1.6 MAINTAINING OPERATIONAL READINESS IN A WARNING ENVIRONMENT: DEVELOPMENT AND USE OF THE SITUATION AWARENESS DISPLAY SYSTEM (SADS)

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1. INTRODUCTION

During the Spring of 2004, the Weather Forecast Office in Norman, Oklahoma (WFO OUN), Warning Decision Training Branch (WDTB), and the NWS Southern Region Headquarters (NWS SRH) collaborated to design and implement a PC-based Situation Awareness Display System (SADS). The SADS resides at WFO Norman and is currently being implemented into severe weather operations. The concept of the SADS display is to help the event coordinator keep a high level of situation awareness (SA) (Endsley 1995) during significant weather operations. The display is not unlike that employed by NASA and by military command centers where assimilating and displaying relevant data sets help the critical decision makers keep a high level of awareness of the state of the mission.

The paper will discuss the proof of concept of this system as well as lessons learned in its inaugural season. The design of the display will be discussed, as well as the efforts expended in designing relevant software to take advantage of non-traditional data sets including television and web cams. Cautions with regard to the ineffective use of such systems will also be discussed.

2. OPERATIONAL NEED

The mission of the National Weather Service Weather Forecast Office is to provide for the protection of life and property for the public it serves. As important as notifying the public of an impending weather threat, is the need for the message to be timely, accurate, and consistent between the forecast office, emergency management, law enforcement, and media partners. Recent advances in technological capability make this coordination not only more necessary, but more challenging. Adding to the challenge is the ever-changing nature of the severe weather warning process. This process is defined by a host of data sets which arrive via numerous sources. As technology has advanced, the amount and complexity of data available to meteorologists has soared by orders of magnitude in recent years.

One method to address the challenges of coordination, consistency, and communication is by modifying the office strategy to include an event or warning coordinator position. The event coordinator is responsible for the “big picture”. He or she keeps a very high level of situation awareness to insure all threats are covered and that the message the public is receiving is consistent.

The concept of the SADS began with a recognition of the SA requirements of the event coordinator position during warning operations. Some of these requirements (listed in Table 1) were drawn in part from a goal directed task analysis (GDTA) currently being conducted with warning forecast operations (Jones,et al, 2003). Had the display been focused on what other positions in the warning operations area might require (short term forecaster, long term forecaster, HAM radio operator, for example), the

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population of the display would have included displays designed primarily for their situation awareness needs. In fact, the requirement for the display to be flexible in order to meet other mission needs was a consideration in the design.

3. DESCRIPTION OF SADS

The SADS consists of a combination of off the shelf hardware, as well as existing and uniquely designed software.

3.1 Hardware

The SADS is a network of PCs which display data and television via multiple LCD monitors (Figure 1). In its current configuration, four small form factor (SFF) PCs were used. The SFF PC was chosen to minimize footprint, heat, and power demands and proved well-suited for these requirements. Each PC was equipped with a dual-display video card so that 2 monitors could be connected to each. A television tuner was also installed in each PC giving the system the ability to display up to 4 separate television signals simultaneously. A total of 8, thin-bezel LCD monitors with 21 inches diagonal width were installed. The monitors were mounted with two vertical supports and two horizontal supports anchored into the building framework in the ceiling. Minimal interactivity is provided by a single wireless keyboard mouse interface, which is connected to the SFF PCs using a keyboard-video-mouse (KVM) switch. The KVM switch can be operated remotely via the keyboard. Sound output from each of the television tuners was connected to an audio switch with wireless remote capability. Wireless speakers situated across the operations area were connected to the switch. This allows the user to quickly select the audio from any of the four television signals. Individual users can also adjust the volume of their speaker as necessary.

The PCs were networked into the office local area network (LAN) and into the Advanced Weather Interactive Processing System (AWIPS) via the Local Data Acquisition Display (LDAD) (Holmes 2002). This allowed access to data from AWIPS and the internet. A separate Linux-based PC was installed to serve as a web server and content management system for the SADS. Images and data were ingest via the internet from the Linux PC. The final content was then displayed in web browsers on the SFF PCs. Custom software was developed to manage and

Coordinator SA Requirements

*1. What warnings are in effect?
-Type, location, expiration time, dissemination (did warning go out to various recipients)
-Warnings from neighboring FOs
*2. What warnings are about to expire and when?
3. What sectors have been defined?
Who is in charge of which sectors?
What threats are they monitoring?
How is workload in each sector (based on a combination of number of warnings, number and severity of reports, number of storms, location of storms?)
4. Status of important equipment
*5. SPC Information
Outlook
Watches
Type, Location,Expiration
Mesoscale Updates
*6. Mesoscale information
What are specific areas of concern?
OUN Web Graphic (public dissemination)
7. Satellite information
*8. Radar information
Big picture - where are storms in OUN and surrounding CWAs
Storm speed/direction
Other storm related information? (Highest FF threat?)
*9. TV Datasets
National perspective, local perspective
Channel A
Channel B
Channel C
Channel D
View from tower cams
Where is location of storm video? Damage video?
What is being said?
10. Human resources status
*What is the workload likely to be over the next few hours?
Who is currently working what shift?
How long have they been at it?
Who is scheduled to come in and when?
Who else is available ?
11. View out the window
*12. Spotter reports
Who reported, what, when, where

Table 1. A partial list of SA requirements for the coordinator position during a warning event. A subset of these requirements (noted by an asterisk *) are supplied via the SADS.

Figure 1. Situation Awareness Display System (SADS) as it was configured for operations during severe weather March 27, 2004. The display consists of independent panels which can be configured based in part on the threats at hand.

serve the content via the web server on the LAN.

3.2 Software

Windows XP Professional was chosen as the Operating System for the SFF PCs (in order to better support the off the shelf television tuner functionality). However, the remainder of the software used by SADS was developed locally using open-source development environments.

An application was developed on the Linux PC to continually ingest images obtained from the internet and process them into a presentation-style animation. Another application was developed to allow users at any AWIPS workstation to select presentations and determine on which monitor the presentations are displayed. At the current time, the presentation choices include Oklahoma Mesonet images, SPC analysis graphics, web-cam images, utility company outage maps, and radar and forecast images from local television meteorologists.

The cornerstone application of the SADS is the warning display application. This program runs on AWIPS and produces a graphic of all current warning information from the local and surrounding WFOs on a map (Figure 2). The counties affected are shaded in with the color corresponding to the warning type. A unique feature of the warning graphic is the plotting of the time to expiration for each warning. This allows warning forecasters to quickly assess what warnings are in effect and how soon will they expire. When the time to expiration is less than a threshold value, the county will flash providing more emphasis on warnings closer to expiration.

A similar application decodes and plots severe storm reports issued by the local and

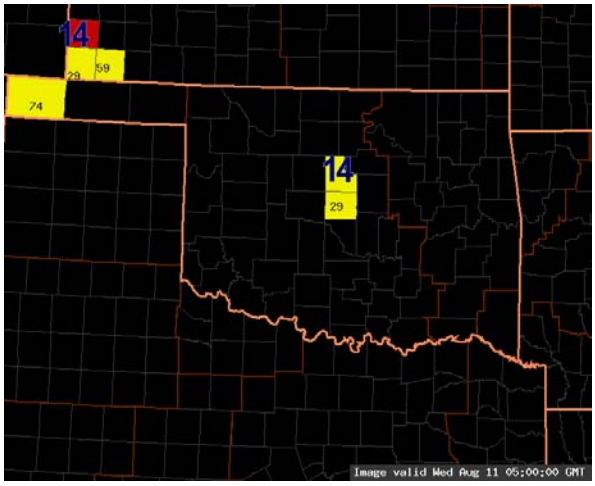

Figure 2. Output from the SADS Warning Display Application. Current warnings are plotted according to type of warning and annotated with the time to expiration in minutes. When a threshold time to expiration is reached, the size of the annotated text increases. When another threshold expiration time is reached, the county will "flash".

surrounding WFOs. Storm reports that are more significant and/or more recent receive greater prominence on the display. The intensity (e.g. maximum gust, hail size, etc.) is also indicated on the plot.

These presentations and graphics are all tied together with a web-based display application that runs on the Linux PC. When the user selects presentations on AWIPS, the choices are sent through the network so the web-based display application can read the choices and display the requested presentations on the SFF PCs' web browsers.

4. Operational Use

Currently, the SADS displays are configured according to the SA needs of the WFO operations event coordinator. These needs vary according to the character of the significant event being managed. In nearly all cases, local television broadcasts occupy at least three monitors. Experience has shown that news coverage and live video are important to understanding the event as is being aware of the information reaching decision-makers in other agencies and the population in general. The contents of the remaining screens vary from event to event and even from one hour to the next as SA needs evolve.

The most common significant events supported by the Norman WFO are associated with severe convective storms. In addition to the television broadcasts, the event coordinator typically configures SADS to display pertinent near storm environment analyses, an overview of the WFO's specialized significant event graphics on the Web, and custom-developed, color-coded maps of recent storm reports and warning management information. Other configuration capabilities include web cameras, flooding-related data sets, topographic mapping, and plume dispersion modeling software for homeland security or hazmat events. The configuration of SADS changes little for routine operations since simply confirming the benign nature of a situation is still an important aspect of good SA.

5. INITIAL FINDINGS

The SADS was first used at WFO Norman on March 4, 2004 and its importance to operational decision making and event management continues to grow. In the spring and summer of 2004, SADS was used to manage nearly every severe weather episode (more than 20 events), several flood situations, and at least two hazmat incidents. These events provided valuable experience into the application and use of SA technology in a WFO. A list of initial applications and considerations is below.

5.1 Applications

SADS broadened and improved the event coordinator's awareness of information flow inside and outside the WFO. For the first time, the coordinator could simultaneously guide information generated by the WFO and assimilate information provided by the media and other sources outside the WFO using one technological system.

SADS provided a central source of information management data sets and improved the group SA of the operations team. The SADS provided a common reference to the team and often set the stage for discussions related to staffing, decision making strategies, and event planning.

5.2 Considerations

A display wall of any type has the potential to introduce confusion, distraction, and even data overload into the operational arena. Simply providing information is not good enough; the information must be shared in context (Klein 2003). Giving users only what they need *at that moment* may seem like a way to combat this, but can actually have negative effects when goals and their relevant cues are constantly changing (Endsley et al 2003). The data presented must be easy to interpret, clear, and relevant to the threat, yet not so focused as to undermine detection capabilities of "low probability" threats. In addition, the data presented should be done so with a means of assessing their validity.

One challenge occurred during a severe weather event in which potentially tornadic storms were a threat. A local TV station doing wall-to-wall coverage chose a "lull" in the action to show archive video from a previous event. However, to the forecast staff (and perhaps even some viewers) it was not immediately evident that the

tornado images being seen on the SADS TV monitors were historical and not live. Some effort was expended to answer "what storm is that video from?!" before a check of the audio, and subsequent TV screen annotations, revealed the archival origins of the tornado video.

Introducing any new technology into operations requires an understanding of its potential impacts and the subsequent changes needed in methodology. ***SADS is more than technology or software, it represents a philosophy of operations.*** For SADS or related technologies to reach their full potential there must be a commitment by the people involved in the operation to embrace the importance of SA in event management. They must work well as a team, recognize and know how to utilize data sets beyond the traditional meteorological data sets, and commit at least one person to maintaining a big picture view of SA and information flow. Applying this approach to operations is perhaps the biggest hurdle as it attempts to overcome the tendency for individuals to become immersed in the details of a significant event or completely focused on specific tasks.

6. FUTURE PLANS

The WFO staff in conjunction with partnering emergency management and law enforcement agencies is investigating the possibility of using additional Web camera output into the display. Of particular interest are articulated Web cameras which can be remotely controlled with regard to tilt and panning capabilities. In addition, the option of using bigger screens, which will make relevant data more easily assessed from further away will be considered. The use of the system in winter weather operations will be studied during the upcoming season.

7. CONCLUSIONS

The Situation Awareness Display System was introduced into weather operations at WFO Norman during the Spring of 2004. Its use and application have been valuable during the subsequent months for severe weather events and even non-meteorological events. Considerable thought was given to the design and use of the system in order to circumnavigate pitfalls and enhance operations.

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