The Mock Urban Setting Test (MUST) and Granite Mountain Atmospheric Sciences Testbed (GMAST) at Dugway Proving Ground

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An ATEC operated proving ground with installation operations managed by IMCOM.

Links Between Field Projects

From a historical perspective, transport and dispersion field campaigns are often linked

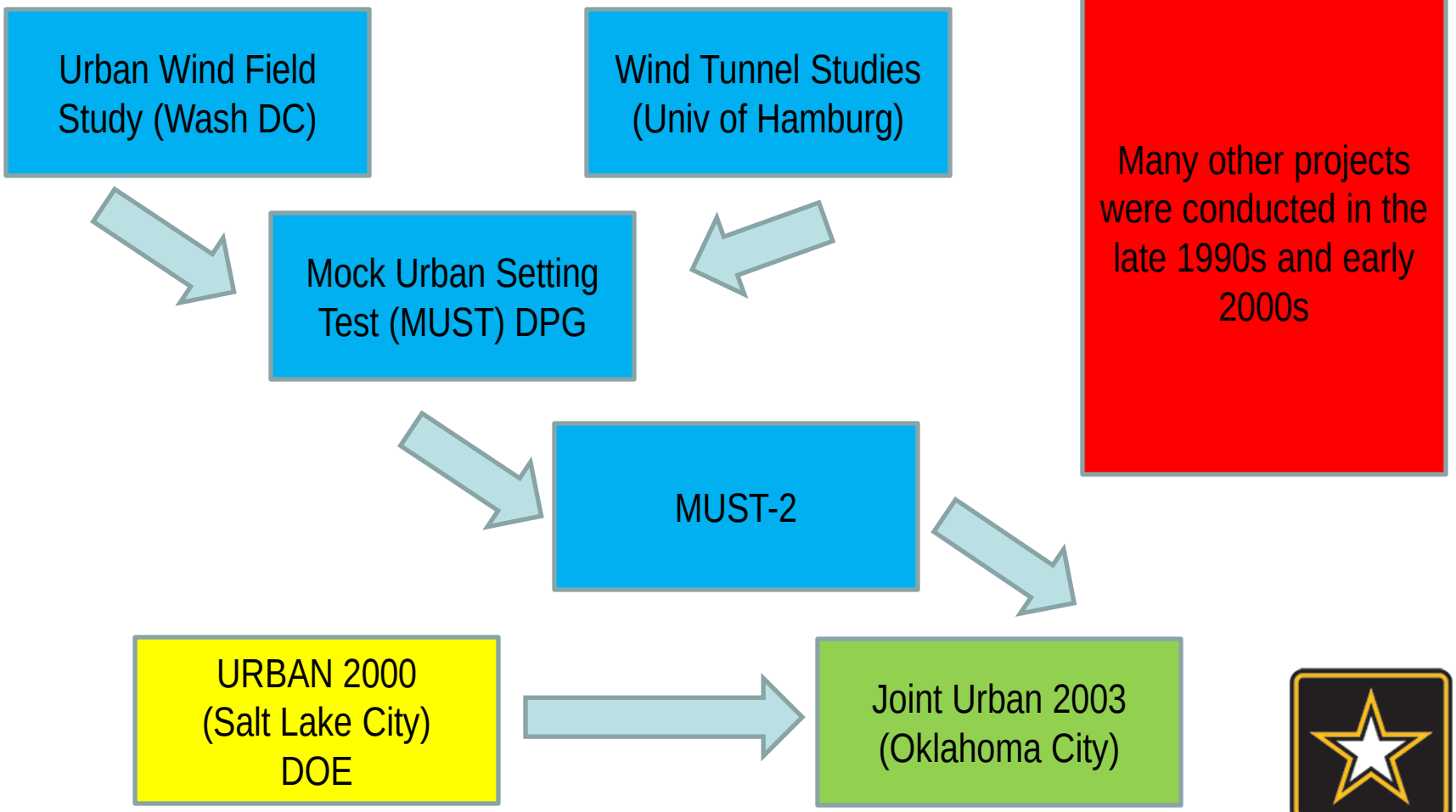
- Sometimes a series of projects is planned from the start, as components of an overall effort
  - Mercury, Gemini, Apollo
- Sometimes new projects are designed independently, but based on previous results and capabilities
  - Space Shuttle

Urban Dispersion Tests

A series of tests led up to the Joint Urban 2003 campaign

- In the US, both DoD and DOE/DHS had programs to study urban diffusion and develop models
- Work also done in other countries, and other US agencies
- By 2000, much field and analytical work had been done
  - Ref: Third Symposium on the Urban Environment, Aug 2000, in Davis CA
  - https://ams.confex.com/ams/AugDavis/techprogram/programexpanded_32.htm

Sequence of Some Urban Projects Leading to Joint Urban 2003



Test Sequence Benefits

Scientific Understanding

- Shift focus to a progression of phenomena
- Add complexity, change scales

Instrumentation

- Learn what works, what doesn't
- Develop new types of platforms where sensors are deployed

Data

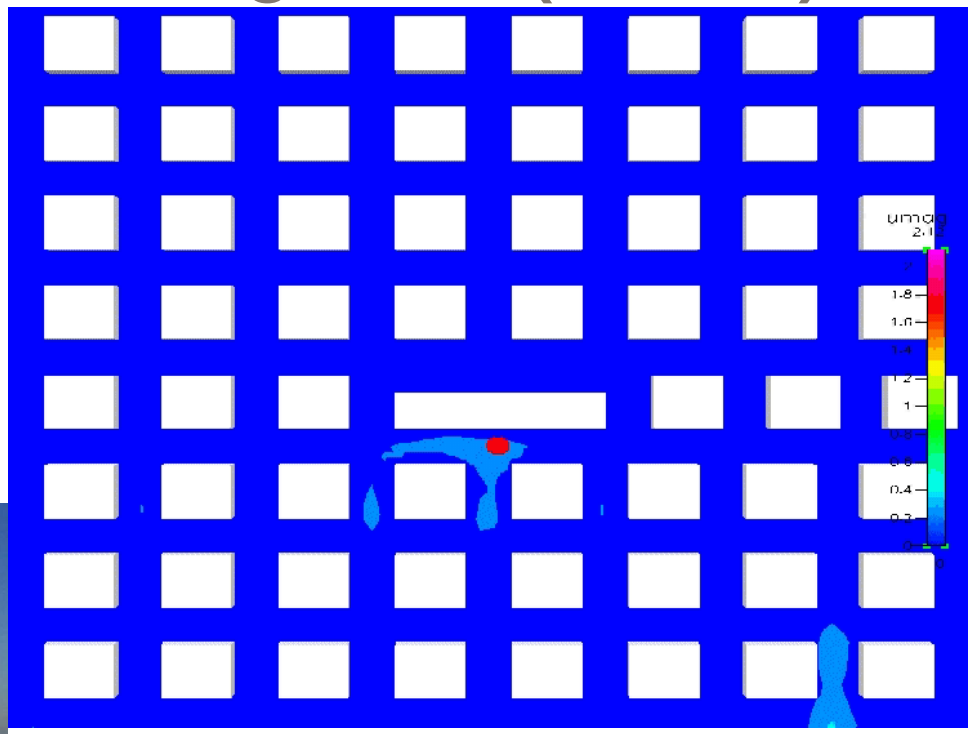
- Improve techniques for data collection, processing, QA/QC

Logistics

- Get equipment in position, coordinate releases and activities
- Test planning, environmental approvals

Mock Urban Setting Test (MUST)

- DTRA funded test program conducted at DPG in 2001
- Objective: to acquire meteorological and dispersion data sets at intermediate scale for use in urban dispersion model development and validation



- 68 trials of either continuous or puff disseminations of propylene
- Urban roughness simulated with regular array of 120 conex shipping containers

Mock Urban Setting Test (MUST)

- DTRA-led project in 2001 conducted at Dugway Proving Ground
  - Intended as intermediate step from wind tunnel to full-scale urban study
  - Dataset proved very rich as stand-alone, and is still being used
- Propylene tracer gas released from within or nearby the conex array and measured using fast-response photoionization detectors (PIDs)
- 63 continuous releases and 5 trials with multiple puff releases
- Meteorological data in and around the array characterized the flow fields, turbulence, temperature and momentum gradients and fluxes, and atmospheric stability
  - Flat ground with sage brush
- Detailed conex location and orientation measurements
  - Allowed accurate follow-on CFD and wind tunnel studies

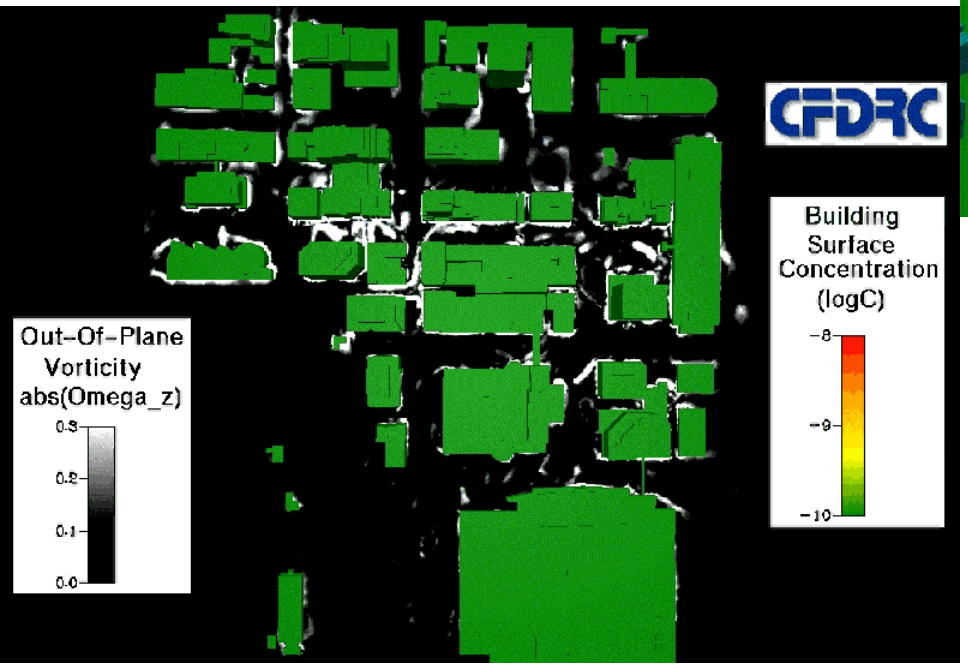
MUST-2

- Planned for 2002 to add complexity to conex array – improve realism
  - Conexes grouped into walls or L-shaped features
  - Multiple levels to reduce skimming flow

- MUST-2 postponed indefinitely by Program Manager in 2002
  - Not enough time to analyze MUST data, conduct MUST-2, and prepare for Joint Urban 2003

Joint Urban 2003

- DTRA / DoE / DHS collaborative test program conducted in Oklahoma City
- Objective: to advance knowledge about movement of contaminants in and around cities and into and within building interiors



- Largest urban dispersion test program ever conducted
- 10 IOPs conducted with either puff or continuous disseminations of SF_6.

U.S.ARMY

Granite Mountain Atmospheric Sciences Testbed (GMAST)

- Established by Meteorology Division in 2009 to meet DPG needs for improved capability for forecasting over mountains on DPG
  - Also study boundary-layer meteorology across entire range
- *GMAST Concept: Improve operations through customer-funded R&D projects*
- Combine long-term data collection with intensive observation periods (IOPs)
- Visiting scientists augment the Dugway data baseline
  - Bring additional equipment, personnel
  - Use Dugway data collection system when possible
- Opportunity to conduct repeated studies, comparing results with other scientists working in the same domain
  - In time, become a standard model evaluation reference

Dugway Meteorological Instrumentation Supporting GMAST

SAMS (Surface Atmospheric Measurement System) - 10 m fixed-site meteorological towers for standard weather measurements (2m and 10m) (35 stations)

mini-SAMS - 10 m fixed-site meteorological towers for high-frequency wind and temperature measurements (52 stations) on 1 mile spaced array over primary test range

PWIDS – 2 m portable meteorological stations for specific test support (114 stations)

32 m portable towers for multiple levels of sensing heights up to 32m above the surface (7 stations)

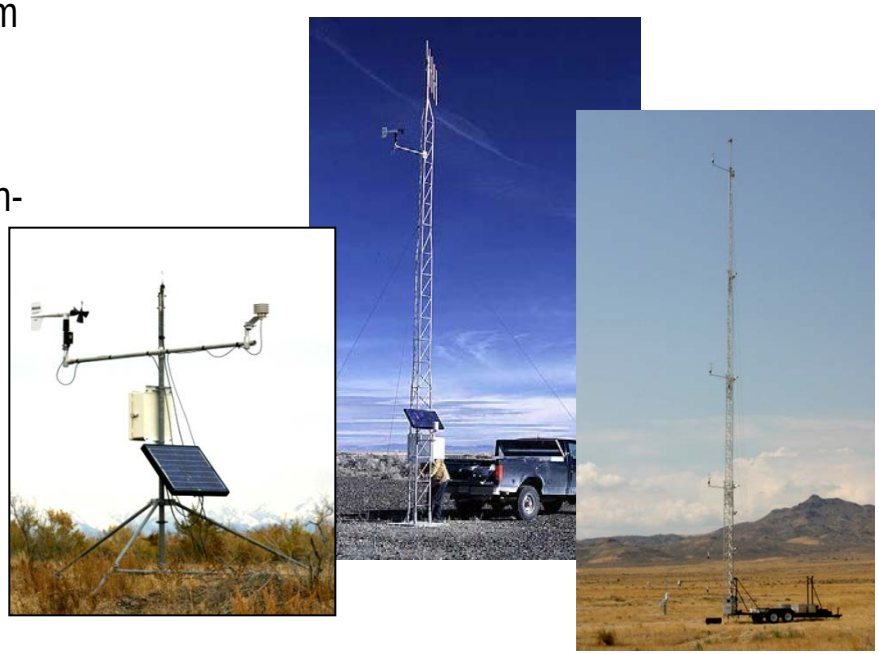
32 m fixed towers for multiple levels of sensing heights up to 32m above the surface (3 stations)

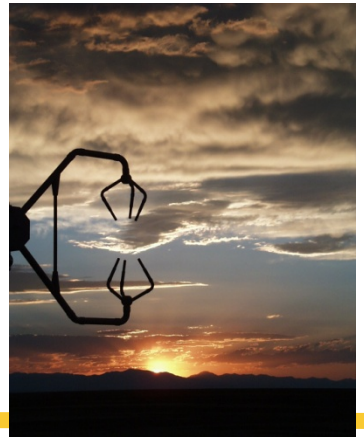
Upper air instruments (5 stations)

-- 3 Vaisala rawinsonde base stations

-- 2 tethersondes

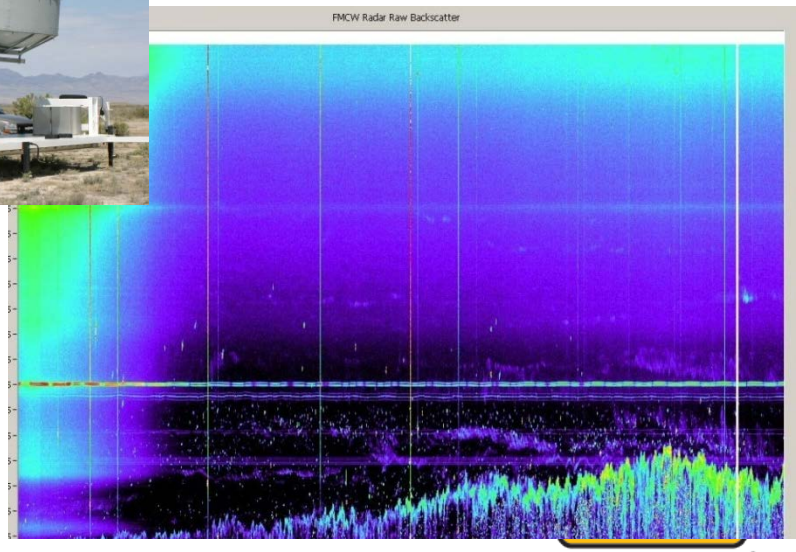
Sonic Anemometers (over 60)





GMAST Instrumentation (Cont)

- Lidar
- Sodars (3)
- Doppler radars (C-band, mobile X-band)
- FM/CW boundary layer radar
- Radar wind profilers (5)
- Ceilometers (3)
- Field Meters (53)
- Radiometers (2)
- Lightning Mapping Array sensors (12)



Data Retrieval and Processing

- Most observational data are relayed via radio to DPG Weather Building
- Data are archived in the ARMADA system
- Data also sent to weather community (MesoWest, 4DWX)
- Provides access for forecasters, consistent units, convenient displays

Four-Dimensional Weather (4DWX)

- Four-Dimensional Weather (4DWX) Program
  - Highly advanced meteorological modeling system developed by National Center for Atmospheric Research (NCAR)
  - Designed specifically to maximize use of dense instrumentation networks at ranges
  - Output tailored to test support requirements
  - Constantly updated using progress from many NCAR customers
- Core capability for forecasters at all ATEC test centers
  - Enabled by consolidating efforts and funds across all ATEC test centers
- Ensemble version of 4DWX runs on HPC system at DPG

Ensemble 4DWX

- Ensemble version of 4DWX running at DPG since 2007
  - 30 members over same domain at same time, with different inputs
  - Provides estimate of uncertainty in forecast results – very useful

- Current system supports only DPG
- Developing ensemble capability for all test centers
  - Using designated partition of a High Performance Computing Modernization Program system at Stennis Space Center, MS

Recent Field Studies

DOE Vertical Transport and Mixing eXperiment (VTMX) (2000) – Salt Lake City

DTRA Mock Urban Setting Test (MUST) (2001) – DPG

DTRA Urban Modeling Program – Joint Urban 2003 in Oklahoma City

DARPA Pentagon Shield (2004) – Pentagon

DHS Urban Dispersion Studies (2005) – Manhattan

Forest Service Long Range Drift Program (2006) – DPG

JSTO Sensor Data Fusion Program – Fusion Field Trial (2007) – DPG

Complex Terrain testbed (GMAST) (2009 →) – DPG

DHS Jack Rabbit chlorine/ammonia tests (2010) – DPG

DoD SERDP Dust Devil (2012) – DPG

Precision Airdrop Wind Sensing (PAWS Demo) I and II (2012-13) – DPG

Complex Terrain Field Studies (MATERHORN) (2012-13) – DPG

Gunship Wind Sensing (PAWS Demo III) (2014) – DPG

DHS Jack Rabbit 2 chlorine tests (2015-16) – DPG, not Met Division

MATERHORN project

- MOUNTAIN TERRAIN ATMOSPHERIC MODELING AND OBSERVATIONS (MATERHORN) (discussed separately at this workshop)
- Collaboration of universities and government
- Two large field tests utilizing the Granite Mountain Atmospheric Sciences Testbed
- Designed to identify and study the limitations of current mesoscale models for mountain terrain weather prediction and develop tools to improve predictability
- Project components:
  - Modeling Component (MATERHORN-M)
  - Technology Component (MATERHORN-T)
  - Parameterization Component (MATERHORN-P)
  - Field Experiment Component (MATERHORN-X)

GMAST Connection to 4DWX

- NCAR makes use of data from GMAST programs to improve 4DWX

- MATERHORN is a gold mine for NCAR model development
  - High resolution wind data over Granite Mountain and nearby areas
  - Surface measurements support physics parameterization development

Jack Rabbit

• The Jack Rabbit field test program was conducted at DPG during April/May 2010 under the direction of the Meteorology Division.

• The Jack Rabbit test objectives were:
  • Construct a disseminator to simulate a 90-ton tanker car release
  • Characterize the vapor/aerosol behavior and properties
  • Determine if a surrogate chemical can be used in place of chlorine
  • Evaluate instrumentation for a potential large-scale program

• Jack Rabbit II (2015-16) involves release of chlorine in a conex array and includes building interior measurements – some people called this MUST-2

Close the Circle

- Use operational experience, extensive instrumentation, and advanced modeling systems to plan and design field studies
  - Site CB referee sensors, weather sensors, and systems being tested
  - Use 4DWX and Transport & Dispersion modeling guidance (HPAC, JEM) along with climatological data and operational experience
  - Use model guidance for safety checks during test activities

- Use results from R&D studies to improve operational capabilities
  - Detailed results from MATERHORN inform forecasters about scale interactions
  - Awareness of flow patterns revealed during MATERHORN, combined with observations, enables more accurate forecasts

Questions and Discussion