

Picking Winners

Emerging Technologies for Countering Terrorism

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- Outline:
1. How do we assess the threat?
 2. Catching terrorists before they strike.
 3. Detecting a biological assault.
 4. Being smart.
 5. Summary and Conclusions.

Assessing the Threat

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- How does the weapon hurt us?



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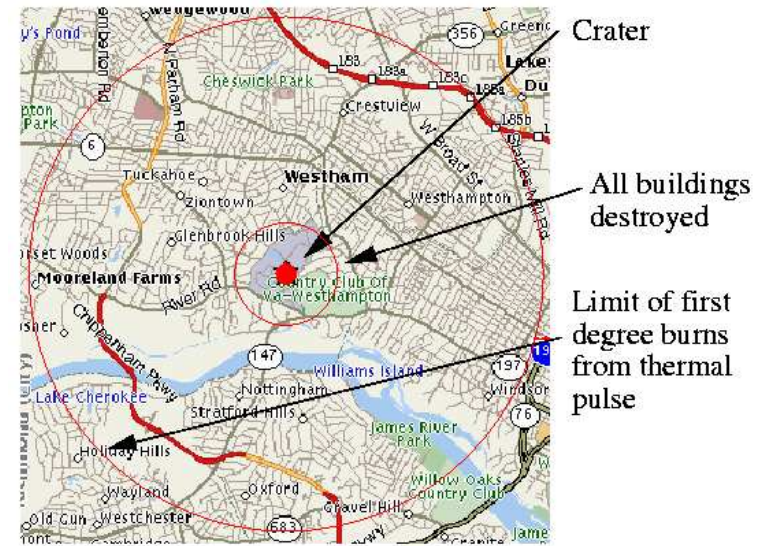
- How can we respond to the threat?

- prevention
- mitigation (*i.e.* cleanup, cures, *etc.*)
- retaliation

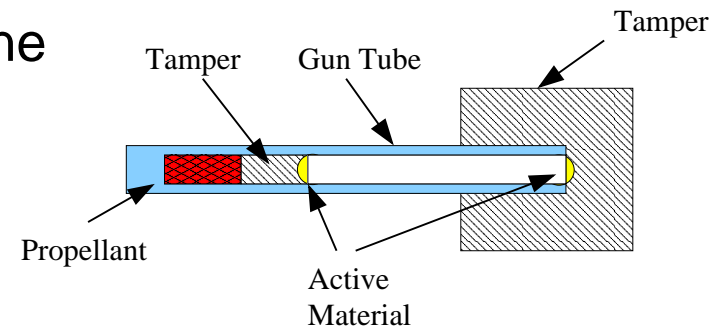


Weapons of Mass Destruction - Nuclear Bombs

- How does it hurt me?
 - Massive release of energy (blast, light) that can cause hundreds of thousands of deaths, long-term increase in cancer rates.
- Can an opponent obtain and deliver it?



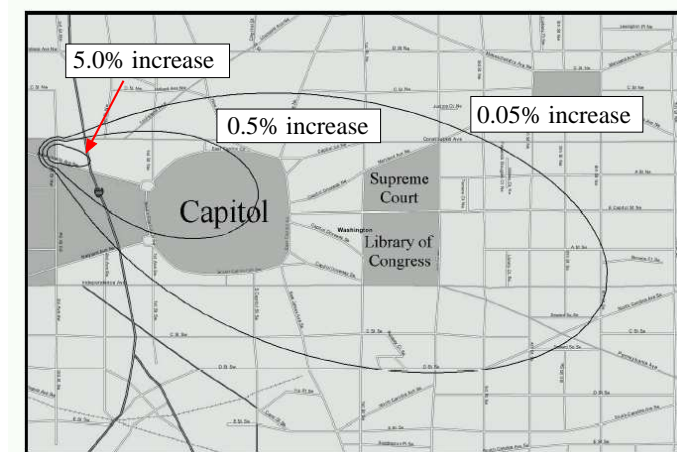
- Building one from scratch can be done by nation-states, but not terrorists.
- Building a bomb with stolen material is still difficult for terrorists.
- It's easy to smuggle things into the US. In 2000, about 700 tons of cocaine came into the US.



- Primary responses are prevention, threat of retaliation (deterrence).

WMD 101 - Radiological ('Dirty') Bombs

- Conventional explosive with radioactive material mixed in.
- How does it hurt me?
 - Initial damage from blast; far fewer casualties than a nuclear bomb.
 - Panic may be a major problem.
 - Increases in long-term cancer rates.
 - Clean-up could be costly.
- Can an opponent obtain and deliver it?
 - Many non-weapons-grade nuclear materials are vulnerable.
 - The technology is not much different from conventional explosives.
- Response is focused on prevention and cleanup.



Weapon of mass disruption!

WMD 101 - Biological Weapons

- Release of a biological agent (anthrax, smallpox, salmonella).
- How does it hurt me?
 - The natural spread of the disease and the indiscriminate nature amplifies the impact of the disease.
 - Some weaponized forms could cause large number of casualties.
- Can an opponent obtain and deliver it?
 - Non-weaponized forms can/have been obtained via mail-order, dirt or stolen from labs.
 - Delivery is difficult for causing large numbers of casualties.
- Response is focused on prevention and mitigation.



WMD 101 - Chemical Weapons

- Release of a chemical agent or toxin (botulinum, sarin, mustard gas).
- How does it hurt me?
 - Different agents have different effects (*i.e.*, incapacitation, blistering).
 - Some forms could cause large numbers of casualties, but most are limited. No amplification occurs.
- Can an opponent obtain and deliver it?
 - Many agents need only standard lab equipment.
 - Delivery is difficult for causing mass casualties.
- Response is prevention, mitigation, and cleanup.



Effect of chemical blistering agent ¹

¹ - *Chemical Warfare by Iraq in Iran-Iraq War*, Stockholm International Peace Research Institute, <http://www.iranvision.com/iraqchemicaluse.html>, Last accessed: 2/4/03.

Stopping a Terrorist Attack

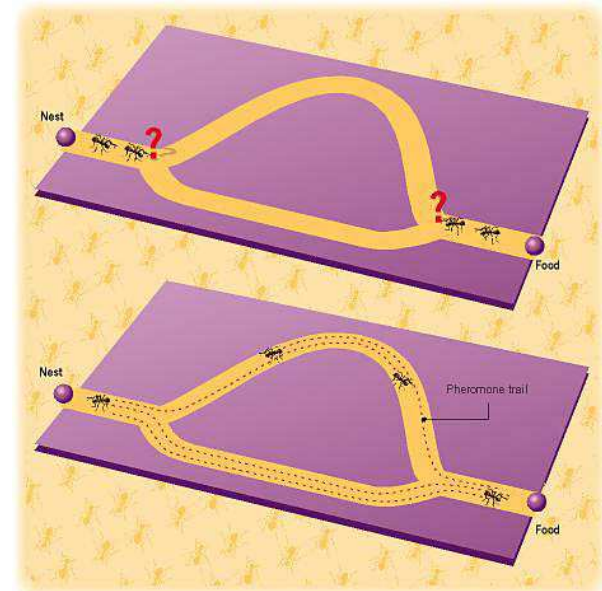
- We have open borders both physically and electronically.
- More and more activities leave an electronic signature (*i.e.* RFIDs).
- Computing power is getting cheaper.
- Bandwidth is growing.
- Wireless is becoming pervasive.
- Volume of available data is huge.



Can we find the electronic signature of terrorists before they act?

Ant Algorithms

- How do ant colonies find food?
 1. Send out lots of ants to search randomly. They follow trails left by other ants and leave trails of their own.
 2. Once they find food the ants follow their trail home marking the route twice.
 3. Successful ants will mark similar paths for other ants to follow so highways to the food source are created.
- What happens when the food runs out? Pheromones evaporate.
- What happens when a traffic jam occurs? Other routes are found.



A group of dumb 'agents' acts smart!

Does It Work?

- Already being used in the telecommunications industry to route traffic.
- Banks and other companies use these techniques to sift through databases (data mining) to identify people with desired characteristics.
- Other optimization problems: sequential ordering, quadratic assignment, vehicle routing, scheduling, graph coloring problem and partitioning.
- Used in swarms of robots for prey retrieval, coordinated movement through rough terrain, and measuring complex areas.
- Has connections to many different areas.
 - Agents need transducers, sensors, and communication.
 - Software.
 - Inspiration is taken from nature.
 - Requires understanding many-particle dynamics in equilibrium and non-equilibrium conditions.

Is It Practical?

- Corporations now use data mining techniques to analyze their companies and 'characterize' their customers.
 - Models of each customer are developed based on their buying habits, inquiries, *etc.*
 - Models are used to target marketing, predict future buying behavior of customers (You!), identify gaps in services.
- The DARPA Information Awareness Office was started to fund projects to develop new computing methods for surveillance (*dataveillance*) and gather information "useful for preemption, national security warning, and national security decision making."²
- Other federal agencies carry on a variety of surveillance and monitoring activities designed to identify terrorists.

² Information Awareness Office, <http://www.darpa.mil/iao/>, accessed 7/24/02.

Are There Customers/Users/Victims?

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- Some say 'GO!'.
 - Businesses identify customers.
 - Target services.
 - Near real-time monitoring of business.
 - Improve the bottom line.
 - Industry ↔ Homeland Security.

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 - Can privacy be maintained?
 - Public outcry over domestic surveillance.
 - DARPA Information Awareness Office loses funding in Congress.
 - Impact on civil liberties.

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Who owns your information? versus **Whose problem gets solved?**

Detecting a Biological Attack

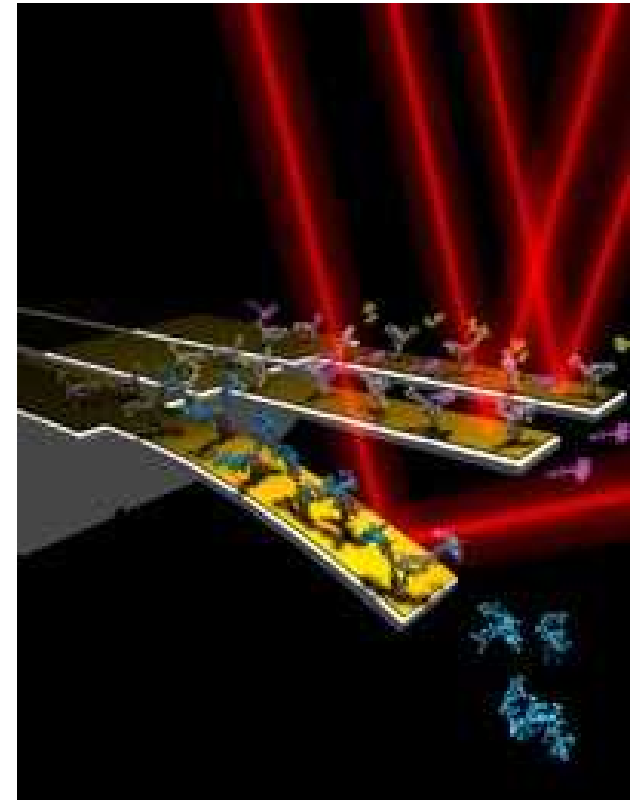
- The attack will not be obvious; it may take hours or days to know.
- Current biological diagnostics are very effective at identifying agents, but they're slow.
- We already have an infrastructure in place to start solving the problem; the US healthcare system.
- A successful attack could produce enough sick people to overwhelm the infrastructure so fast response time is essential.



Can we detect the presence of biological agents quickly, inexpensively, and effectively?

A Micro-Cantilever for Biological Detection

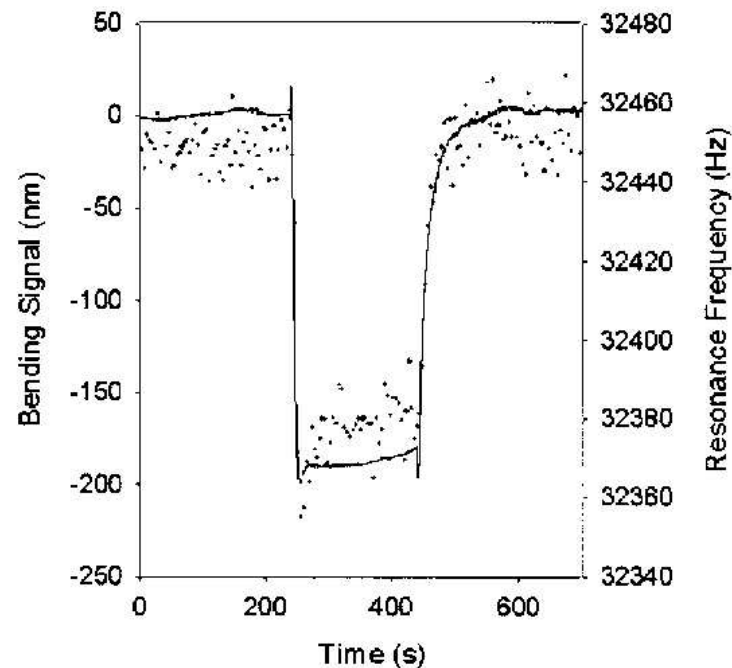
- Fabricate a diving-board-shaped cantilever $50 \times 200 \mu m$ using standard microchip manufacturing methods.
- Coat the top surfaces with antibodies for protein markers for specific diseases.
- The targeted proteins bind to the cantilever causing it to bend. The more proteins that bind the greater the bending.
- Detect the bending with a laser or other method.



A fast, inexpensive, sensitive biosensor!

Does It Work?

- For PSA or prostate-specific antigen (a protein marker of prostate cancer which is the number two killer of men in the US) the technique is sensitive to 20 times below the clinically relevant threshold.
- Plastic explosives have been detected at the level of 10 ppt within 20 seconds of exposure.³
- Escheria Coli bacteria (a major cause of food-borne disease) has been detected at a limit of 10^6 cfu/mL with microcantilevers.⁴



³ L.A.Pinnaduwege, *et al.*, Appl. Phys. Lett., **83**, no. 7, (2003).

⁴ J.Zhang and H.F.Ji, Analyt. Sci., **20**, 585 (2004).

Is It Practical?

- IR sensors have been developed that are cheaper than older alternatives by a factor of 25.
- The PSA technology has already been transferred to the private sector via a Cooperative Research and Development Agreement (CRADA) between Oak Ridge National Laboratory and several companies.
- The Microelektronik Centret (MIC) in Denmark is an academic research facility with 11 industrial collaborations including using microcantilevers for biodetection.
- Lots of activity in the research community for biodetection.
- Some companies are building or developing chemical or biosensors, but most of the companies are using microcantilevers for other purposes.

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- Some say 'GO!'.
 1. The \$700 billion/year healthcare industry.
 2. Homeland security agencies (federal to local) may use them.
 3. Synergistic relationship with manufacturing, *i.e.* improvements in chip manufacturing can improve the microcantilevers.
 4. Other challenges (*i.e.*, landmine detection) add incentives.

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- Some say 'MAYBE!'.
 1. It's expensive; about \$100 million to develop medical diagnostic tests.
 2. Drug companies won't want them.
New genetic tests could identify patients that will not benefit from the company's drugs and reduce sales.

"most interesting marketing question of the next decade"

*Samuel Colella,
Versant Ventures*

Science Policy and Education

- Policy-makers are in dire need of technical expertise in writing laws to evaluate national security threats, handle privacy, and regulate medical diagnostic testing.
- People are hungry for information.
- An educated electorate is essential.
- Training the populace could save lives in the event of an attack.
 - Panic will amplify the effect of an attack.
 - Panic is greatly diminished when people receive training.

Summary and Conclusions

- When assessing threats keep the three rules in mind.
 1. How does the weapon hurt us?
 2. How does an opponent obtain and deliver it?
 3. How can we respond?
- Ant algorithms are a promising tool for sifting through data to gather intelligence and prevent a terrorist attack.
- There are significant privacy issues.
- Microcantilever sensors are a promising sensor technology for biodetection.
- It's not clear if the economics is favorable.