J1.1 OVERVIEW OF THE MOCK URBAN SETTING TEST (MUST)

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1. INTRODUCTION

The Mock Urban Setting Test (MUST) was a scaled urban dispersion experiment conducted for the Defense Threat Reduction Agency (DTRA) at the U.S. Army Dugway Proving Ground (DPG) Horizontal Grid test site. Its objective was to acquire meteorological and dispersion data sets at near full-scale for the development and validation of urban toxic hazard assessment models. MUST collaborators included the U.S. Army Research Laboratory (ARL), Canadian Defence Research Establishment Suffield (DRES), UK Defence Science and Technology Laboratory (DSTL), U.S. Department of Energy (DOE) Los Alamos National Laboratory (LANL), and researchers from Arizona State University (ASU) and the University of Utah (U of U).

MUST was designed to overcome the scaling and measurement limitations of laboratory experiments and characterization difficulties presented by real urban settings. Urban settings create their own roughness-induced boundary layers, or roughness sublayers (RSL) that affect the dispersion of toxic materials in ways that are poorly understood. Multi-national efforts are currently underway to develop and test urban dispersion models. Data sets presently available for these purposes are primarily from laboratory (i.e. wind tunnel and water channel) experiments or experiments conducted in real urban settings. However, it is not possible to achieve proper scaling or to obtain detailed RSL measurements in laboratory settings, and real cities are overwhelming in their size and complexity. In consequence, there are few adequately scaled and thoroughly documented urban dispersion data sets that meet the needs of urban dispersion model developers. The need for a well-documented baseline urban dispersion data set led DTRA to sponsor MUST as an intermediate step between laboratory and full-scale urban dispersion experiments.

2. MUST TEST DESIGN

MUST was conducted at the DPG Horizontal Grid test site, which is located in the Great Basin desert of western Utah [40° 12.606′ N, 113° 10.635′ W, 1310 m above mean sea level]. Horizontal Grid consists of a series of roads formed in an 805 m (0.5 mile) square. It contains a central 32-m rectangular walk-up tower and 28 parallel roads spaced at 30-m intervals. The roads are oriented 240/060°, which is normal to the predominant southeast-northwest wind directions. The test site is predominately flat, with a slope of 0.5 m per kilometer. Vegetation around Horizontal Grid consists of sparse greasewood and sagebrush of 0.5 to 1.0 m height, creating a surface roughness within the range of 2 to 4 cm.

To create a simplified, but near full-scale urban dispersion experiment, MUST was designed using a 12 by 10 array of conex shipping containers (12.2 m long, 2.4 m wide, and 2.5 m high) placed in the center of Horizontal Grid along the sides of the roads. The conexes were spaced to produce a flow regime bordering between wake interference and isolated flow. The array was sufficiently large to create its own internal RSL, but sufficiently small to be adequately characterized using available instrumentation. Tracer gas (propylene) puffs or plumes were released from positions within or immediately upwind of the MUST array, and dispersion through the array was measured using fast-response photo-ionization detectors (PIDs) positioned along sampling lines within the conex array.

MUST was designed to accommodate vertical as well as horizontal tracer sampling and meteorological characterization. The conex array was positioned around the 32-m tower that served as a platform for tracer gas samplers,

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infrared imagers, and meteorological equipment. Six-m towers were also erected near the center of each of the array's four quadrants. Additional towers were positioned within, upwind, and downwind of the conex array for wind, temperature, and turbulence profile measurements. Remote sensing from positions around the conex array was used to characterize the state of the boundary layer during MUST.

3. INSTRUMENTS AND MEASUREMENTS

The propylene tracer was disseminated during MUST through a tripod-mounted 0.05-m diameter pipe. User-selected flow rates ranged between 150 and 225 L min^{-1}. The disseminator was capable of producing either a continuous release or puffs of 5-s duration. Disseminations took place from a variety of positions in front of, between, behind, and on top of conex containers located upwind of the sampling lines. Infrared imagery captured near-source plume dispersion, while the sampling lines documented dispersion at distances of several 10s of m to 100 m or more.

The PIDs used as gas concentration detectors during MUST were the Aurora Scientific, Inc. digital photoionization detector (digiPID) and the Industrial Development Bangor Ltd. Ultraviolet Ion Collector (UVIC®). PIDs draw a stream of air across the face of an ultraviolet lamp that radiates it with photon energy of 10.6 electron volts. This energy is sufficient to ionize the propylene tracer as it passes through the sampling tube. These ions are collected on sampling plates downstream of the lamp, and plate current generated by ion impingement is converted to signal voltage that is related by calibration to tracer gas concentration. UVICs and digiPIDs provided gas concentration data at the rate of 50 samples per second. A total of 48 digiPIDs and 25 UVICs were mounted within the conex array along sampling lines and on the 6- and 32-m towers to provide horizontal and vertical tracer gas sampling.

Meteorological measurements included detailed wind, temperature, and turbulence measurements immediately within and above the conex array, and boundary layer profiling from positions around this array. Sonic anemometers mounted on towers within, upwind, and downwind of the array characterized array flow and turbulence. Near-surface temperature profiles and conex container surface temperatures documented thermal fields within and outside the conex array. U of U participants performed collocated measurements of gas concentration and velocity components using a scalar transport probe (Metzger and Klewicki, 1999) that integrates hot-wire anemometers with miniaturized digiPIDs. Boundary layer profiling outside the conex array included tethersonde flights by ASU participants, refractive index structure measurements using the Army's frequency-modulated continuous-wave radar, temperature profiles measured by ARL's microwave radiometer, sodar- and radar-derived wind profiles, and solar and terrestrial radiation measurements. Surface weather stations surrounding the MUST array provided additional mesoscale flow information.

4. TEST CONDUCT AND RESULTS

MUST trials were scheduled either from 0200 to 0900 Mountain Daylight Time (MDT) or from 1800 to 2400 MDT to obtain dispersion data over a wide range of wind and stability conditions. The trials program emphasized nocturnal and transition periods because these are the periods when toxic release hazards are the greatest. Sixty-eight useable trial events, including 63 continuous releases and 5 multiple puff trials, were completed during MUST. These provide a total of 16 hours of continuous release data and 4.75 hours of puff data. Biltoft (2001) provides a more detailed description of MUST.

MUST test data are archived on sets of compact disks to be shared freely among test participants. Others interested in using the MUST data sets should contact DTRA. Analyses of MUST data are just beginning.

5. REFERENCES

Biltoft, C.A., 2001: Customer report for Mock Urban Setting Test. Report No. WDTC-FR-01-121, U.S. Army Dugway Proving Ground, Dugway, UT.

Metzger, M.M and J.C. Klewicki, 1999: Combined hot-wire anemometry and photoionization in the measurement of scalar variance transport. *In Proceedings of the 3rd ASME/JSME Joint Fluids Engineering Conference*, San Francisco, CA, 1-9.