Assessment of Electromagnetic and Passive Diffuse Infrared Sensors in Detection of IED-Related Behavior

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Overview

- We want to monitor urban public areas for suspicious behavior.
- This is useful for counter-IED operations (besides crime prevention).
- Wireless sensor networks could be a cheaper and more robust alternative to video surveillance.
- Finding suspicious behavior from sensor networks can be automated.
- We experimented with some simple approaches using magnetic and infrared sensors from Crossbow Technologies.
- We ran human subjects through the sensor field while engaged in various activities, some of them suspicious.

Detecting IED emplacement

- Improvised explosive devices (IEDs) are a serious problem in Iraq and now other countries.
- Detection of emplaced (buried or camouflaged) IEDs has been quite unsuccessful in Iraq.
- Tracking down IED organizations (a JIEDDO focus) isn't working well because they are decentralized and adaptive.
- So the best hope is to catch IEDs during emplacement – intrinsically suspicious activity usually involving deception.
- This requires very distributed sensing.

IED components

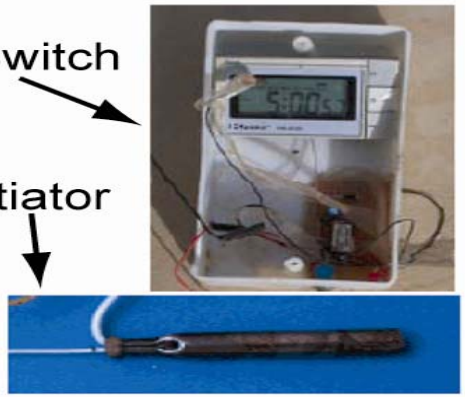
Main Charge

Explosive Filler

Initiating System

Switch

Initiator

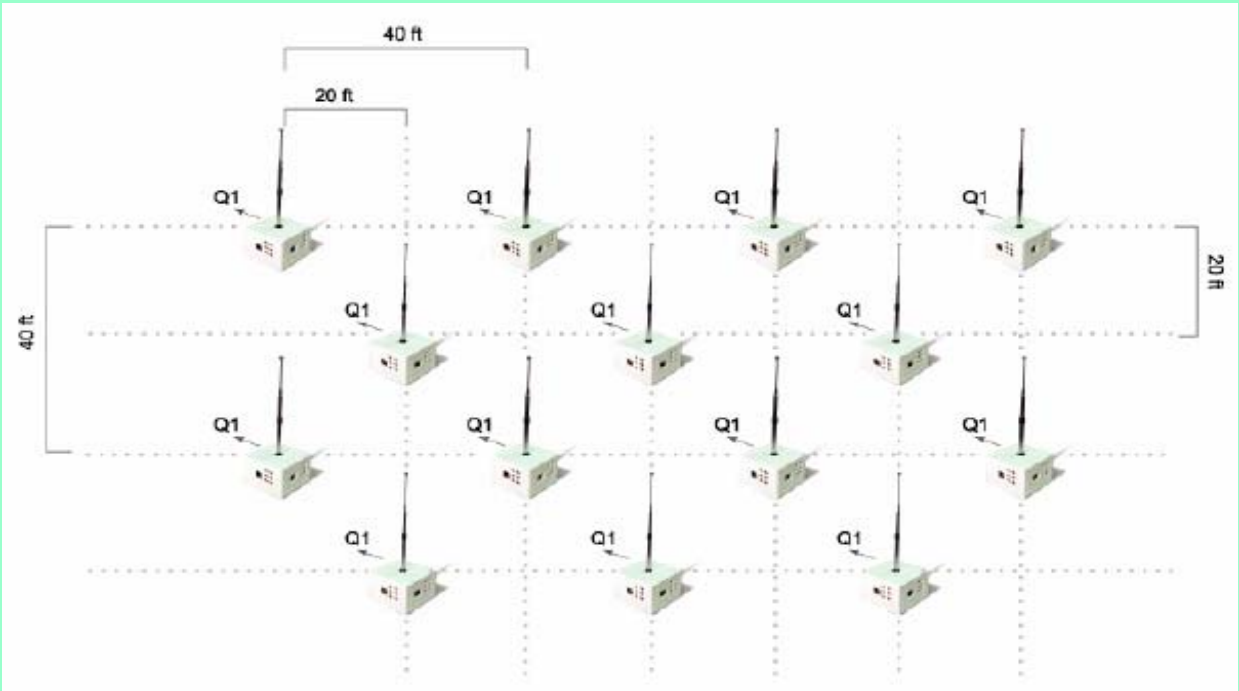


Power Sources

Casing

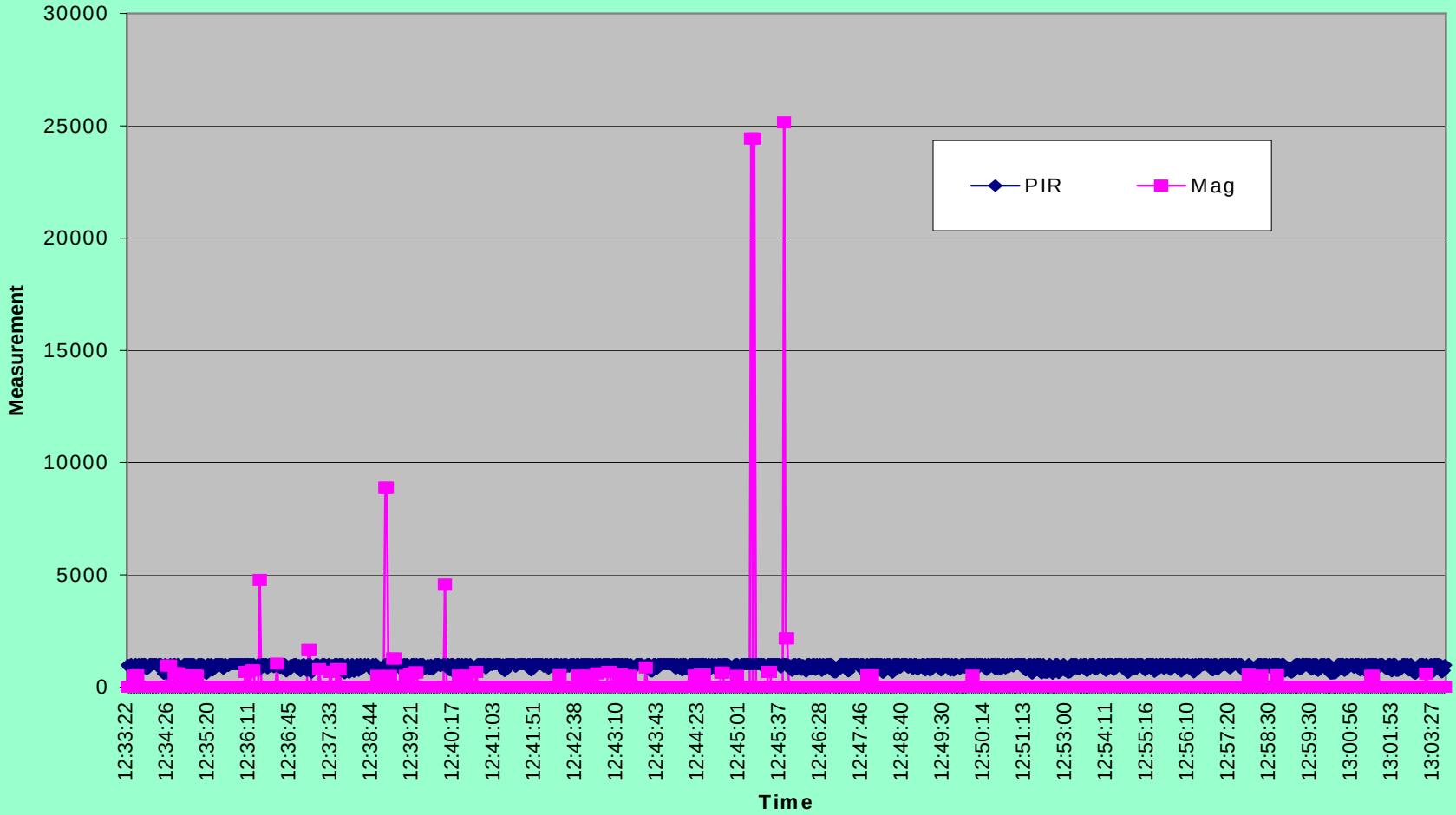
Containers

Crossbow MSP-410 base station, mote, and example dense deployment

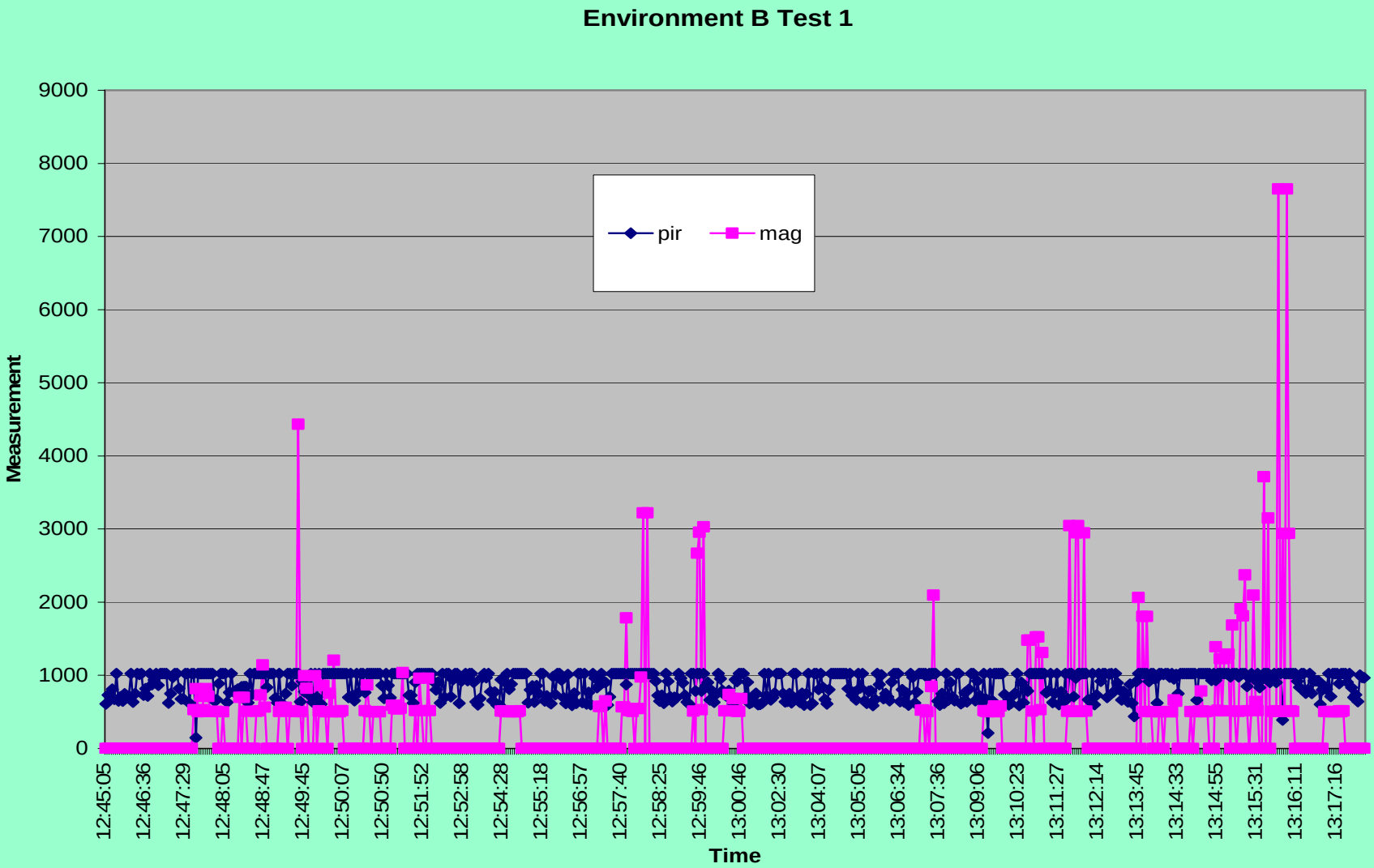


Settings of our first experiments

Signals observed in shopping center



Signals observed along street



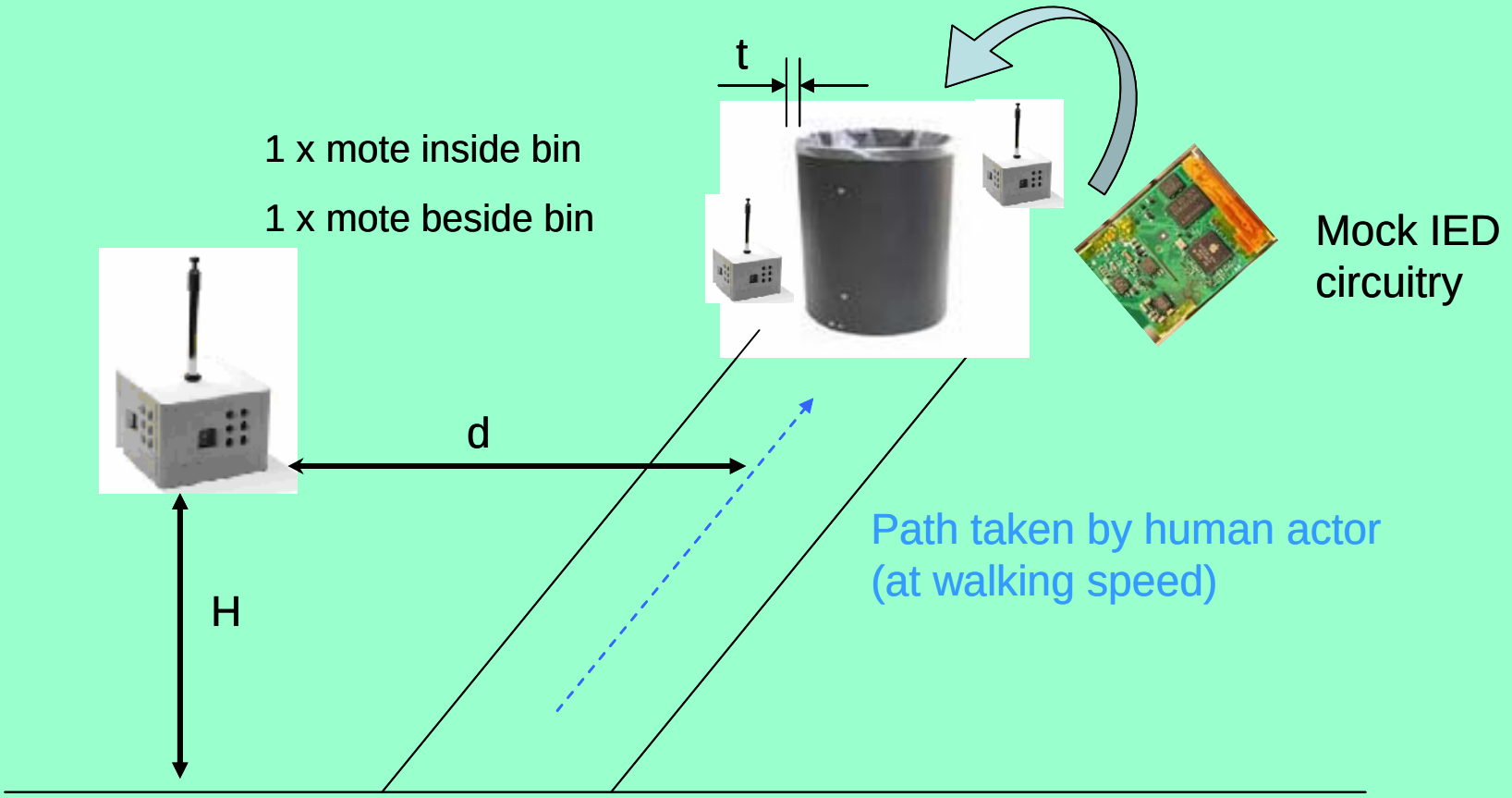
Experiments with magnetic detection of nails

***X* / nails**	**Magnetic readings at H / cm**					
	0		**45**		**80**	
	Distance from mote, d / cm					
	10	**50**	**10**	**50**	**10**	**50**
5	207	144	559	560	488	492
10	215	150	667	596	654	512
20	219	184	882	598	886	534

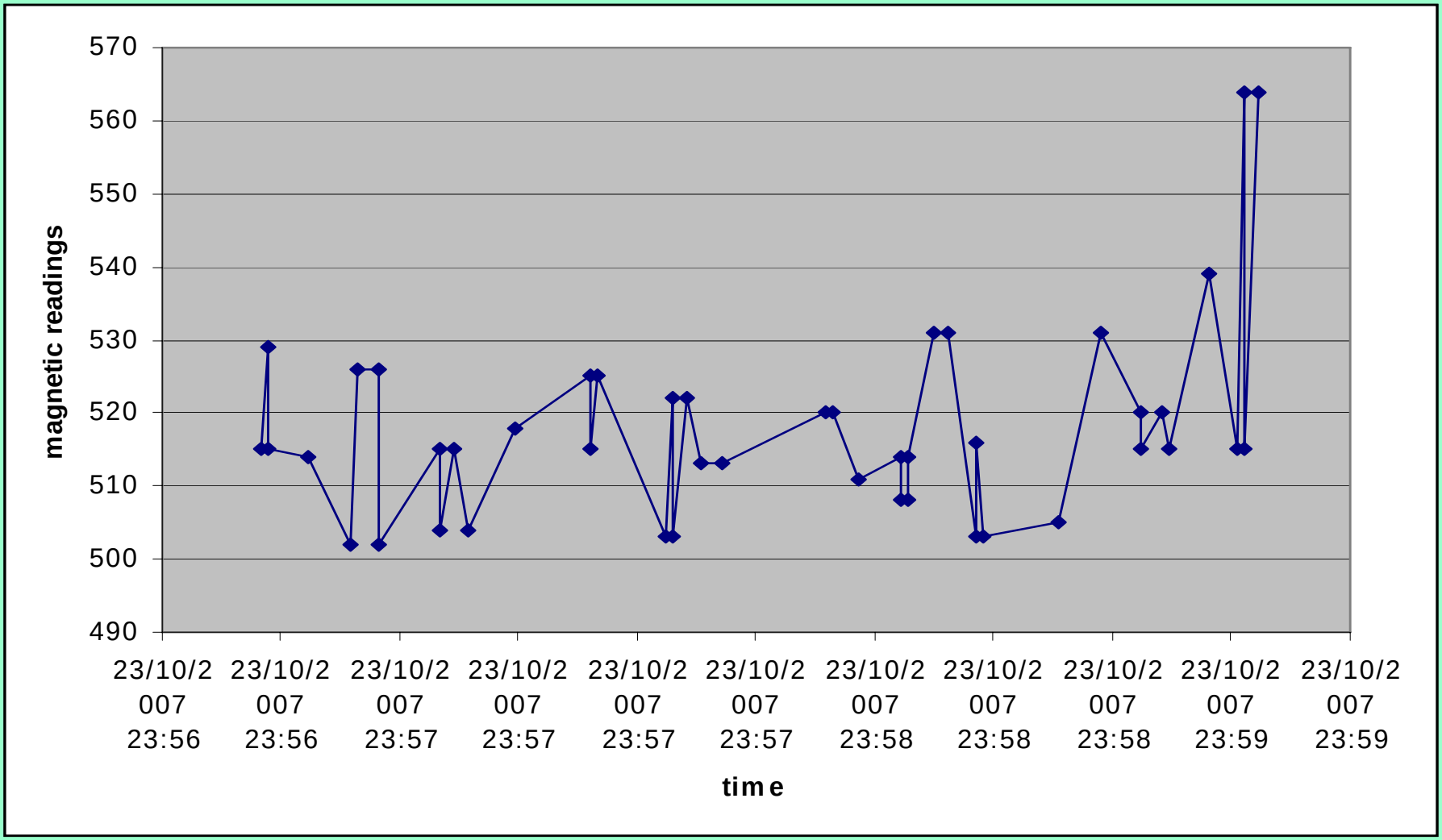
Further nail experiments

H / cm d / cm	Magnetic Readings		
	0	45	80
10	294	589	680
50	221	578	619

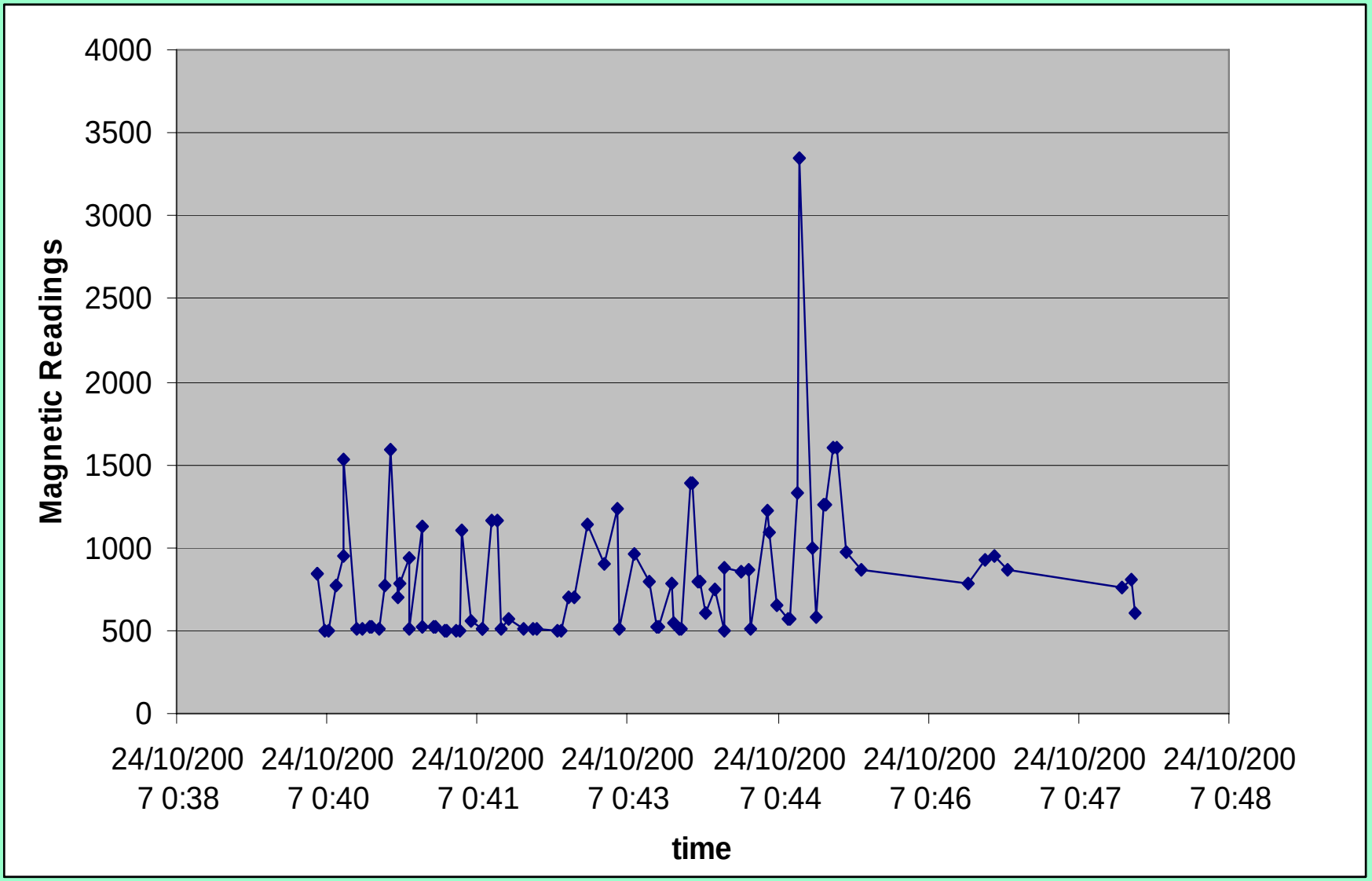
Trash bin experiment



Magnetics: gradual emplacement in bin



Sudden emplacement in bin



Magnetic readings from bin emplacement

H / cm t / cm	Mote 1			Mote 2		
	0	45	90	0	45	90
0.2	0	483	497	509	516	539
0.5	0	285	455	-	-	-
1	0	268	421	-	-	-

Conclusions from these experiments

- Crossbow sensors have trouble characterizing small objects.
- Setting thresholds as average readings is crude – time of day important.
- Diffuse infrared sensors detect humans but this is not useful for IED detection by itself.
- Some close objects were not detected by infrared sensors because the beams were too narrow.
- Infrared sensors were susceptible to air disturbances and temperature variations.
- Magnetic sensors triggered without ferrous materials.
- Magnetic sensors may be more useful in restricted deployments such as in receptacles.
- More motes should be used to reduce false positives.
- Our sensor topology appeared to be a good for areas of limited ingresses and egresses.
- The experiments required high power consumption; design may need to be different when power is more critical.

Subsequent work

- Use of multiple sensors could improve decision making.
- Imaging, seismic, and chemical sensors could improve the selectivity of the thresholds for IEDs.
- Localization in the sensor field can be done with various forms of triangulation.
- Develop explicit clues for suspicious behavior (e.g. nonzero acceleration norms).
- Study concept of contagion of one agent's suspiciousness.
- Behaviors particularly related to IEDs can be sought, e.g. digging for laying a command wire.

New work on detecting suspicious behavior

Suspicious movements for rf20041216_150734fi (Flag: 0)(Scale: 1)(pictures 1 through 440)

initial location: pathID(pic#)(ave of max and ave suspicion)
suspicion(low...high): blue...red

Simpler example: Note halts at trash bin and at car

Suspicious movements for rf20050110_172844fi (Flag: 0)(Scale: 1)(pictures 13 through 336)

initial location: pathID(pic#)(ave of max and ave suspicion)
suspicion(low...high): blue...red

The most useful factor in suspiciousness: Acceleration norm

- Let x(i) be vector position at time i.
- Let N be the number of positions in a track.
- Let d be the time scale.
- Then average acceleration norm can be computed as:

$$a(d) = (1/d(N-2d)) \sum_{i=d+1}^{N-d} \left\| -x(i-d) + 2x(i) - x(i+d) \right\|$$

- The average of a(1), a(2), a(4), a(8), etc. provides a good broad metric of suspiciousness.

Block diagram of proposed system