IMPLEMENTATION OF REMOTE NOISE AND VIBRATION MONITORING SYSTEM AT THE PANYNJ WORLD TRADE CENTER

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1. INTRODUCTION

Rebuilding the Port Authority of New York & New Jersey (PANYNJ) World Trade Center (WTC) site is a complex endeavor involving a multitude of contractors and agencies. The Federal Transit Administration (FTA) established site-wide Environmental Performance Commitments (EPCs) for several environmental disciplines including noise and vibration. On behalf of the PANYNJ, Paul Carpenter Associates, Inc. (PCA) initiated, deployed and currently maintains a state-of-the-art remote noise and vibration monitoring system. The monitoring system includes four (4) noise and five (5) vibration monitors placed along the perimeter of the WTC site in Lower Manhattan. ButterJAM established a web interface which queries noise and vibration monitoring databases within the off-site server. The data is automatically sent to an innovative compliance website which displays appropriate data and allows access by authorized users. The system provides e-mail alerts, warning of any noise or vibration limit exceedance or equipment malfunction. In addition, the system automatically generates reports and directly e-mails reports to authorized personnel.

This paper introduces the noise and vibration monitoring system, generally describes the operation and features of the system and accompanying website and discusses challenges as well as lessons learned while commencing this large-scale data portal.

2. MONITORING SYSTEM

PCA performed research to identify remote noise and vibration monitoring equipment that met the compliance reporting needs for the WTC site. The following sections describe the monitoring system chosen by PCA on behalf of the PANYNJ.

2.1. Noise Monitoring

PCA chose the Bruel & Kjaer 3639 Noise Monitoring Terminal (NMT) for remote noise monitoring at the WTC site. Each NMT includes a Bruel & Kjaer Type 2250 hand-held analyzer/sound level meter, a Bruel & Kjaer 4952 outdoor microphone, Bruel & Kjaer 7843 Environmental Noise Management Software, a First Power FP12170 12-V back-up battery, a Sierra Wireless Raven X V4221-V wireless modem and a digital multi-band directional antenna 489-DB. The sound level meter, wireless modem and back-up battery are stored within a cabinet. Each NMT requires AC power and adequate cellular signal strength. The rear mounting bracket allows for installation on street light poles within the perimeter of the WTC. Currently, NMTs are located along the north, east, south, and southwest quadrants of the site.

2.1. Vibration Monitoring

PCA chose the Instantel Series IV Advanced Vibration Monitor for remote vibration monitoring at the WTC site. The system includes the vibration monitor, a triaxial geophone and battery-power supplies as well as a serial 3G modem to allow cellular data transmission. The system also includes the Blastware Compliance Module software, which enables transfer of the data to an off-site server. The vibration monitors are located within five historic structures of significance near the perimeter of the site.

3. WEB INTERFACE

The noise and vibration monitoring system documents source levels and remotely transmits data in real-time to a project-specific server, via cellular technology. The off-site server is located within the PCA office. ButterJAM developed a web-based content management system which allows for quick deployment of data using modular building blocks and customizable configuration schemas. The web interface queries specific data stored on the PCA server from within the Bruel & Kjaer and Instantel databases. Customized reporting modules were written to provide easy-to-read formatted PDFs which are generated automatically as well as on-demand based upon real-time data and calculations. Security modules were added to enforce complete access control and user restrictions. Data modules were written to provide specific processing and data intake routines to interpret data generated by the WTC on-site noise and vibration monitoring system. Within each created module, routines were added to sense and detect any conditions that warrant alerts or special processing. Additional modules enhance the usability and functions requested to analyze and interpret the data more efficiently. The end result is a website that is virtually automated in data intake, processing, display and reporting.

4. COMPLIANCE WEBSITE

ButterJam created an innovative compliance website utilizing the noise and vibration data queried from the Bruel & Kjaer and Instantel systems, respectively. The website serves as a user-friendly platform for authorized PCA and PANYNJ personnel to quickly identify real-time noise and vibration data. In addition, the website catalogues and

archives all previous data. By traversing the calendar module on the website, users can view previous data sets instantly.

In order to present noise data in a user-friendly format, data from each NMT is separated by individual noise web pages. A time history graph detailing 1-min L_{eq} noise level data documented during the current 24-hour period is rendered in real-time. The graph includes a static line depicting noise compliance levels by time of day. In addition, hourly L_{eq} noise data is included within a 24-hour table.

Each noise web page includes uploaded audio files recorded by the system based on pre-set trigger levels. The user may download or listen to the audio files directly from the website. Providing these audio files on the website enables PCA and PANYNJ officials the opportunity to identify specific construction activities that may have caused noise exceedances or complaints.

The compliance website also provides several unique features including a post-processing tool for noting noise data documented during inappropriate weather conditions. Authorized users may also enter notations and observations on the website as well. This feature is especially useful to track noise sources unrelated to the WTC site in the event of noise exceedances or complaints. Lastly, each noise web page includes compliance noise data within a table highlighting the current and previous four (4) periods, which converts to the color red in the event an exceedance is documented.

Each vibration web page includes a time history graph, which plots maximum peak vector sum (PVS) levels based on the current 24-hour period. In addition, the time history graph includes a static line depicting the vibration compliance level. The maximum PVS levels for each hour are listed within a 24-hour vibration table.

In order to provide the PANYNJ with timely daily summary reports, the system automatically generates the report at a specific time each day. Daily reports are automatically emailed to select individuals and made available on the website. In addition, monthly reports are automatically generated and catalogued on the website.

5. ALERTS

The system was established to provide three (3) types of automated alerts. Alerts are sent by the system and received by authorized individuals simultaneously via e-mail with pre-defined messages. In the event one of the noise or vibration monitors fails to submit data, an alert is automatically sent to PCA staff for troubleshooting. The second type of alert is sent to PCA staff and selected PANYNJ individuals indicating a noise or vibration level exceedance. Lastly, the third type of alert generated in the morning by the system is a courtesy indicating the number of audio files recorded and uploaded to the compliance website during the overnight period.

6. CHALLENGES / LESSONS LEARNED

PCA faces several logistical issues with maintaining operation of the remote noise and vibration system. Our challenges and lessons learned are listed below.

Strong cellular signal - Most vibration monitors were placed within basements or sub-basements where cellular signals are weak. PCA installed stronger antennas however periods of weak signal occasionally persist. In the event the signal is too weak to conduct the automated data transfer, PCA manually pushes data once signal strength recovers.

Continuous, uninterrupted power - AC power is supplied to all NMTs. Several NMTs receive site power from the WTC electrical grid. In the past, power had been accidentally interrupted, and units failed to report data. To ensure continuous AC power, site electricians provide the NMTs with secured, dedicated power.

Calibration Downtime - Each noise and vibration monitor requires yearly laboratory calibration. Under the first year of operation, PANYNJ requested PCA remove all vibration units during a period when no heavy blasting was expected. However, the PANYNJ requested complete noise coverage during calibration. Therefore, a spare NMT was installed to replace each unit when individually sent in for calibration. All units were calibrated and re-installed at the site within a two week period. The calibration process is logistically challenging and requires several months lead time.

Software Upgrades – The noise and vibration monitoring software systems were found to possess programming bugs. PCA communicated issues with the software manufacturers to resolve software glitches. Both manufacturers are currently developing fixes to improve operating systems.

7. CONCLUSIONS

The remote monitoring system and supportive web-based system developed by PCA and ButterJAM provide a technically advanced form of reporting and client interaction. The automatic reporting and alert system allows pre-selected parties to receive reports and alerts simultaneously. This form of posting exemplifies this era and offers an immediate, accurate and inventive method of project delivery.

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