Disparate Sensor Integration for CB Defense

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Objective

- Application of non-CB, force protection sensors in Chemical/Biological detection
- Sensors to be used in a dual use mode
- Earliest warning capability, detection made seconds after explosion

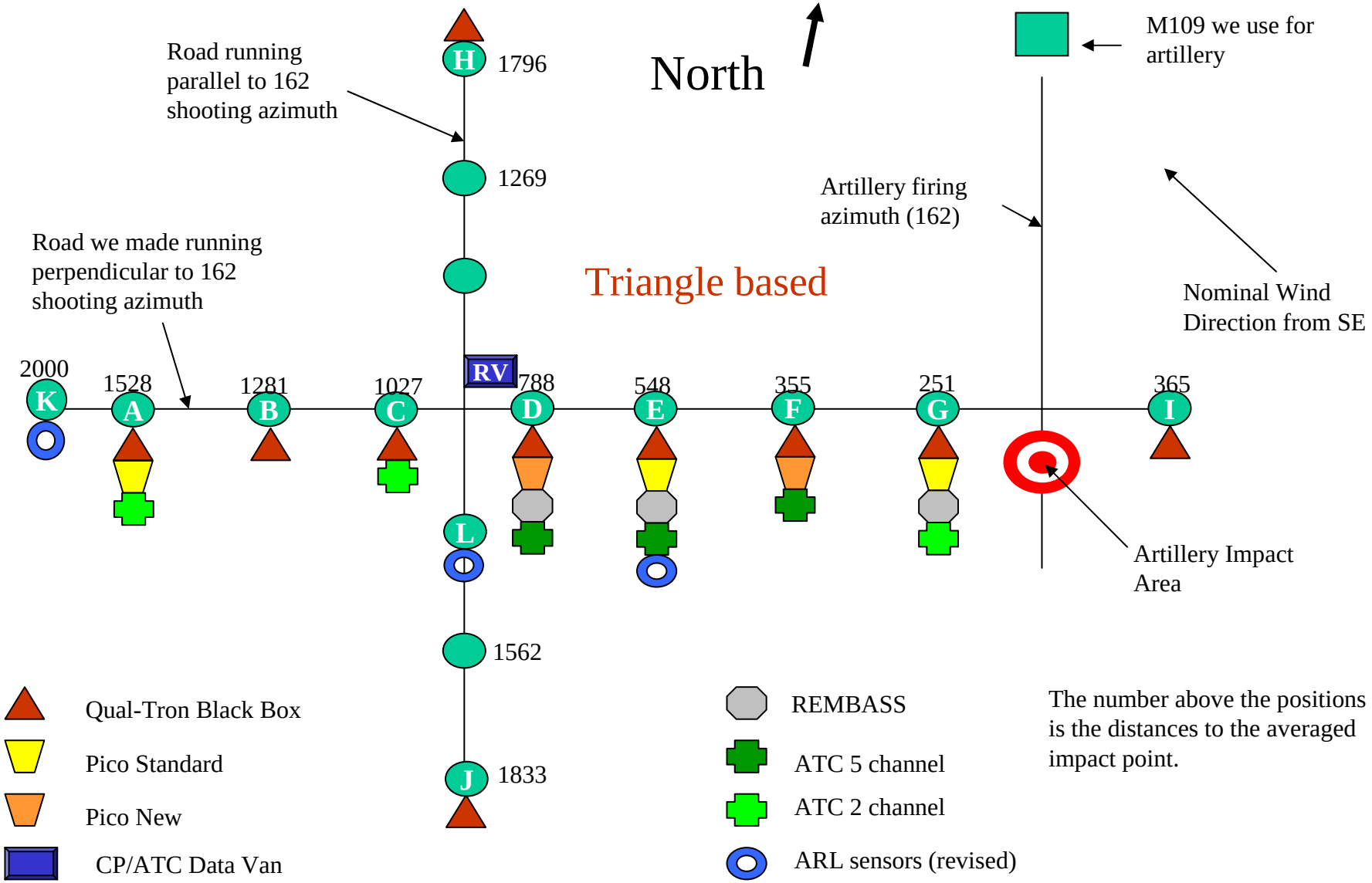
Type of sensors used

- Acoustic
- Seismic
- Visible Cameras
- Infrared Cameras
- Existing intrusion sensors

Field Test

- Total of 260 155 mm artillery rounds
  - Equally divided between conventional and simulated CB rounds
  - Equally divided between air burst and point detonation
- Order of fire was random
- First 160 rounds are used for algorithm development
- Last 100 rounds are blind shots used to test the reliability of the algorithms

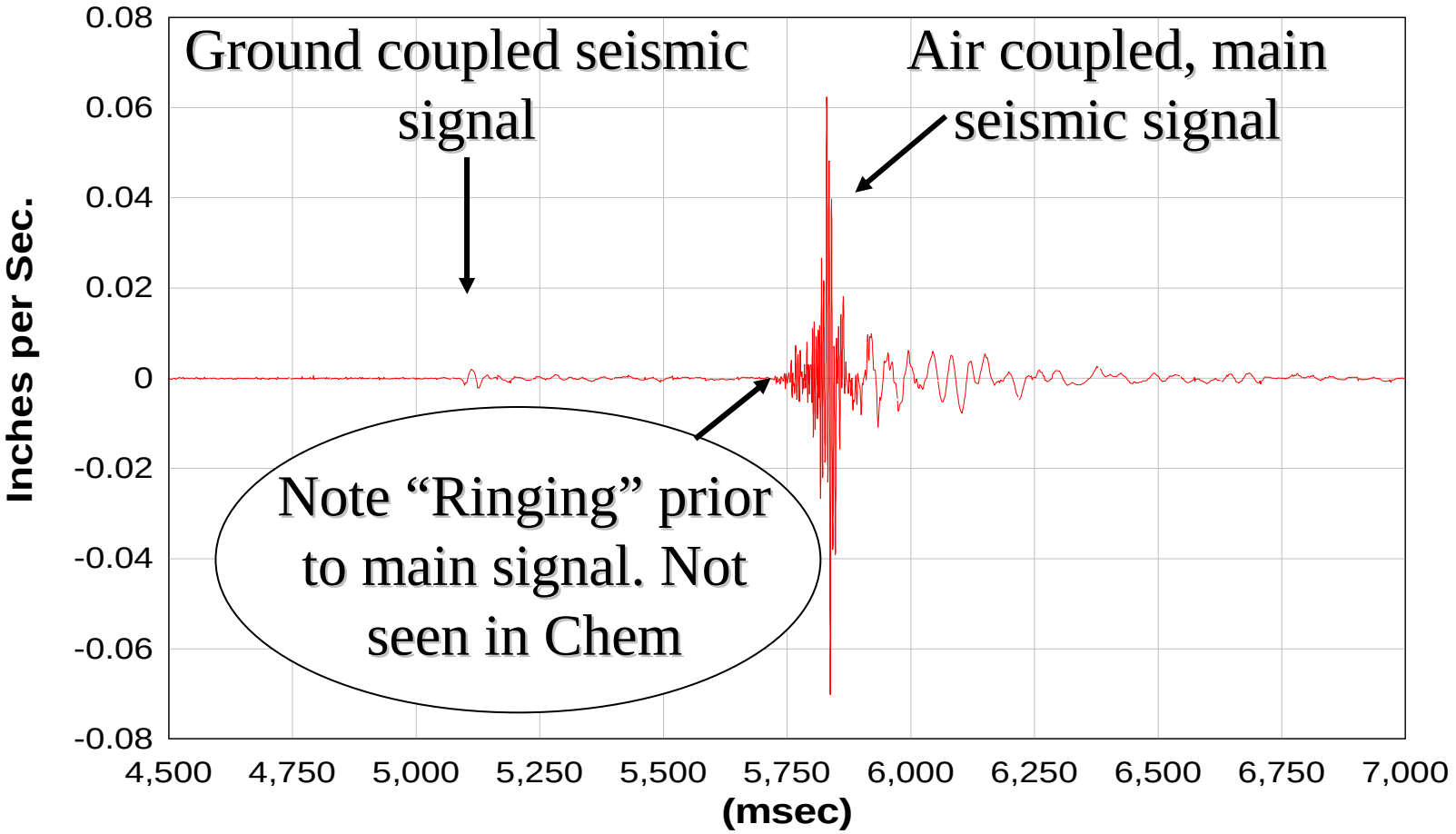
Sensors Layout



Initial Analysis

- Difference in maximum intensity between the HE events and the Chemical simulated events
- A “pre-ringing” effect occurred before the HE events

HE Seismic Signature



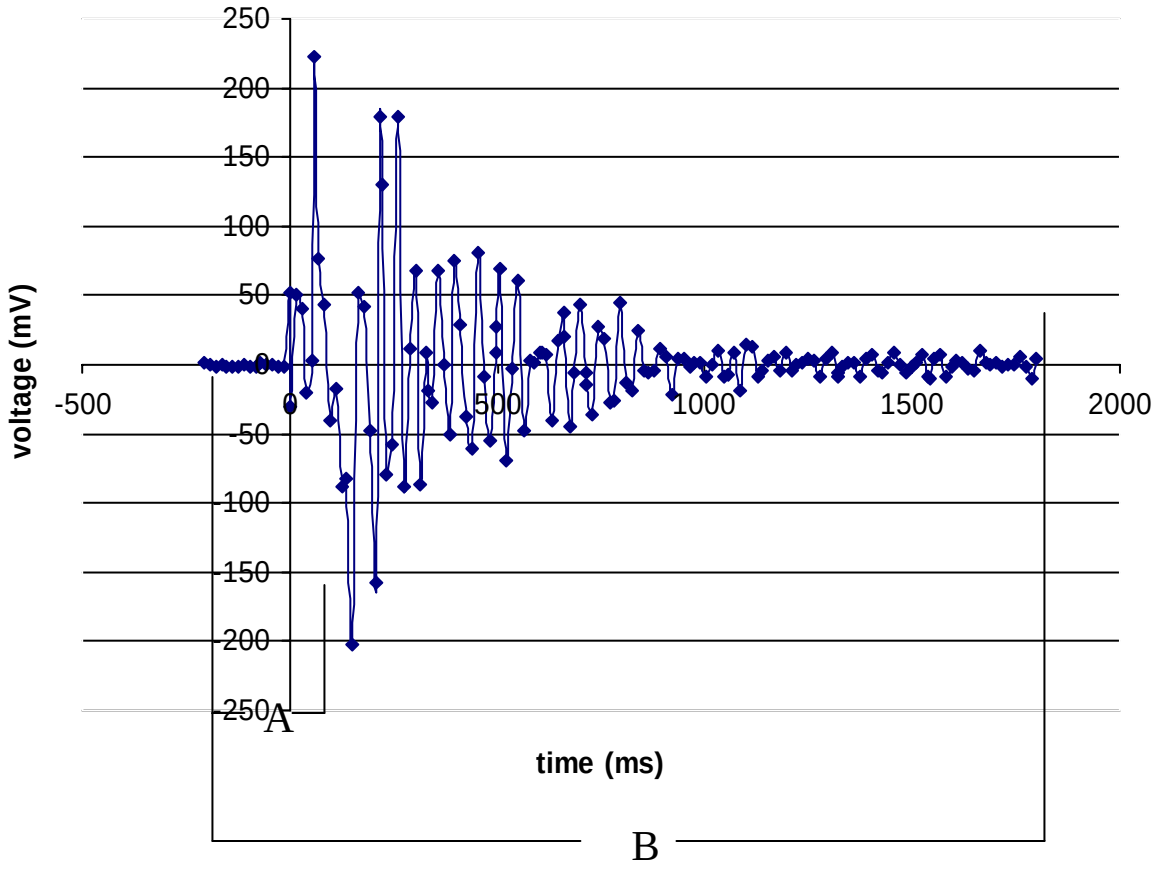
Status

- Several algorithms based on single sensor signatures were developed from
  - Acoustic signature
  - Seismic signature
  - IR signature

Seismic Analysis

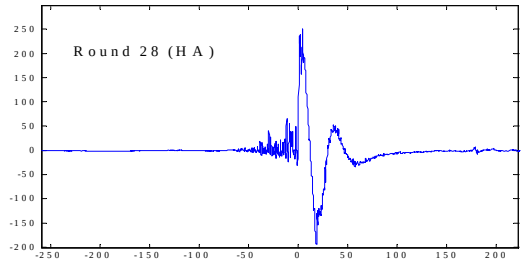
- Ratio between time to seismic signal maximum (A) to total length of seismic signal (B) can differentiate between CB and HE rounds (Initial data – 90% accurate)

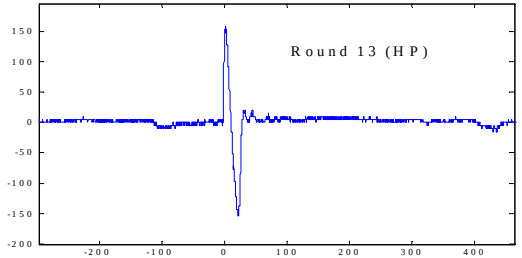
Example of the Seismic Ratio

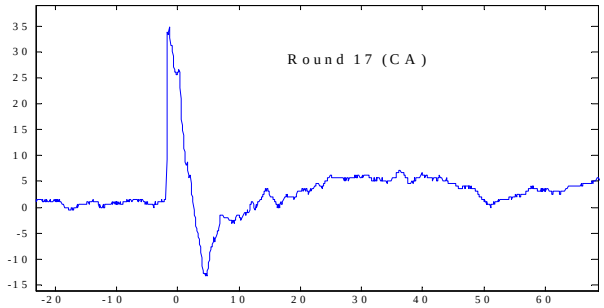


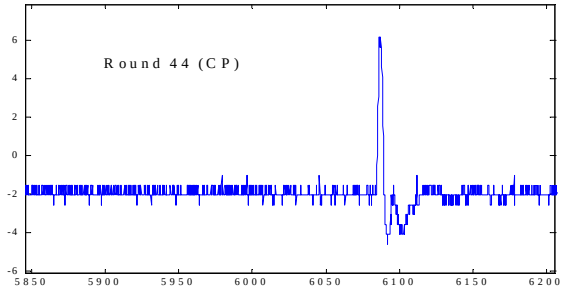
Acoustic Analysis

- The area under the positive peak is a good discriminator









Integrated Area Under the Positive Peak

	HE		Chemical	
	Air Burst	Point detonation	Air Burst	Point detonation
Mean	0.534	0.356	0.0385	0.00538
STD	0.0798	0.0586	0.0107	0.00687
$mean \pm STD$	0.454-0.614	0.297-0.415	0.0278-0.0492	0-0.0123
$mean \pm 2STD$	0.374-0.694	0.239-0.473	0.0171-0.0599	0-0.0191
$mean \pm 3STD$	0.295-0.773	0.186-0.532	0.0064-0.0706	0-0.0260

Results and Performance

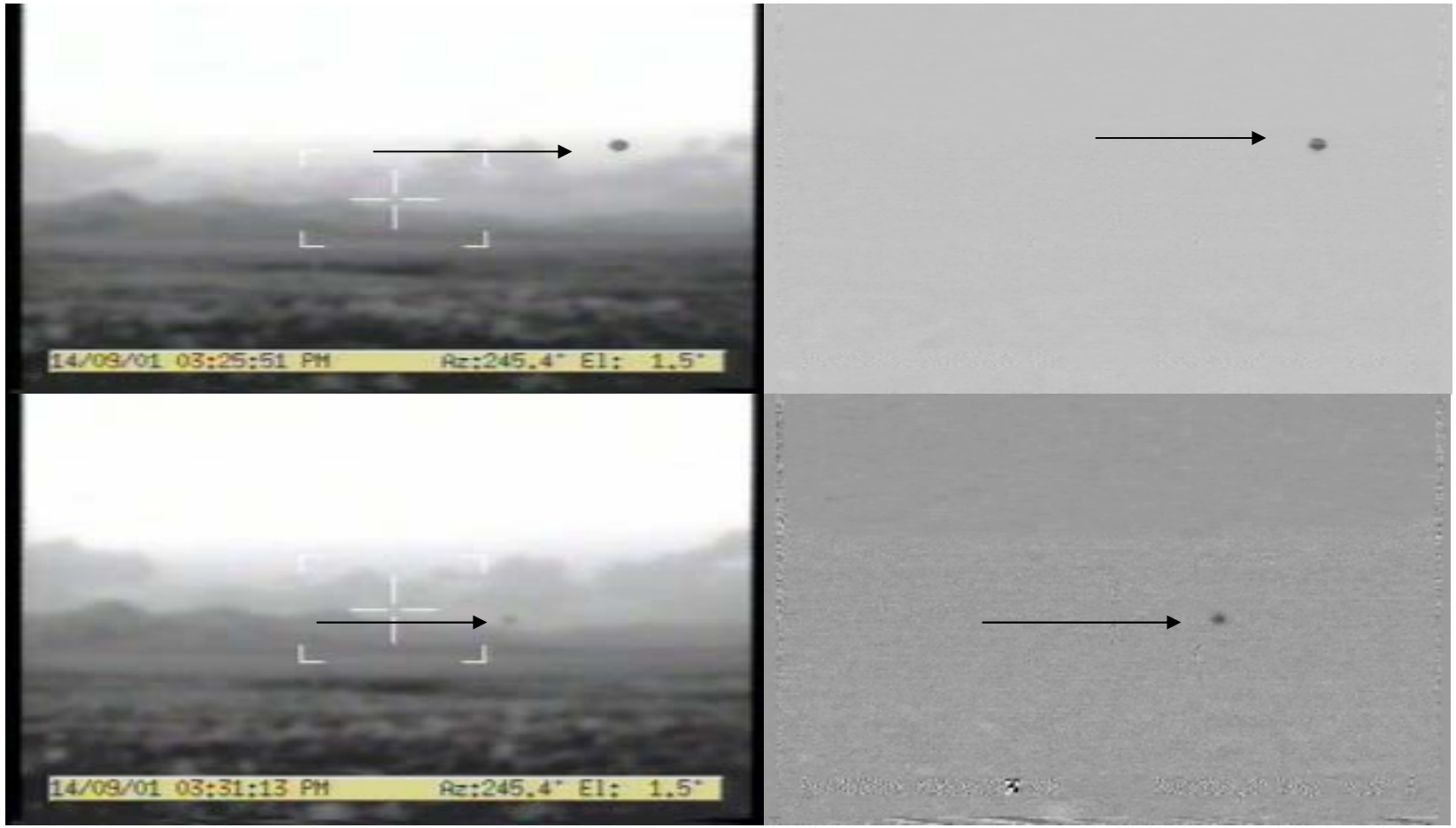
- If area under positive peak < 0.11 Pa then a chemical event occurred
- Further discrimination of a chemical rounds mode of detonation is possible
  - Area < 0.02 Pa – chemical point detonation
  - 0.02 Pa < Area < 0.11 Pa – chemical air burst
- The algorithm was able to determine if an event was chemical or conventional with 100% accuracy
- It was correct 47 out of 48 times on the mode of detonation

IR camera Analysis

- Discrimination characteristics include
  - Size of fireball
  - Shape of fireball (Eccentricity)
  - Duration of the fireball
  - Grey scale of the image
  - Rate of expansion

First frame after detonation

Top: HE round Bottom: Chemical Simulant Round



Second frame after detonation

Top: HE round Bottom: Chemical Simulant Round

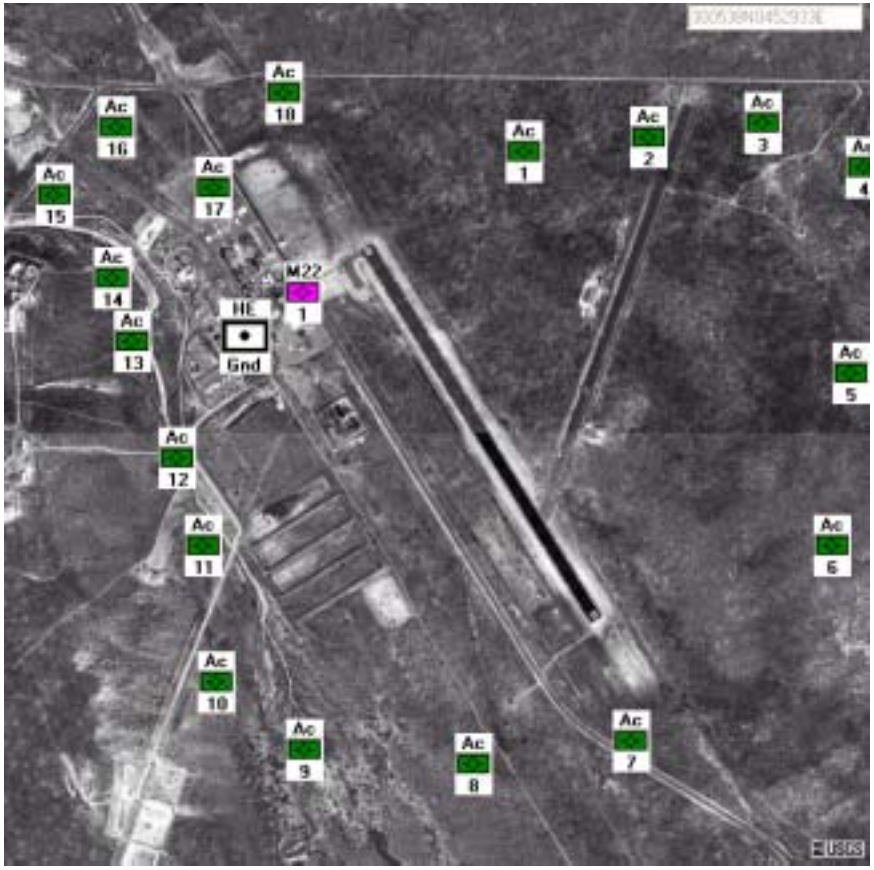
Observation

- Chemical simulant air bursts have a larger gray scale and shorter duration
- Fireball HE air bursts expand faster
- HE point detonation have a larger eccentricity value
- Chemical simulant point detonation has all negative values for growth

Modeling and Simulation Effort

- Acoustic/Seismic as $1/r^2$ function
- Decision process based on intensity only
- Support multiple sensors and sensor types
- Scableable
- Manual placement of sensors/events
- Supportable to the future
- Capture and display interactions of non-CB sensors to event
- Capture response by CB sensors

Modeling and Simulation of HE and Chemical events on a Fixed Site



Modeling and Simulation

Example 1

Type of Event: HE

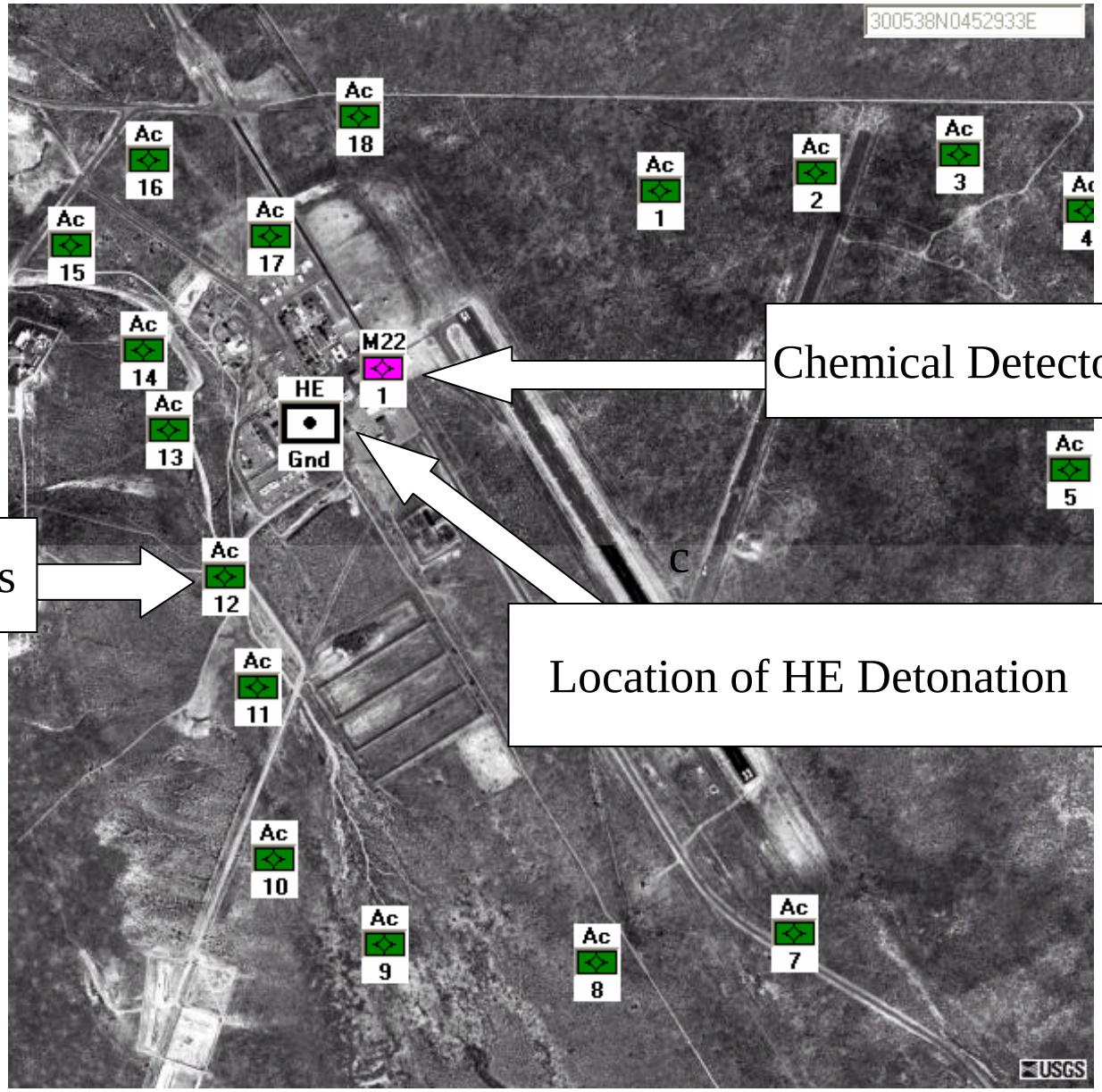
Sensors:

ACOUSTIC

CHEMICAL - M22

Modeling and Simulation

Edgewood Chemical Biological Center



Chemical Detector

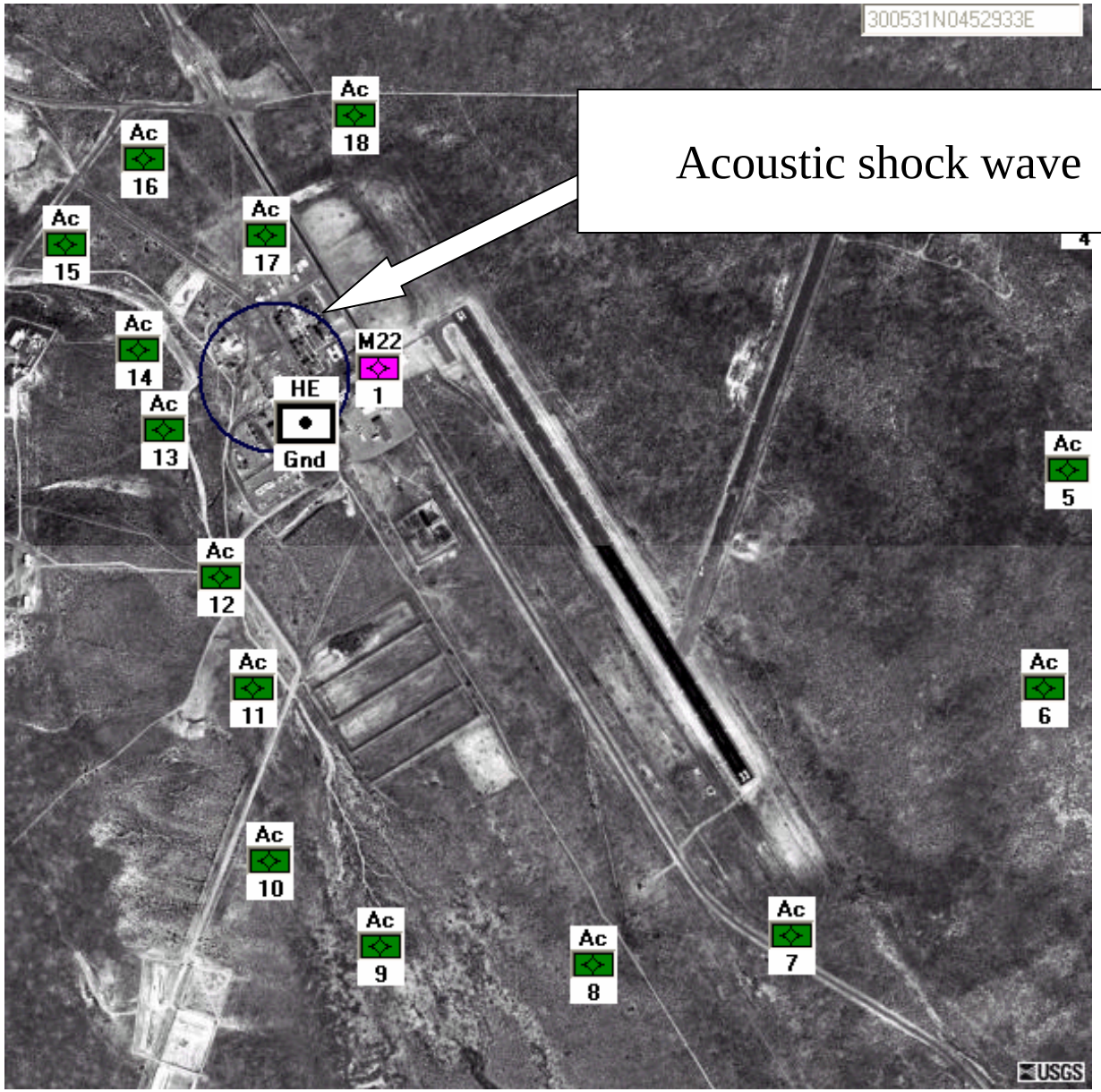
Acoustic Sensors

Location of HE Detonation

T=0 seconds

Modeling and Simulation

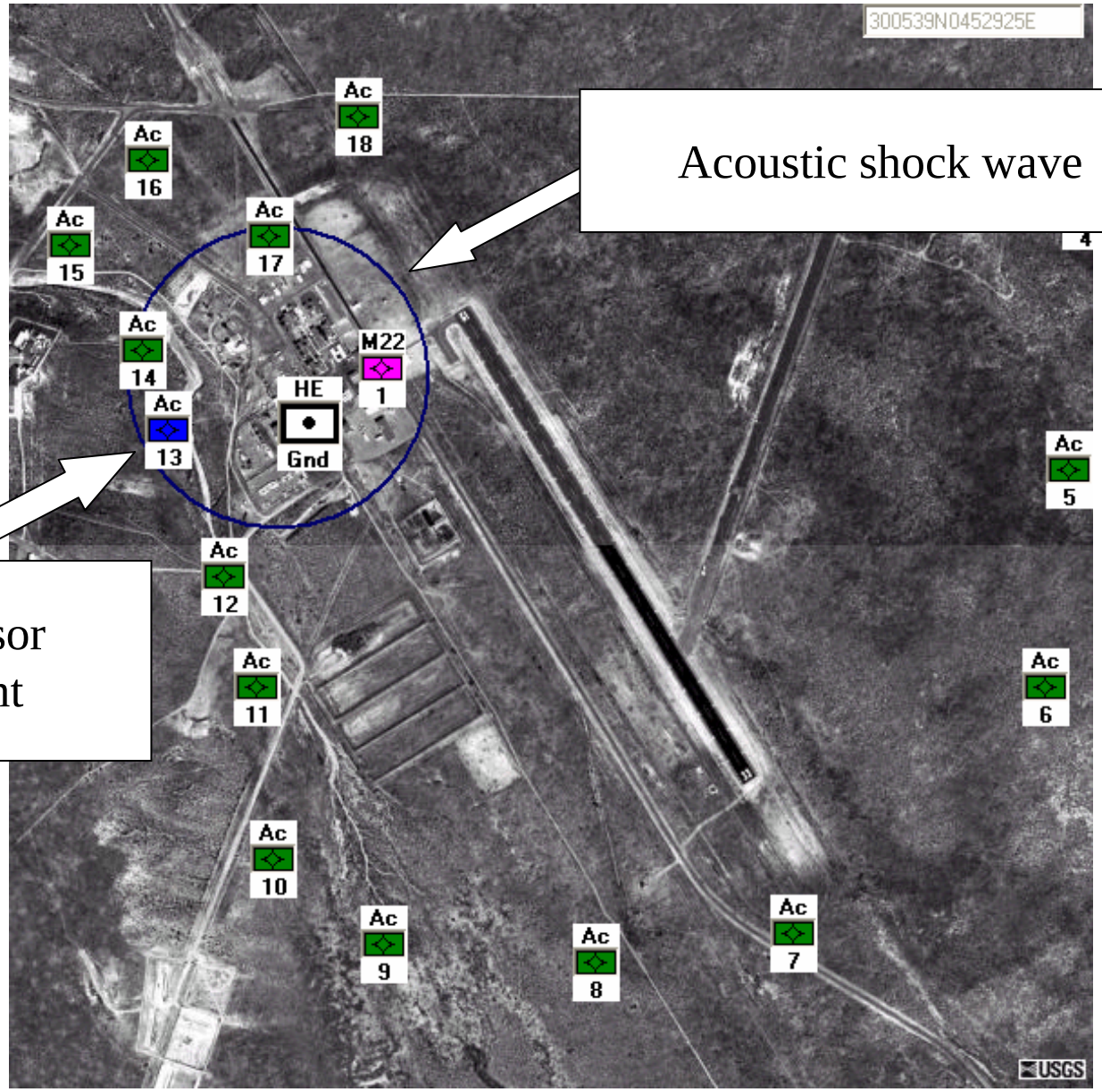
Edgewood Chemical Biological Center



T=1 seconds

Modeling and Simulation

Edgewood Chemical Biological Center



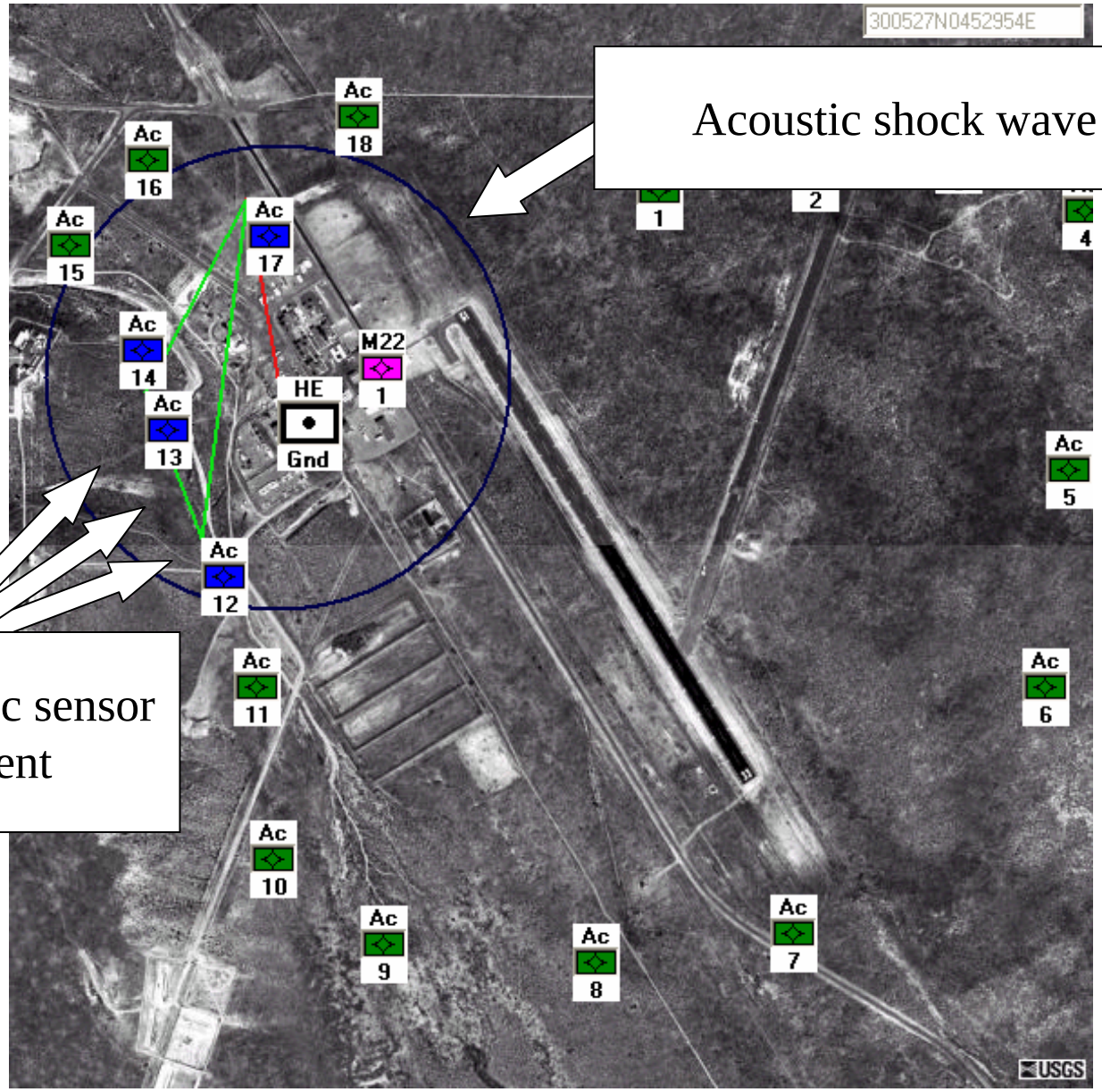
Acoustic shock wave

Acoustic sensor detects event

T=2seconds

Modeling and Simulation

Edgewood Chemical Biological Center



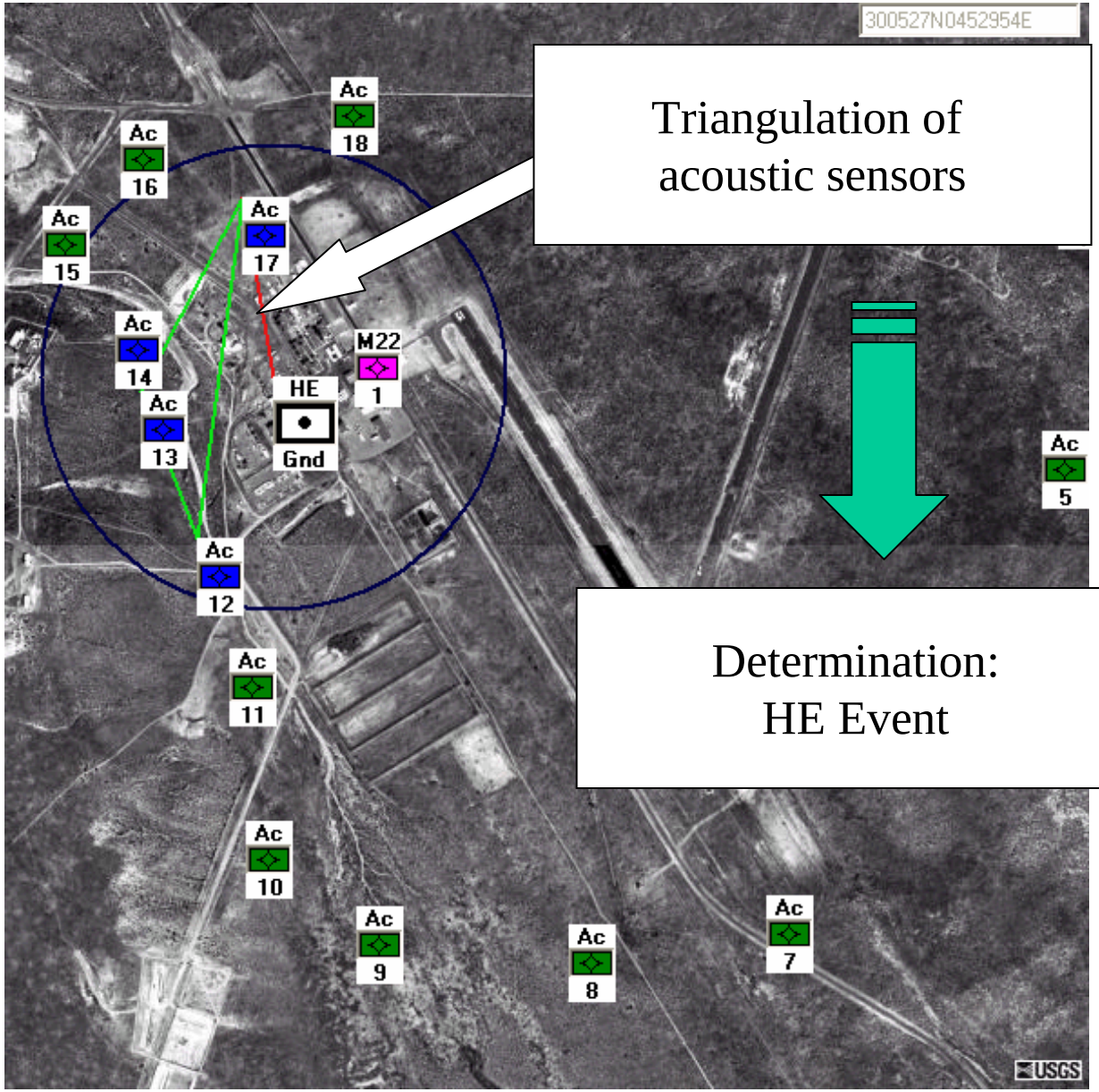
Acoustic shock wave

Multiple acoustic sensor detects event

T=3seconds

Modeling and Simulation

Edgewood Chemical Biological Center



Triangulation of acoustic sensors

Determination: HE Event

T=3seconds

Example 2

Type of Event: Chemical

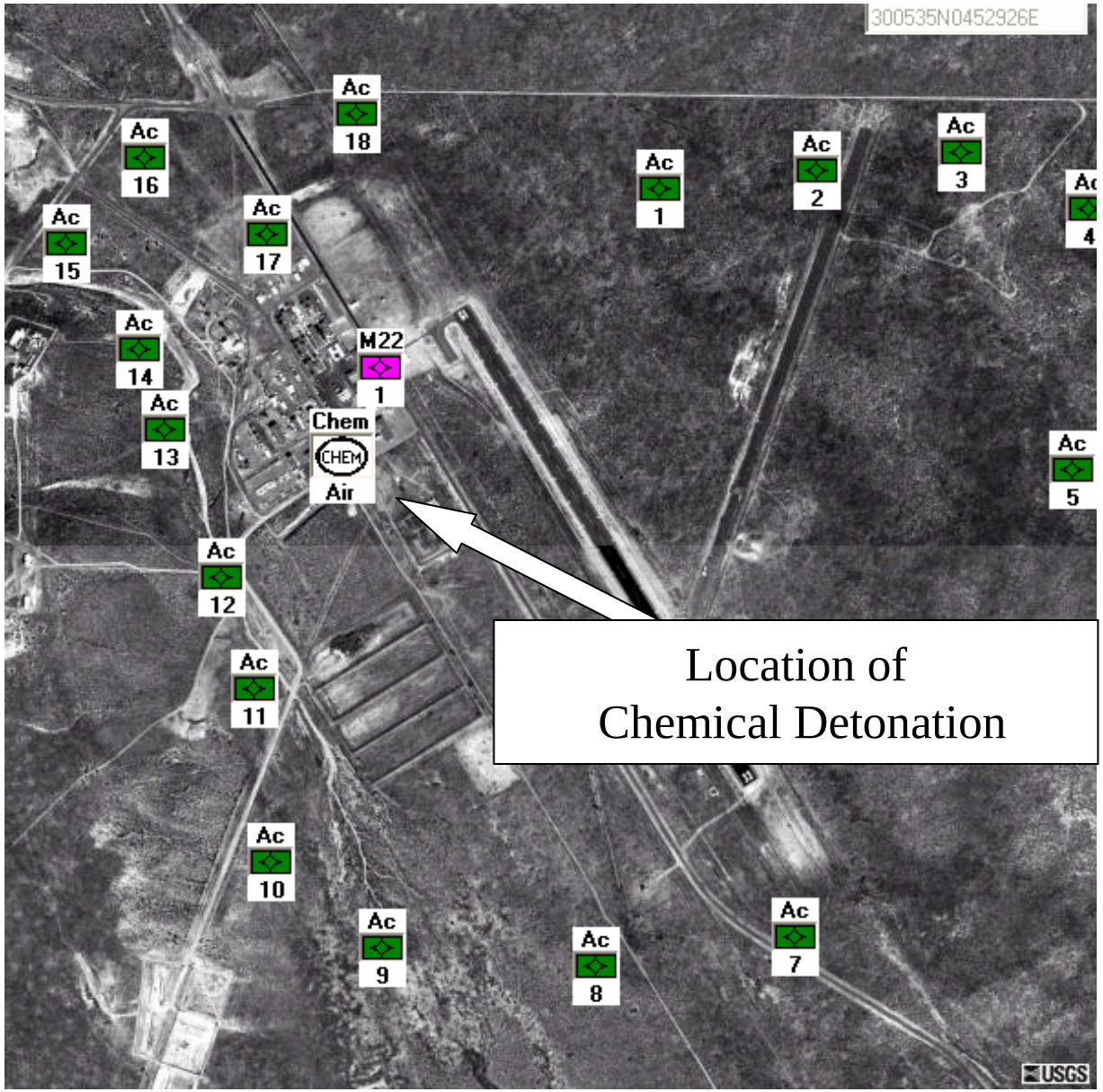
Sensors:

ACOUSTIC

CHEMICAL - M22

Modeling and Simulation

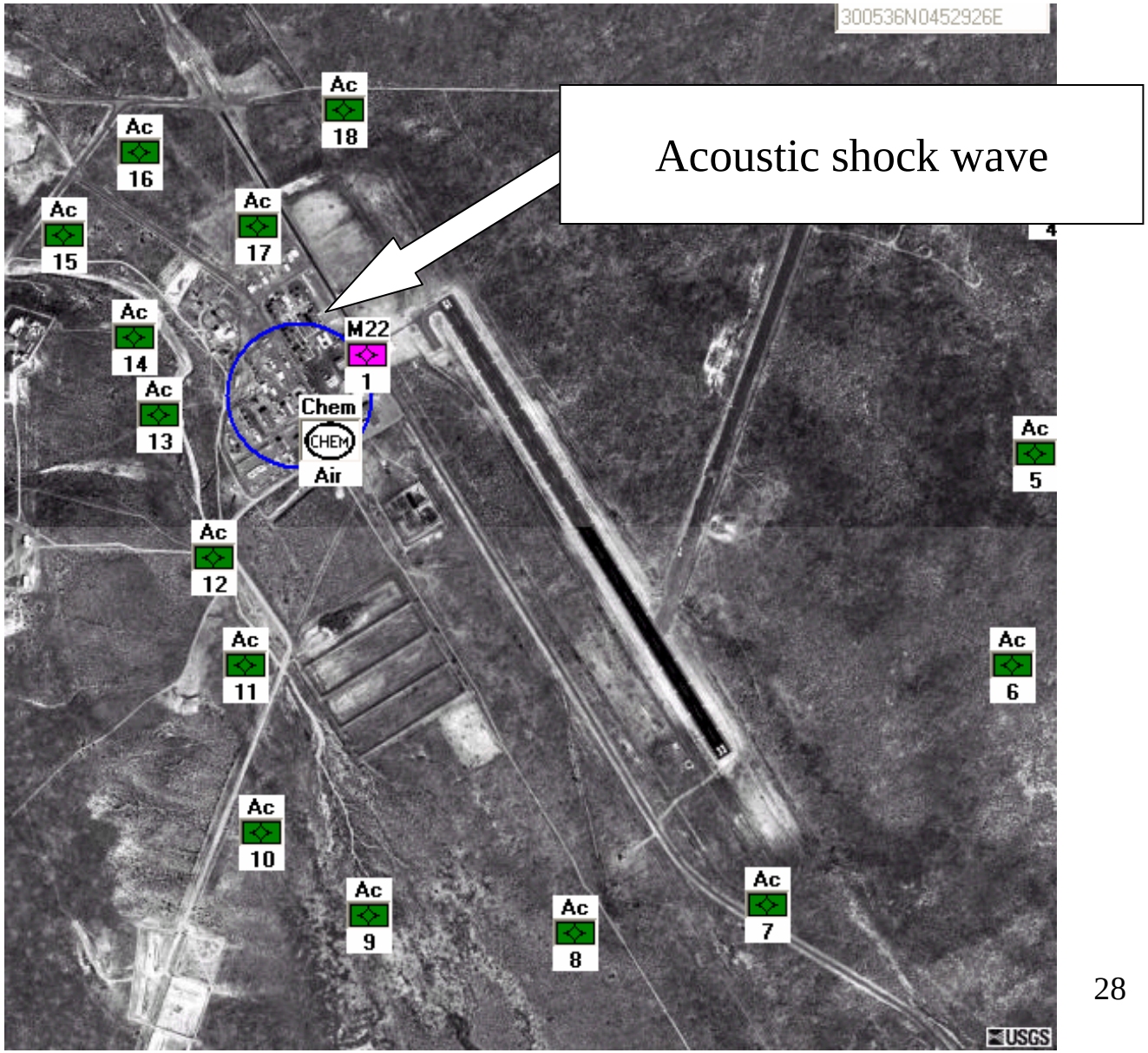
Edgewood Chemical Biological Center



T=0 seconds

Modeling and Simulation

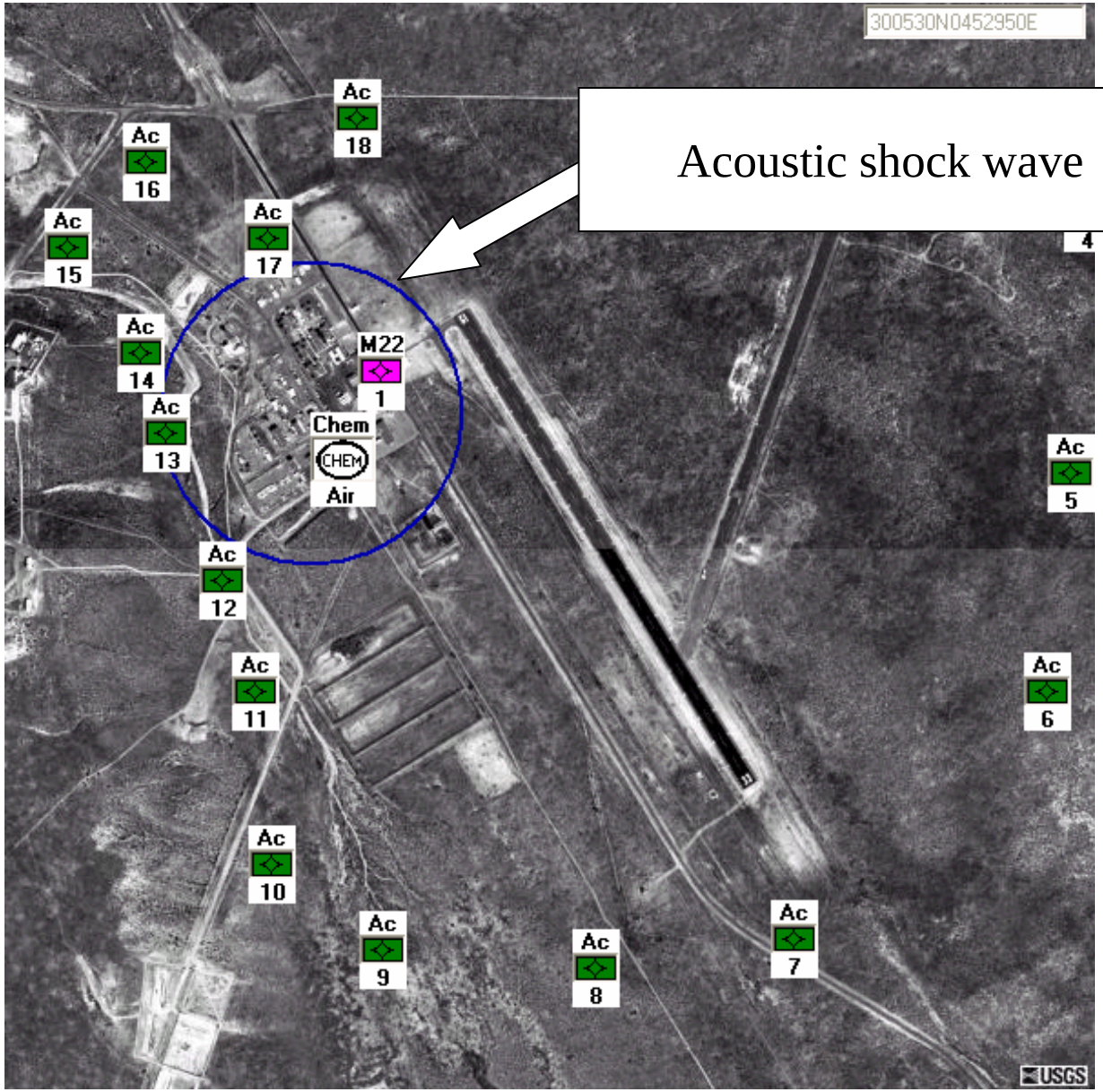
Edgewood Chemical Biological Center



T=1 seconds

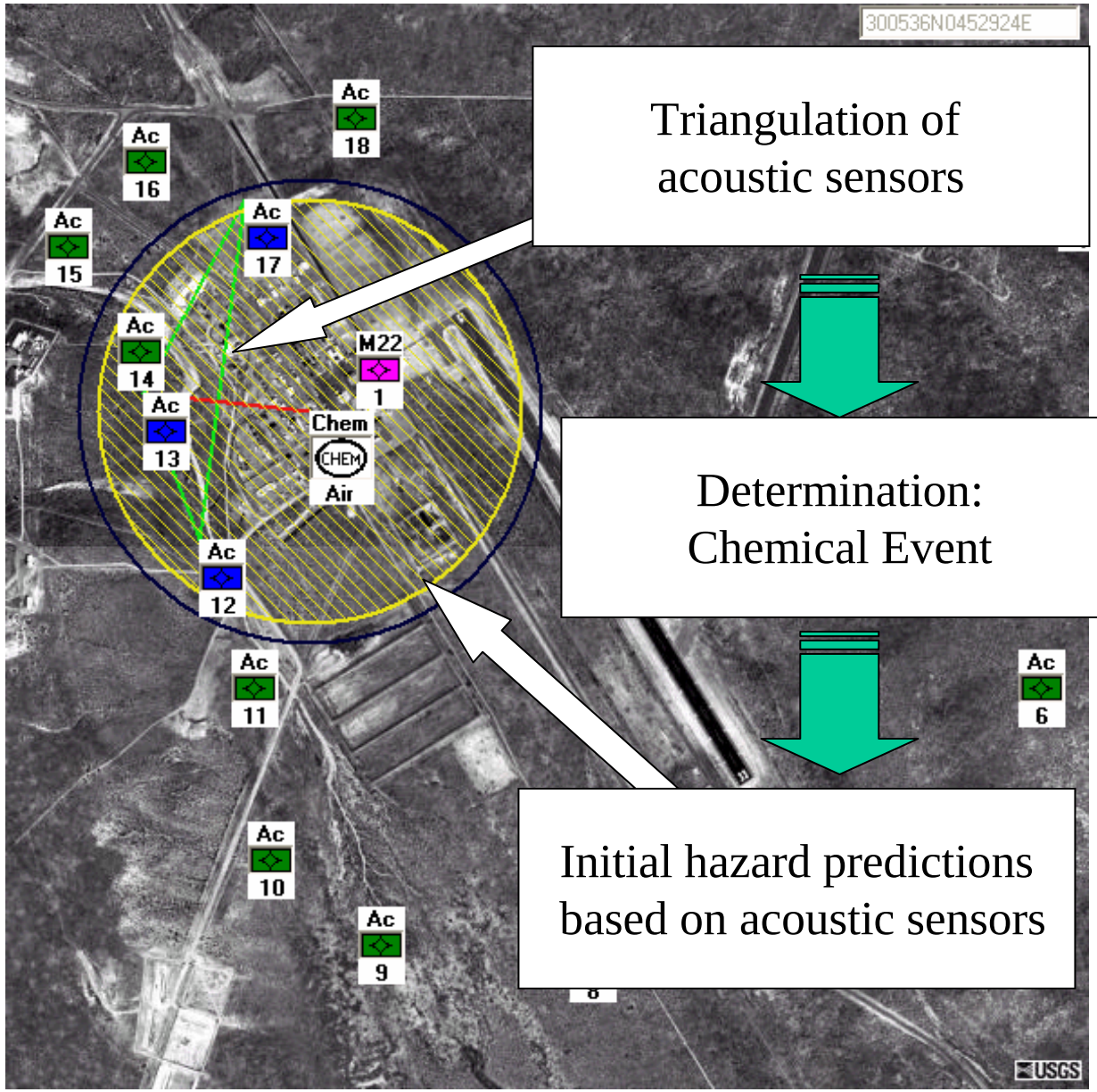
Modeling and Simulation

Edgewood Chemical Biological Center



T=2 seconds

Modeling and Simulation



Triangulation of acoustic sensors

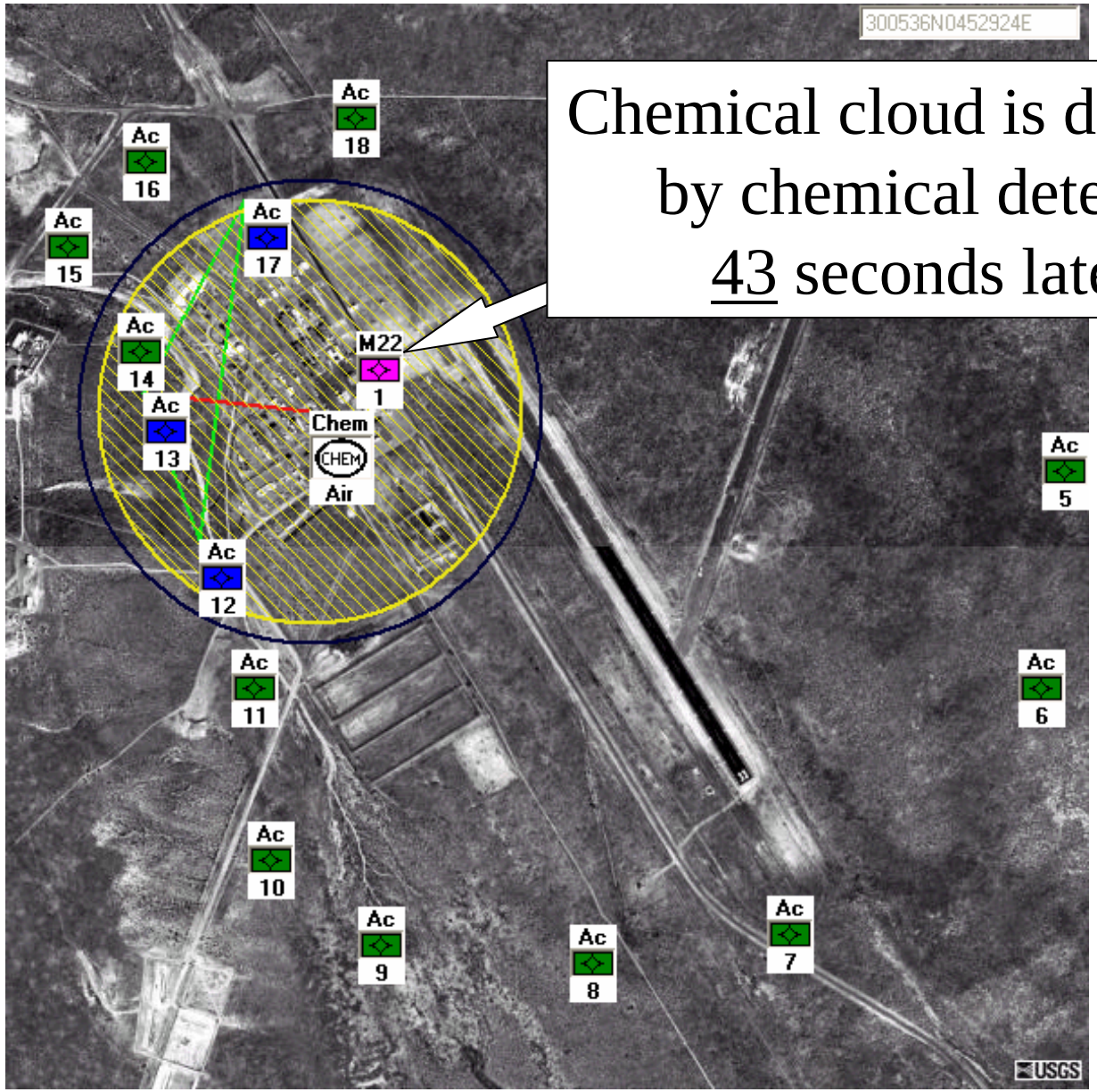
Determination: Chemical Event

Initial hazard predictions based on acoustic sensors

T=3seconds

Modeling and Simulation

Edgewood Chemical Biological Center



Chemical cloud is detected by chemical detector 43 seconds later

Modeling and Simulation

Example 3

Type of Event: Chemical

Sensors:

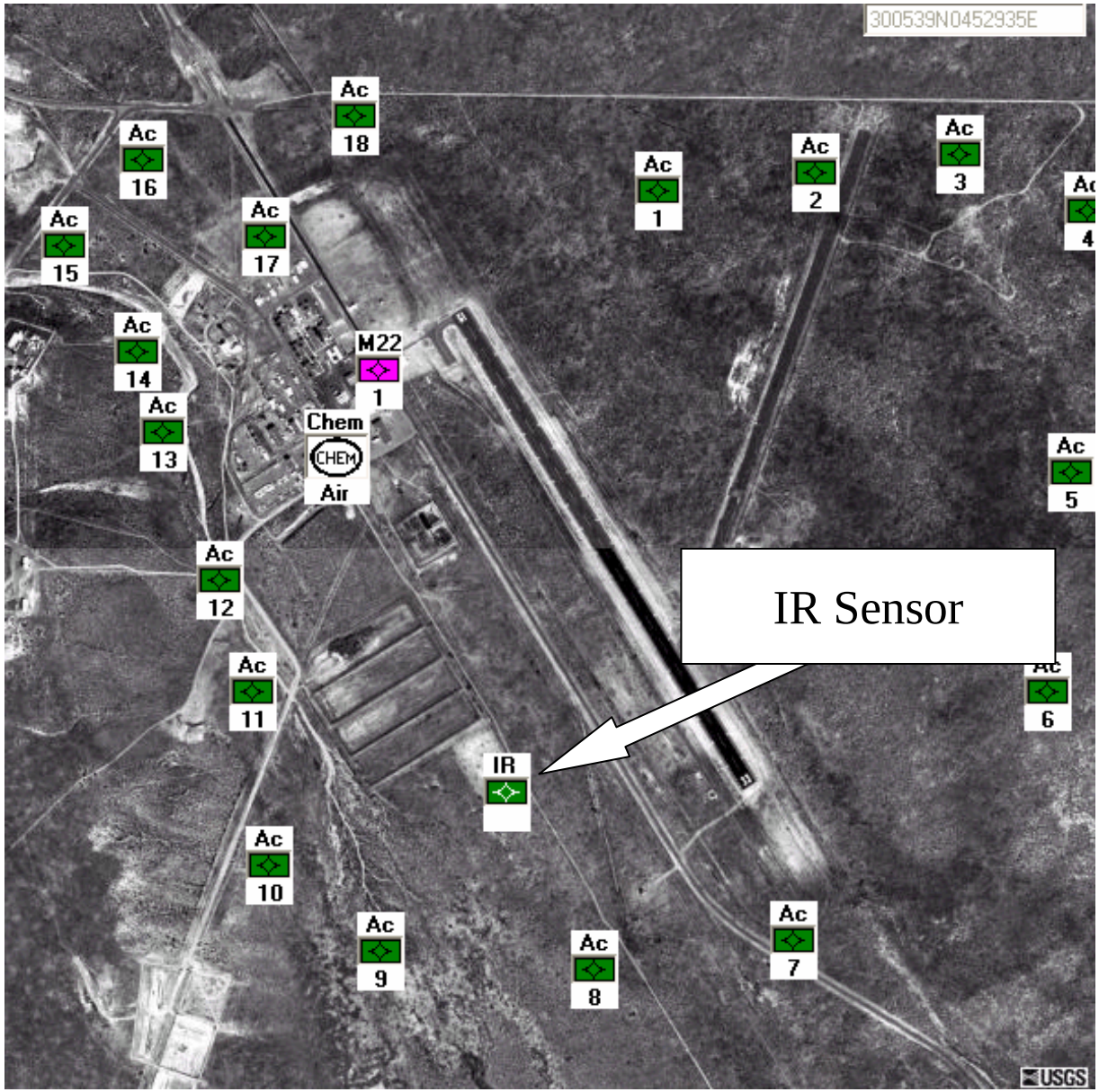
ACOUSTIC

CHEMICAL - M22

IR

Modeling and Simulation

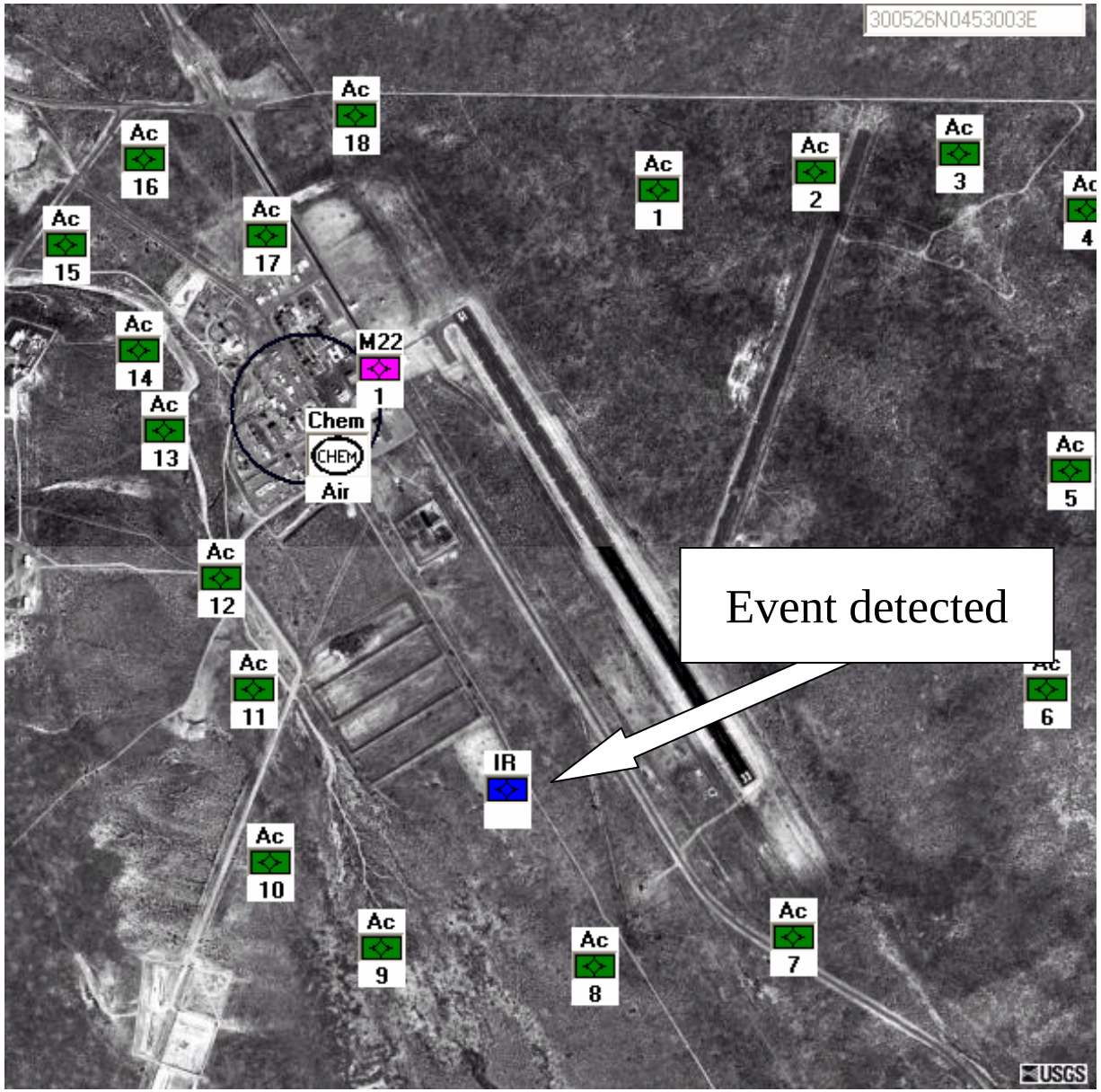
Edgewood Chemical Biological Center



T=0 seconds

Modeling and Simulation

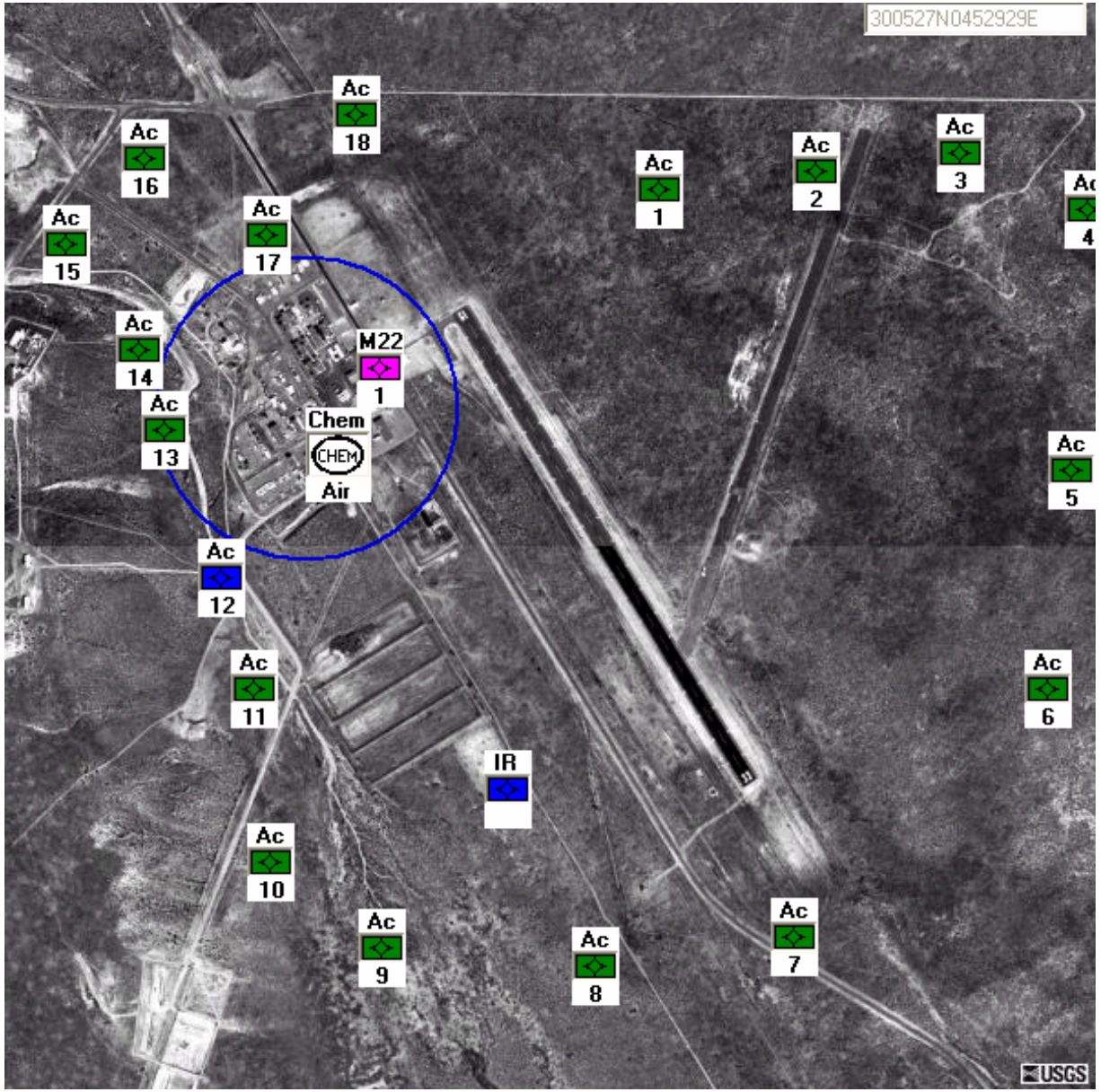
Edgewood Chemical Biological Center



T=1 seconds

Modeling and Simulation

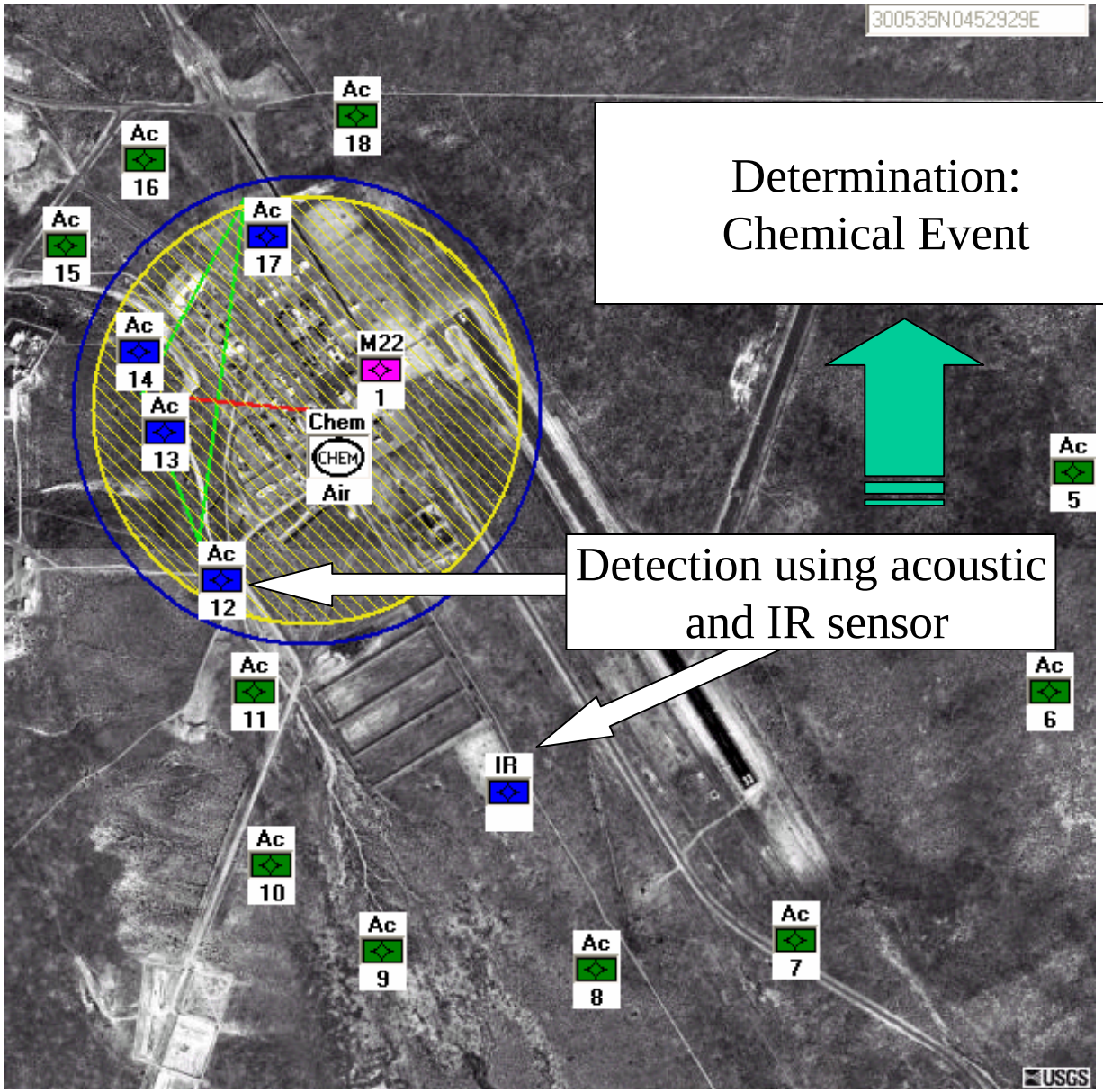
Edgewood Chemical Biological Center



T=2 seconds

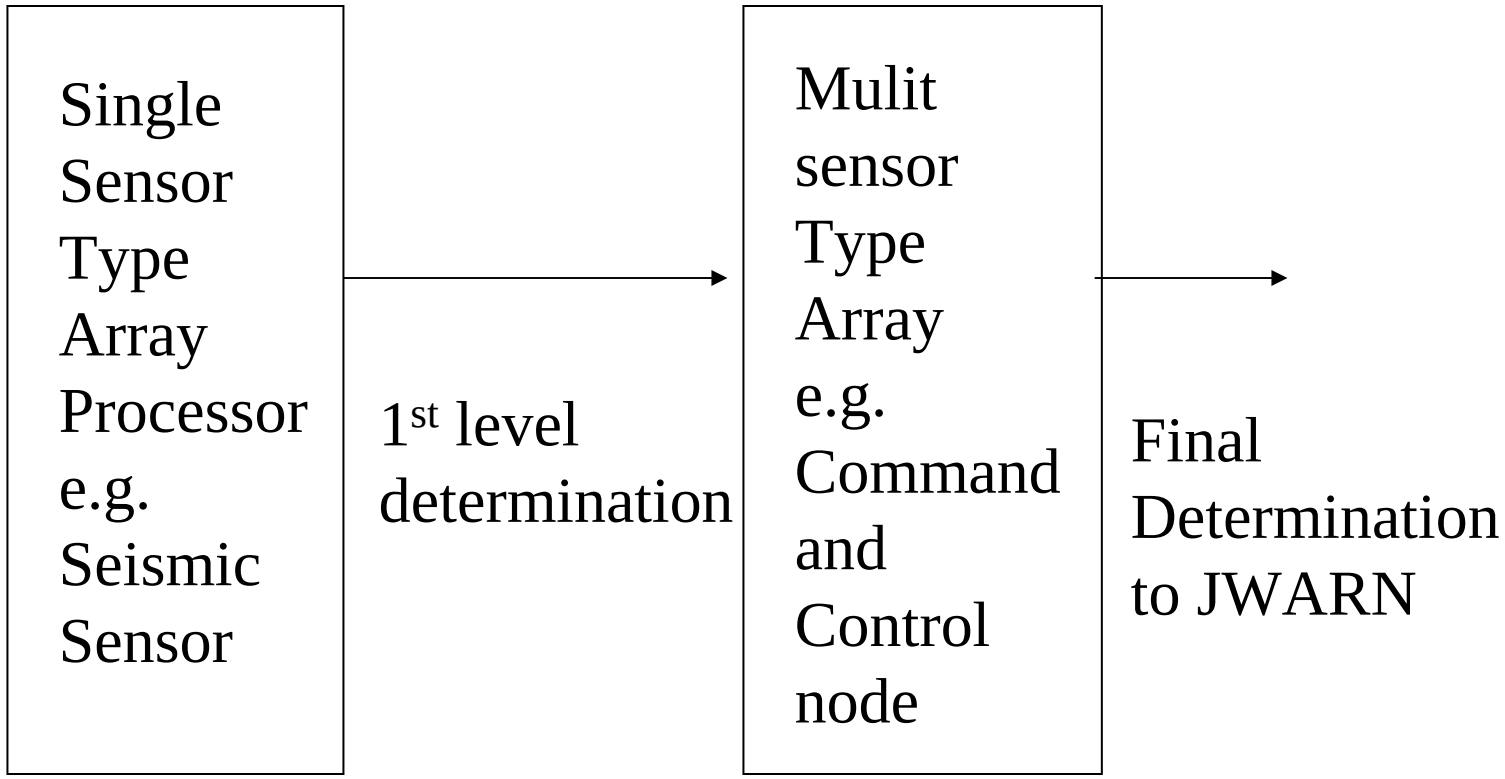
Modeling and Simulation

Edgewood Chemical Biological Center



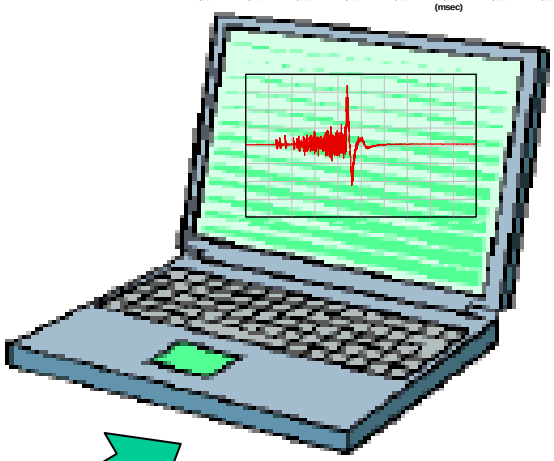
T=3seconds

DSI Decision Layers



Single Sensor Configuration

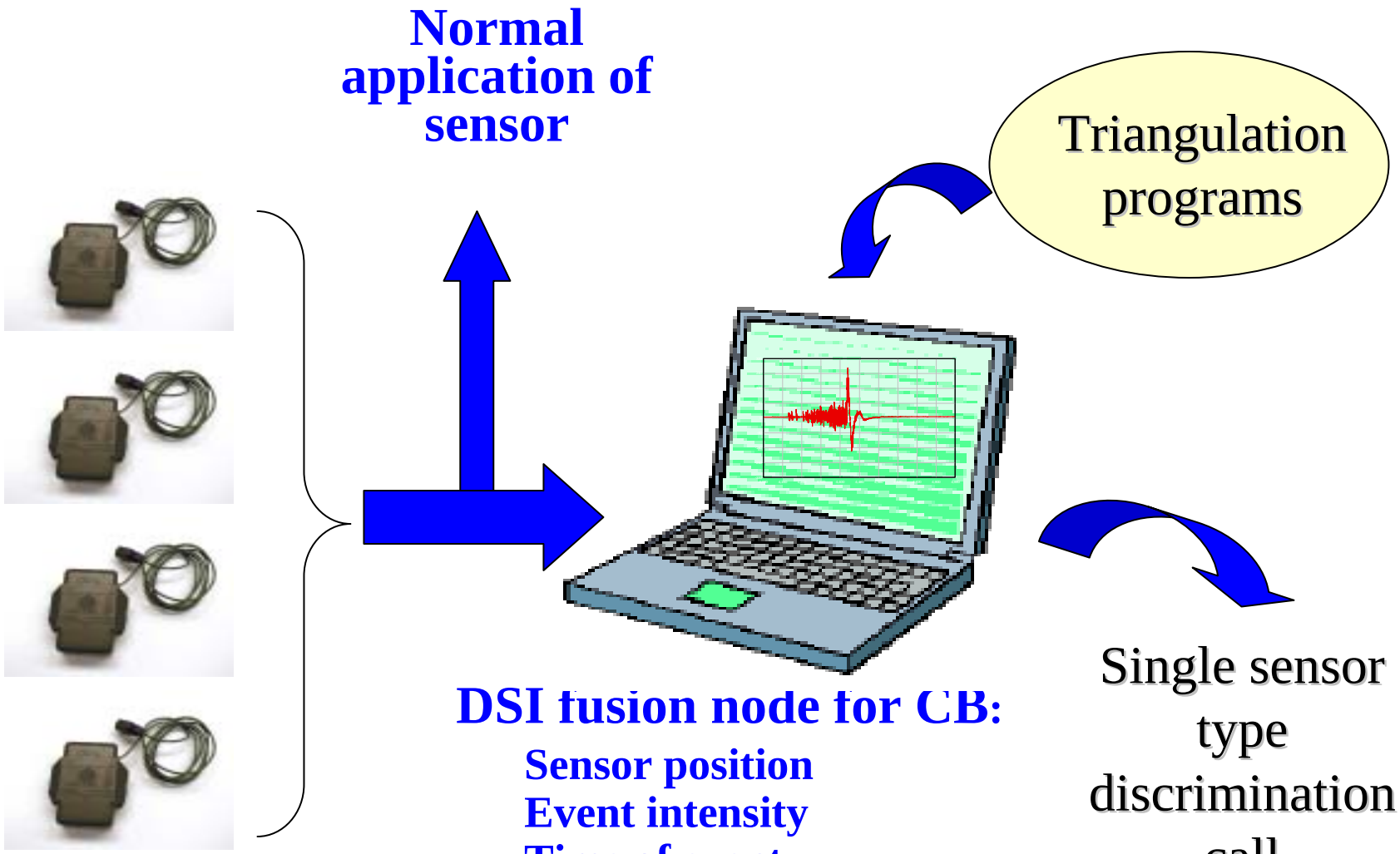
Seismic Sensor



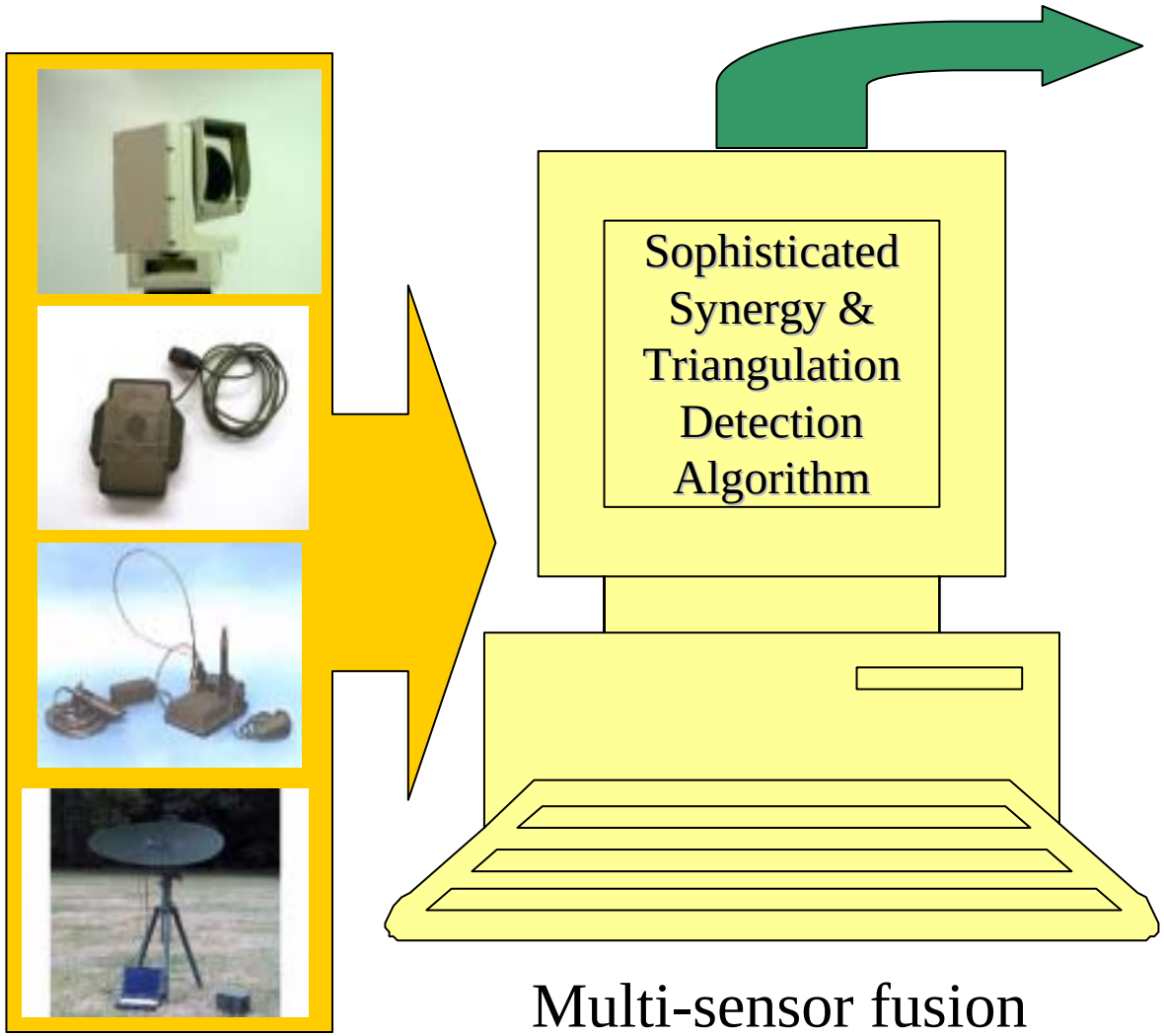
Extract unique and distinguishing features

Pass data and discrimination info to fusion node

Fusion of Common Sensors



Multi, Non-CB Sensor Fusion



Multi-sensor fusion node

C4ISR Host/ JWARN

- Detection Algorithm uses a combination of triangulation and intensity to determine if event is a CB or HE.
- Takes advantage of synergy between multiple same type sensors.
- Takes advantage of synergy between different types of sensors

Overall

- Disparate, non-CB, intrusion sensors have information that can be used to make a determination
- Information is already in the battlefield
- Provides early warning to soldiers of CB event
- Can allow soldier to go from MOPP IV to MOPP II much more easily
- Relieve fatigue of soldier

END