in focus, the other by retaining some linking element of one display while switching to another. The system described by Barr at the workshop as “Pliable Display Technology” is of the first kind. All of the spatial context is retained at all times, but the region of interest and its neighbourhood are smoothly expanded around a centre controlled by the user. It is a sophisticated version of a system that provides for zooming and panning, that does not require the user to build the context entirely from memory.

In some tasks, some aspects of the task may be better performed using a 2D display, whereas other aspects of the same task might be better with a 3D display of the same data. It is possible to allow smooth transitions between 2D and 3D displays of the same scene, and if the user controls that transition, context maintenance is very probable.

Failure to maintain context in a passively observed dynamic display causes problems in a specific important situation, characterized by the question: “Where is the UAV looking?” An operator who has been tracking the UAV probably has no problem with this, but one who has missed some transition or who comes into the middle of a flight may have a great deal of trouble aligning the display with other representations of the terrain.

Adding and subtracting layers over a map, or “blinking” alternation between a present and a future situation is a context-maintenance mechanism of the second kind, which can be effective whether the user controls the alternations or passively observes them. What happens in this mode is that a fixed aspect of the display has its context changed. The change draws attention, making what was context into the focal information for which the unchanged aspect becomes context.

Interactions are not limited to those between a single user and the display. Displays are often used to support interactions among users observing the same display (whether on the same physical hardware or on physically separated systems). Supporting several users is essential in developing the Common Operational Picture. In this situation, the display becomes a medium of communication, and it becomes important that the manipulations performed by one user be correctly interpreted by other users. Cultural differences in the interpretation of symbols may extend to differences in the interpretation of dynamics imposed on the display by an interacting user.

Always, when display technology is the subject of discussion, the questions of “clutter”, resolution, and display size are raised. More objects can be placed on displays of high resolution or of large size than on smaller or lower-resolution displays. But the mere presence of many irrelevant objects tends to divert attention from objects that should be salient for the task at hand.

“Clutter”, however, has two faces. From one point of view, it can take the display of many objects for the “big picture” to emerge, just as in the non-computational world, we make sense out of scenes that contain myriads of objects. So “clutter” does not refer only to the simultaneous display of large numbers of objects. If those objects cohere to form a pattern that is meaningful in the task context, there is no clutter. If the task requires the user to see and interpret individual objects within a mess of similar objects, then there is clutter. Between these two extremes may lie displays such as road maps or other networks, which make little sense if there are too few displayed nodes, or if there are too many. In the case of road maps, the notion of clutter offers another face: if all the roads were to be shown in the same kind of line and colour, the map would be distinctly cluttered, but the clutter is removed by the visual distinction among salient major roads and weakly displayed minor roads that can be readily located by reference to the major roads.

One factor that is often forgotten is that people often are not aware of the errors they experience. For example, from a static viewpoint, visual space is non-Euclidean, in that radial distances tend to be shortened in comparison with lateral distances. But the viewer’s interactions with objects in space reduce this effect, and bring at least the near space toward the Euclidean space most people believe they always see. This non-Euclidean perception can cause problems when distances are assessed within quasi-realistic displays, whether they are 2D or 3D.

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Various miscellaneous topics were touched upon. These include methods of making displays intelligible by reducing the number of mental spatial transformations required for their interpretation; the use of non-visible spatial audio, either alone or in conjunction with a visible display, to assist the detection of anomalous events or patterns; the problem of colour-blindness and the value of redundant coding of object attributes; the differences that might exist between displays intended for distribution over the Web and those intended for local presentation; the need to train users to use specific displays; ways of “making good things and bad things look different”; and not least, the fact that displays most liked by users are not necessarily the displays the users use best.