# Effect of Workspace Awareness Support on Distributed Team Collaboration

**Mark Ashdown**
Thales Research and Technology
Worton Drive, Reading, RG2 0SB, UK
mark@ashdown.me

**Yale Song**
Massachusetts Institute of Technology, CSAIL
32 Vassar St, Cambridge MA 02139, USA
yalesong@csail.mit.edu

**ABSTRACT**
We have combined tabletop and handheld displays in a remote collaboration system to support members of a distributed team. Collaboration over visual information such as maps is aided by workspace awareness support, such as telepointers and viewports. We report the results of an experiment in which 13 teams completed simulated emergency response missions.

**Author Keywords**
Asymmetric collaboration, workspace awareness.

**ACM Classification Keywords**
H5.3.d. Information interfaces and presentation (e.g., HCI): Evaluation/methodology.

## INTRODUCTION

We have implemented a system for remote collaboration between a large tabletop display and small handheld displays. We have tested it with an emergency response scenario. A tactical actor uses a high-resolution tabletop display to arrange a map, a timeline, and reports. These workspaces are shared with one or more searchers out in the field, via a touchscreen handheld device.

The tabletop is a 60-inch four-projector 5.9-megapixel display with pen input, based on T3 [1]. The handheld has a 4.5-inch touch screen (Figure 1).

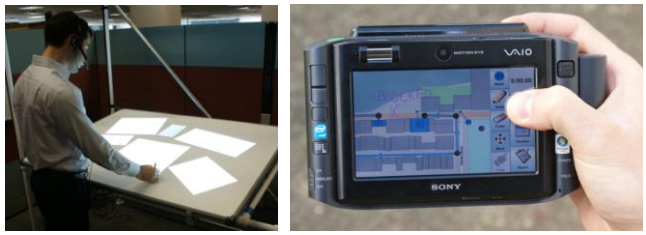


**Figure 1. Tabletop and handheld displays.**

The differences in the display devices and the roles of the participants require a different user interface for each device. Also, we wish to investigate the difference that workspace awareness features (WAFs) can make. The WAFs in this system [2] are telepointers, traces showing a history of telepointer movement, viewports indicating the region of a workspace that another person can see, and continuous feedthrough of map annotation, user interface widgets, and direct manipulation. Also, when the WAFs are enabled, an over-the-shoulder view shows an interactive copy of the handheld display on the tabletop. Synchronous updates to provide such features will be more demanding of the wireless network supporting the handheld device, but they may provide improvements in subjective or objective measures of the product or process of the collaboration [3].

Gutwin and Greenberg found that similar features improved collaboration [4]. They used conventional PCs and a task purely in the shared workspace, whereas we are using a tabletop and handheld, and have one participant moving around in a virtual environment.

We conducted an experiment to assess the effect of the WAFs. Some results are described below, and we will provide more detail in the poster session. We would like to get feedback on our proposed changes to the collaborative interface, and insights for alternative designs.

## EXPERIMENT

We performed an experiment in which participants worked in pairs. The tactical actor used the tabletop display. The participant representing the searcher used the handheld, and walked around a virtual city via a 3D display on a conventional PC. The two could talk to each other at all times via headsets and voice over IP. The experiment had two conditions: with and without the WAFs.

Participants first completed a demographic survey including questions on their experience with relevant technology. They were then introduced to the collaborative system, and asked to read some instructions. They completed collaborative missions in each of the two conditions. Each mission was preceded by a shorter practice mission, and followed by a questionnaire. The order of the missions was fixed, and the order of the conditions (with and without WAFs) was counterbalanced. There was a final questionnaire on preference between the two conditions, and a retrospective review of a video of the two missions to elicit feedback on problems and features that could be added.

## RESULTS

Thirteen pairs of people participated in our experiment (26 people in total). The mean time to complete a mission was 17.8 minutes (SD = 4.5). There was no significant effect of the WAFs on this time.

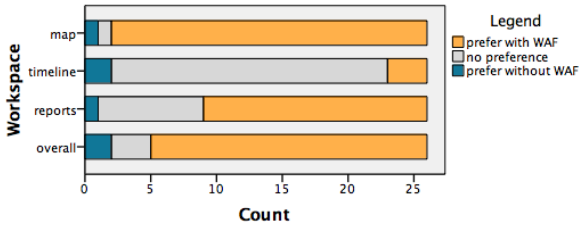


**Figure 2. Preference for the two conditions.**

Participants used versions of three shared workspaces with and without the WAFs. Figure 2 shows their stated preference.

The words spoken by the participants were assigned to several categories: Status "I've entered the site", Guiding "Go this way", Situation Awareness (SA) updates "The road is blocked here", Reporting (voicing information which should be entered into a form), Feedback "OK", Social (joking), Meta-coordination "Can you see what I've drawn", and Other. Guiding and SA utterances were classified as deictic or non-deictic, depending on whether they involved pointing within a workspace. Deictic guiding was possible without WAFs by using annotations. Figure 3 shows that there was significantly more deictic guiding in the condition with WAFs.

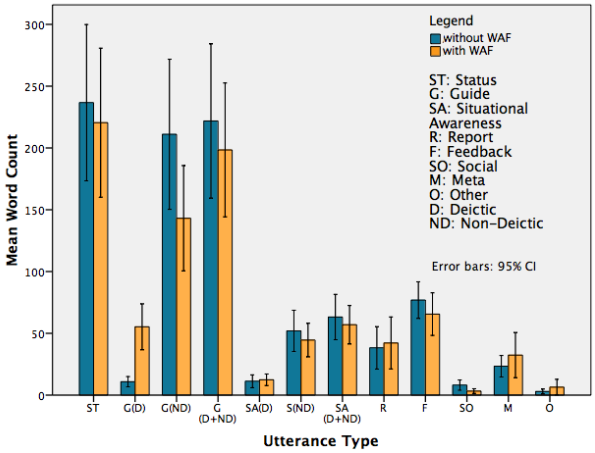


**Figure 3. Word counts for utterance types.**

Reports containing information obtained by the searcher had to be entered. The entry could be done by either participant. Figure 4 shows the proportion of reports entered by each one. Collaborative reporting was not available when WAFs were disabled.

The tactical actor had the option of remotely panning the map on the handheld by dragging a region on the tabletop map. Around half of the teams used this option. The tactical actor usually indicated his intention to pan the other person's map vocally, before doing so. This seemed to be a courtesy, implying he was encroaching into the other person's territory.

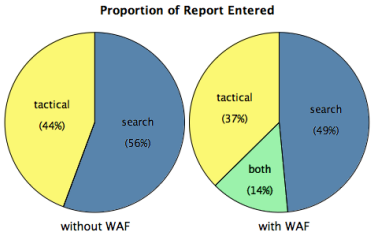


**Figure 4. Proportion of reports entered by each participant.**

## DISCUSSION

Participants preferred to have the WAFs for the map and reports. The amount of guiding was the same in the two conditions, but more of it was deictic when the WAFs were enabled. Collaborative reporting was used a little, but feedback indicated the concurrency could be a source of error.

Qualitative feedback and suggestions were obtained from the questionnaires and retrospectives. On the tabletop, there was mode confusion on the map because the toolbar was often out of the user's field of view. The over-the-shoulder view was useful for monitoring the other participant's actions and remaining aware of his restricted view, but interaction with it should probably be disabled because of possible errors due to concurrent access from multiple displays. Simple sketch recognition was used for entering waypoints that formed a route on the map, but inaccuracy in the recognition was magnified by the time pressure of the mission, causing frustration for some users.

On the handheld, auditory icons, and possibly vibration, would help by directing the user's attention to the device at the right time. Lack of precision when drawing with the finger on the handheld was a problem. This could be alleviated by providing a collection of drag-and-drop symbols for common incidents.

## ACKNOWLEDGEMENTS

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