Design and Deployment of a Mobile Monitoring Vehicle for Measurement of Gases and Aerosols

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Introduction

Measurement of ambient air quality parameters is traditionally conducted using permanent and semi-permanent stationary enclosures. When there is a requirement for the quantification of site or area level impacts, short-term event monitoring, peak exposure assessments or comparative analysis, the use of a mobile monitoring platform is advantageous.

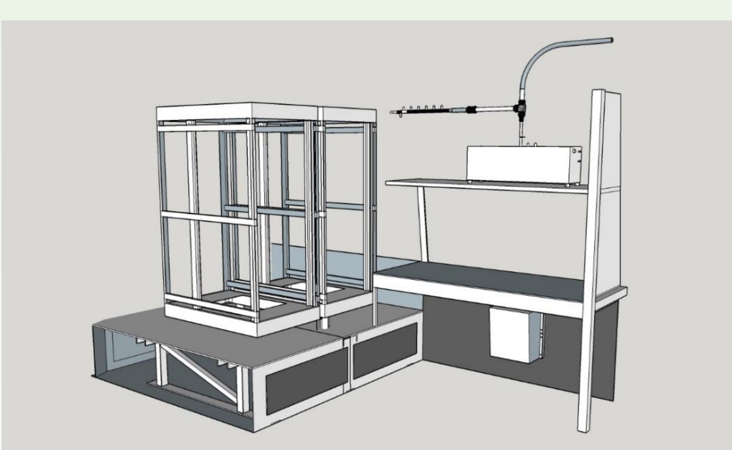
Key aspects of a mobile monitoring platform are; the system's ability to perform to a quantifiable standard in its requisite uses, to be autonomous in operation, have the ability to measure both stationary and in motion, versatility in travel surface capability (on and off-road in all-weather conditions), maintaining a "ready" state for rapid deployment, and to have remote capabilities for data collection, instrument control and remote maintenance.

To date, autonomous mobile platforms have short operational timeframes or are unable to provide a stable internal operational environment in all-weather conditions. In addition, mobile monitoring platforms have typically only been capable of measurement while moving at slow speeds over short distances.

Vehicle Chassis and Workspace Layout

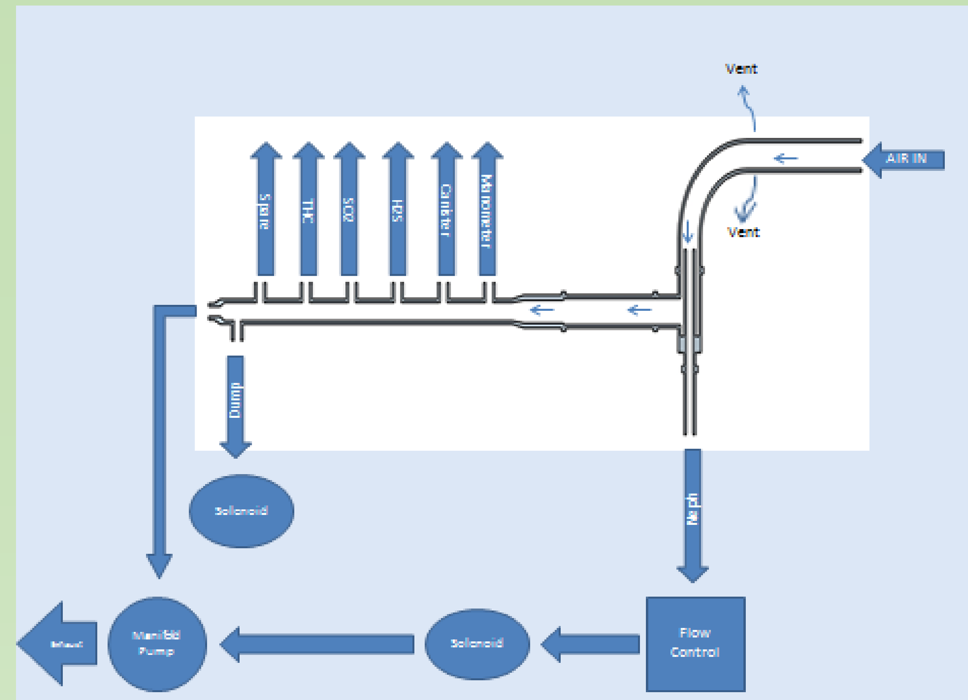
The vehicle chassis chosen for this mobile application was a 2015 Mercedes Sprinter Cargo Van 3500 4WD. The rear area of the van is broken into a work area located in the mid-section of the van and the instrument racking and component storage area, located in the rear area over the wheel wells.

The interior roof, wall cavities and support beams were insulated using fire-retardant polyurethane spray foam insulation to maximize thermal resistance (R-value) and sound proofing, while minimizing weight



As the intended use for the vehicle was for on and off road applications the interior support structure for the housing of the instruments was engineered to maintain the secure mounting of installed instruments and associated support equipment. To accommodate the racking of a standard 19" instrumentation chassis, two 49" 28U racks were installed atop of a 13" tall battery cabinet/racking frame. All of the material connections between the floor and the ceiling were spaced with rubber spacing washers. The racks were shock mounted to the lower cabinet assembly and upper roof support assemblies. Upper roof supports were added to the interior framing of the vehicle for added structural support. To accommodate the inlet manifold connections and to provide additional strength to the driver protection wall, a shelf was built in the work area behind the driver's seat to mount the Nephelometer. A fold down, 4" deep table was installed below the nephelometer shelf behind the driver's seat to allow for the storage of tools, spare materials and other requisite equipment for the successful operation of the vehicle in multiple applications. To minimize the weight, all of the interior framing components were constructed of aluminum.

Split Stream Sample Manifold



To streamline the sample intake system and to allow for the measurement of both gases and aerosols from the same air mass a split stream sample manifold was developed based on a Pitot tube type intake and a T-type inlet manifold design. The manifold intake has two configurations, one for stationary measurement applications with a rain capped vertical inlet tube, and a second bent intake for in motion, or temporary stationary measurement.

Sample air enters the inlet tube and prior to the 90 degree bend, excess pressure is vented. The air stream then moves along the radial bend where it will split between the vertical pathway and travel down to the nephelometer measurement cell (maintaining as close to laminar flow as possible), or alter direction around the nephelometer intake tube and travel along the horizontal flow path allowing the individual instruments to sample from the stream. The vertical flow path to the Nephelometer is controlled using a needle valve and measured using a mass flow controller. The Nephelometer flow path can be closed off from the sample stream using a solenoid valve. The analyzer sample intake tubes enter the manifold from the top and protrude into the manifold to sample mid-stream. The sample air travelling through the horizontal and vertical pathways use the vacuum from a single diaphragm pump and the forward entry pressure to maintain flow.

Power System

For the vehicle to have autonomous operation the power system was engineered to have a large battery storage bank and a charging system that can provide power from the vehicles engine, or from a standard 120VAC plug. A double conversion sine wave Uninterruptable Power Supply (UPS) was installed in series to provide power to sensitive instrumentation.

To provide power for in travel or autonomous operation, the vehicle is equipped with a 220A alternator and a second 270A alternator. The use of the two alternator system removed the need of an onboard generator system. At high idle the dual alternator system can providing 370A @ 13.5VDC. The battery bank is comprised of four 330Ah lithium batteries, providing a total of 17000W of available power. Lithium batteries were chosen over standard batteries for the application due to weight considerations, the lifecycle of the batteries (number of discharge cycles), lithium batteries do not require a vented installation, and the quality of power output does not change through the period of discharge.

With the combination of the dual alternator, hybrid charging/invertor system, and battery bank the vehicle can operate for approximately 90 hours. These operational times are broken into 5 hour periods where the monitoring instrumentation is running from the power in the battery bank alone and then from the vehicle power system in conjunction with the recharging of the batteries. The vehicle fuel storage is 92 litres, and at high idle uses approximately 2 litres per hour, giving 45 hours of total run time of the vehicle. With 10 hours of operational time per run cycle, and 9 possible run cycles on the available fuel storage of the vehicle, 90 hours of unattended operation is possible, with half of the operational measurement periods being unaffected by the engine exhaust.

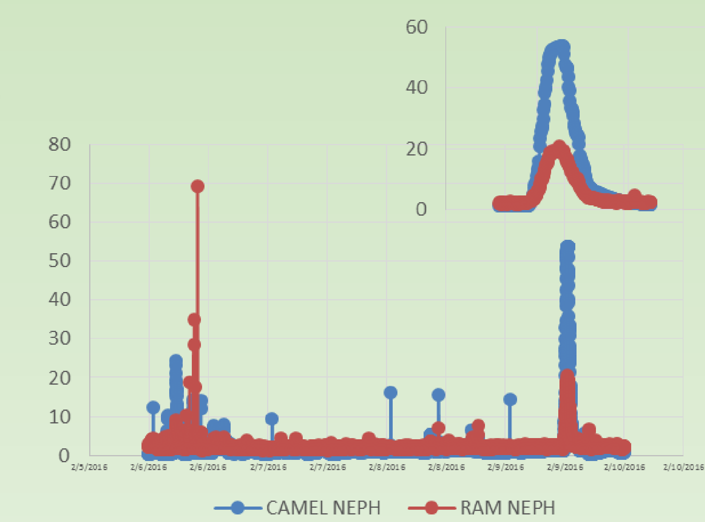
Remote Vehicle Management and Data Acquisition System

With the number of operational instruments and sensors installed in the vehicle and the desire to have the vehicle to be operated in an "unattended" state, a remote management / data acquisition system was installed. The data acquisition and control system (DAS) that was used is a computer based software platform that allows for the integration of the digital and analog communication devices in the vehicle. The DAS is configured to record the measurement parameters and associated diagnostic and meta-data information for each of the devices and instruments in the system.

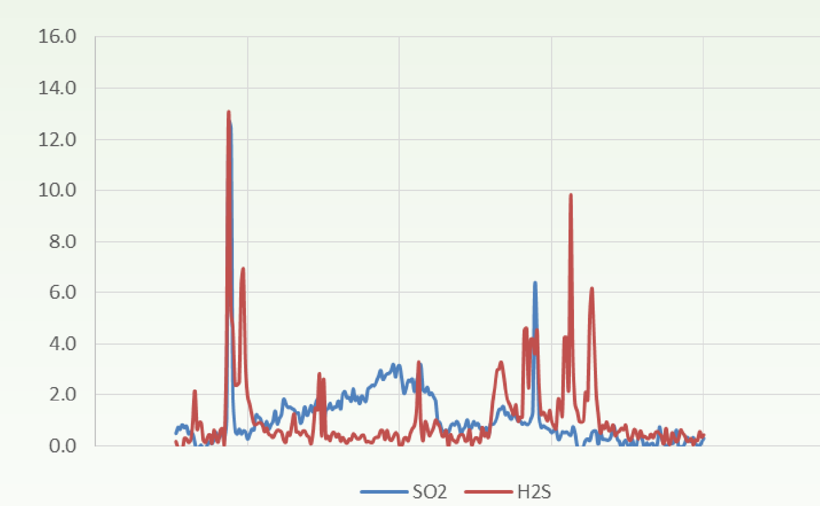
Using the remote management system allows a user to view and control the onboard instrumentation, perform remote maintenance and calibration checks, view the video feed and images of the roof mounted camera, as well as being able to assess the overall operational health of the vehicle.

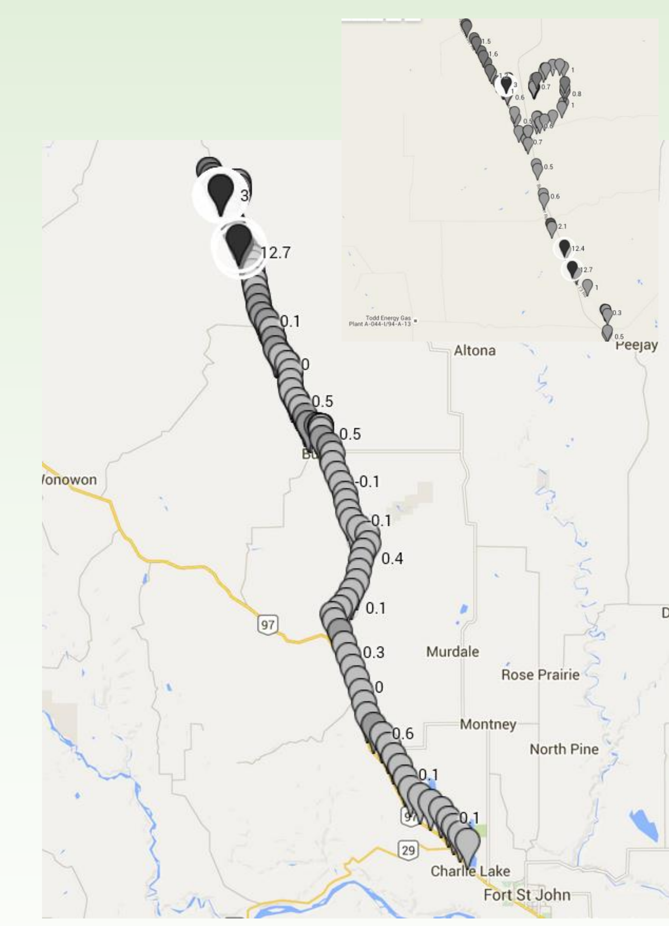
Measurement Results and Comparison

Since the deployment in November 2015 the vehicle has been utilized for ambient air quality measurements around oil & gas facilities during startup and shutdown activities, for fugitive emission measurement around industrial areas, as a response unit to air quality complaints, and for smoke measurement during extreme early spring wildfire events.



During periods of inactivity the vehicle has been collocated with existing ambient air monitoring stations to compare the operation of the split stream manifold and requisite instrumentation. To date, during correlation periods no elevated readings have been observed.





Summary

The design and construction of this mobile monitoring vehicle was performed with attention to the needs of an autonomous air monitoring vehicle capable of measuring ambient air quality in stationary and in-motion applications. The enclosure was designed to accommodate a variety of instrumentation in a secure and stable environment to assure the collection of precise and accurate data. As data collection is ongoing for this monitoring vehicle, the results will be assessed and compared where possible, and continual improvements will be made to operational efficiency in operation and ease of use for operators.