Overview of the 2015 – 2016 Jack Rabbit II Chlorine Release Field Trials

Presentation to:

20th Annual George Mason University Conference on Atmospheric Transport and Dispersion

Homeland Security
Science and Technology

Transport Canada

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Jack Rabbit Program

- **Problem:** DHS and its partners and stakeholders in the HSE must better understand behavior and consequences of large-scale chlorine releases.

  - Millions of tons of chlorine, a potent toxic inhalation hazard (TIH), are shipped annually through highly-populated areas
  - Transported in bulk as a pressurized, liquefied gas via road, water, rail
  - An accidental or intentional release can rapidly generate a lethal vapor cloud

  - Hazard prediction models *are not consistent* with the evidence, data, and observations from previous fatal chlorine disasters
  - Rapid Cl_2 releases have never been tested at operationally-relevant scales
  - Critical knowledge and data gaps exist for source terms and other phenomena relevant to modeling and emergency response
  - There is insufficient understanding, knowledge, and documentation of large-scale chlorine releases to properly inform, train and prepare emergency responders
  - 2010 Jack Rabbit 1-2 ton chlorine trials identified phenomena and scaling factors that required additional testing.

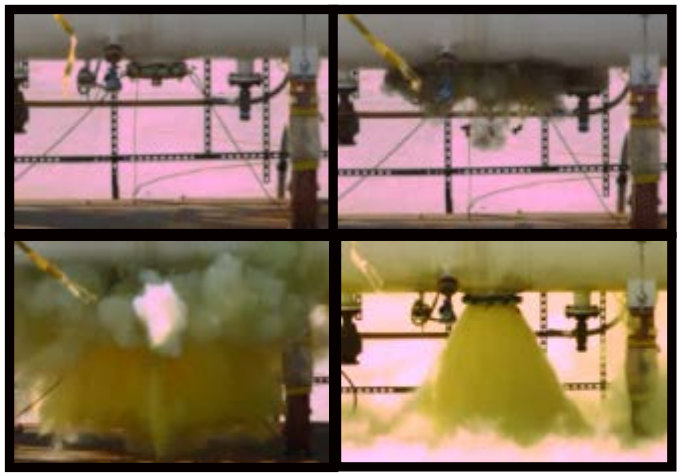
Recent Chlorine Releases

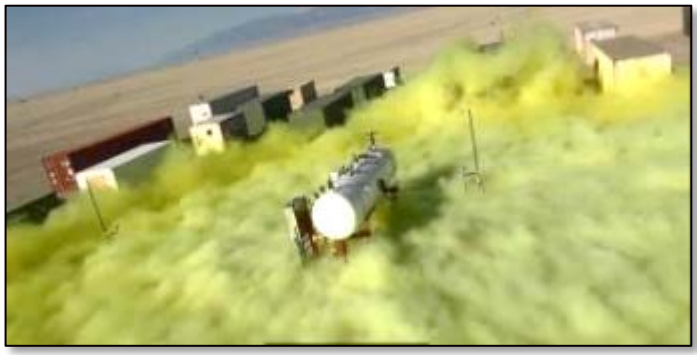
- Festus, MO, 2002
  - Ruptured 1-inch Cl_2 fill line
- Macdona, TX, 2004
- Graniteville, SC, 2005
- Iraq Chlorine Attacks, 2007-2008
  - Chlorine 1-ton containers and cylinders
  - Approximately 15 attacks
- Syria, N. Iraq Conflicts 2014-2015
  - Chlorine 1-ton containers
  - Chlorine “Barrel Bombs”

Jack Rabbit II - Trials

Large-scale chlorine release field trials in 2015-2016 to fill critical data and knowledge gaps for improved modeling and emergency response.

- 5 successful trials in 2015: 5-9 tons Cl_2
- Tracking downwind cloud and concentration to 7+ miles
- Quantifying source term parameters
- Simulated urban test grid to study effect of buildings
- Building infiltration and shelter-in-place studies
- Emergency vehicles and equipment exposure testing
- Studies of Cl_2 reactions with environment and surfaces
- 7 additional trials in 2016: 10-20 tons Cl_2





Partnerships

- **Over 50% of the cost of the test was contributed from various partners, either by direct funding or in kind support**
- **DTRA:** Direct funding and support for field experiments. Numerouse staff directly participating in program management, planning, field trials, and analyses
- **Transport Canada:** Direct funding via Technical Annex agreement, and direct participants
- **TSA:** JR II partner and sponsor of Scientific Advisory Group
- **Utah Valley University:** Along with **FEMA**, **U.S. Fire Administration**, **IAFC, IAB** - Led team of partners fielding emergency response vehicles and several important experiments relevant to first responders
- **Chlorine Institute:** Donated program's chlorine, equipment, and tanker truck.
- **Association of American Railroads** (**AAR)**
- **American Chemistry Council (ACC)**
- **Honeywell Analytics / RAE Systems**

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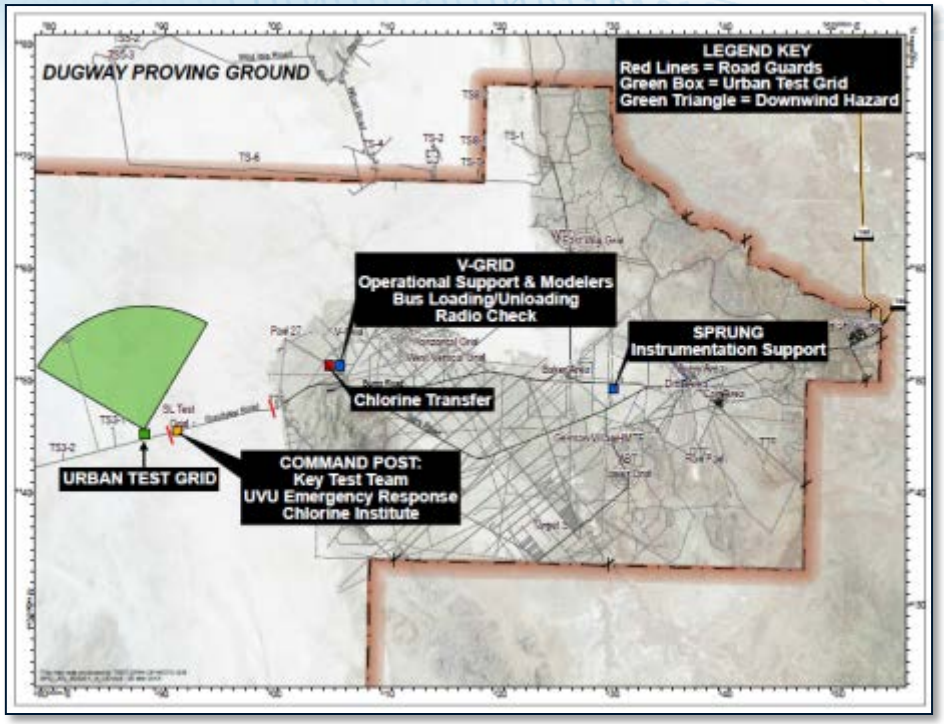
Test Site – Dugway Proving Ground

- U.S. Army's Dugway Proving Ground, UT selected as test site and performer
- Extremely remote, unpopulated test range in barren desert salt-flats
- Unique and well-understood reproducible weather in July-September – 2yr study
- Successfully secured multiple levels of Federal and State approval:
  - Utah Title V Permit >10 tons Cl_2
  - Environmental Assessment / NEPA
  - CWC Treaty Compliance
  - Clean Air Act
  - Migratory Bird Act
  - UXO and Cultural Public Hearings



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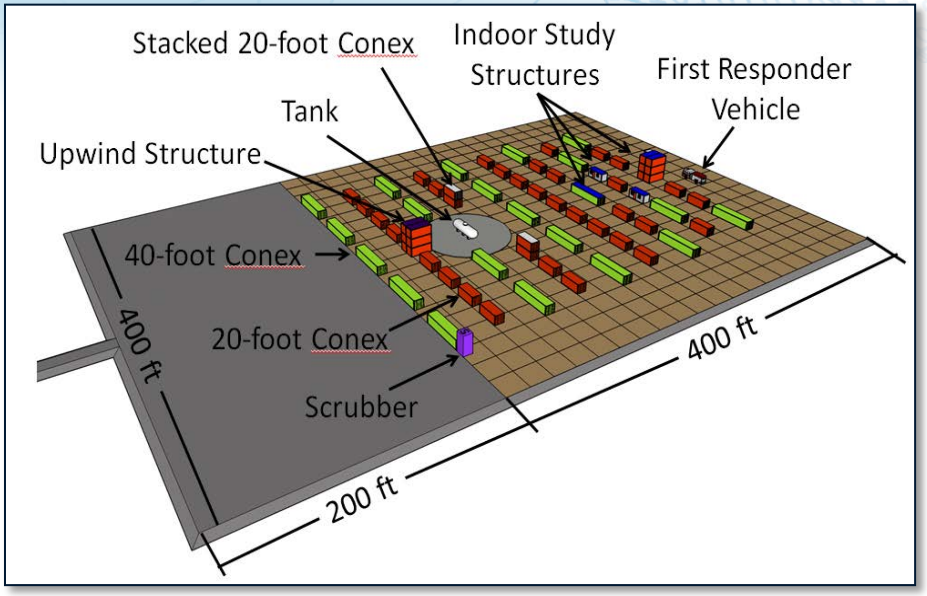
Urban Test Grid (UTG)

- "UTG" constructed with over 80 Conex containers and mobile structures to simulate buildings and obstacles
- Release tank positioned in the middle of UTG on circular concrete pad
- Instrumentation deployed at stations throughout UTG to capture key data:
  - UV Jaz, Canary, MiniRAE – Concentration
  - Thermocouples, IR Cameras - Temperature
  - Guided Wave Radar (GWR) Liquid Depth
  - PWIDS, SODAR, SAMS Towers - Meteorology



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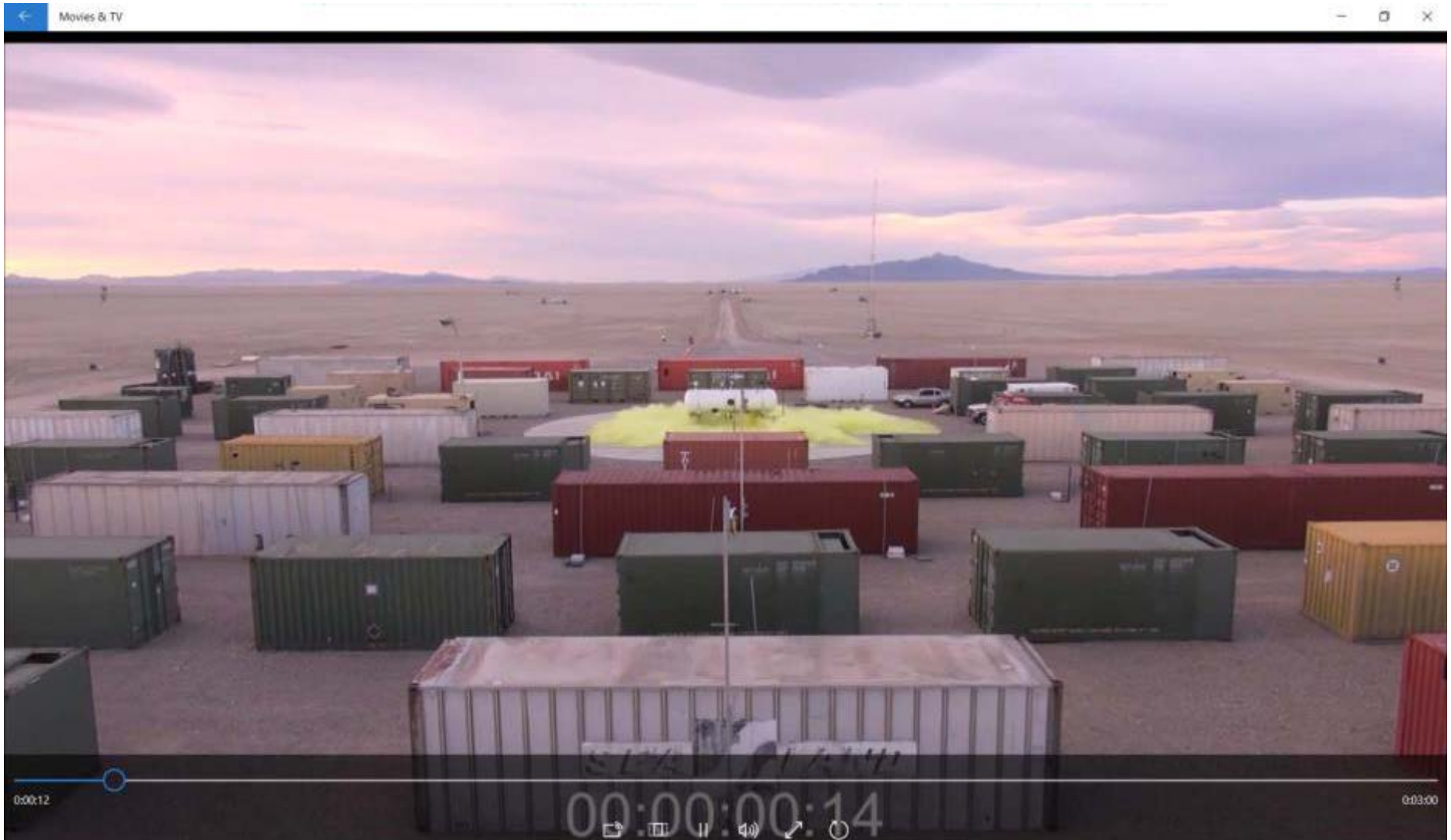
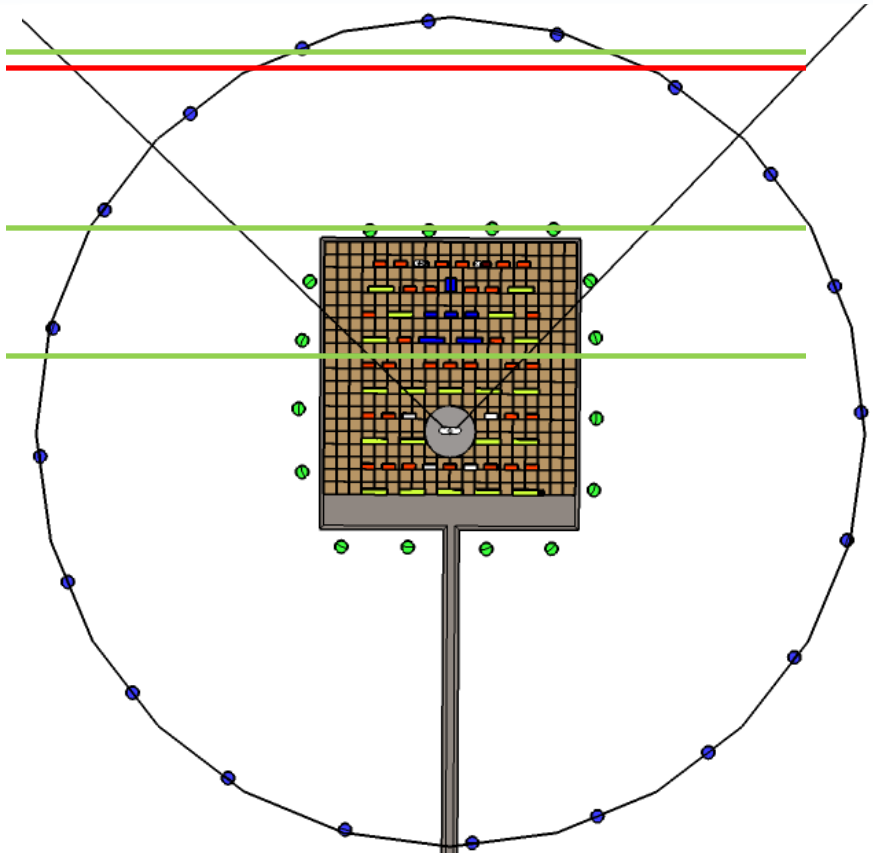
Urban Test Grid (UTG)

- JR II Cloud, Trial 5, looking toward south (upwind) 0.5 sec after release starts



Near Field Testing Grid



- 16 UV/Vis Jaz instruments measure Cl_2 in the near-field
- Upwind “retrograde” cloud flow, monitored at 200-m ring
- Indoor Study areas, and effect of buildings

-UV Canary
-Jaz Unit
-UV Sentry Line of Sight
-Midac OP-FTIR Line of Sight

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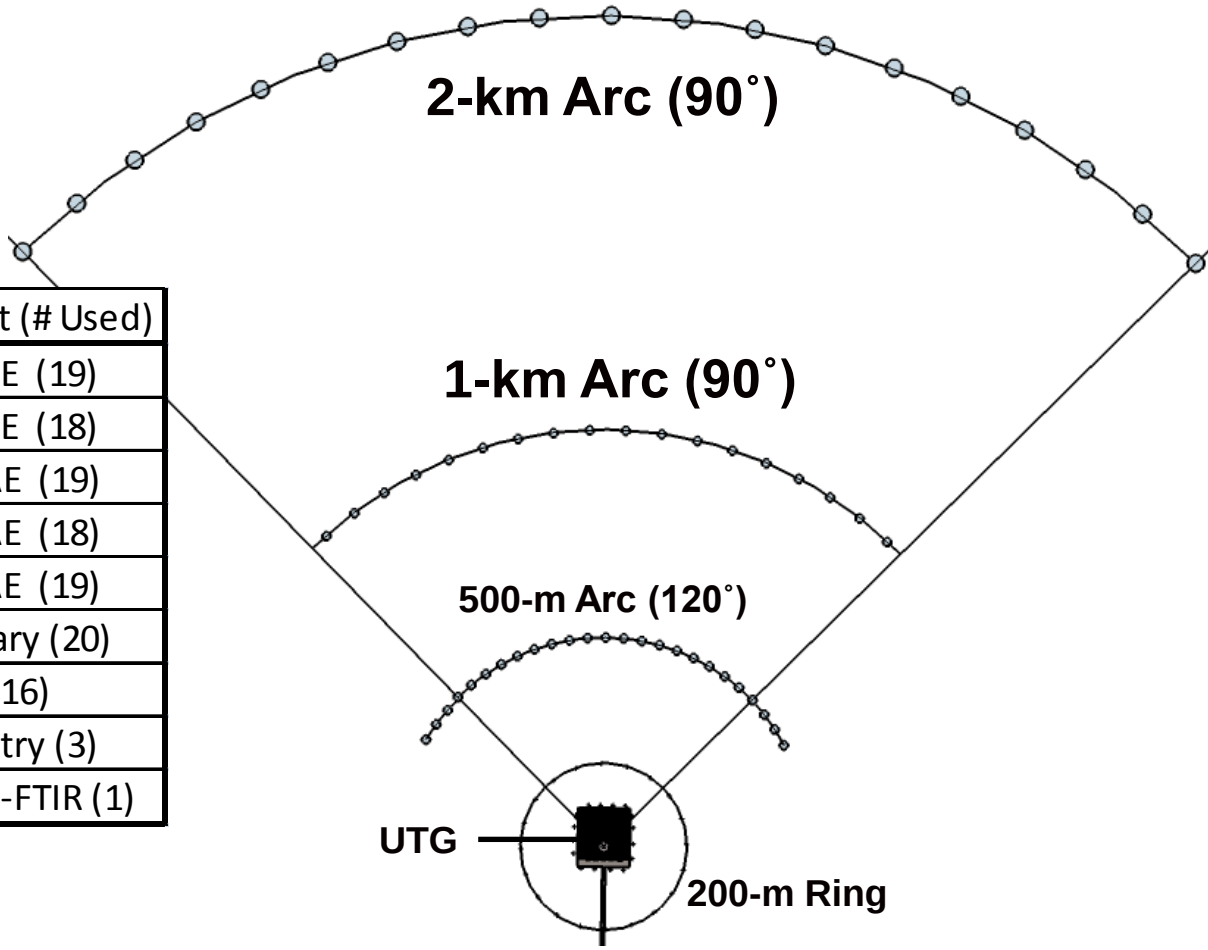
Mid-Range Test Grid

Instrumentation Location	Instrument (# Used)
11-km Arc	ToxiRAE (19)
5-km Arc	ToxiRAE (18)
2-km Arc	MiniRAE (19)
1-km Arc	MiniRAE (18)
500-m Arc	MiniRAE (19)
200-m Ring	UV Canary (20)
100-m Ring	Jaz (16)
UV Sentry	UV Sentry (3)
Midac OP-FTIR	Midac OP-FTIR (1)



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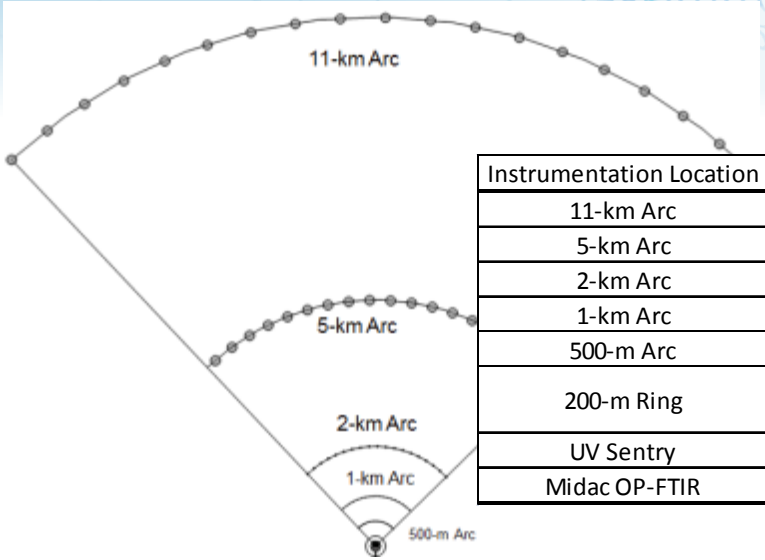
Extended Test Grid

- Beyond UTG, instrument stations positioned on arcs at 200m, 500m, 1km, 2km, 5km, and 11km
- Plume tracked to 11km and beyond via 3 LIDAR stations:
  - 2 UV Differential Absorption LIDAR (DIAL)
  - 1 Mie-Scatter LIDAR (Aerosol)



Instrumentation Location	Instrument (# Used)
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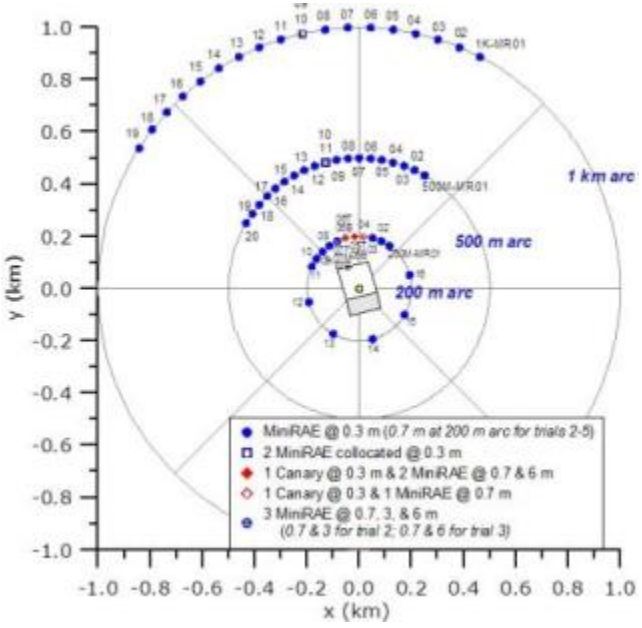
1-km Arc	MiniRAE (18)
500-m Arc	MiniRAE (19)
200-m Ring	UV Canary (4) MiniRAE (18)
UV Sentry	UV Sentry (3)
Midac OP-FTIR	Midac OP-FTIR (1)



UV-Dial LIDAR

Emergency Responder Experiments

- Deployed Emergency Response Vehicles, Equipment 100m from release
  - 3 fire trucks, 2 ambulances, cars (windows up, running, AC variable)
  - No vehicles stalled on any trial
  - Significant corrosion to all metal surfaces
- Exposure / Effect on Common Materials and Surfaces
  - Creosote soaked items such as poles and rail road ties
  - Asphalt Shingles, Wood, Hay, Grass
  - Rail Ballast

- Studies will provide key data and findings to improve ER safety and operations:
  - Survivability in vehicles
  - Immediate and long-term operability of ER vehicles and equipment
  - Determination of vertical concentration gradient impacting vehicles
  - Validation of CP and Isolation Zones

Emergency Responder Experiments

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Emergency Responder Experiments

Indoor Studies

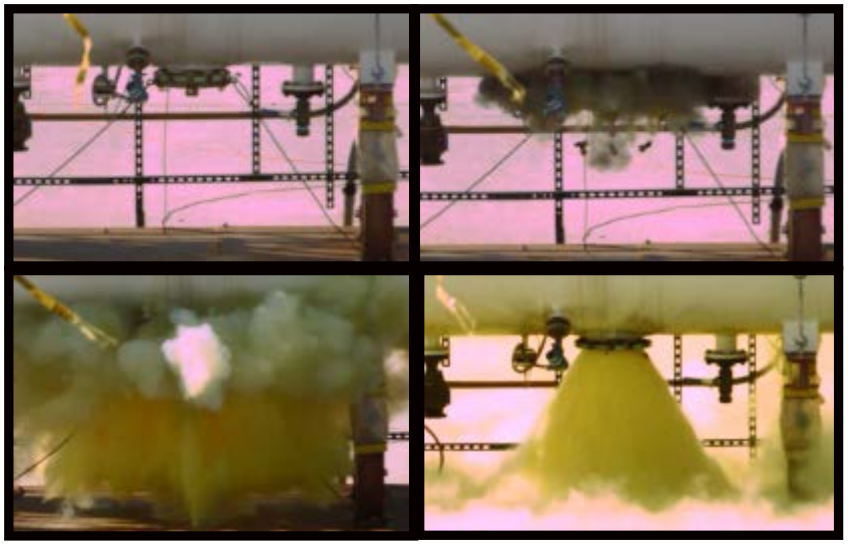
- DTRA-funded, led by Dr. Mike Sohn, LBL
- Total of 6 large mobile trailers configured to mimic residential and office structures
- Additional Conex containers configured and equipped with interior and exterior sensors to record concentration of cloud and ingested Cl_2
- Studies are investigating and will reveal:
  - Indoor concentration profile generated by outdoor cloud
  - Effect of varying conditions including HVAC operation, windows, air exchange rates, materials
  - Examination of shelter-in-place procedures and guidance
  - Indoor exposure profiles – will lead to improved consequence assessment

Dissemination

- 5 successful Cl_2 release trials:

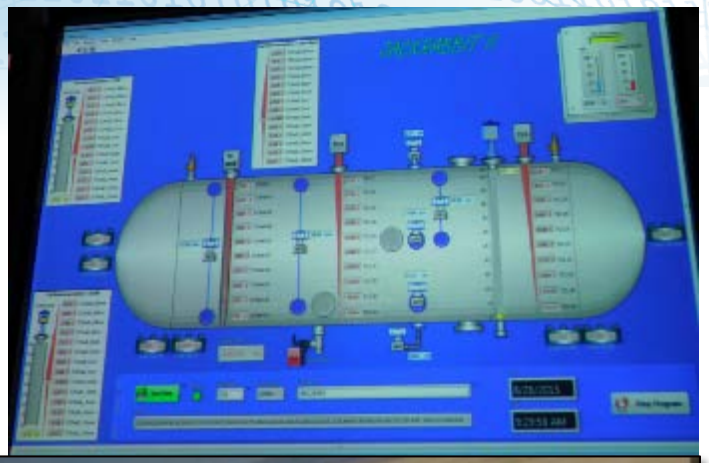
	Date	Time (MDT)	Mass Cl_2
1	24-AUG-15	7:35:45 AM	5.0 Tons
2	28-AUG-15	9:24:21 AM	9.0 Tons
3	29-AUG-15	7:56:55 AM	5.0 Tons
4	01-SEP-15	8:38:50 AM	7.5 Tons
5	03-SEP-15	7:28:19 AM	9.0 Tons

- Time of day and year precisely selected in order to achieve required “go” criteria:
  - 2-6 m/s wind
  - 90º wedge NNW
  - Temp. Inversion
  - Atmos. Stability
- Reengineered 10-ton propane tank
- Explosive bolts released blind flange to expose 6-inch hole in bottom of tank
- Tank instruments measured key source-terms:
  - Temperature
  - Pressure
  - Mass Flux
  - Vapor Void Space
  - Liquid Volume
  - Liquid Depth



Key Information From JRII Tests

- Source Terms: Quantifying the release parameters – release rate, rainout and liquid pooling, tank conditions
- Effect of buildings and obstacles on the initial cloud and downwind concentration profile
- Infiltration into buildings: profile generated by outdoor cloud under varying conditions (HVAC, sealed windows, etc.), to inform shelter-in-place guidance
- Effect of cloud on Emergency Response equipment, and materials
- Downwind concentrations to 11+ km



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JR II – Phase 2 FY16

- Total of 7 chlorine release trials planned at the DPG JR II Test Grid (V-Grid)
- V-Grid open to JR II team on **August 22nd**
- Release trials will begin on **August 29th** and must end by **September 30th.**
- 6 release trials 10-ton tank using different release angle orientations:
  - 0º (straight up), 90º (horizontal), 135º (45º from ground), and 180º (downward)
- 1 release trial from 20-ton tank
  - 180º (downward)
  - 20-ton tanker truck vessel used as release tank
  - Explosively breached
- Structures / Conex containers removed for Phase 2 trials with the exception of 1 mobile building remaining for follow-up work for LBL indoor experiments
- VIP Day scheduled for Sep. 8-9, 2016
- Release trials scheduled:
  - **August 29th**
  - **August 31st**
  - **September 2nd**
  - **September 7th**
  - **September 9th**
  - **September 12th**
  - **September 14th**

Future Efforts

- Following the completion of the 2016 Phase 2 release trials, several studies and reports are planned
  - Source Term Analysis
  - Downwind Dispersion Analysis
  - Chlorine Reactivity Study
- No further chlorine field release trials
- Targeted follow-up studies using laboratory experiment
  - Wind tunnel analysis and validation
  - Laboratory-scale reactivity studies
- Future research efforts will not necessarily focus on large-scale field trial releases, and will focus on other widely-transported TIH chemicals of concern:

Ammonia (NH_3)
Chlorine (Cl_2)
Sulfuric Acid (H_2SO_4)
Acrylonitrile (C_3H_3N)
Ethylene Oxide (C_2H_4O)
Hydrogen Fluoride (HF)

Sulfur Dioxide (SO_2)
Hydrogen Chloride (HCl)
Hydrogen Cyanide (HCN)
Bromine (Br_2)
Nitric Acid (HNO_3)

Data and Video Transition

- Homeland Security Information Network (HSIN) is being used to share data with stakeholders

  https://hsin.dhs.gov/Pages/Home.aspx

- To request access, send email to Jack.Rabbit@st.dhs.gov

- After being nominated and approved, access will be granted to the Jack Rabbit II HSIN Site:

  https://hsin.dhs.gov/ci/chm/jrwg/Pages/default.aspx

- DHS S&T CSAC Points of Contact:

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