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

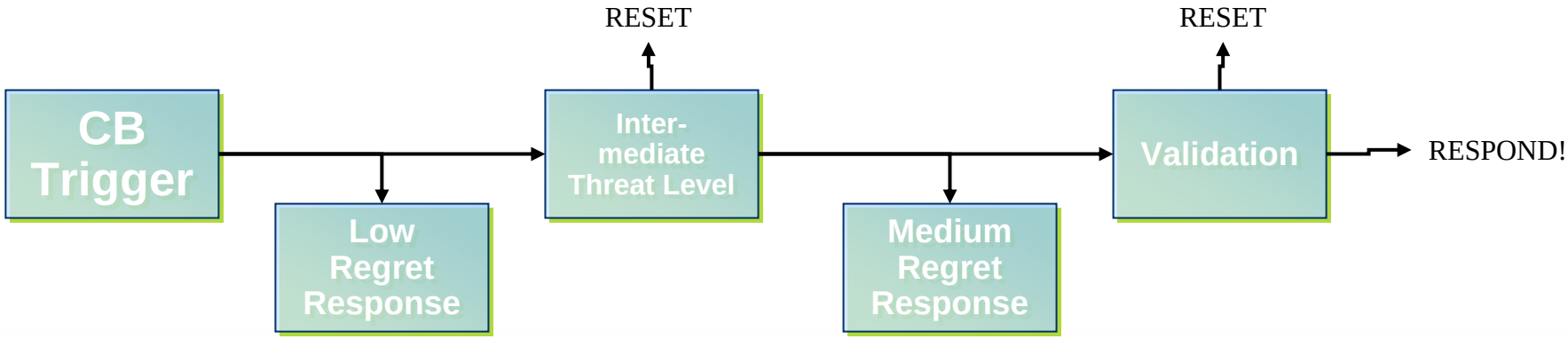
Current Sensor Limitations

- 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)

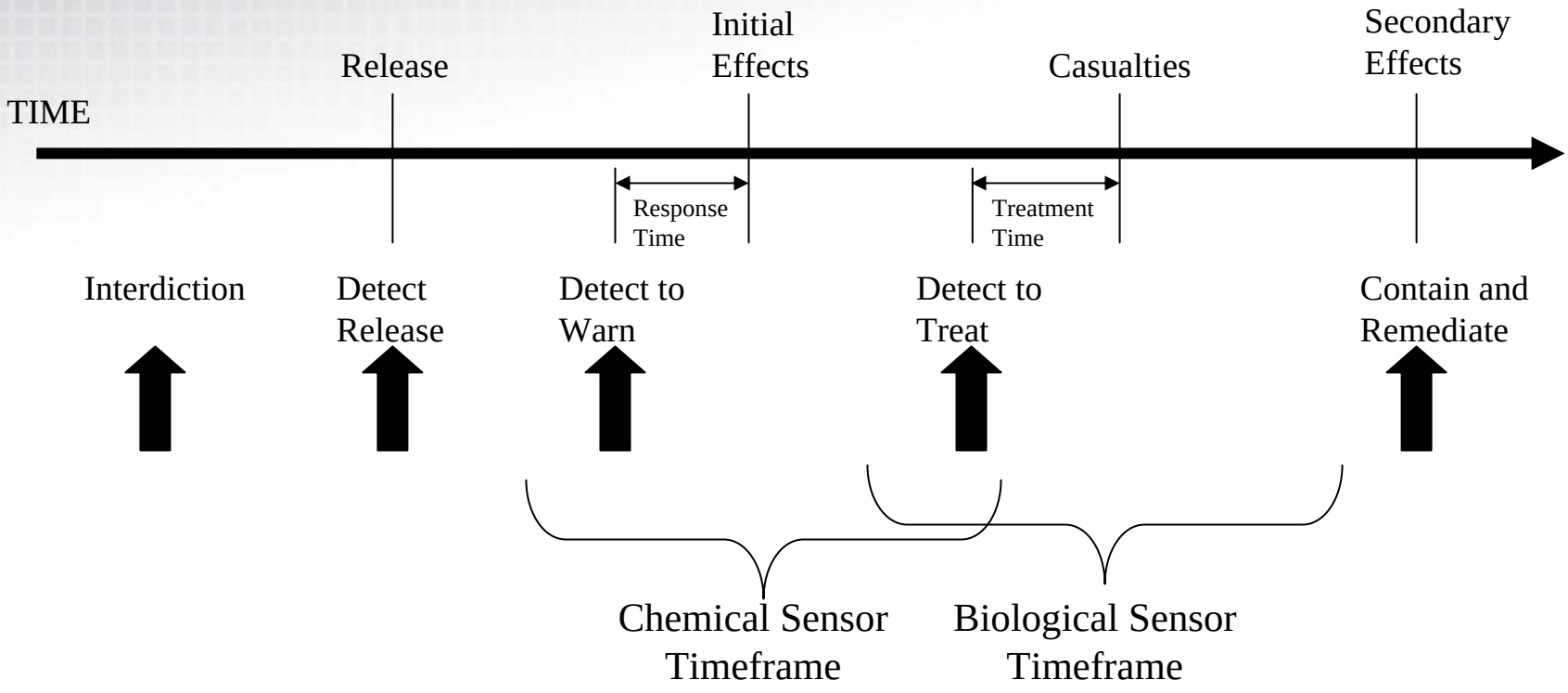
Operational Use of CBRN Sensors

- 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'?



Sensor Event Timeline



- **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

THREAT	SIZE	CHEMICAL	LOCATION	AMOUNT	RELEASE
Industrial / Stored Chemical	Large	Known	Known	Known	Explosive
Rail Accident / Sabotage	Large	Known	Restricted to Rail Location	Known	Explosive / Derailment
Tanker Truck	Moderate	Possibly Known	Unknown / Possibly Restricted	Estimated	Spray / Explosive
Chemical Warfare Agent	Small	Unknown	Unknown	Unknown	Spray

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 polices 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