Chem-Bio Protection Without Chem-Bio Sensors:
Low Cost, Dual Use, Alternative Sensor and Information Architectures

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Overview / Disclaimer

- Current Sensor Capabilities / Limitations / Strategies
- Event Timelines
- Threats and Observables
- Alternate Detection Architectures for Overarching Detection Model
  - Acoustics
  - Radar
  - Video
  - Electro-Chemical
  - Procedural
- Summary
Current Sensor Performance

• Sensors Do Not Provide Protection
  – Sensors provide warning to enable protective measures
  – Warning MUST be sufficiently detailed and reliable to allow protective measures to be enabled

• Current Capabilities
  – Chem:
    • IMS / SAW provides detection and ID in seconds to minutes for agent present at sensor
    • FTIR provides detection, ID, bearing/location in seconds for agent at range
  – Bio:
    • Particle Count / UV Fluorescence provide bio/non-bio detection in seconds to minutes for agent present at sensor
    • Active laser provides bio/non-bio detection, bearing/location in seconds for agent at range
    • HHA / PCR provides bio presumptive ID in tens of minutes
    • Lab tests provide confirmed ID in hours
Current Sensor Limitations

• Breadth of Agents Detected
  – Chem: usually CWAs and a few TICs
  – Bio: specific agents tested (usually 5-10)

• Sensor Detection Range
  – Point sensors: range is effectively 0. Agent must be present at sensor air intake
  – Stand-off sensors: 1-50km

• Info Provided / Timeliness
  – No source location for point sensors
  – Id for detection sensors often not specific (e.g. bio vs. non-bio, agent class)
  – Detection / ID time too long

• Cost: Initial Cost High; Lifecycle Cost High

• False Alarms (Nuisance Alarms)
  – Sensors cannot reliably distinguish between normal chemical or biological sources and threat
  – Example: 19 month alarm data from operational system
    • Chemical Alarms: @260,000 alarms; 13,817 events (1 per hr)
    • Biological Alarms: @9,600 alarms; 4,869 events (8 per day)
Operational Use of CBRN Sensors

• Cannot Implement Protective Responses Based on Chem-Bio Sensors Alone

• Validation Procedures
  – Threat Levels: graduated responses and information gathering
  – Multiple Phenomenologies:
    • redundant biological ID; lab tests
    • video / investigation for chem
    • Additional / alternate chemical sensors (e.g. handheld)

• Chem-Bio Sensors Become ‘Triggers’ for Validation Procedures

KEY QUESTION: Can We Use Alternative ‘Triggers’?

![Diagram showing the process flow with nodes labeled CB Trigger, Low Regret Response, Intermediate Threat Level, Medium Regret Response, Validation, and RESPOND!]
Arrows denote key detection breakpoints where earlier detection provides transformational value.

Time between Initial Effects and Casualties is short for chem events and longer for bio events.
# Chemical Threats

<table>
<thead>
<tr>
<th>THREAT</th>
<th>SIZE</th>
<th>CHEMICAL</th>
<th>LOCATION</th>
<th>AMOUNT</th>
<th>RELEASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial / Stored Chemical</td>
<td>Large</td>
<td>Known</td>
<td>Known</td>
<td>Known</td>
<td>Explosive</td>
</tr>
<tr>
<td>Rail Accident / Sabotage</td>
<td>Large</td>
<td>Known</td>
<td>Restricted to Rail Location</td>
<td>Known</td>
<td>Explosive / Derailment</td>
</tr>
<tr>
<td>Tanker Truck</td>
<td>Moderate</td>
<td>Possibly Known</td>
<td>Unknown / Possibly Restricted</td>
<td>Estimated</td>
<td>Spray / Explosive</td>
</tr>
<tr>
<td>Chemical Warfare Agent</td>
<td>Small</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Spray</td>
</tr>
</tbody>
</table>
Biological Threats

- Non-contagious
  - Large release
  - US Mail
- Contagious
  - Cougher
  - Contaminated products
- Location always unpredictable
- Agent type and amount unpredictable
- Small releases not detectable by any sensor type
Protection Options

• Perimeter Protection
  – Requires policies and procedures to implement; may require restrictions to flow of commerce
  – Pre-Event; not a response

• Collective Protection
  – Passive (not dependent on sensors)
  – Active (low regret response)

• Individual Protection Equipment (IPE)
  – Requires notification before exposure
  – Medium regret response

• Evacuation
  – Requires knowledge of agent location / transport
  – High regret response

• Decontamination
  – Requires knowledge of agent type / location
  – Medium to High regret response

• Treatment (e.g. antibiotics)
  – Requires knowledge of agent type / exposure
  – Medium to High regret response
Observables

• Threat / Intention
  – Communications
  – Web sites
  – Precursor purchase
• Release / Release Mechanism
  – Agent container/release mechanism
  – Smoke / cloud
  – Explosion
  – Traces of agent on container
  – Suspicious behavior
• Agent
  – Spectral signature
  – Florescence
  – Particle size
  – Cloud
• Agent Effects
  – Duress (animal or human)
  – Casualties
  – Treatments (treatment purchase)
  – Bleaching / material effects
  – Death
Alternative Detection Strategies

• Acoustics
  – Detect and locate explosion / derailment

• Radar
  – Detect and locate suspicious behavior in aircraft / watercraft

• Video
  – Detect duress, physical intrusion, smoke, suspicious activity
  – Also used for validation

• Electro-chemical sensors
  – Special purpose detection of known chemicals

• Procedures
  – Perimeter protection CONOPS
  – Data sharing (existing sensor data)
  – Source tracking (large, known chemical sources)
Acoustics

• Description
  – Small arrays of microphones with detection algorithms for explosive events

• Applicable Threats
  – Explosive releases of chem or bio agents
  – Derailments, sabotage using explosives

• Advantages
  – Detects release itself (earliest possible detection of release)
  – Provides standoff detection
  – Provides bearing/location and time of source release

• Disadvantages
  – Ineffective against spray releases or other non-explosive releases

• Dual Use
  – Gunshot / explosion detection
  – Situational awareness

• Cost
  – Low hundreds of dollars for purchase and installation
  – Largely maintenance free
Radar

- **Description**
  - Existing flight or surveillance radars along with procedures to identify suspicious behavior

- **Applicable Threats**
  - Air or Water vehicle releases

- **Advantages**
  - Detects release itself (earliest possible detection of release)
  - Provides standoff detection
  - Provides bearing/location and time of source release

- **Disadvantages**
  - Ineffective against small releases, planted explosives, or sabotage

- **Dual Use**
  - Intrusion Monitoring
  - Flight / maritime control and situational awareness

- **Cost**
  - Expensive, but often already installed in maritime or airport applications
Video

• Description
  – CCTV cameras installed at strategic areas and linked to command center
  – Intelligent video algorithms to identify events of interest

• Applicable Threats
  – Chemical releases with immediate effects on people or animals
  – Visible clouds or smoke
  – Threats that require physical intrusion (e.g., into an air intake mechanical room)

• Advantages
  – Cameras are quickly becoming ubiquitous through physical security programs
  – Possible interdiction of event (in intrusion case)
  – Provides detailed visual evidence for situational awareness; may also be used for validation
  – Long range available

• Disadvantages
  – Intelligent video algorithms to detect smoke, visible clouds, or duress are immature and may false alarm
  – Requires line of site to event or event’s effects
  – Possible day/night issues

• Dual Use
  – Situational awareness for all types of security and response applications
  – Detection of duress due to other causes than CB event

• Cost
  – Low hundreds of dollars for purchase and installation / Intelligent algorithms more expensive
  – Largely maintenance free
Electro-Chemical Sensors

- **Description**
  - Arrays of (typically 1-8) electro-chemical sensors each of which detects only a specific chemical

- **Applicable Threats**
  - Known agent at a known or restricted location

- **Advantages**
  - Detector placed near agent to detect release near release point (effectively standoff)
  - Extremely low false / nuisance alarm rate
  - Identifies source location through known storage location

- **Disadvantages**
  - Not effective against bio releases
  - Only effective against one agent per sensor

- **Dual Use**
  - Safety of hazardous chemical storage
  - Environmental sensing within a facility (e.g. radon / carbon-dioxide)

- **Cost**
  - Mid hundreds of dollars per chemical for purchase and installation
  - Moderate maintenance
Procedures

• Procedural changes provide opportunities to leverage existing detection capabilities or reduce vulnerabilities

• Examples:
  – Perimeter Interdiction
    • Vehicle Searches: swabbing sprayers or tanker trucks reduces ability to introduce quantities of agent to controlled area
    • ‘Trusted’ Personnel Programs (e.g. trusted shippers): identifies normal use of equipment / activities that are confusing sources for suspicious behavior and reduces impact on those activities from onerous procedures
  – Data Sharing
    • Existing data collection (e.g. chemical sensors at chemical plants) could be shared with EOC as part of situational awareness
  – Source Tracking
    • Implement a source tracking program for large chemical / biological hazardous materials similar to the tracking program for Level 1&2 radiation sources
    • Provides location and load information for large amounts of hazardous materials of all types
Summary

- CB sensors have limitations that, in an operational environment, require them to act as triggers to additional validation procedures.
- Other detection capabilities exist that can act as CB triggers and can for some threats:
  - Detect earlier in the event timeline.
  - Provide additional useful information such as source location.
  - Detect broad spectrum of agents.
- Alternate detection capabilities are typically:
  - Already deployed for other uses.
  - Lower lifecycle cost than CB sensors.
  - Have existing personnel to support.
- Procedural additions can provide detection and/or validation capabilities without the cost of additional detectors.

Alternate Detection Capabilities Should Be Evaluated To Replace or Augment Traditional CB Sensors in Specific Applications.