

# A Human Factors Perspective on Air Traffic Control and the Design of Technology for Dark Environments

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## **ABSTRACT**

In this position paper, I discuss how air traffic controllers interact with technology in dark environments. In particular, I discuss how working in the dark has affected the design of information and communication technology that controllers use.

## **Author Keywords**

Air traffic control, lighting, displays, usability

## **ACM Classification Keywords**

H.5.2 [Information Interfaces and Presentation]: User Interfaces—*Ergonomics*

## **INTRODUCTION**

Since the earliest days of air traffic control (ATC), controllers have worked at least partially in the dark. This affects how controllers do their jobs and influences the design of the technology they use. This position paper outlines some of our experiences developing ATC technology for use in the dark. It also discusses several areas where interaction research in dark environments could benefit ATC.

## **AIRPORT TRAFFIC CONTROL TOWERS**

Tower controllers monitor aircraft as they take off, land, and move between airport terminals and runways. Their work requires direct observation of aircraft through the windows of the tower cab. They also interact with a variety of information and communication technology. To reduce glare during the day, and maintain their dark adaptation and reduce reflections at night, controllers regularly change the room lighting, raise or lower the window shades, and adjust their displays [4].

The dynamic lighting conditions make it difficult to design

technology that is always usable. First, technology that addresses problems in one condition sometimes creates problems in another. Controllers need very bright displays during the day so that information is usable in direct sunlight. Although modern sunlight-readable monitors work well in daylight, they can create usability problems in the dark. For example, sunlight-readable LCDs commonly incorporate extra bright backlights [1]. However, such powerful backlights are unnecessary in the dark and may be unacceptably bright, even at the lowest setting. Similar issues have been noted in the consumer electronics industry, where large flat panel TVs that work well in room lighting may be too bright for a dark home theater [3].

Second, as darkness falls, controllers decrease the brightness of their displays. In this regard, old displays were more usable than new ones. In particular, old displays provided knobs or dials for adjusting brightness and contrast. Each brightness knob, even those produced by competing manufacturers, worked basically the same way. Controllers could adjust brightness quickly and without devoting much attention to the process. On the other hand, modern brightness controls are usually provided in on-screen menus that users navigate using multipurpose buttons. These menus are often slow, difficult for users to learn and understand, and may cause mistakes and frustration. Worse, each model and manufacturer uses a different menu design. When tower controllers transition from daylight to darkness, they may need to adjust the brightness of 5 to 8 separate displays, each with its own menu and interaction method. Configuring their systems requires too much effort and attention.

Third, systems such as in-vehicle navigation systems often provide separate day and night modes. The day mode typically uses a light background, such as tan or light gray, and the night mode uses a dark background, such as black or dark blue. Until recently, all ATC systems used yellow-green symbols and text on a dark background. With the introduction of color monitors, several systems have explored separate day and night modes for the tower.

We have found that day and night modes do not provide many human factors benefits, and they make the user interface design process more difficult. In particular, color schemes developed for dark backgrounds usually must be

modified for light backgrounds. Foreground colors can appear different depending on the background color. Some color combinations do not provide adequate contrast and are difficult to read [2]. For example, yellow is commonly used in ATC systems to indicate special conditions. Yellow contrasts well with a dark background and is easy to read in night mode. However, when used in day mode with a light background, yellow appears washed out and is hard to read. Using a different color to code special conditions in day mode would have created an inconsistency between the modes and possibly increased confusion or errors. In the end, we found that the night mode worked well in both conditions and did not advocate separate day and night modes.

### **RADAR ROOMS AND ARTIFACTS**

Controllers working in radar facilities have worked or continue to work in the dark. The first ATC radar displays were extremely dim, and the radar targets were barely visible in office lighting. As a result, the original ATC radar rooms looked like the insides of submarines: no windows, the room lights were turned off completely, the switches and keyboards needed backlighting, and the controllers needed task lights to read and write.

This dark environment persisted until the 1990s. New radar displays allowed the room lights to be raised, which had several interesting consequences. First, controllers who had worked for many years in the dark were not ready to give it up entirely, even though the technical rationale for a dark room no longer existed. Even today, most radar rooms are substantially dimmer than office environments. There is no evidence that controllers need dim lights or that they perform significantly better under such conditions. Instead, controllers just seem to prefer it that way. Perhaps dim lights remind them of an era when a dark room made ATC seem a little more exotic and mysterious than other knowledge work. Bright lights are for corporate drones, but *controllers do it in the dark* (or so the joke went). This preference may change as the controller workforce ages and is replaced by a generation who has never worked in the dark. Furthermore, there is interest in moving some tower controllers out of traditional towers into “staffed virtual towers,” which would be similar to radar rooms. Controllers would rely on information technology, possibly supplemented by video or graphics that replicate the out of the window view. Like the radar controllers before them, tower controllers transitioning to virtual towers may wish to preserve some elements of the bright and dark environments to which they are accustomed.

The second consequence of raising the lights in radar rooms was the need to re-create useful artifacts of the dark environment. For example, the phosphors of the original radar displays faded very slowly. In office lighting, targets were no longer visible approximately 5 seconds after they were drawn; however, in the dark, targets were visible for 15-25 seconds. Because targets were drawn every 5

seconds, the series of fading old targets formed a “history trail” that allowed controllers to judge aircraft speed, direction, and turns. The history trail, which controllers used constantly, was an artifact of the old display technology combined with the dark environment. It was extremely useful and required no additional computer processing.

When displays that did not have slow-fading phosphors arrived, the room lights could be raised, and the history trail had to be re-created by the ATC computers. For each aircraft, this meant 3-10 additional objects that needed to be tracked and drawn. Because the history trail no longer faded naturally, the new systems tried to emulate the fading by rapidly adjusting the history trail colors. This strained the graphics processors and never yielded a history trail quite as good as the original [1]. This is an example of extensive development work that was needed because the dark environment created artifacts that were needed in the bright environment.

### **RESEARCH NEEDS**

Although ATC is slowly moving out of the dark, some controllers will continue to work in the dark for the foreseeable future. Interaction research is needed to answer questions such as the following. First, how can technology respond automatically to changes in lighting? Manual configuration requires effort and attention that would be better devoted elsewhere. Second, what human factors benefits do separate day and night modes provide? Is it possible to create one mode that can be used equally well in both conditions? Should the two modes be as similar as possible, or should they be obviously different, so that users are unlikely to confuse them? Third, what social factors lead some people to prefer working in the dark? How can a population accustomed to working in one environment transition to another? Finally, what techniques and heuristics have people invented that help them use technology in dark environments? Is it advantageous to re-create or preserve those techniques in bright environments?

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**BRIEF BIO**

Kenneth Allendoerfer has worked as an engineering research psychologist at the Federal Aviation Administration since 1995. In that time, he has been involved in the design or evaluation of the user interface for many of the information and communication systems

currently used by air traffic controllers. Mr. Allendoerfer is also a doctoral candidate in the College of Information Science and Technology at Drexel University. He has spent more time alone in dark rooms with controllers than he likes to admit.