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Release Mitigation Safety Spray System for Chem Demil Applications IPR

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Sandia National Laboratories

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Original Funded Proposal Scope and Schedule

- **Tasks/Deliverables**
- **Task 1:** Test decon candidate chemistries for compatibility with current chem detection systems
- **Task 2:** Modeling, analysis, and testing to design spray safety system to mitigate release in EDS operational geometry and environment
- **Task 3:** Build and install prototype spray mitigation safety system at selected operational test location
- **Task 4:** Test and characterize performance of installed prototype system

Deliverables: Prototype spray mitigation safety system, installed and tested in a selected operational environment

Schedule **(assumes funding arrives by October 2008)**

Feb 2009 – PM 5: Decon chemistry selected (Task 1)

May 2009 – PM 8: Preliminary spray safety system design completed (Task 2)

September 2009 – PM 12: Spray safety system design finalized (Task 2)

June 2010 – PM 21: Prototype installation complete (Task 3)

September 2010 – PM 24: Testing and characterization of prototype system complete (Task 4)

- Original Budget – FY 09, $500K; FY 10, $500K
- Amended schedule - Redirected to PBA application (?)
- Self-determined scenarios, $635K, aggressive 10-month year schedule ($630K spent to date)

Significant progress towards an engineered solution

Project Status

- **Modeling, analysis, and testing to design spray safety system to mitigate release in EDS operational geometry and environment**
  - ✓ Nozzle characterization – Well defined
  - ✓ Modeling for proposed scenarios – Mustard and Phosgene
  - ✓ Chemistry optimization – Successful at bench scale
  - ✓ Results of aerosol chamber tests
    - Maximum immediate efficacy following 1-minute charged spray is >3 orders of magnitude; 5 orders of magnitude 20 minutes post-spray and ND at 30 minutes post-spray
    - Filter samples provide confirmation of pre-spray simulant concentrations and rate of particle fallout post-spray
    - Filter samples also provide comparison of rate of post-spray particle fallout to neutralization rate of simulant captured in vapor and aerosol droplets (as collected by BioSamplers and measured by GC)
    - Analyses of pooled floor samples – non-detectable

Conclusions - Spray density capability of new structure based on experimental outcome provided by smaller aerosol chamber tests; increased efficacy demonstrated by varying spray parameters.

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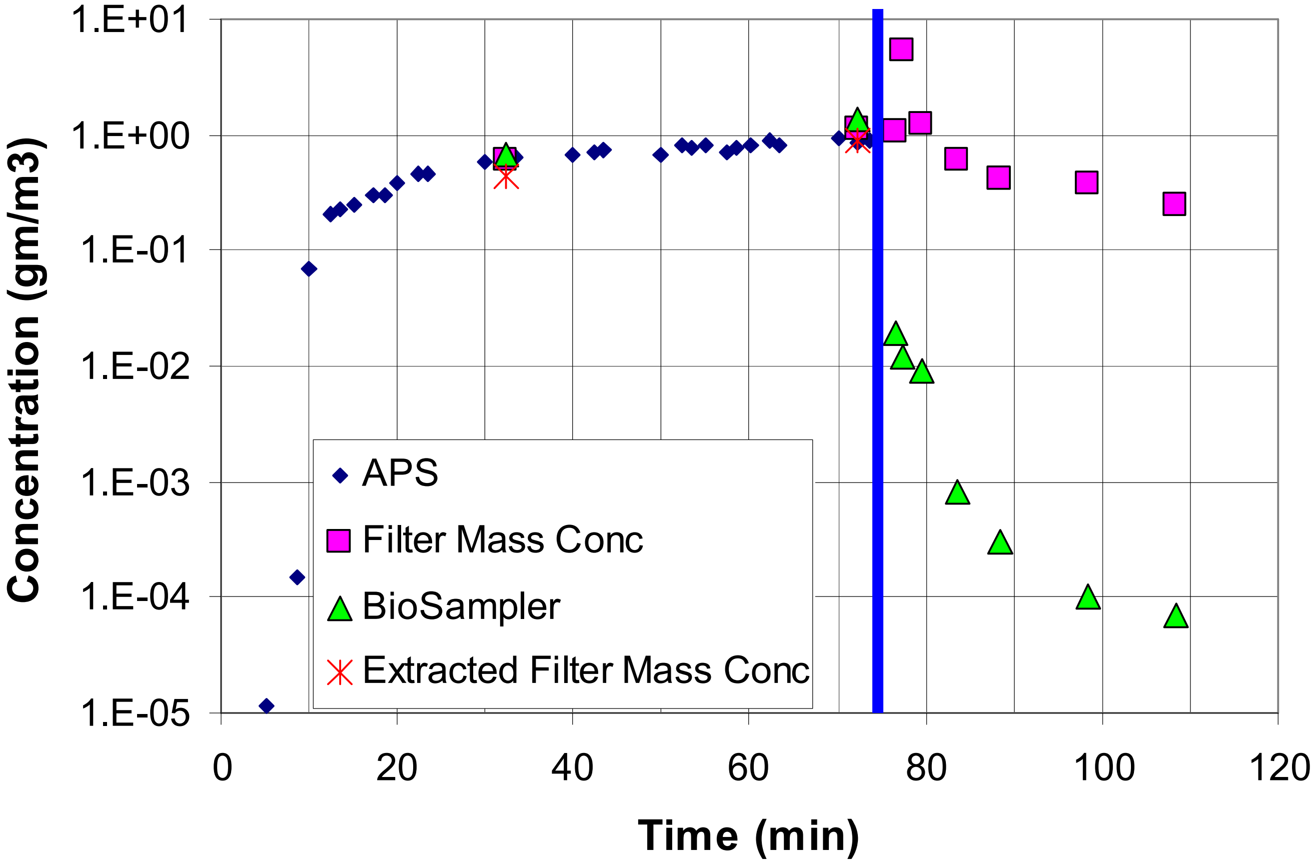
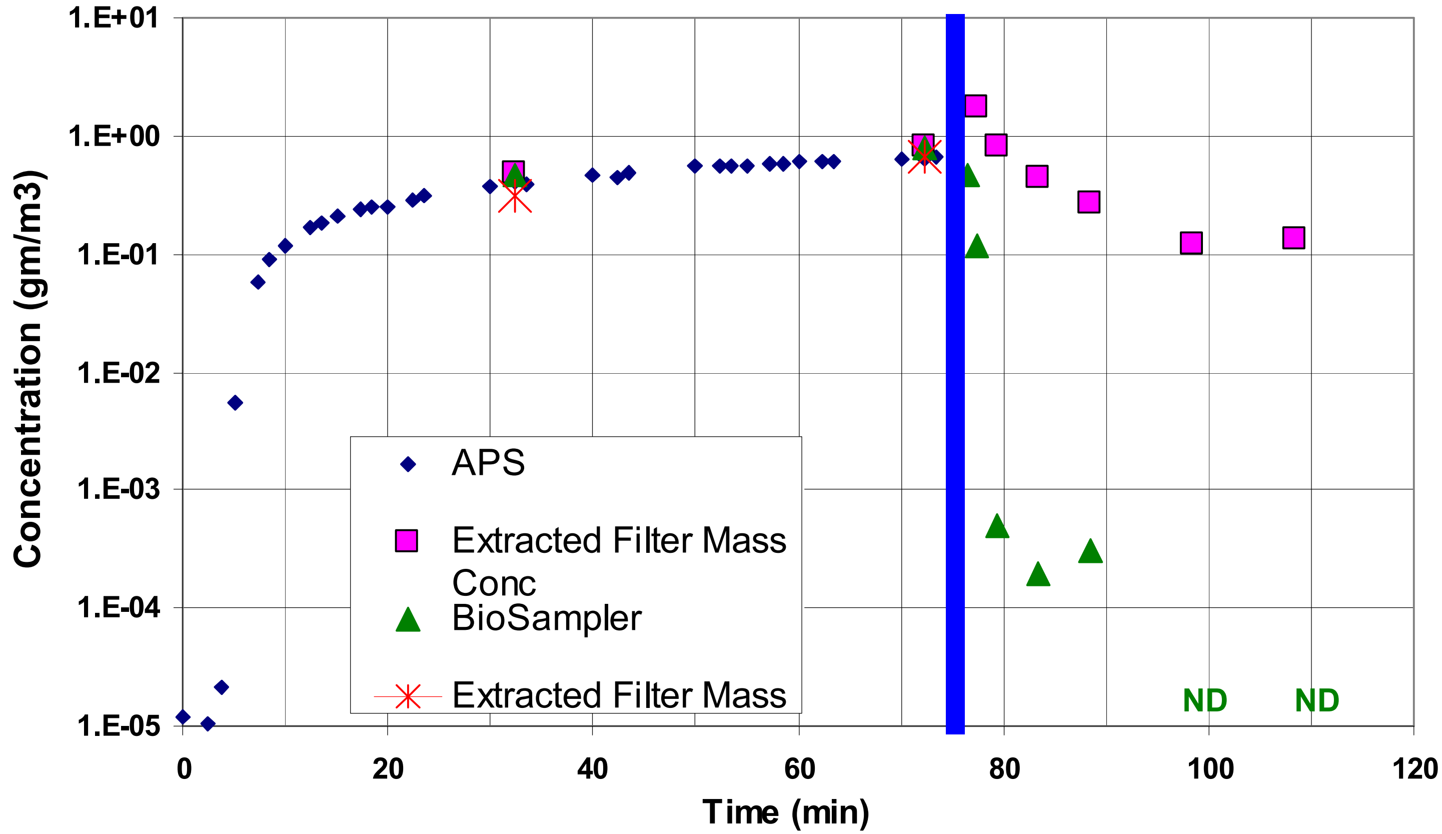
Rapid Knockdown and Neutralization of Aerosolized G-Agent Simulant, 1-minute Charged DF200 Spray in an Unmixed chamber environment



Maximum efficacy of >4 orders of magnitude reduction at 30 minutes post-spray

Rapid Knockdown and Neutralization of Aerosolized G-Agent Simulant, 2-minute Charged, Staged DF200 Sprays
Reduced air flow for Minute 2



Increased neutralization rate with 2-minute, charged spray deploying smaller (~ 30 μm) than larger droplets (~ 60 μm)

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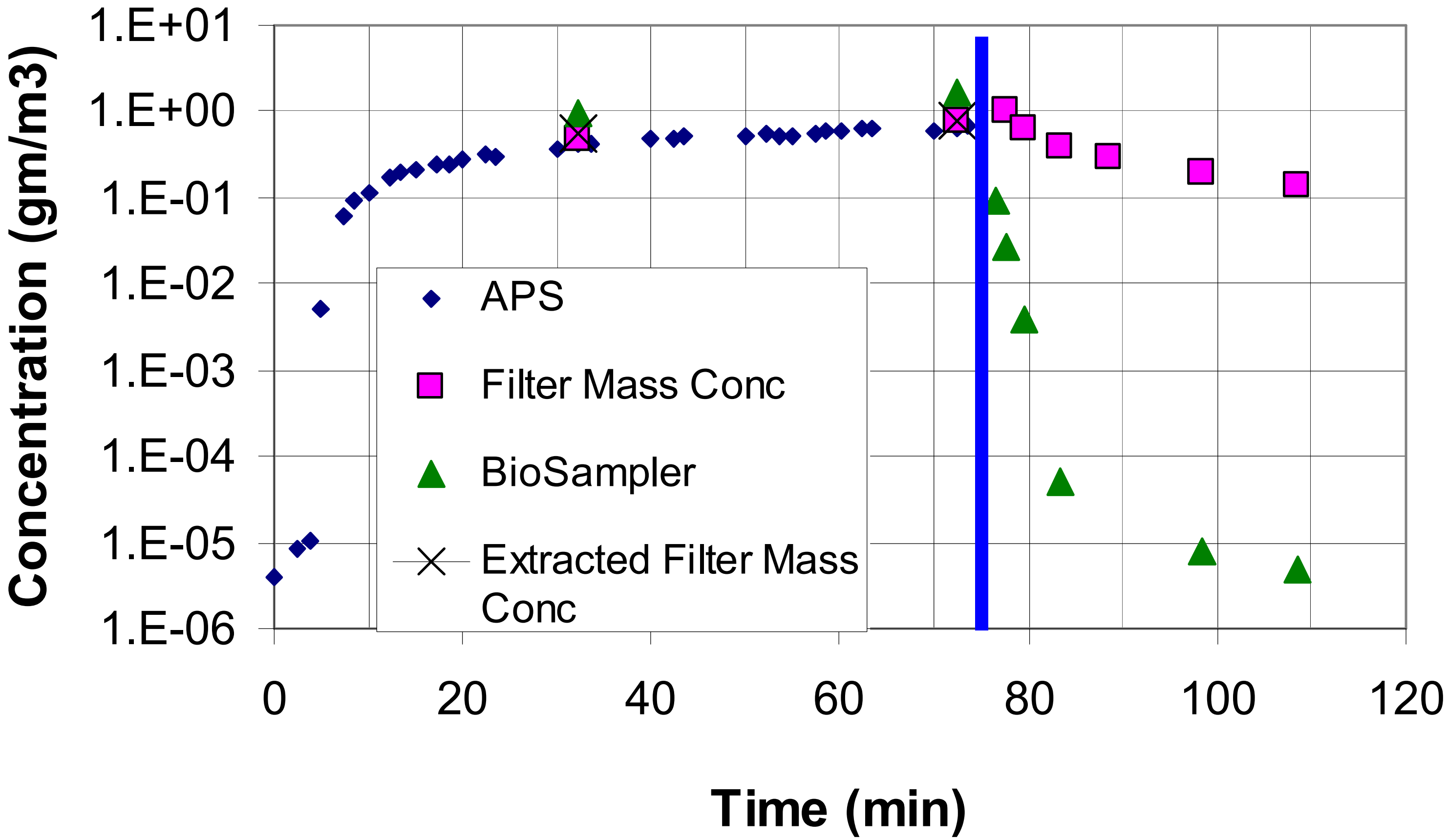
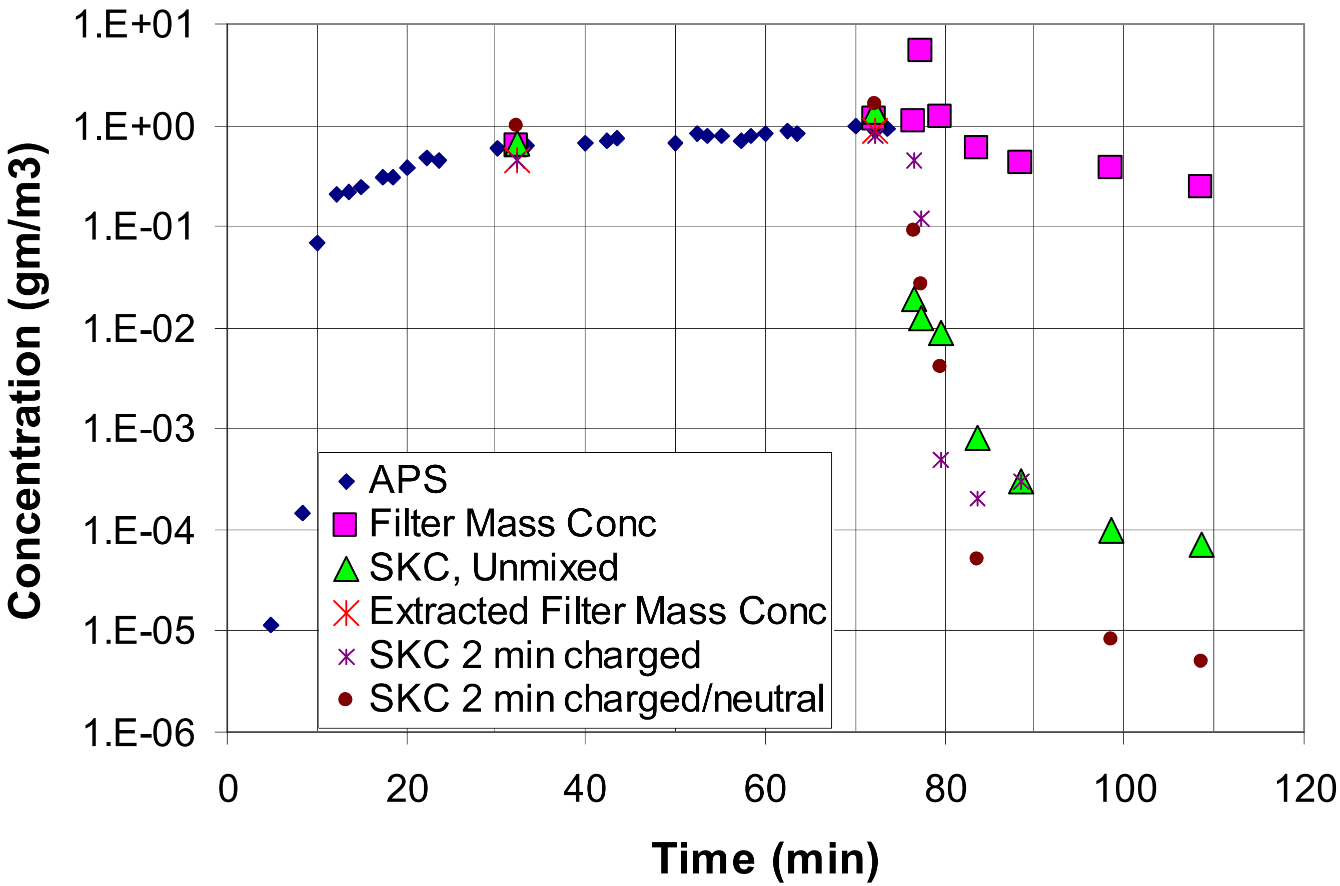
Rapid Knockdown and Neutralization of Aerosolized G-Agent Simulant
1-minute Charged & 1-minute neutral DF200 Sprays
Reduced air flow for Minute 2



Maximum efficacy of >5 orders of magnitude at 30 minutes post-spray

Increased reduction of airborne concentration is impacted by increased spray duration and change in electrostatic charge

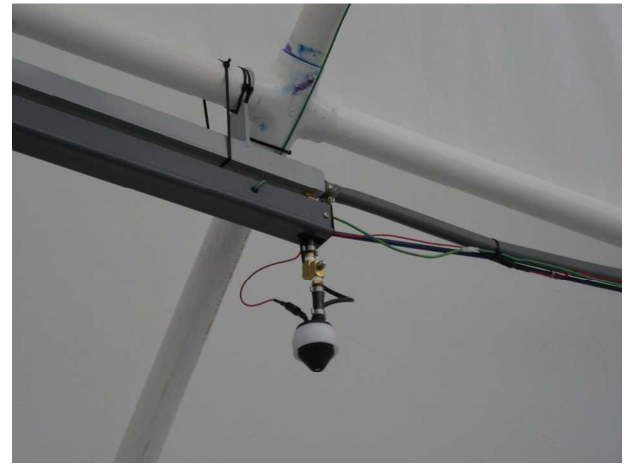


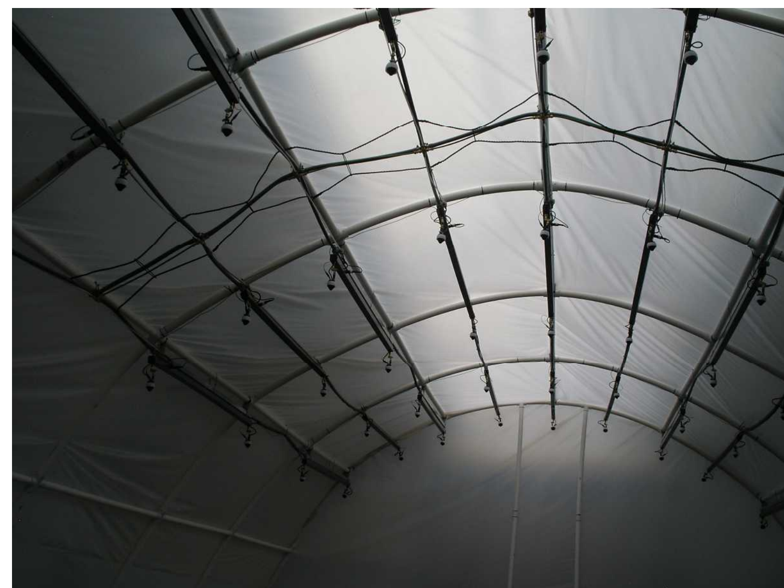
Improved knockdown by change in spray parameters

Project Status, con't

- **Modeling, analysis, and testing to design spray safety system to mitigate release in EDS operational geometry and environment**
  - ✓ Design of prototype system
    - Completed, based on current experimental spray densities
    - Spray nozzle booms are modular, can be readily re-located
- **Evaluation of MINICAMS**
  - – Incomplete, attempted DOS-based system; will incorporate purchase of software within Roadmap
    - "If TVA wants to provide MINI-LINK systems or CHROM-LINK systems to Sandia, then we would more than happy to provide upgraded software to them as needed. Otherwise, because we do not sell stand-alone MINI-LINK or CHROM-LINK software, we would prefer that TVA not provide stand-alone software to them either." April 20, OI Analytical
- **Build and install prototype at SNL**
  - ✓ Required extensive planning for ES&H permits & procedures, site permits
  - ✓ Some site preparation and installation costs offset with contributing SNL Center support funds
  - ✓ ESS technical evaluation and consultation

Prototype Mitigation Spray Safety System at Sandia National Labs





Roadmap Phase I

- **Test and characterize performance of current prototype system**
  - Complete experimental in current aerosol chamber ($72K, 6 weeks)
    - Six tests: optimized chemistry for G-agent & mustard simulants
      - Increased mixing fan capability
      - Staged Sprays using optimized chemistry, two simulants
    - Complete MINICAMS interference assessment - software purchase
  - Demonstration to provide an assessment of performance and proof of concept in operational geometry and volume
    - Based on Threat Scenarios 1 & 2
    - *DMMP as simulant?*
    - Assess a reduced # of sampling points in operational volume
      - Proposed 9x9x3 grid, 21 Samplers in cluster design (6 samplers/cluster), 126 Total Samplers $6K/node, 4 weeks to install, Lab View programming, large pump
      - Incorporate BROOM to increase speed, ease and accuracy of sampling collection, track analyses, provide sampling and simulant analyses contour maps
    - Additional mixing capability, DC valves and DC power supply
    - Estimated hardware costs of $185K
    - Spray system functionality testing (test manifolds, switch and high voltage controls) – 4 weeks, ~$118K labor plus purchases

Roadmap Phase I, con't

- 1 pre-Demonstration readiness test – 1 week prep, 1 week to assess, perform ($32K labor and materials)
- Deliver Full-Scale Demonstration – 1 week prep, 1 week to assess, perform and preliminary report ($46K labor and materials)
  - Provides proof of concept in operational geometry and volume
- Analysis and Reporting ($110K labor plus purchases)
- Management and Development ($118K)
- Travel to CWD, 4 staff personnel ($20K)
- BROOM Integration ($20K)
- Schedule:
  - October-December, 2009 – Purchases, installation
  - January-February, 2010 – Characterization of operational volume
  - March 1, 2010 – Pre-demonstration readiness
  - April 1, 2010- Final Demonstration
  - May, June – CWD 2010
- Go/no-go for larger full scale application

Estimated cost of Phase I - ~$700- $720K

Roadmap Phase IIA
A Fielded System, 2010

- **Field, install and test prototype system**
- **Prototype assembly and deployment ($385K)**
  - Spray system will mount on existing structure
  - Additional sensors, detect & deploy – automated, or manual?
  - Hardware (tanks, plumbing, air compressor, electrical, data acquisition, sampling/detection pre-filters, floor containment) - $100K
  - Shipping, logistics ($50K)
  - Travel for design
  - 1 staff + 1 tech, ½ time for 6 months; plus .25 FTE
- **CONOPS and Guidance for Use ($160K, labor and purchases)**
  - 2 staff, ½ time (6 months)
  - Understanding of current event response is 1st task!
- **Travel ($92K)**
- **Management ($63K)**
- **Operational Demonstration at facility (Qualification Test - $110K)**
  - Travel - 5 personnel, 4 weeks each ($20K)
- **Schedule – 6 months from identification of location, ideally June – November, 2010**

Estimated cost for Phase IIA – $710K - $725K

Phase IIB - Technology Development Roadmap

- **To explore and bound the PERFORMANCE ENVELOPE, we need the following:**
  - Additional modeling to narrow parameter space for testing
  - Different Threat scenarios will be tested and evaluated
  - Full Scale experiments to pinpoint efficacy and capability
  - Increase sampling density and confirm density of instrumentation demonstrates smooth contour; alter if necessary
  - Incorporate BROOM to increase speed, ease and accuracy of sampling collection, track analyses, provide sampling and simulant analyses contour maps
  - More heavily instrumented capability

R&D focused to improve & optimize prototype system for different agents

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Phase IIB - Technology Development Roadmap, con't

- **Four primary parameters provide effective neutralization**
  - Droplet size
    - Staged Sprays of multiple spray sizes to enhance overall performance
  - Charging
    - May enhance efficacy
    - Enhanced particle collection
    - Magnitude of applied voltage may impact aerosolized peroxide concentrations
  - Chemistry
  - Mixing – large gains in efficacy possible (increased # of collisions and contact time)
    - **Mixing characterization** w/ smoke (propylene glycol) to assessment flow and movement in chamber
    - 3 confirmatory measurement methods, 10 DustTracs (log data), filters and GC prior to spray; purchase FID
    - Macro vs. Micro-scale mixing
    - Macro-scale: Fans, <u>nozzle number, position and orientation</u>, multi nozzles produce multiple droplet sizes
    - Micro-scale: Air entrainment, droplet/chemistry interactions can increase mixing and contact time
    - >1 mixing characterization test/day; blow air out and squeege water out between tests
    - Schedule 2 months to complete mixing characterization

Optimization strategies based on staged sprays and improved mixing

Phase IIB - Technology Development Roadmap, con't

- **Baseline performance in smaller, 14.5 m^3 chamber first, then perform in larger chamber ($126K, 2 months)**
- **Additional 14 samplers provide a greater density of information ($128K, 1 month)**
- **Determine efficacy over range of simulant material choices ($534K)**
  - **Choose simulants based on physical properties:**
    - Vapor vs. particle
    - Vapor insoluble vs. water soluble vapor
    - Water insoluble particle droplets
    - Water soluble particle droplets
  - Eight full-scale simulant tests
    - Budget for 12 tests - Labor + materials, $67K each
    - Schedule – 1/week, 1-2 tests per month maximum, 4 months duration
- **Analysis and Reporting ($250K)**
- **Travel ($66K) – increased for program development activities**
- **Management ($231K, Staff + Post Doc)**
- **Schedule to complete full simulant testing – 6 months**
- **Parallel to Phase IIA if SNL management commits to increase in personnel resources**

Determine efficacy in optimized full-scale system
Estimated cost for Phase IIB - ~$1,350K

Technology Development Roadmap Summary

- **Current Period of Performance (Phase I)**
  - $635K, from receipt of funding to today; 10 months
  - Operational geometry installed; Strengthened proof of concept in 14.5m^3 & began exploring optimization strategies
- **Phase I - Test and characterize performance of current prototype system**
  - $710K, 6 months (October 2009 – April, 2010)
- **Phase IIA – Fielded System, Operational Demonstration & CONOPS**
  - $720K, 6 months (June, 2010 – November, 2010)
- **Therefore, from project start to Fielded System**
  - $2,065K, 22 months
- **Phase IIB – R&D to bound the Performance Envelope**
  - $1,350K, 12 months (January, 2011 – December, 2011; could conceivably start in June, 2010)

From project start to Fielded system and Optimization to Bound Performance Envelope – 34 months, $3,415K

Our Team

- **Acknowledgements:**
  - Brandon Servantes
  - Jonathan Leonard
  - Mollye Wilson
  - Ashley Allen
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  - Matt Tezak

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  - J. Bruce Kelley
  - Brent Haroldsen
  - Duane Lindner
  - Dan Rondeau

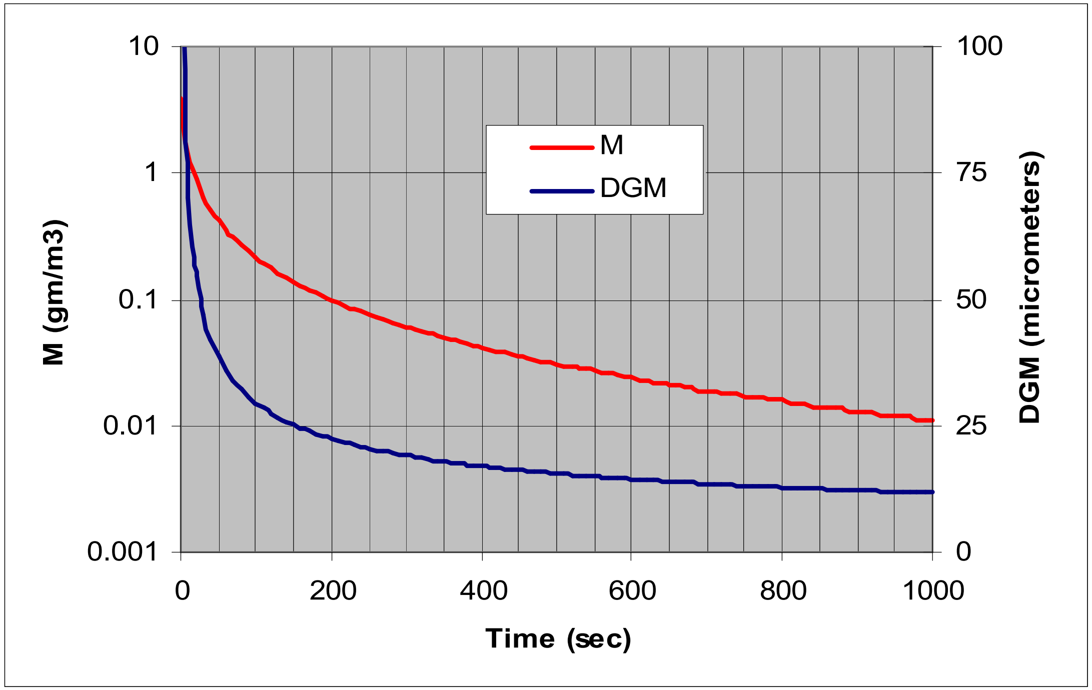
Backup Slides

Threat Scenario #1

Based on a theoretical accident at a typical EDS deployment and operation site such as Spring Valley, MD

- **30’ by 60’ by 12’ to 19’ high containment structure**
- **4.2 inch mortar shell, center burster configuration with 0.73 pounds of explosive**
- **3.0 Kg of HD**
- **Source term is a liquid drop dispersion**
  - Geometic mass mean droplet diameter of 150 µm
  - Estimated geometric standard deviation of 2.5 µm
- **Initial airborne dispersion mixed through out the building volume of ~ 4.8 gm/m^3; The larger drop sizes will settle out fairly quickly.**

Threat Scenario #1 Definition



- **Airborne drop size and mass concentration decrease from 150 to 30 micrometers and 3.9 to 0.22 gm/m3 in 100 seconds**
- **~ 0.9 gm/m3 additional vapor for a total airborne concentration of 4.8 to 1.12 gm/m3**

We will design to mitigate this airborne source.

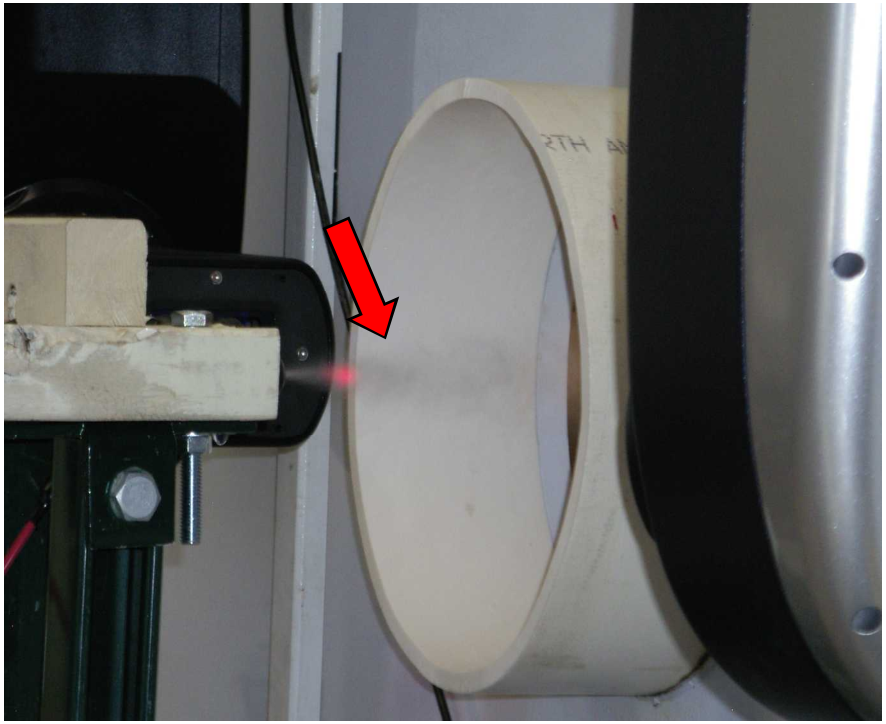
Threat Scenario 2

- **4.2 inch mortar shell, 6.25 pounds of phosgene**
- **Explosive dissemination**
- **Average concentration of 4.72 gm/m3**
- **Assume that all of the phosgene will be vaporized**
  - any drops impinging on surfaces will vaporize
  - given volume of air has sufficient heat capacity to vaporize all 6.25 pounds of phosgene with less than a degree K drop in temperature.

- **Livens projectile, 28 pounds of phosgene**
- **Buster of 2.11 oz (60 gm) TNT**
- **21 gm/m3 average concentration phosgene will be vaporized with about a 4 degree K drop in air temperature**

ESS nozzle and Aerosol chamber characterization

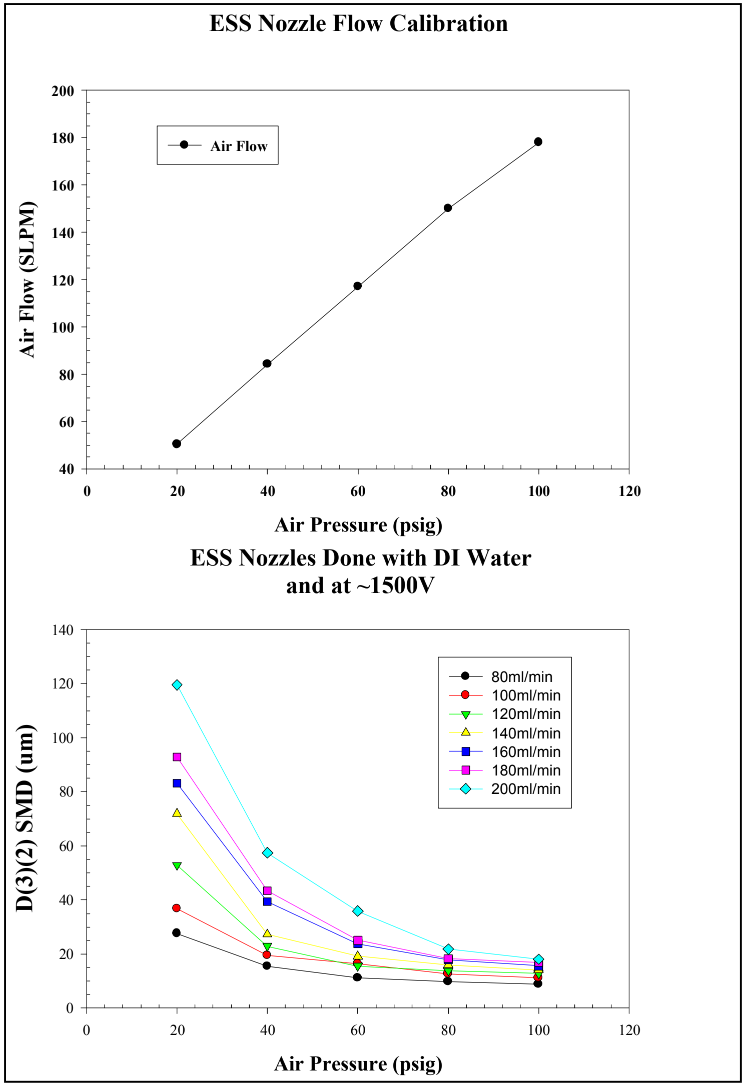
- **Test and characterize new ESS nozzle design (Spring 2009)**
  - Vary air and liquid flows to produce varying droplet sizes and spray densities
  - Measure droplet sizes
    - Average droplet diameter <30µm (@ 100 psi dispersion air)
- **Other nozzles capable of generating smaller droplets may also be tested**



ESS nozzle characterization (side-view) – A close-up photo of the spray emitted from the ESS nozzle tip (red arrow).

ESS nozzle and Aerosol chamber characterization

- **Near-linear response with respect to air flow (SLPM) and air pressure (psig).**
- **Volume mean particle size (µm) as a function of various liquid flow rates (80-200 ml/minute) and various air pressures (20-100 psig).**



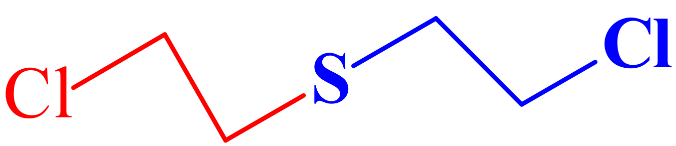
We defined test spray parameters based on nozzle characterization and desired performance.

Chemistry Optimization

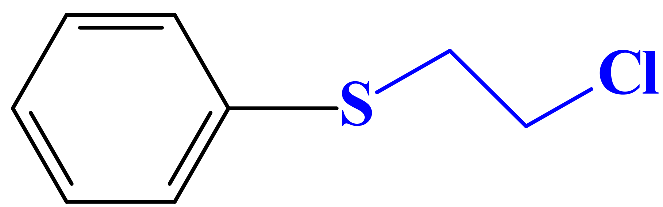
- **We will optimize the DF-200 chemistry to better mitigate for HD releases**
  - Increasing solubility of agent into formulation is key

Decontaminant	HD Simulant (solution tests)	
	5 Min.	60 Min.
DF-200	70.0	99.8
DF-200, modified	99.3	ND

Mustard (HD)



2-Chloroethyl phenyl sulfide



Extensive effort to plan, purchase and install new Sprung Structure

- ***All of the ES&H permits and procedures have been written and are either in review or have been approved and they include:***
  - *NEPA - Written and through first review process, - To purchase and install Sprung Structure.*
  - *Security Service Request - Written and Approved - To remove security fence or install a man gate.*
  - *PHS -Written and Approved - To install, Sprung Structure, Spray System and perform demo.*
  - *OP - Written and in Review - For construction activities, erect Sprung Structure.*
  - *Discharge Permits - Written and Approved - For discharge of DF200*
  - *Biological Survey Permit - Written and in Review - To determine that there are no wildlife issues*
  - *Dig Permits - Written and in Review - For Grading, leveling and surface preparation.*
  - *Utility Spotting Permit - Written and in Review - For spotting Utilities before surface preparation.*

- ***The costs for erecting Sprung Structure:***
  - *30' x 80' Sprung Structure with 2 man doors, and 2 roll up garage doors with Sky Lights - $73K*
  - *Site Preparation - $30K - Includes Clearing Site, Grading, Gravel work, Creating a Man Gate in Fence, Rental Equipment and Setup and installation of Sprung Structure.*
  - *Site Preparation with optional concrete footer - $38K - This is the preferred option, it would allow us to pour a permanent concrete floor later in the future, if we get additional funding and or customers.*
  - *Temporary Leak Proof Floor - $5K to $30K there are a lot of options here, we could go as simple as lay down a leak proof tarp or build a wood floor and seal with roofing material, or the most expensive option would be asphalt or concrete.*
  - *Spray System - $10 to $30K the details have not been worked out on this yet and is only a rough estimate.*

- ***Estimated Total - $125K to $150K***

Dan Lucero, 1/26/2009