A Comprehensive Methodology for Evaluating the Effectiveness of CBRN Protection Systems

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Overview

- CBRN System Evaluation
  - Current Practice
  - Gaps
- System Modeling
  - Effectiveness
  - Knowledge Structure
  - Costs
  - Response Criteria
- Integrated Biological Architecture Analysis

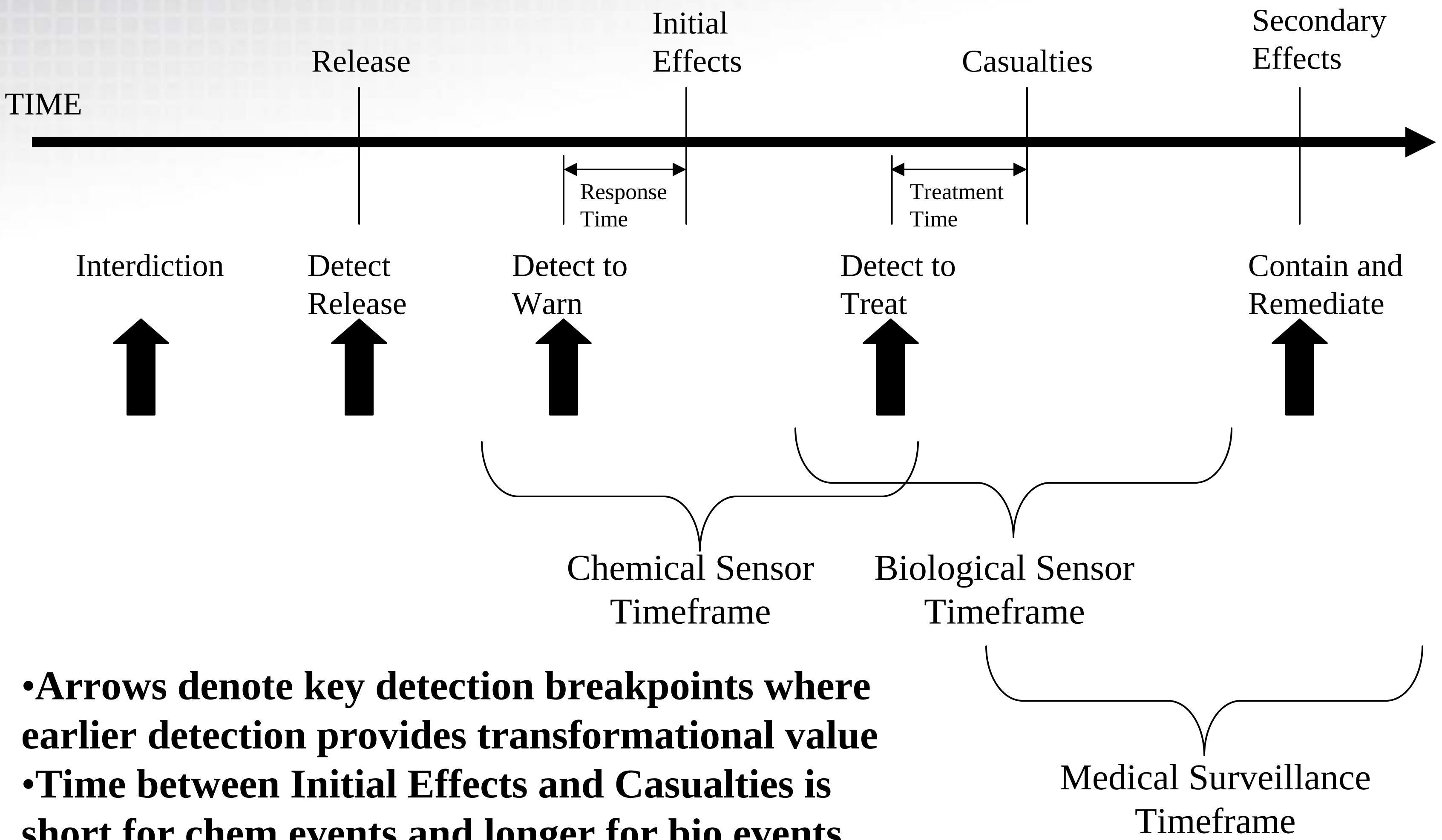
Key Questions

- How much protection is provided against a CBRN incident by a particular CBRN protection architecture?
- What is best value in improving existing CBRN protection architectures?

Current Practice

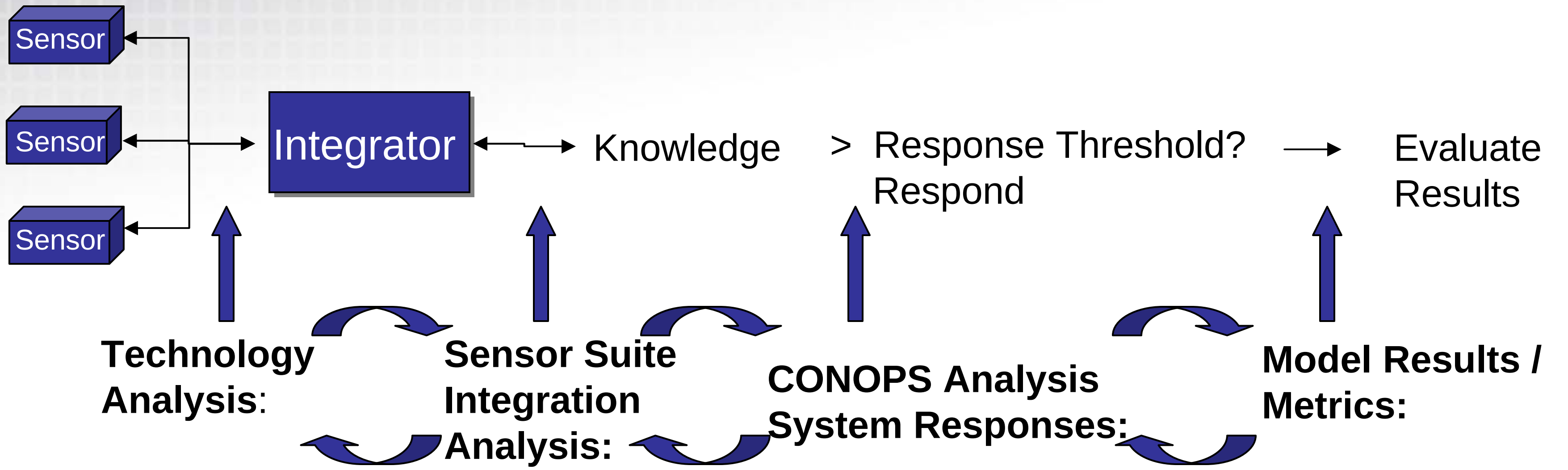
- Typical approach is to analyze sensor placement
  - If plume > sensor threshold at sensor location, sensor detects (success; base protected)
  - Most approaches iterate over possible release locations to determine P(detection) over the range of scenarios
- Gaps in typical approach
  - Protection is only provided if effective response is performed in sufficient time. Typical approach ignores responses and time to respond.
  - Unlikely in any operational deployment for high regret response based solely on sensor detection. Typical approach ignores alarm validation requirement and time to perform.
  - Cost of system is driven by false alarms not detection of real release. Typical approach only looks at sensor response to release, not system response in a typical operational envorinment. Typical approach calculates cost by cost to purchase and deploy sensors.

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**

Example Breakpoint Analysis Process



Bio vs. non-Bio; chem ID; gamma counts	Suspect Event	Low Impact Response	•Estimated Casualties given response •Amount of area contaminated •Time to restore operations •Cost –Restoration –Economic Impact of Event
Bio ID; Multiple sensor detects; Rad Isotope	Probable Event	Serous Impact Response	
Lab tests; Video validation; Explosion Detection	Confirmed Event	High Regret Response	

IPP Bio Knowledge Architectures

Architecture	Knowledge Structure	Implemen-tation	Key Responses	Advantage: critical personnel	Advantage: all personnel
Current: no sensor	No detection; ID when symptoms appear	Medical examinations	•Treatment after symptoms	None	None
Baseline: Periodic ID	No detection; ID attempted every 24 hours using PCR (confirmed)	DFU collection; lab processing once per day	•Provide treatment (antibiotics) •Passive Collective Protection	Treatment prior to symptoms; COLPRO limits exposure	Treatment prior to symptoms
Triggered ID	Detect when agent at facility (suspect); triggers PCR analysis (confirmed)	Point bio detector (BAWS) with auto-PCR	•Lockdown on confirmation @30min after event	Lockdown prevents personnel exposure upon exit	Warning to avoid area; earlier treatment
Standoff +point ID	Detect prior to exposure (suspect); triggers PCR analysis (confirmed)	Standoff Bio (LIDAR) with auto-PCR	•Lockdown on confirmation @30min after event	Target remediation of affected area	HVAC control possible for non-critical areas
Standoff ID	Detect and ID prior to exposure (confirmed)	Standoff Bio LIDAR + IR Taggent	•Lockdown *prior* to event exposure	Earlier lockdown prevents exposure to personnel in facility	Earlier warning allows shelter in place
Standoff Neutralization	Detection and ID prior to exposure + neutralization	Standoff Bio LIDAR + IR Taggent + sufficient laser power	•Standoff neutralization of agent cloud	Exposure prevented	Exposure prevented to most personnel

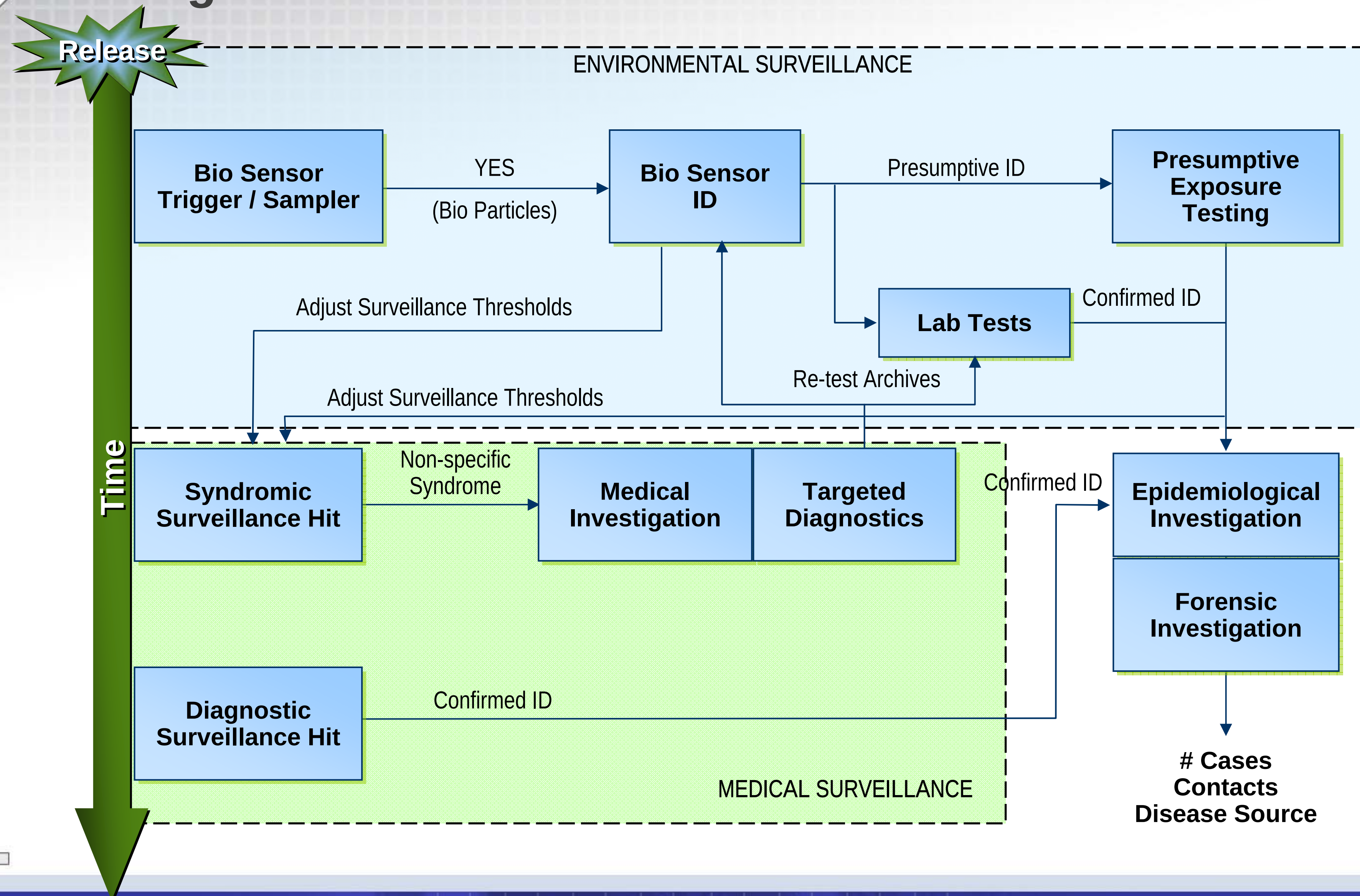
IPP Bio Knowledge Architecture Costs

Architecture	Implemen-tation	Estimated Cost	Cost Assumptions
Current: no sensor	Medical examinations	No Cost	Only costs to implement detection considered
Baseline: Periodic ID	DFU collection; lab processing once per day	•@$150/test → $30k/yr. •HEPA Filters for ColPro → $2,500 / facility	Assume tests will become cheaper as more are done
Triggered ID	Point bio detector (BAWS) with auto-PCR	•@$150/PCR test with 3-4 tests per day → $100k/yr. •Trigger sensor → $50k •ColPro as above	Assume advanced trigger algorithms reduce number of tests; also decrease in cost per test
Standoff + point ID	Standoff Bio (LIDAR) with auto-PCR	•Same PCR as above, same false alarms •Trigger sensor → $250k	Assume reduction in trigger sensor cost over time to $150k
Standoff ID	Standoff Bio LIDAR + IR Taggent	•IR Taggent → $300k •Trigger sensor as above	O&M of taggent consumables + delivery vehicle
Standoff Neutralization	Standoff Bio LIDAR + IR Taggent + sufficient laser power for decon	•Equivalent to Standoff Id costs since sensor re-used for neutralization (??? prob need separate laser for decon)	Additional power costs are small compared to overall cost

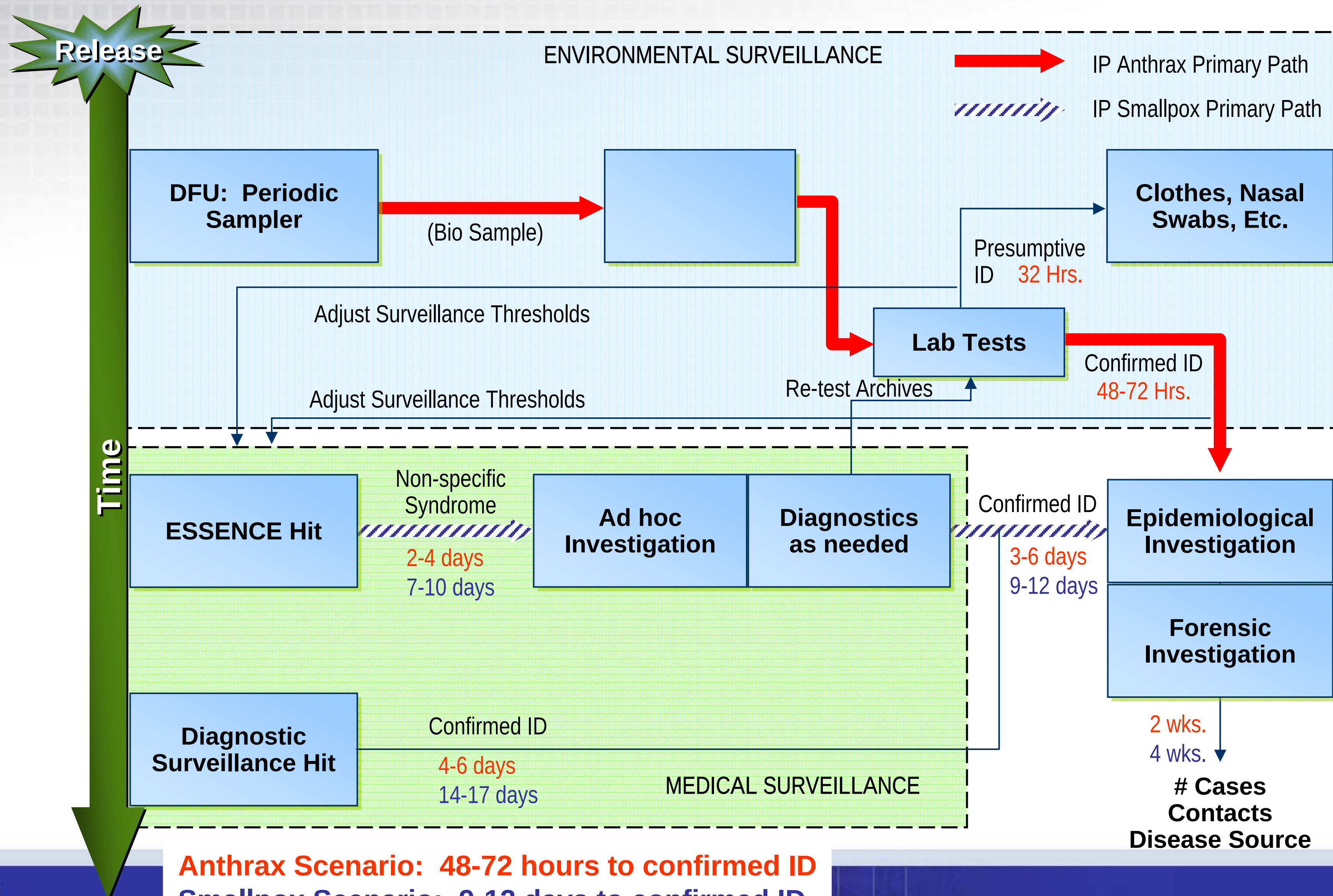
Response Table Example

RESPONSE	INFO REQUIRED	RELIABILITY REQUIRED	EXPECTED RESULTS	OBSERVABLES
Arrest and seize	1.Attack is planned. 2.Location of attackers/agent prior to attack.	Suspect (provided there are manageable suspect alarms).	Threat stopped with no ill effects.	•Attacker comms •Release equipment (sprayer)
Stop release	1.Attack is underway. 2.Location of attack.	Suspect (can usually investigate and evaluate)	Less agent released	1.Spraying
Shelter in place	1.Attack has occurred 2.Facility is in the agent's path	Suspect – HVAC control. Probable – restrict movement	Filtering reduces exposure *while inside the building.*	1.Agent itself before inside exposure
Don IPE	1.Attack has occurred 2.Facility is in agent's path 3.Type of agent	Probable – Confirmed	IPE reduces exposure until they can get to safe area	1.Agent itself before exposure
Personal decon	•Person has been exposed to agent •Type of agent	Probable – Confirmed	Decon reduces exposure of personnel	1.Agent itself before or after exposure
Area decon	1.Attack has occurred 2.Specific agent 3.Area Affected	Confirmed	Area decon reduces illness from re-aerosolization	•Agent itself (surface) •Agent effects (illnesses)
Treatment (CIPRO)	•Attack has occurred •Specific Agent •Person likely infected	Confirmed	Prevents death; reduces illness	1.Agent itself 2.Agent effects (to treat secondary infections)
Neutralization	•Attack has occurred •Cloud Location	Confirmed	Prevents exposure	1.Agent itself

Integrated Bio Surveillance Architecture

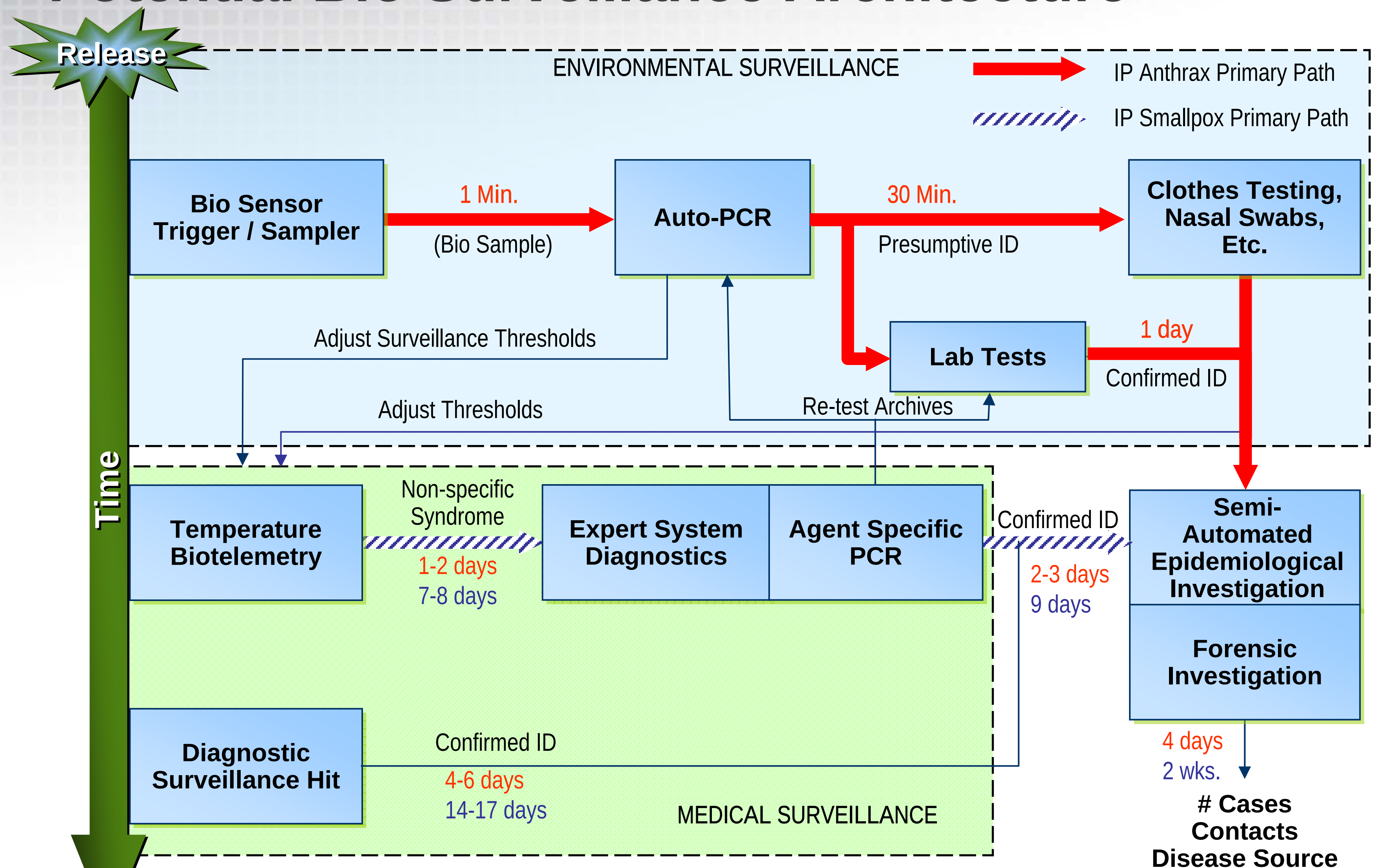


Current Bio Surveillance Architecture



Anthrax Scenario: 48-72 hours to confirmed ID
Smallpox Scenario: 9-12 days to confirmed ID

Potential Bio Surveillance Architecture



Anthrax Scenario: 1 day to confirmed ID
Smallpox Scenario: 8 days to confirmed ID