



## Report on C4i Study: Brunel Command Wall System Design Recommendations.

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## **Authors**

<b>Neville Stanton</b>	<b>Brunel university</b>
<b>Darshna Ladva</b>	<b>Brunel University</b>
<b>Laura Rafferty</b>	<b>Brunel University</b>
<b>Guy Walker</b>	<b>Brunel University</b>
<b>Daniel Jenkins</b>	<b>Brunel University</b>
<b>Paul Salmon</b>	<b>Brunel University</b>

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# 1 Executive Summary

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This document reports on the design recommendations for the C4i Brunel Command Wall System as at March 2006. The process of review, of which this report is a part, is ongoing, and follows the completion of two empirical studies carried out using the system. The recommendations are derived from the following:

- the results and limitations identified in earlier studies,
- participants' comments,
- the experimenters own observations,
- and the Critical Decision Method (CDM) interviews undertaken during the studies.

The aim of this report, therefore, is:

1. To extract and summarise any improvements that could inform the next iteration of the Brunel Command Wall System.
2. To describe the empirically derived responses to the limitations identified in the previous studies.

The recommendations are grouped under two headings: refinements to the study and usability of the system. Refinements to the study are concerned with methods, procedures and outcomes. They form the response strategy for how future studies are to be conducted. Usability of the system is concerned with developing responses that could inform the evidence-based design of future iterations of the system.

## 2 Introduction

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The aims of the study reported below are as follows:

- To extract and summarize the responses to limitations identified in the Brunel Command Wall system in its current state.
- To extract and summarize any improvements that could be made to the Command Wall system from its current state.

This report provides an opportunity to compare the results of two studies (Detailed in HFI DTC Report 1.5.3/1 and 1.5.3/2). During the first study, the participants acting in the role of commander were randomly assigned to one of three conditions. The three conditions in this experiment were a paper based system, with paper co-ordinates and paper maps, a radio based condition with radio coordinates and paper maps, and the Brunel Command Wall (the so-called electronic system). This was a between subjects design based on comparing three command systems. The task was to use either of the systems to undertake a Battlefield Area Evaluation (BAE), in which the main output was a Situation Overlay representing the actual state of the Battle-space. Information used in the construction of the Situation Overlay was extracted from the environment by three field agents. These field agents had a pre defined area that they each searched, and they reported back on specific informational artefacts placed around it. The commander's performance was measured as it related to the command system's ability to support their task of creating the situation overlay, based on the information relayed to them by the field agents.

The second study followed the same procedure as the first, only this time with four conditions and two independent variables. Rather than the medium (paper, radio, electronic), the focus was on information source type and information decay. Information source type is split into two conditions: information push and information pull. Information push meant that information was pushed on the users as it became available. Information pull meant that participants controlled when they received new information (they had to request it). Information decay was also split into two conditions, permanent display and temporary display. Permanent display meant that the information remained visible to the commander throughout the experiment. Temporary display meant that information disappeared after forty five seconds.

Both studies were designed with the assistance and input of army personnel and followed direct observation of army command activities at the Land Warfare Centre in Warminster. They are situated within a more generalised aim, which is to provide foundation data to guide successive experiments and design iterations. Experimental concerns such as adequate control and the isolation of key variables of interest led to the development of an experimental scenario with certain key militaristic features. More complex and progressively more accurate military scenarios will be adopted in successive studies as our understanding of these key variables builds. This report, therefore, is part of an ongoing cycle of testing, review, re-design, and further testing.

## **3 Recommendations**

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### **3.1 Refinements to the Study**

#### **3.1.1 Simple Characteristics**

##### **3.1.1.1 Background**

External validity questions whether or not it is possible to generalise the results to the population as a whole. One aspect of this is whether or not the results can be generalised from a student participant population to a specifically military population. In both studies the sample of participants consisted of students.

##### **3.1.1.2 Recommendation**

In order to cross-check external validity it is recommended to use individuals with military experience, such as those from the Territorial Army, Cadet Forces, active or non-active Service Personnel. Although there is little reason at this stage to suspect a large difference (especially in view of the DTC's aim to develop systems that can be used quickly and easily by a new generation of recruits) this would, nonetheless, permit a valuable comparative analysis.

#### **3.1.2 Task Characteristics**

##### **3.1.2.1 Background**

Tests which are not rigorously standardised can easily result in inaccurate results. So there is a need to ensure that there are no differences between the conditions other than the independent variable. In the first study it became apparent that there were other, subtle differences between the conditions, for example, in respect to information source type.

In the first study, within the paper condition, the participants were given a list of the co-ordinates and codes at the beginning of the experiment. They could then choose to PULL the information from this source, as and when they wished during the experiment, returning to it at will. In the electronic condition, however, information is PUSHED at the participants as and when the simulated field agent(s) report it. In other words, they can not choose when they receive new information and have to wait until it is given. This may affect the overall time taken to complete the experiment as the participants in the electronic condition may be waiting around for the next code (it had information PUSH features) whereas the participants in the paper condition do not have to (using paper maps, clear overlays and a list of coordinates is clearly a case of information PULL). The radio condition, on the other hand, appears to be a mixture of the two; it embodies features of information PUSH and PULL. In the radio condition, participants are contacted by the simulated field agents as soon as they find a new code but the field

agents ask if the commander (participant) is ready to receive it, and wait until they are ready to present the information. The initial communication as to the presence of information to be reported is a case of information PUSH, the commander's readiness to accept the incoming information is a case of information PULL. Thus all three experimental conditions have a mixture of push and pull presentation and so the differences between the conditions could be influenced by this rather than the independent variable.

### **3.1.2.2 Recommendation**

A study has been designed (and carried out) based around the idea of information source type (push and pull). The aim is to isolate information source type from medium, and to gauge the effect of these two factors independently.

## **3.1.3 Key for Maker Codes**

### **3.1.3.1 Background**

Although a paper 'key to codes' and 'plan view of the search area' is provided, there is enough room to place both on to the third, right hand screen of the command system itself.

### **3.1.3.2 Recommendation**

Plan view of search area and the key for codes should be on the command system screen to avoid having to constantly refer to paper materials<sup>1</sup>.

## **3.1.4 Participant Training and Briefing**

### **3.1.4.1 Background**

It also became apparent through comments and the CDM questionnaire, that participants felt extra training would have been beneficial, for example, more instructions and more time to study the key. Other participants, however, commented that the instructions were too long, and consisted of many irrelevant points.

### **3.1.4.2 Recommendations**

Revisit the experiment instructions and consider revising and improving their clarity and brevity.

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<sup>1</sup> This recommendation may be superseded by the next generation of system using COTS technology.

### **3.1.5 CDM Questionnaire Wording**

#### **3.1.5.1 Background**

The wording of the CDM probe questions was found to be ambiguous in some cases.

#### **3.1.5.2 Recommendation**

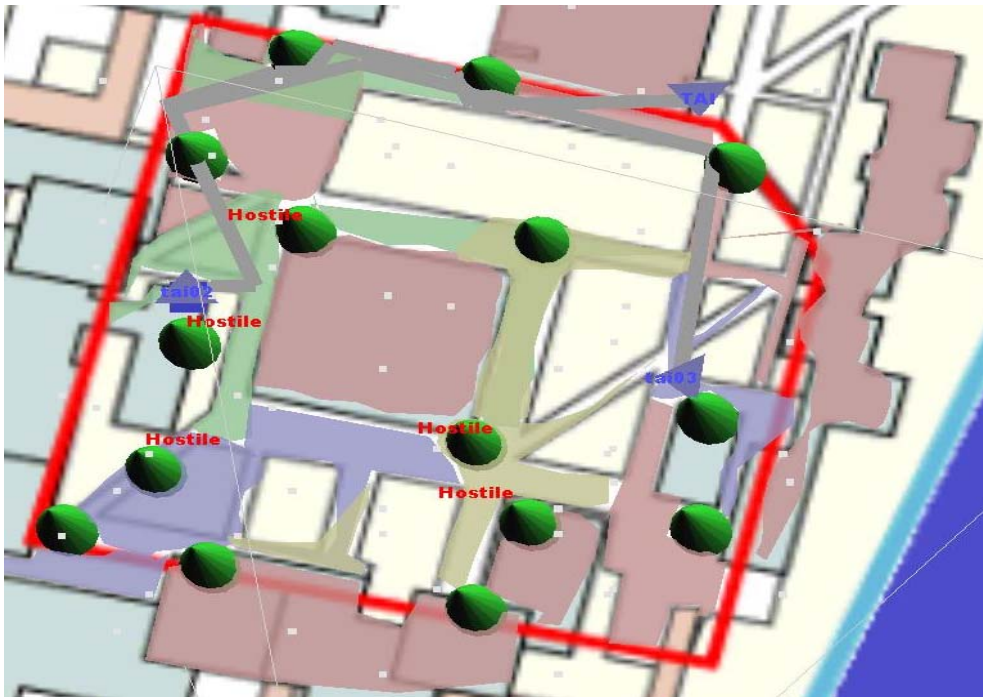
The CDM probe questions are pre-existing and validated. They are, nevertheless, somewhat ambiguous for participants. It is proposed to subtly reword some items to ensure the questions are relevant to the scenario and also for the questions to be more specific (where possible). It is also recommended that alternative knowledge elicitation techniques are considered with a view to pooling relevant (and validated) question items.

### **3.1.6 Experimental Battlespace 'Area/Border of Operations'**

#### **3.1.6.1 Background**

When asked which aspects of the situation overlay task were found to be most confusing one participant answered "*when I had to mark the buildings outside the box.*"

Some participants went over the top and marked up entire buildings outside the red border that should not have been marked up. This is shown in Figure 1 below. Other participants didn't mark up any buildings outside the red border and thus missed the information cone in the bottom left hand corner, which referred to a building three stories or higher which was on the border itself.



**Figure 1 - An example of a participant creating a situation overlay beyond the specified area (marked in red)**

### **3.1.6.2 Recommendation**

It is recommended that participants should only be asked to mark up inside the red border. If necessary the border should be adjusted to aid clarity.

### **3.1.7 Information Presentation**

#### **3.1.7.1 Background**

During the experimental process it was noted that some participants (in the electronic condition) were waiting for the next code to be appear, this clearly affected the speed of their performance. If participants were able to pull the informational codes whenever they were ready to receive them, so long as the units had information to relay, this would improve their performance.

#### **3.1.7.2 Recommendation**

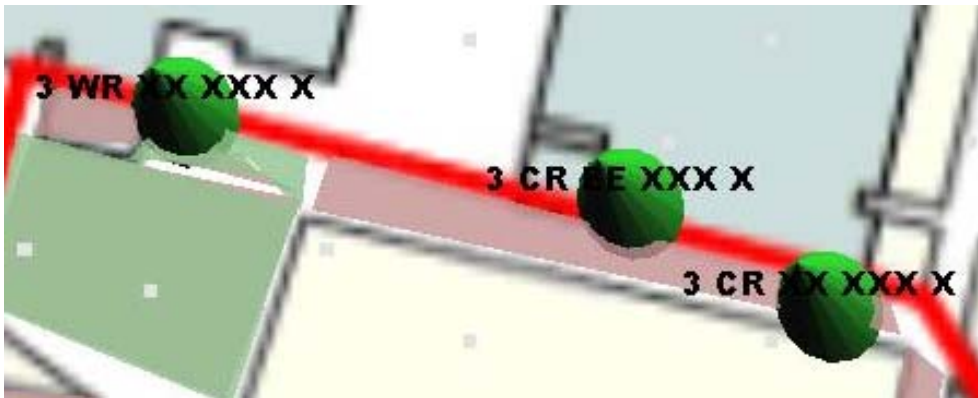
It is recommended, within the context of future studies/system iterations, that participants control the speed of information presented to them from the field.

## 3.2 Usability of System

### 3.2.1 Colour Coding

#### 3.2.1.1 Background

During the experiment it was often observed that participants sometimes experienced some difficulty and confusion when marking up the situation overlay. This confusion could affect task performance.



**Figure 2 - Evidence of confusion when labelling buildings three stories or higher and congested routes. They tended to mark one and not the other.**

In this example, the participant understood that three meant they should colour the nearest building red, to represent a three story building, as they had done this for the first, left hand side code. However, the second and third cones denoted both a three storey high building and a congested route (both requiring the red colour code<sup>2</sup>). In the event, a number of participants only managed to mark up the congested road part of the code, completely ignoring the 'three stories or higher' part.

Specifically, it was seen that when the codes included both instructions (three stories or higher and congested routes), some participants would mark up one and not the other. It was also observed that this inaccuracy of marking up would sometimes occur despite the fact that the instructions were placed on different codes and are labelled in different places on the map. As well as this being observed by the experimenter, it was also found that participants themselves supported this amendment as some commented on this in the CDM questionnaire. One participant noted that

*“I think the Key needs to be clearer. For example I don't think the colour red should be used to a three storey building and a congested road. It is slightly confusing.”*

Some participants also commented that the colours used on the map were quite similar and were difficult to distinguish. For example, the minefield areas were labelled in a very

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<sup>2</sup> This was a constraint placed on the experiment by the first generation command wall system.

light pale yellow and the route areas were labelled in white. This is shown in Figure 3. In the section of the map illustrated, it is quite difficult to distinguish which of the two lighter areas is the white route area and which is the yellow minefield area. This difficulty becomes even greater for participants during the experiment because they are sat at a distance from the screens, making the colour definition even more difficult to divine. This point is elaborated by one of the participants during the CDM interview: *“The colours did not seem to correspond to the key, they are too pale and all similar”*.



**Figure 3 - Similarity of the colours of the routes and minefields, making it difficult to distinguish between the two.**

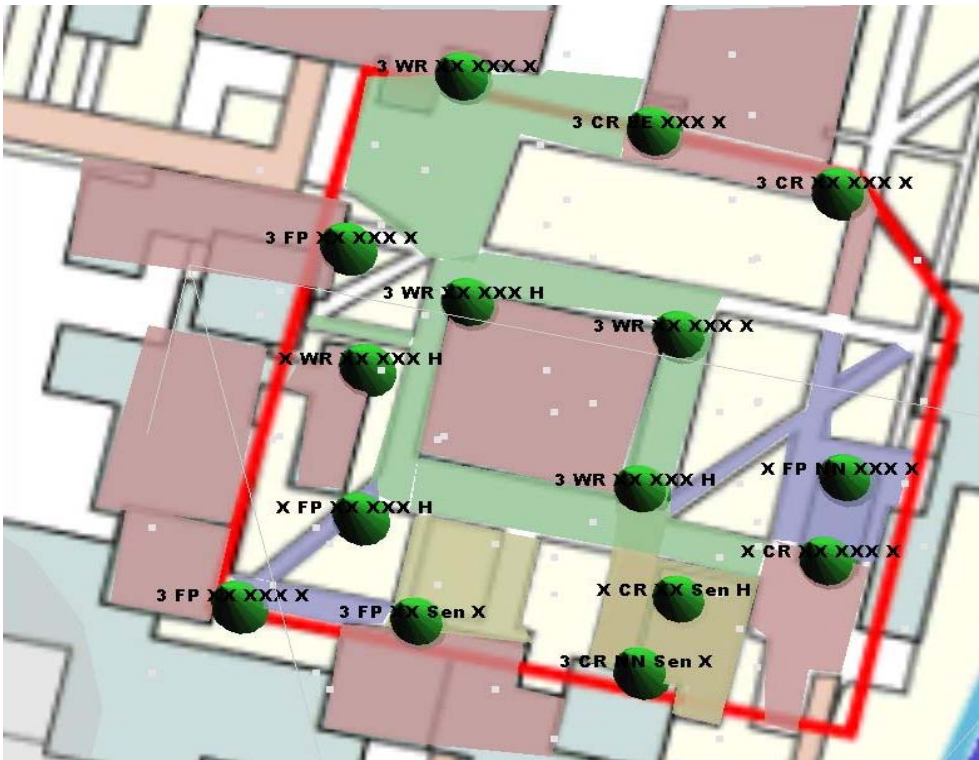
### **3.2.1.2 Recommendations**

An amendment that could be made to the current system, to help avoid confusion, would be to have different colours for labelling the congested routes and buildings three stories or higher. A simple alteration that could be made to the map before any marking up is to change the colours of the different areas to improve their clarity.

## **3.2.2 Visual Clutter and Overlap**

### **3.2.2.1 Background**

It was observed that participants found it difficult to identify the correct markers as the cones in some conditions appeared all at once. This made the screen seem cluttered and, therefore, made it harder to read the abbreviated numbers and letters. This is shown in Figure 4.



**Figure 4 - All codes and cones displayed simultaneously**

At present the cones are dark green and the writing of the code is black, which blends together in some circumstances, causing the middle section of the code to become difficult to read, as shown in Figure 5. It was observed that during the experiment(s) several participants were unable to read the code and had to ask the experimenter. Participants also made points such as these during the CDM interview:

*‘background colour is too dark to read the letter’*

*‘when I couldn’t see the information properly because the markers were blocking’*



**Figure 5 - Example of problem arising with colour coding and overlap**

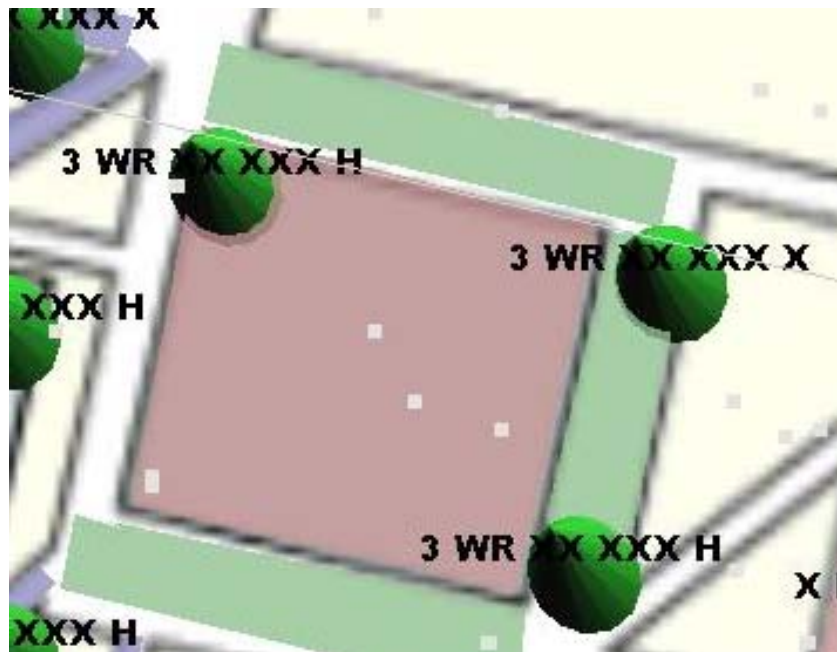
A final aspect of the marker codes that the participant’s found confusing was the inclusion of ‘XXX’ in the code string (to denote ‘no information given’). The CDM discovered that participants found it difficult to read the codes when XXX’s were included.

Referring to the middle part of Figure 6 it is possible to see that there are three separate cones surrounding the central building, each of these cones refer to the same building (that must be marked up as three stories or higher). This confuses a lot of participants as

they look for a separate building to mark up for the next two cones, once they have marked up the first.

When asked if they found any aspects of the study confusing one participant mentioned that

*‘yes, especially when you just marked a building and then a new cone arrives around the site indicating that the building is still to be marked’*



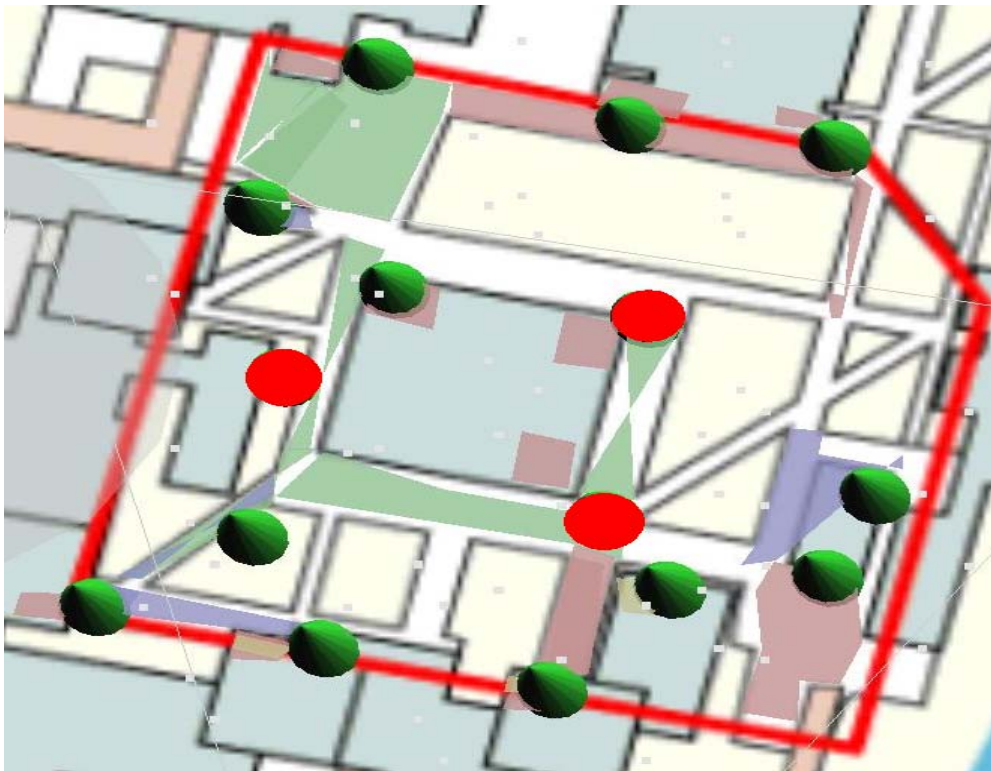
**Figure 6 - All three codes state the same instructions**

Participants often seemed to become confused as to which cones they had marked up already and which were yet to be coded for. This occurred, specifically, in the Pull conditions in the Push Pull study. In this case participants had to request to see the code. Once the cones have appeared they all look identical.

It could be argued that the visualisation and clarity of the codes and cones could affect the time taken to process and mark up the information, particularly in the push temporary condition, in which the code is displayed for only a short period of time.

### **3.2.2.2 Recommendations**

1. Enable cones to turn red once they have been marked (Figure 7).



**Figure 7 - Illustration of cones turning red to remind the commander that they have been dealt with.**

2. It is recommended to remove the 'XX's' from codes to make them less confusing, shorter, simpler and straight to the point. So instead of having a code informing the commander about a footpath due north saying X FP NN XXX, it would simply say FP NN.
3. Modify the codes so that only one cone refers to one area, rather than multiple cones, e.g. one from each of the three field agents.
4. Change the colour of the cone to a lighter shade so that none of the code is blocked by the cone.
5. Change the size of the cones by making them slightly smaller so they do not overlap.

### 3.2.3 System Tools

#### 3.2.3.1 Background

In the CDM questionnaire a participant mentioned that it was “difficult and time consuming trying to amend a mistake”. Creating a faster and simpler form of deleting the marked up areas could reduce the amount of time taken to complete the task(s) successfully. Figure 8, Figure 9 and Figure 10 below, show the steps that participants take to delete an area on the situation overlay.



**Figure 8 - Step 1: Participant must select the clear (un-shaded) pentagon icon**



**Figure 9 - Step 2: Participant must use mouse and cursor to draw around previously shaded area (shown by the faint grey line around the red area)**



**Figure 10- Step 3: Participant returns to pentagon icons and selects the one with the cross in the centre**

A number of participants remarked on the fact that more drawing tools/functionality would be helpful. For example: “since most of the buildings are rectangular, it would be nice if the users of the system could have the added option of choosing rectangular shapes instead of just pointing at edges to choose a shape”.

### **3.2.3.2 Recommendations**

Improve the tools used by participants to delete incorrect marking on the situation overlay. A simple ‘eraser’ tool (as found in MSPaint) is offered as a simple solution for further consideration. Other tools, that it is recommended to consider, are a greater range of colours, so that coding could be more specific and precise, and a rectangular shaped block drawing tool.

## **3.2.4 2D versus 3D Visualisation**

### **3.2.4.1 Background**

The value of the 3D visualisation, at least for the current task(s), was questioned by some participants. For example, one CDM questionnaire response included: “The main uncertainty was from the 2D & 3D maps as they were giving conflicting accounts of the situation”. Many of the participants stated that they focused mainly on the 2D plan view of the battlespace and largely ignored the 3D view. This, of course, may be an artefact of the simplicity of the task, some discrepancies due to the instantiation of the current 3D view, or, indeed, a genuine population effect regarding the efficacy of 3D per-se.

### **3.2.4.2 Recommendation**

Remain vigilant to the actual versus expected benefits of 3D representations.

## **3.2.5 Granularity of Co-Ordinates**

### **3.2.5.1 Background**

The participants also commented that the co-ordinates were perhaps too vague and could be made more precise through the use of decimals. This would allow the commanders a greater sense of certainty about the locations of interest on the situation overlay. Along with creating more exact co-ordinates, greater confidence about locations could also be achieved.

### **3.2.5.2 Recommendations**

Additional decimal places could be incorporated into subsequent trials to improve accuracy, as could a higher resolution grid coordinate system. In order to reduce uncertainty as to what area a marker cone was referring to some form of visualisation could encompass the area which the cone was coding for. This would mean that the field agents would draw a net, for example, around each cone to symbolise how far the congested road stretched, or how far they could see that it stretched for. This would reduce any confusion as to the size of the areas to be marked up.

## **3.2.6 Directional Information**

### **3.2.6.1 Background**

Some participants suggested that the directional section of the marker code is removed and replaced with some form of arrow attached to the cone. Participants also specifically mentioned in the CDM interviews that such a reduction from the code would be useful.

### **3.2.6.2 Recommendation**

Apply an arrow shape to the marker cone which points in the appropriate direction when road direction is specified.

## 4 References and Bibliography

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