JP1.8

DESIGN AND DEPLOYMENT OF TRAFFIC SIGNAL STATIONS WITHIN THE OKLAHOMA CITY MICRONET

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1. INTRODUCTION

In North America, the majority of real-time, continuous, research-quality atmospheric observations are not collected within the core regions of cities. Thus, a general disconnect exists in which the majority of observing sites are collected in rural areas away from the densest populations. Yet, recent publications have addressed that urbanization has and will continue to increase worldwide (United Nations Human Settlements Program, 1997; Dabberdt et al., 2000; United Nations, 2003) and a growing need exists for improved atmospheric observations for a variety applications including public health and safety.

The success of the Joint Urban 2003 field experiment (Allwine et al., 2004) provided the opportunity to assess the feasibility of a permanent urban-atmospheric monitoring network deployed across the Oklahoma City metropolitan area. Thus, with the assistance of the City of Oklahoma City, the Oklahoma City Micronet (OKCNET), a dense network of automated weather stations designed to improve atmospheric monitoring across the Oklahoma City metropolitan area, was deployed after nearly five years of design and testing. The OKCNET project included the deployment of three new (four total) Oklahoma Mesonet sites (McPherson et al. 2007) within Oklahoma City and the installation of 36 sites mounted on traffic signals. The Oklahoma City Micronet was officially commissioned on 8 November 2008.

The process of implementing a network of this magnitude and type required expertise and innovations from technicians, researchers, and computer scientists who have had success with other atmospheric observing networks. Every aspect of the OKCNET was scrutinized including the hardware, site selection criteria, and installation procedures. As such, similar to the success of the Oklahoma Mesonet, the Oklahoma City Micronet has provided a solid foundation for the development and installation of future urban observing networks.

2. HARDWARE

2.1 Vaisala WXT510

The Oklahoma City Micronet utilizes the Vaisala WXT510 multi-parameter weather transmitter as it source for meteorological measurements. The sensor package is compact and light weight, has no moving parts, and uses very little power, while still providing research quality data. Each WXT510 consists of three main parts:

- a PTU module for measuring temperature, humidity, and pressure,
- a WindCap sensor for measuring wind speed and direction,
- a RainCap sensor for measuring precipitation.

When operating within OKCNET, data from the WXT510 are collected and transmitted every minute to the Oklahoma City Micronet operations facility via the Oklahoma City “Wi-Fi"(TM) network (the City of Oklahoma City boasts the largest municipal IEEE 802.11 Wi-Fi (TM) mesh network in the world) where the data are quality assured, processed, archived, and displayed on the internet.

2.2 Active Components

Each station had components whose cost, durability, and power consumption were carefully analyzed before being chosen for use. In addition to the manufactured stations, the use of the Oklahoma City's Wi-Fi (TM) nodes manufactured by Tropos Networks were defined as a necessity for both power supply (which established a voltage supply of 48V) and data communications. Along with the WXT510 for meteorological observations, a Campbell Scientific CR200 data logger was used to collect, store, and process data. Because the logger utilized serial communications and the Tropos node was based on internet protocol (IP), a Lantronix UDS 1100 was used

Figure 1. The Vaisala WXT510 Weather Transmitter (photo by Vaisala)

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to communicate with the CR200 via IP. Additionally, a PowerDsine Power Over Ethernet unit, or POE, was installed to separate power and communications from one ethernet line. It also served as a 48 V to 18 V converter, which was necessary to facilitate the battery charging function of the data logger. Finally, a 7.5 Ah, 12 V battery was used as a secondary power supply.

Each station's power production and consumption capabilities during both normal conditions (WXT heating element not active) and peak power consuming conditions (WXT heating element operating at 100%) was a critical component in the feasibility of the station's design. Through laboratory power measurements, each station (WXT510, UDS-1100, CR 200, POE, and battery) is expected to consume 2.5 W of power (194 mA at 12.86 V) when the WXT-510 heater is not in use. With an average POE power supply of 7 W, a station surplus of 4.5 W would remain to re-charge the station battery.

The estimated maximum current draw of the WXT510 heating element (from Vaisala) when operating at 100% is 1.1 A at 12 V. This leads to a power consumption of the heating element during maximum heating of 13.2 W. When the power consumption of the heating element during maximum draw (13.2 W) is added to the normal power consumption of the system (2.5 W), the result is 15.7 W — the maximum power consumption of the system during heating. Thus, when the WXT510 heater is operating at 100% heating mode, each station is expected to consume 15.7 W, which would leave a station deficit of 8.7 W. The nearly 9 W power deficit during peak heating is compensated by the battery. As such, the battery serves not only provide temporary power during the loss of POE, but also for the operation of the system during heating element use.

2.3 Passive Components

In addition to the active components, critical decisions were made concerning the passive components, mainly the enclosure and its associated mounting equipment, of each station. For the purposes of durability and overall aesthetics, the main exterior components of each site were comprised of aluminum and stainless steel.

The enclosures used as part of the OKCNET traffic signal stations are Pelco Inc. cast aluminum traffic cabinets. The enclosures are similar to items already used by Oklahoma City for other traffic duties. The WXT510 sensor is connected to the top of the enclosure via a threaded aluminum pipe. Once assembled, the design allows for quick installation or replacement of units, and also meets the aesthetic requirements.

Within the enclosure, a magnetic door switch manufactured by Cherry Switches was added to monitor site visitations by field technicians. Thus, whenever the door switch is triggered, the data logger records this information so that quality assurance of the data during a field technician's visit can be maintained.

To secure the enclosure to the traffic pole, Pelco Inc. stainless steel mounting brackets, bands, and banding clamps were used. Similarly, stainless steel zip ties were used to secure the ethernet wire that runs from the station to the Tropos unit to the traffic pole. These components resulted in a strong, secure mount to the traffic pole. Further, the stainless steel material blended well with the color of the traffic poles, thus leading to a very low visual profile of the site, which was a request of the City of Oklahoma City.

3. SITE SELECTION GUIDLINES

The deployment of traffic signal stations at specific locations was dependent upon a number of factors. First and foremost, because the traffic signal stations were designed to function in conjunction with the wireless access points installed across Oklahoma City, only traffic signals with an access point could be utilized for the Oklahoma City Micronet. As such, Oklahoma City personnel also provided the locations of Tropos nodes across the Oklahoma City metropolitan area to be used for site selection.

A second main component of the site selection process was focused on addressing the spatial and temporal scales of motion in the atmosphere throughout the metropolitan area. As such, within the central business district where the impact of buildings on atmospheric conditions is complex, the traffic signal sites were installed at an increased density. However, as the complexity of the surface conditions decreased from the urban to rural areas, the station spacing increased. The result is a network whereby the station spacing increases from the rural to urban and provides important observations used to quantify the transition of the atmosphere from rural to urban areas.

At the request of the City of Oklahoma City, the Oklahoma City Micronet deployed stations across the Metropolitan area. Not only was a concerted effort employed to provide increased weather and climate information within the various communities of Oklahoma City, but also to deploy stations in the numerous watersheds that are impacted by heavy rainfall events and to provide invaluable temperature observations during winter weather episodes.

Special attention was also given to installing stations near important community centers or landmarks in Oklahoma City including schools, the Oklahoma City airport, Wiley Post Airport, Tinker Air Force Base, the Bricktown entertainment district, the Ford Center, the Oklahoma City Health Sciences Campus, Quail Springs Mall, and Penn Square Mall.

The traffic signal sites were also chosen to sample the atmosphere in a location representative of the surrounding area and specifically avoided locations with overhead power lines for the safety of OKCNET technicians. Additionally, the Mesonet Sites deployed in Oklahoma City (OKCW, OKCN, OKCE, SPEN) followed standard protocols for installing Oklahoma Mesonet stations. The overall average station spacing of the 40 Oklahoma City Micronet sites is approximately 3.3 km between locations.

4. INSTALLATION

In December 2007, an initial station was installed in the central business district of Oklahoma City for final testing. Once completed, 35 additional OKCNET traffic signal stations were installed over the course of three weeks in May 2008. Each installation was accomplished within approximately one hour from start to finish, and could not have been accomplished without a dedicated and flexible partnership between the OKCNET installation team and the Oklahoma City Streets and Traffic department.

A typical OKCNET site installation began with an arrival inspection of the site by the installation technician and the OKC bucket truck operator. This inspection was preformed to insure the site was at the correct location, and to identify any surrounding obstructions, such as power lines. If any critical obstructions were present, they were recorded, along with the ground conditions directly under each site. The next step was to secure each site package, consisting of a WXT510, an enclosure housing, and all operational equipment, to the top of the traffic light pole (Fig. 2). Using stainless steel strapping and galvanized steel tightening buckles, each pack was mounted on either the east or north facing side of its pole.

Once each package was securely mounted, an ethernet cable, secured by stainless steel zip ties, was installed along the luminary arm from the Tropos unit to the enclosure, supplying both power and communications. Once the connection was made, a verification of both power and communications was performed using specific testing equipment. If problems were identified in the either power or communication supply, troubleshooting was performed on all necessary site equipment. If all OKCNET equipment functioned normally, IT officials from both Oklahoma City and the Oklahoma Climatological Survey were contacted to diagnose possible problems with other pieces of equipment (e.g., the Tropos unit). Upon establishing the presence power and communications, the installation technician would request a remote clock check of each data logger, as well as a program download to the logger to ensure proper data transfer.

Once the data logger program download was successful, the installation technician aligned each WXT510 for proper wind direction measurements. Because so much metal was present near each site, the use of a compass to determine magnetic north was nearly impossible. Thus, the positioning was accomplished by adjusting an alignment collar on the base of the WXT parallel to the nearest north/south running street, or perpendicular to the nearest east/west running street. This alignment ensured the transducers responsible for wind speed and direction measurement were aligned geographically north.

Finally, metadata for each station was recorded. Panoramic pictures were taken from a position of approximately 2 meters north of each site (in some cases, the pictures were taken from another side due to bucket truck limitations). In all, 8 pictures were taken at each site level facing the following directions: north, northeast, east, southeast, south, southwest, west, and northwest. Using a laser rangefinder, the installation technician also measured the height above ground level to the center of each WXT510. Once this number was recorded, a last check of the equipment was performed to ensure the site was functioning properly. Finally, before enclosure was closed, a desiccant pack was added to prevent the condensation of water on all equipment within the enclosure.

Figure 2. An OKCNET technician installs a traffic signal station.

5. CONCLUSIONS

Through innovation and expertise, the Oklahoma City Micronet can collect meteorological observations within and urban setting using state of the art technology. Each station was carefully designed to be robust, low power, and aesthetically inconspicuous while at a reasonable cost. Careful consideration was made to select each site in the network to be spatially important, representative of the immediate environment, and crucial to end users' desires. As a result of the portable design of the each station, the installation procedures are quick and low cost. Overall, the Oklahoma City Micronet has provided a solid foundation for the development and installation of future urban observing networks.

6. ACKNOWLEDGEMENTS

The authors would like to give special thanks to the many people at the City of Oklahoma City and the Oklahoma Climatological Survey who provided assistance in numerous ways. Funding for the Oklahoma City Micronet and support for this study was provided by (1) the State of Oklahoma via capital bond issue to improve facilities at the University of Oklahoma and (2) the Office of the Vice President for Research at the University of Oklahoma. The Oklahoma Mesonet is supported by Oklahoma's taxpayers who fund the Mesonet through the Oklahoma State Regents for Higher Education.

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