Facility Defense
Against Aerosol Attack

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### Report Documentation Page

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### Supplementary Notes
Workshop paper from the New England Bioterrorism Preparedness Workshop held 3-4 april 2002 at MIT Lincoln Laboratory, Lexington, MA, The original document contains color images.

### Abstract

### Subject Terms

### Report Classification
unclassified

### Classification of Abstract
unclassified

### Number of Pages
19
Outline

• Facilities and attack scenarios

• Sensing an attack

• Facility protection techniques
Types of facilities

• Simple structures
  – Residences, barracks

• Buildings with ventilation system
  – Multiroom office building
  – Large open space (arena, terminal, …)

• Subway

• Outdoor sites
  – Stadium
  – Public gathering
  – Military operations
Simplified Ventilating System

Exhaust

Fresh air intake

Louver

Return fan

Temperature & humidity

Supply fan

Zone 1:
Occupied space
"6 exchanges / hr"

Mixing box

Standard filters:
30% pleated
80% electrostatic

Zone 2
Types of Attacks

- **External attacks**
  - Nearby cloud release
  - Burst release into air intake

- **Internal attacks**
  - Burst release into air return
  - Burst release into a large open space
  - Low level continuous release

- **Small amounts of agent are substantial threats**

  1 gram bioagent uniformly dispersed into $10^8$ liter building ($100m \times 100m \times 10m$);
  Corresponds to lethal exposure ($100$ ppl $\times 10$ liter/min $\times 10$ min; $10^{10}$ particles /gram)
Modeling an Attack

Burst release in an interior room

- Bioagent - 15 grams over 5 sec
- Room-Hall coupling - 10%

Lumped parameter models are well established
instantaneous and uniform concentration within each room

Initial particle dispersal and deposition are more complicated to model.
Emergency Management Measures

- **Information**
  - Observing suspicious activity
  - Knowing who to treat
    - Primarily, but not exclusively, bio agents
    - Records of access (badge swipes, tickets,...)
    - Voluntary response to public announcement
    - Physical examination
  - Preserving forensic evidence

- **Plan of action**
  - HVAC emergency management decision tree
    - Suspicious event near air intake -> shut down intake
    - Suspicious event inside building -> full fresh air
  - Communication channels
  - Evacuation plan
    - Orderly movement to controlled safe area, avoid cross contamination
Outline

- Facilities and attack scenarios
- Sensing an attack
- Facility protection techniques
Rationale for Sensing

- **Issue alarm**
  - initiate facility response
  - high $\text{Prob}_{\text{detection}}$; low $\text{Prob}_{\text{false alarm}}$; wide range of agents

- **Identification of agent**
  - initiate medical treatment

- **Mapping of contamination zone**

- **Assessing decontamination (“all-clear”)**
State-of-the-Art Bio / Chem Sensors

Sample Based
- Culturing
  - Immunoassay strips
- PCR / DNA analysis

Continuous Monitoring
- Particle number, size
- UV laser fluorescence

Chemical
- Detection tickets
- Gas chromatography / mass spec
- Ion mobility spec
- Surface acoustic wave

BAWS-III
- intake
- outflow
- Ethernet radio port
- LED indicator

REC BioHAZ
Graseby GID-2A
Sensor Architectures for Building Defense

Distributed
- Trigger and Sampler Distributed in each room
- Sample carried to identifier in central location

Centralized
- Trigger head in each room
- Aerosol transport in ducts
- Centralized laser, sampler, and identifier
- Aerosol transport system in ducts
- Trigger, Sampler, and Identifier located in central location

High Cost ← Centralized ← Low Cost
Atmospheric Aerosol Content


Indoor total background #
Bioagent lethal exposure*
State-of-art detection limit
Indoor biological background #

*LD50/10min
# normal blg ventilation
False Trigger Rate

- Sensor will trigger less frequently when operated at higher threshold.

- e.g. BAWS-III operating within Lincoln Lab

- Extrapolation to High Thresholds:
  - $P_{\text{DET}} > 0.9$
  - Simulated $B_g$ Release
  - Measured Background
  - 200 ppl, 500 ppl, 1000 ppl
  - 1/6 day, 1/60 day, 1/360 day
  - 1/19 day, 1/120 day, 1/500 day

MIT Lincoln Laboratory
Indoor Standoff Aerosol Detection

- Any point sensor is limited by aerosol transport in large open space.
- Need to detect the release promptly at a specific point
- Bio sensor concept:

<table>
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<tr>
<th>Method</th>
<th>Dwell time</th>
<th>Range cell</th>
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<tr>
<td>Elastic</td>
<td>0.1 sec</td>
<td>1 m</td>
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<tr>
<td>UV LIF</td>
<td>10 sec</td>
<td>3 m</td>
</tr>
<tr>
<td>Diff SWIR</td>
<td>10 sec</td>
<td>2 m</td>
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Minimum for detecting 1000ppl threat

50m range, eyesafe laser; 100 lux lighting
Outline

• Facilities and attack scenarios

• Sensing an attack

• Facility protection techniques
Facility Protection Measures

• Physical security
  – Protect fresh air intakes (location, access, surveillance)
  – Personal screening (may be difficult in civil defense)

• Ventilation system protection
  – Passive air filtration
    › Upgrade filters (best ASHRAE filters > 95%)
    › Overhauling the system (HEPA / carbon)
  – Positive pressure to overcome infiltration
  – Sensor triggered airflow control
Passive Air Filtration

- In-line passive filtration is well established
  - HEPA filters remove >99.97% suspended particles > 0.3 um.
  - Activated carbon filters adsorb most chemical vapors

- Substantial cost to overhaul existing ventilation system
  - Purchase and replacement of filters
  - Increased blower motors for higher pressure drop
  - Reinforced ductwork
  - Very little infiltration is allowable (gasket seals, overpressure)
  - Increased energy costs

- Research topics
  - Low pressure drop filter structures
  - In-line sterilization (UV, radiation, thermal,...)
## Facility Defense Effectiveness

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<th>Protection Measures</th>
<th>Estimated Exposure Reduction</th>
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<td>“Unprotected” building</td>
<td>1</td>
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<tr>
<td>Upgraded standard filters (or in-room HEPA)</td>
<td>10-100</td>
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<tr>
<td>In-line HEPA filters</td>
<td>100-1000</td>
</tr>
<tr>
<td>In-line HEPA filters with overpressure and triggered airflow control</td>
<td>&gt; 1000</td>
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Estimated exposure reduction to external bio attack
Summary

- Most buildings with ventilation systems are vulnerable to aerosol attack via a number of scenarios.

- Without deployed sensors, an attack may go undetected resulting in higher exposure and lack of treatment to exposed occupants.

- There are some simple measures that can be used to increase situational awareness and provide limited protection.

- A substantial degree of protection can be achieved at substantial cost with sensor triggered airflow control and HEPA/carbon filters. In this case, sensors may be operated at higher thresholds.