Micropower Impulse Radio [MIR] (U)

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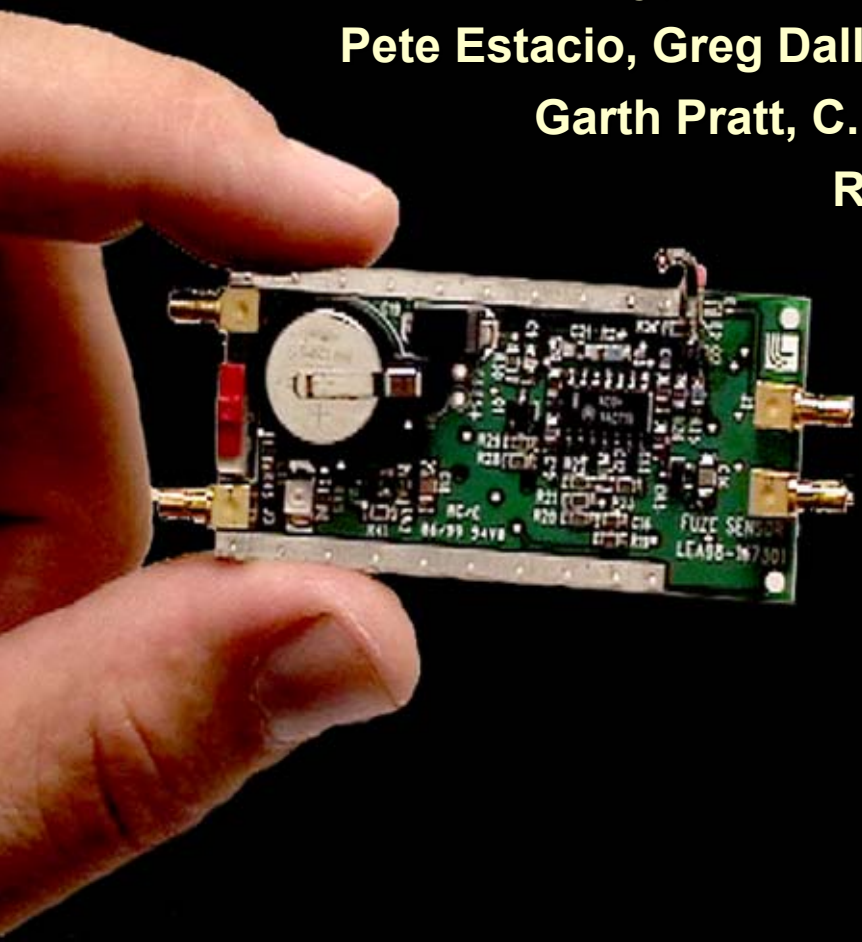

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Outline

Introduction

Wideband wireless technology

WTC Response

Applications

Conclusions

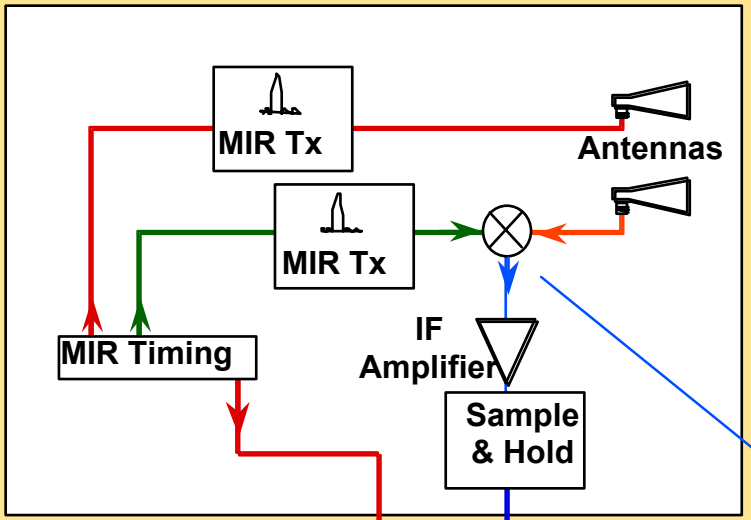
- Motion Sensing
- Breathing Sensing
- Heartbeat sensor
- Security Shell
- Electronic Tripwire
- Rifle Sensor
- Aimpoint Sensor
- Shipment Security Sensor System (LS4)
- Satellite security Sensor
- Proximity Fuze
- Satellite Approach Sensor
- Through-Wall Position Sensor
- Imaging Sensor
- HERMES Bridge Inspection

LLNL was created to design and test nuclear weapons

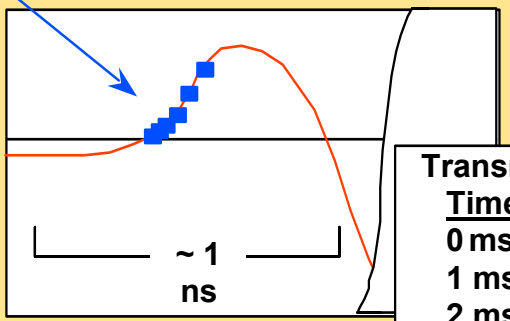
- Multidisciplinary laboratory - Engineers and physicists developing technology in a (secure) university setting
- Impulses from the beginning - Electric impulses were used to initiate nuclear events and electromagnetic impulses result

- Accept the big challenge - Over 7000 technical personnel and over $10B in capital facilities means LLNL can tackle large complex projects

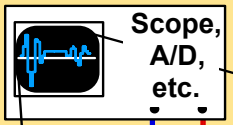
Simplified MIR block diagram showing gated receiver

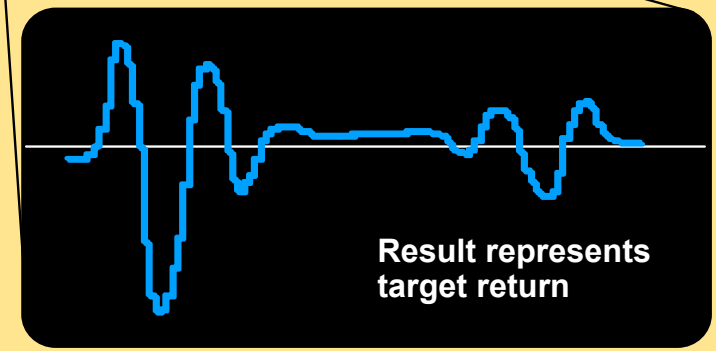


Gated mixer "clocks in" the return waveform at increasing intervals (~10 ps)

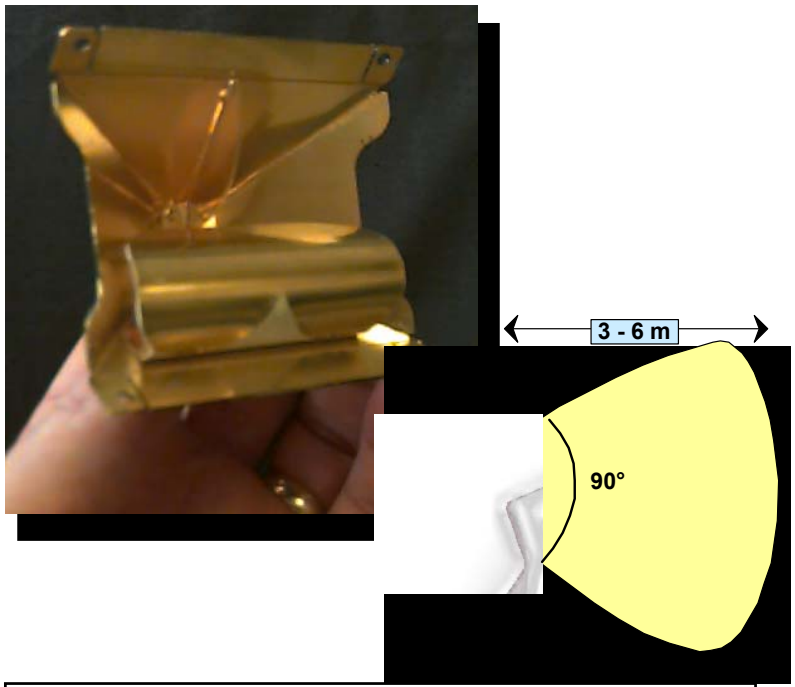


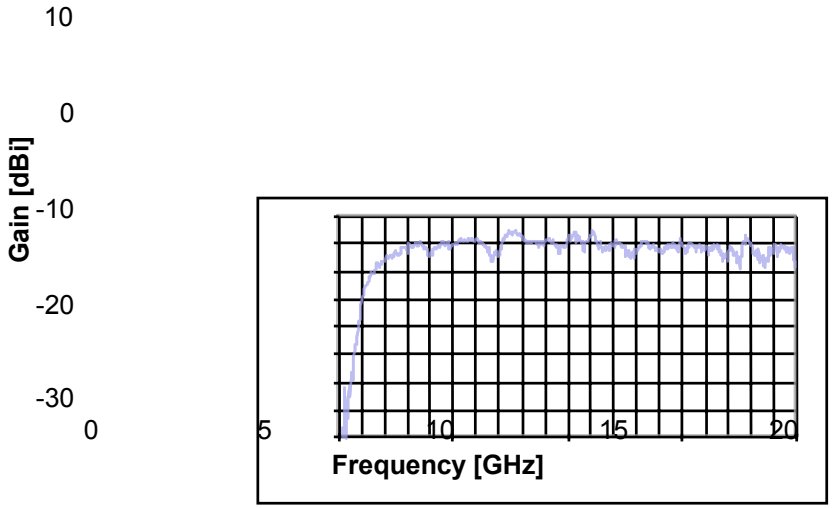
Transmit Time	Receive Time
0 ms	0 ms + 10ps
1 ms	1 ms + 20ps
2 ms	2 ms + 30ps
•	•
•	•
•	•

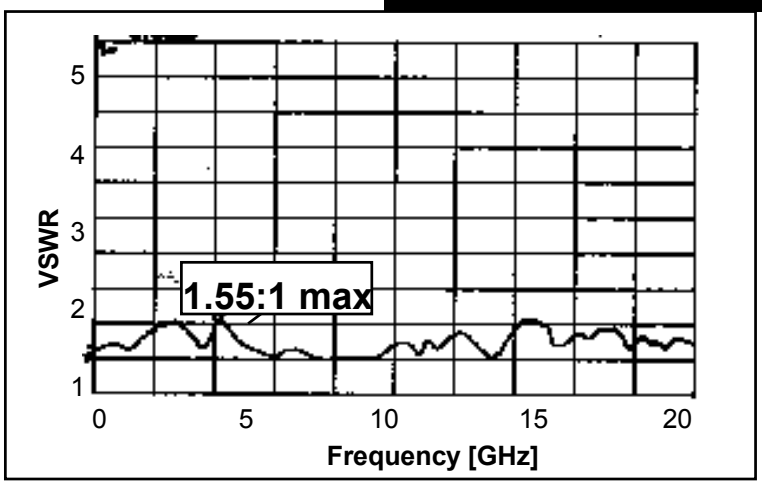




LLNL developed high performance antennas for micropower impulse radar applications







Features:

Wideband (1.5 - 20 GHz)

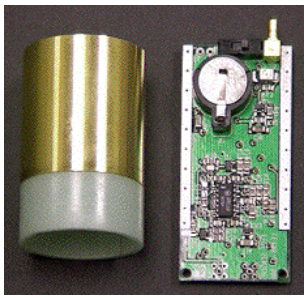
Impulse (50 Ω match, DC - 20 GHz)

Beamwidths 15° to 360°)

Compact (e.g. 3 in x 1.7 in for 90°)

Lightweight (45 g)

Primary Advantages - Stealth and Low Power



Watch battery

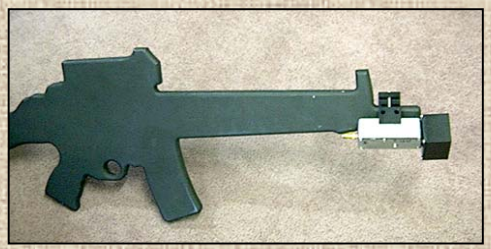
9V battery

- Wideband signals are virtually undetectable
- Tested at top USN, Army & Luga facilities - no detection!
- Religion is “Small, Light & Cheap”
- Many other advantages derive from using impulses...

Emergency Response to the WTC Attack

Sensor Search and Rescue Efforts
Sept 13-Sept 19

Three sensors were used at the WTC site



Key Features

- Detects breathing
- Battery Operated (1 hr)
- Visual LCD display
- Two-piece unit

- Detects Motion
- Battery Operated (6 days)
- Visual LED display

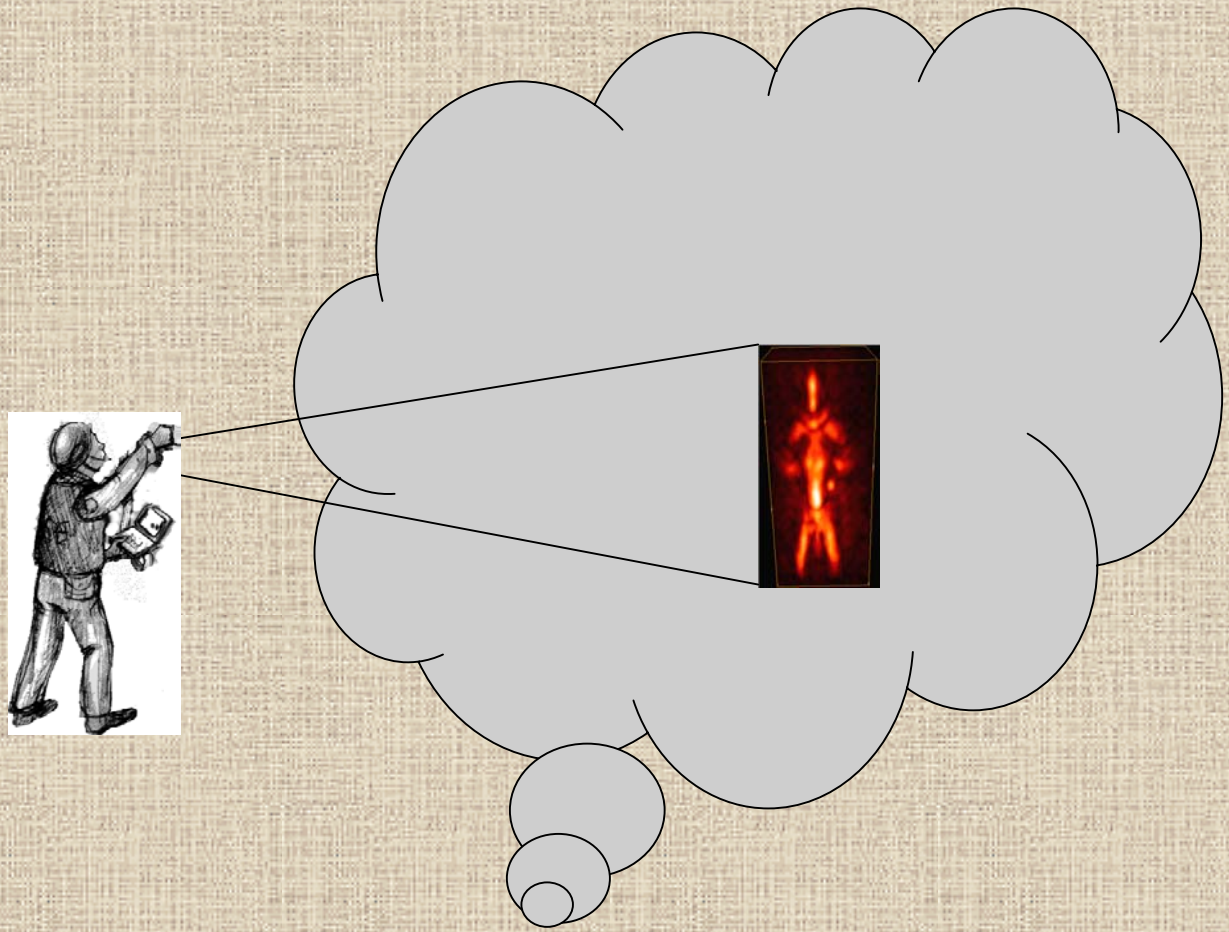
- Detects Motion
- Battery Operated (6 days)
- Visual LED display
- Water-resistant

What's next ...

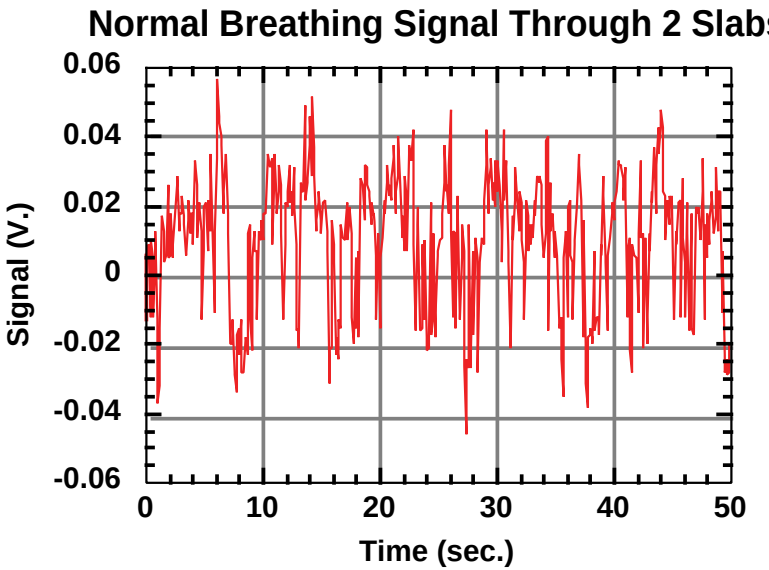
MIR could indicate motion inside

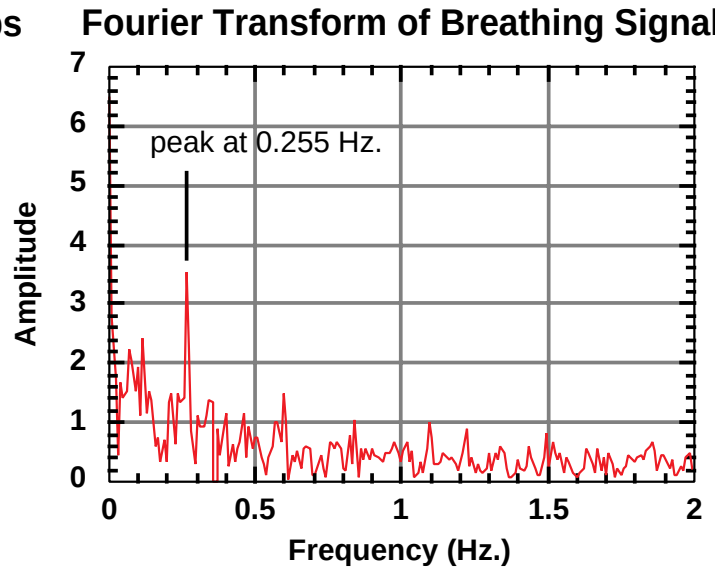
70% of urban assault casualties occur at the entrance

Squad tool could also see through smoke or sheetrock walls

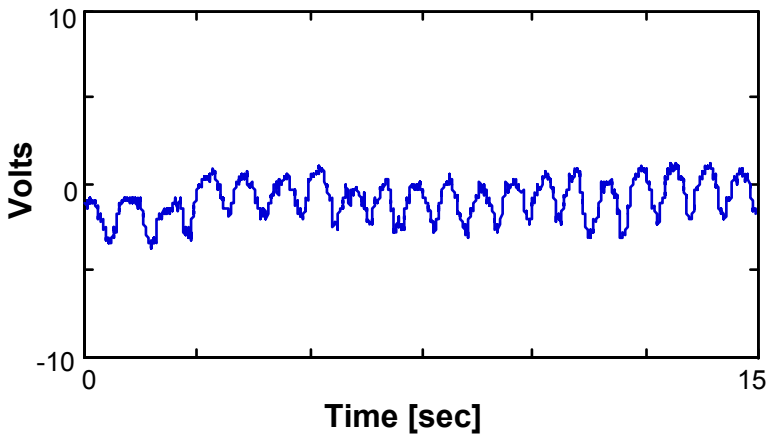


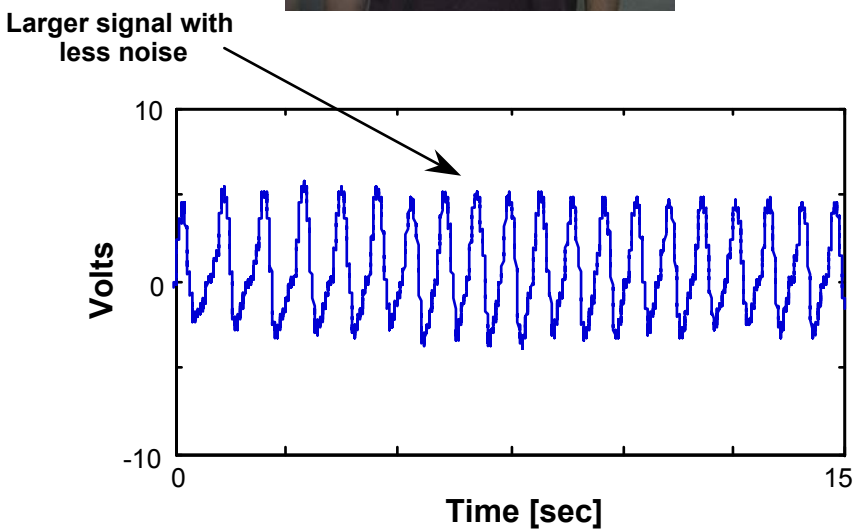
Detection of breathing signals through reinforced concrete using the Rubble Rescue Radar



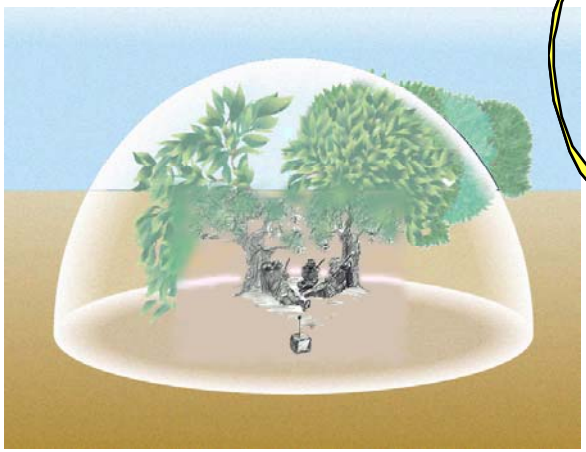


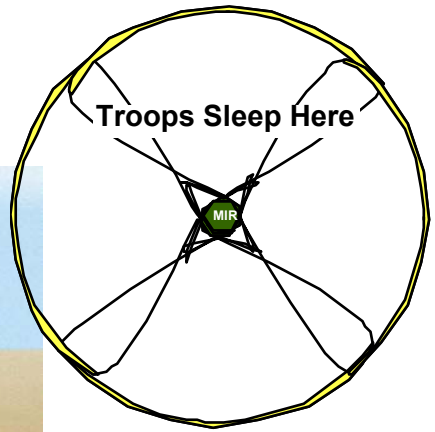
Dielectric antennas improve MIR heart monitor signal response and reduce package size



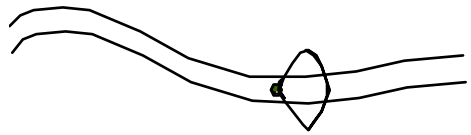


Each MIR covers 90° azimuth and might have multiple uses

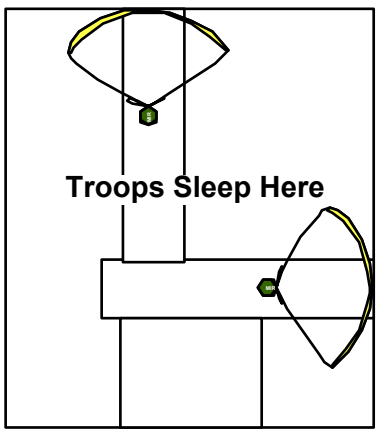




Four MIR's Form 360° Bubble



Individual MIR used for Trail Ambush or Trap



Individual MIR's Gaurd Building Access

Range gate provides precise protective "bubble"

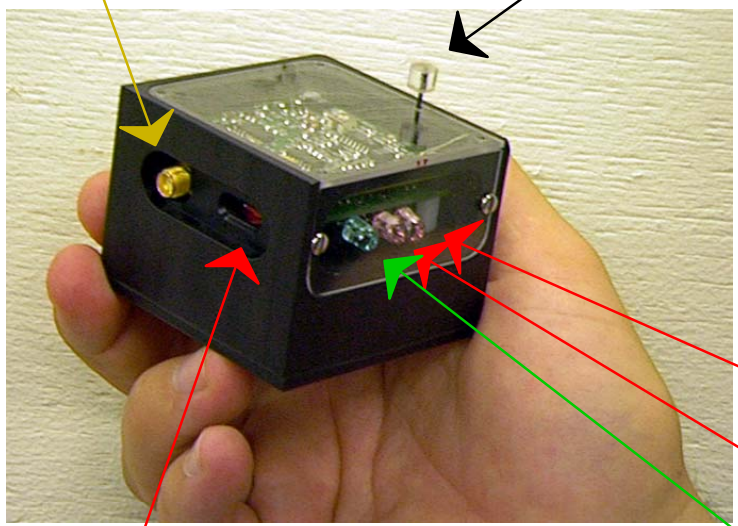
"Stealthy" signal is difficult to detect

Quadrant sensor could protect sleeping troops

LLNL electronic trip-wire

Contact closure
(120Ω)

Pull pin
(starts timer)



Off-On switch

Indicator LED's

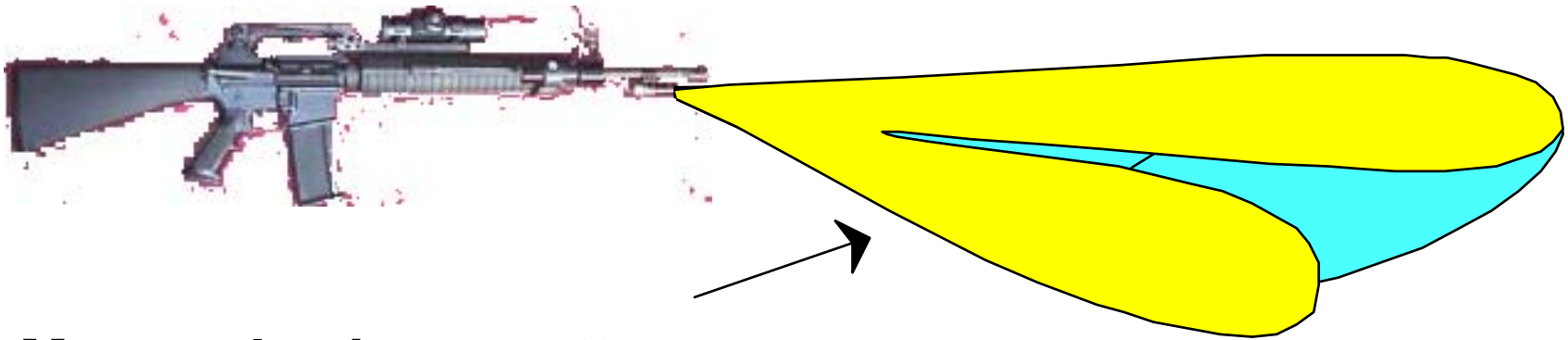
- Second red = Fire
- First red = Armed
- Green flashing = Timer started

70% of urban assault casualties occur at entrances

ISS might detect interior motion through closed doors

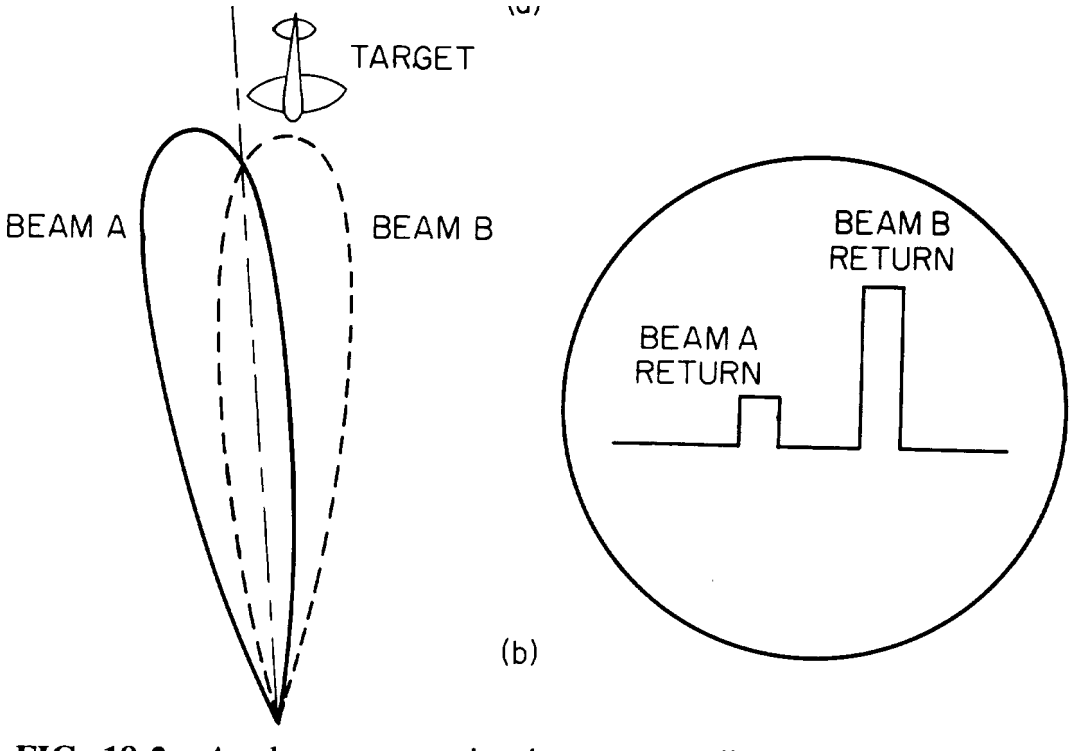
Multichannel system may allow point and shoot capability

Today: sense motion (4’ - 100’)

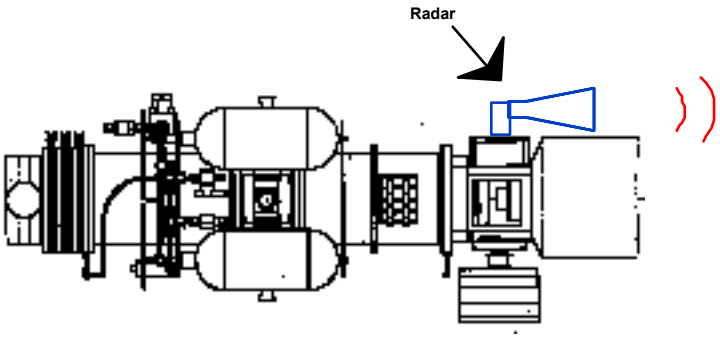


Monopulse beampattern
used for precision pointing

Monopulse works by subtracting the two beams and driving a control loop to zero

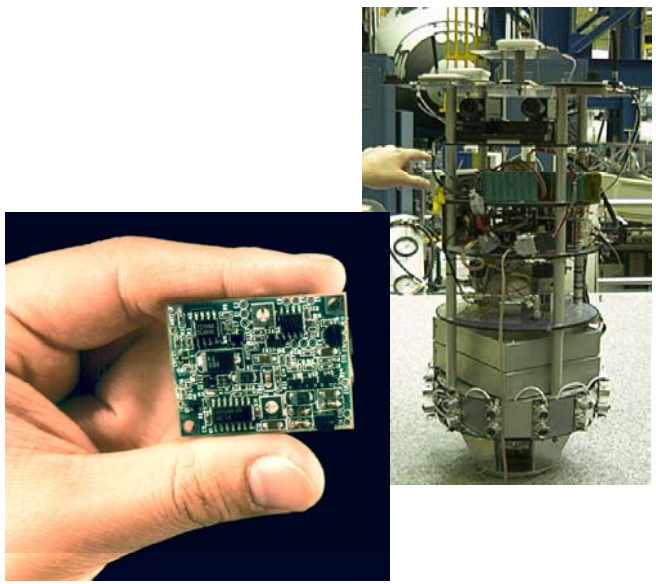


Micro-power impulse radar may be modified for use aboard autonomous space vehicles for precise ranging



Precise position is important:

- **For collision avoidance**
- **For remote or autonomous control**

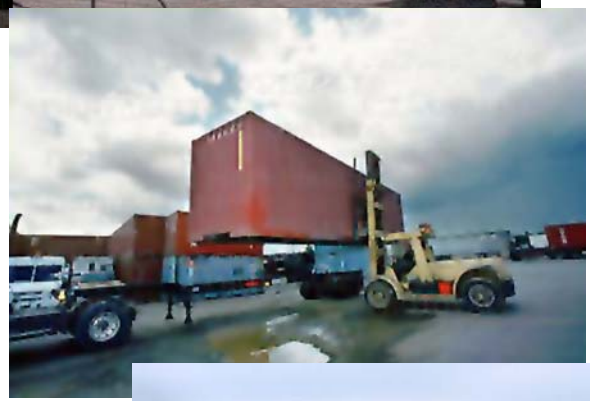


MIR's precise position measurement capability may provide a solution

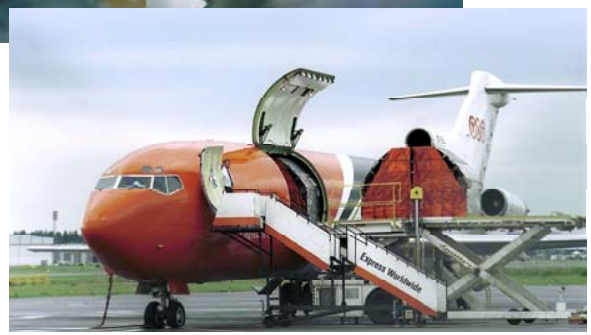
- **Low cost**
- **Low Power**
- **Rugged and compact**

Majority of off-shore gross tonnage is containerized and is currently not protected from WMD shipments

Sea - Nearly standard shipping containers

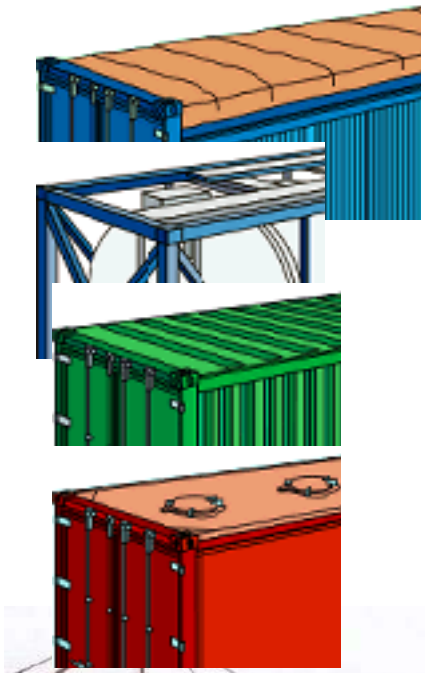


Land - Large shipping containers

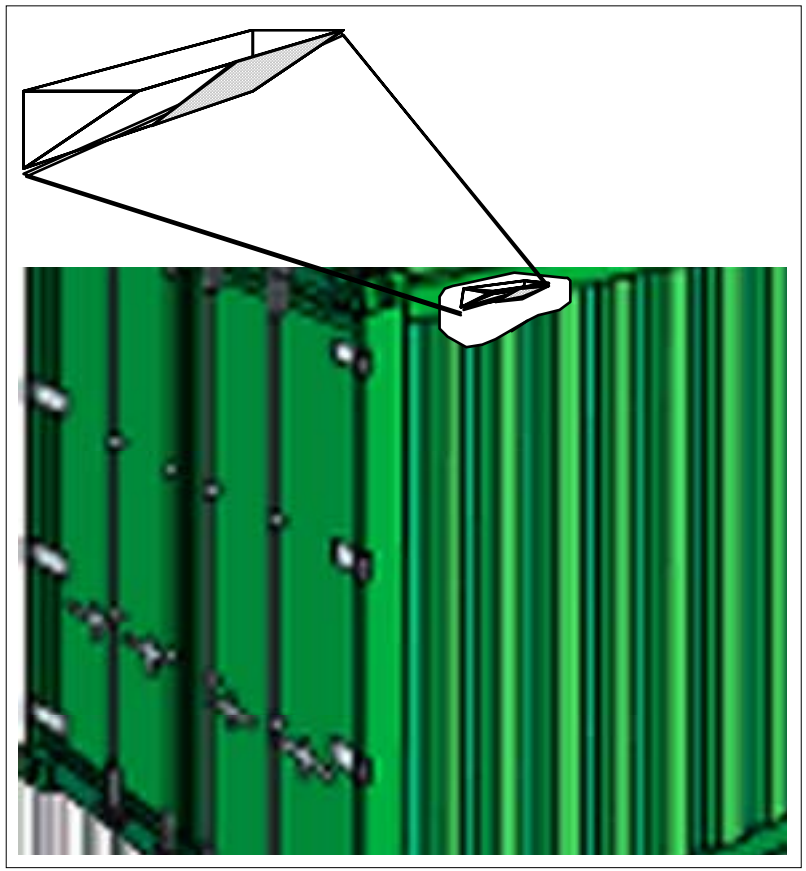


Air - Shipping containers

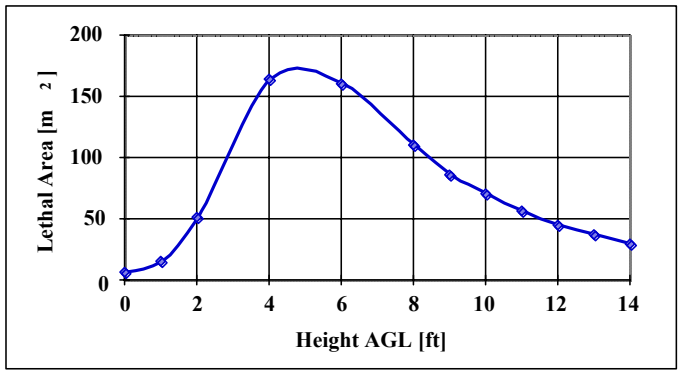
LLNL Shipping Security Sensor Suite (LS4) could provide onboard sensing for shipping containers and trailers



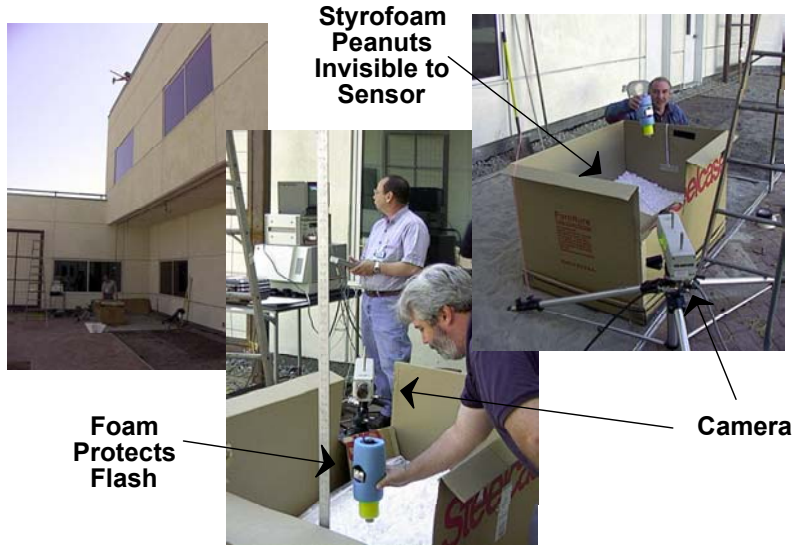
LS4 could be small, unobtrusive and fit the variety of containers in industry

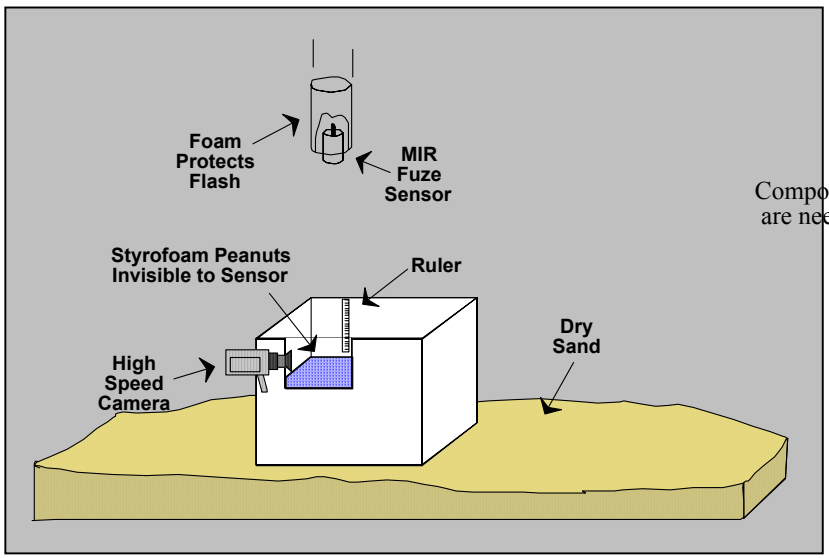


Proximity fuze sensor demonstrates revolutionary capability for small munitions



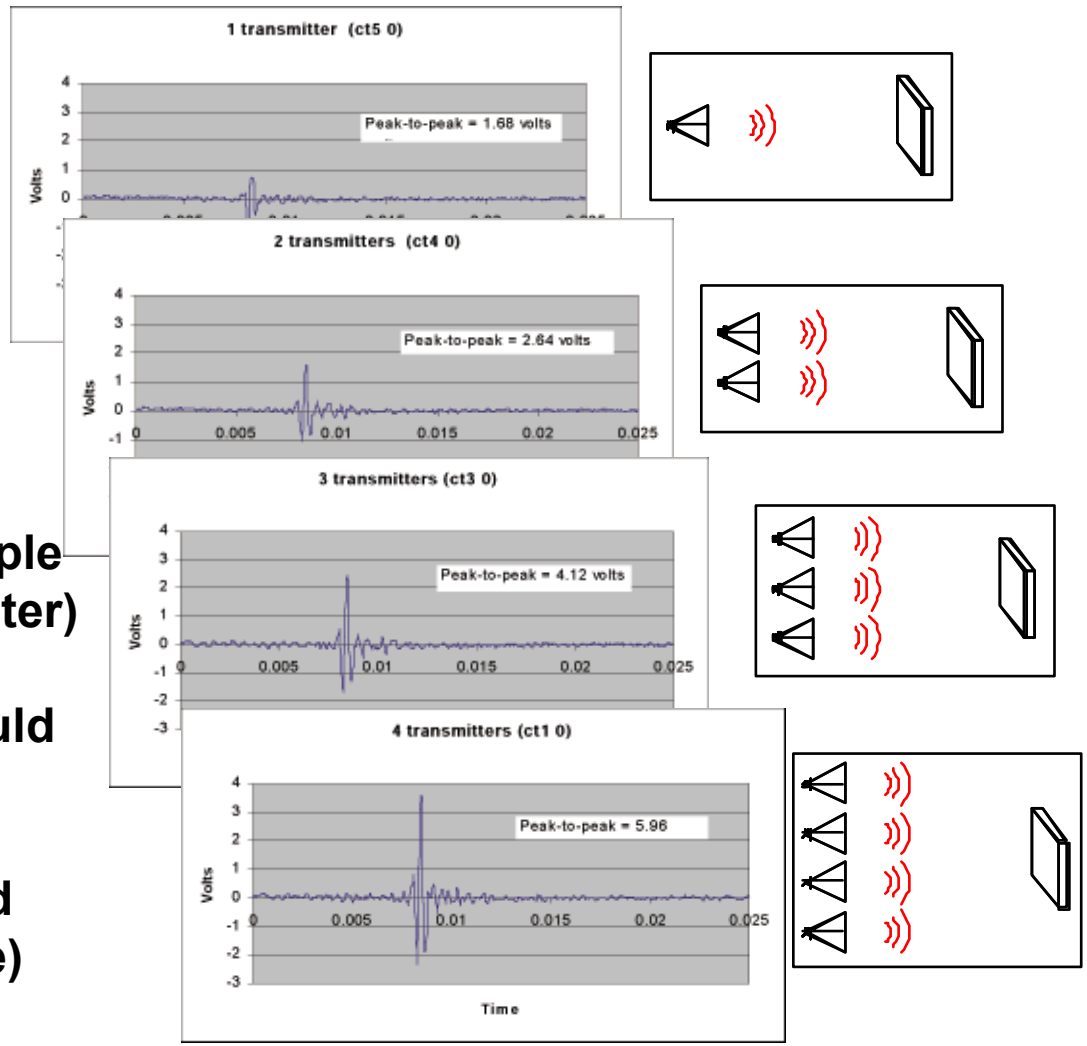
Lethality increases dramatically with burst height





QuickTime™ and a Component Video decompressor are needed to see this picture.

Coherent pulse addition has been demonstrated



- Alignment achieved with simple variable resistor (potentiometer)
- High-speed, low-cost A/D could be used for time alignment
- Scalable technique (unlimited number of elements possible)

Wideband Radar Imaging: Simulation Showing Detection & Imaging Capabilities of Motion Through Walls

Simulation parameters

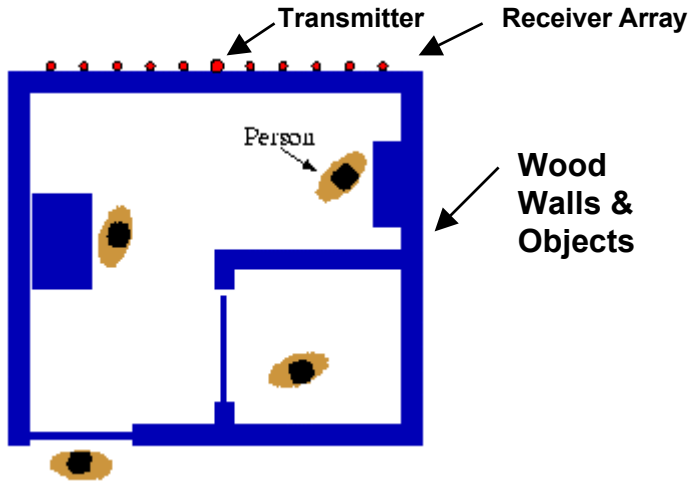
Radar access from outside of one wall

Room size: 3 x 3 meters

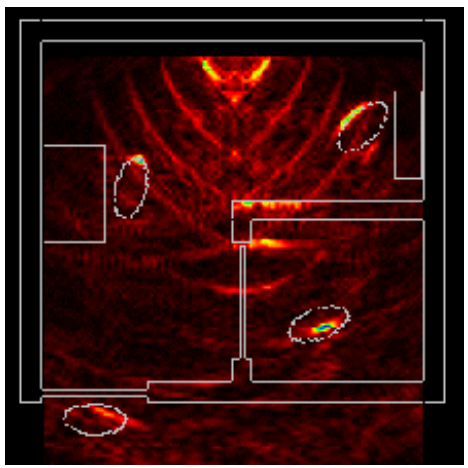
Motion of people is less than 1 cm

Bistatic data acquisition

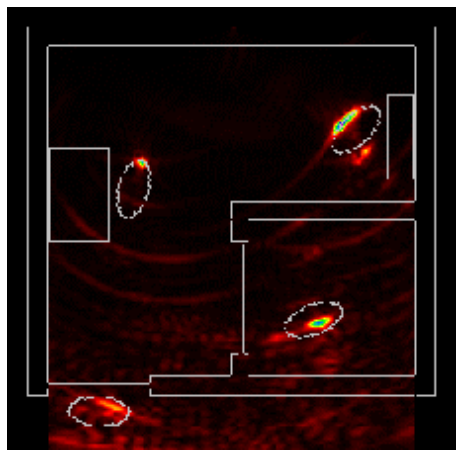
- **single transmitter**
- **linear array of receivers (100 elements)**
- **frequency band: 1 GHz to 4 GHz**



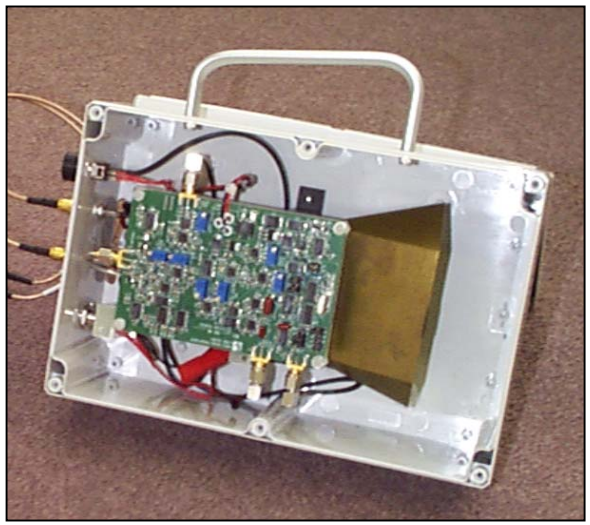
Radar Image of Stationary Scene



Radar Image of Motion Only

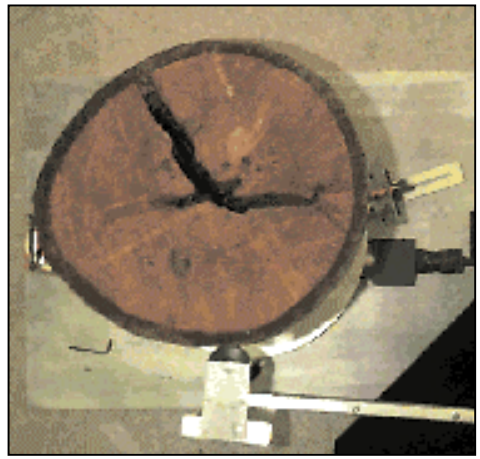


Hand-held Impulse Radar for NDE

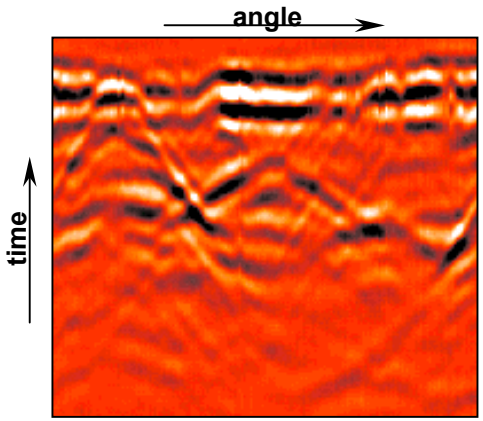


Radar imaging of a utility pole

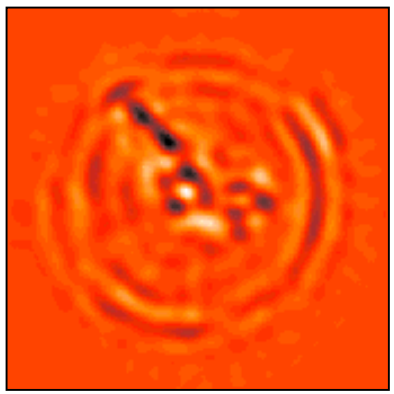
Rotational Stage Testbed



Utility pole containing a fissure



Radar data from a 360 degree circular monostatic scan of the utility pole



Reconstructed slice of utility pole clearly shows the fissure

FHWA

"HERMES will revolutionize the way bridge inspection is done…" Erol Kaslan, Caltrans

Old inspection method

"Listen" for damage

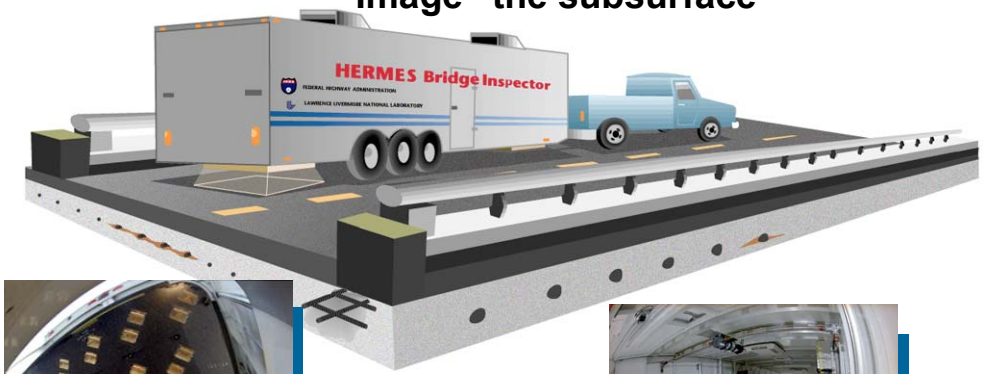
Remove asphalt

Drag chain

- Destructive and costly
- Requires closure of bridge (inconvenience)
- Poor resolution (feet)

New inspection method

"Image" the subsurface



Radar array

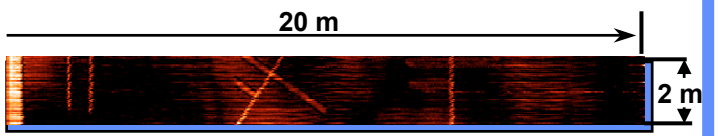
- Non destructive and inexpensive
- Travels at highway speeds
- 1-inch resolution in 3D to 1-foot depth

Estimated savings in U.S. = $25 million dollars per year. Target the critical bridges; reduce unnecessary repairs.

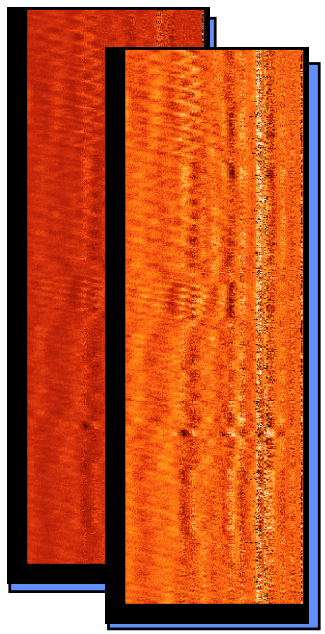
FHWA

HERMES uses 64 impulse radars to scan the bridge deck at highway speeds

Calibration phase

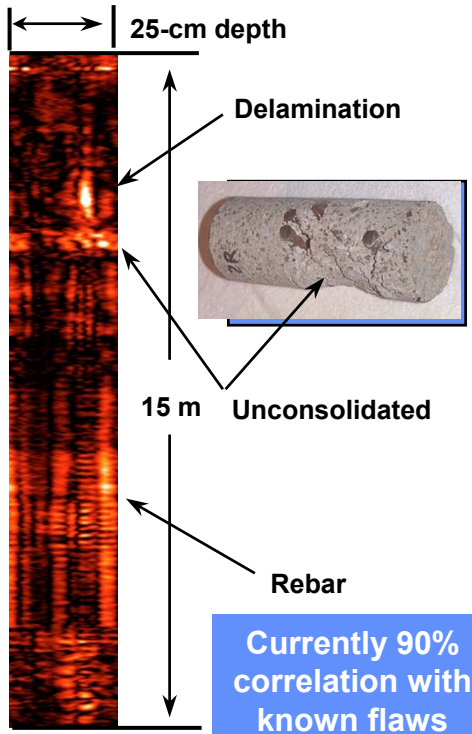


Acquisition phase

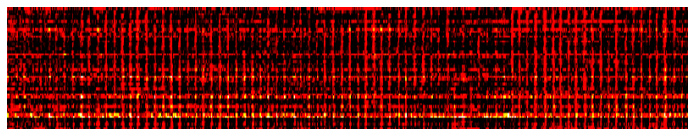


64 channels of raw data

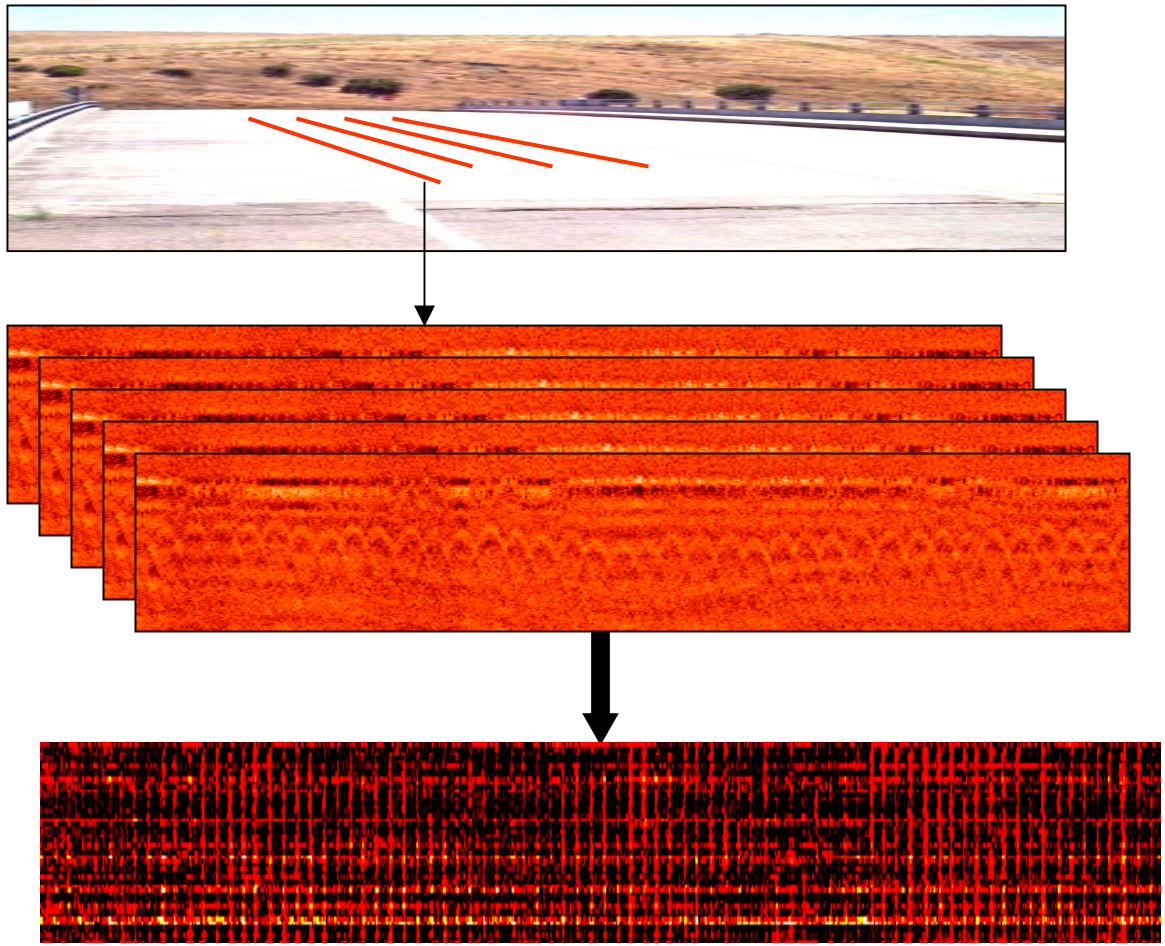
Analysis phase



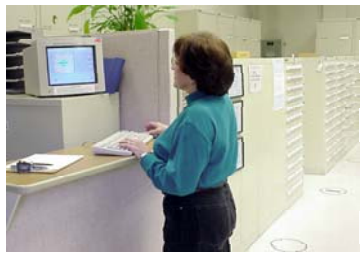
Currently 90% correlation with known flaws



Radar 3D tomographic imaging



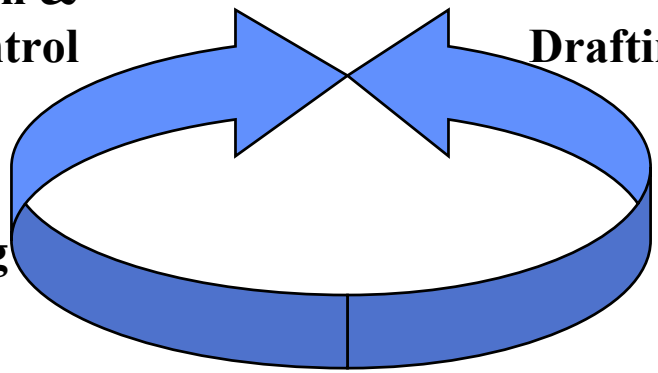
LLNL's Engineering Support Department



Engineering Support

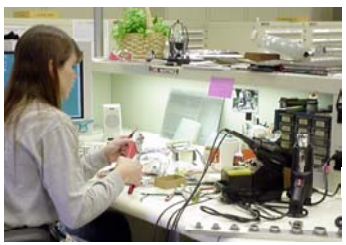
Coordination &
Quality Control

Drafting & Phototooling



Special Processing

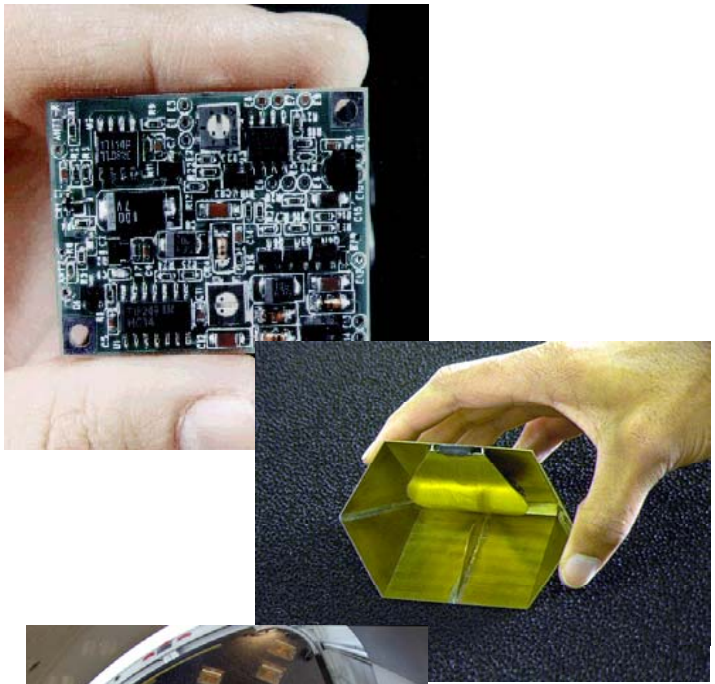
Rapid Prototype
Service Centers

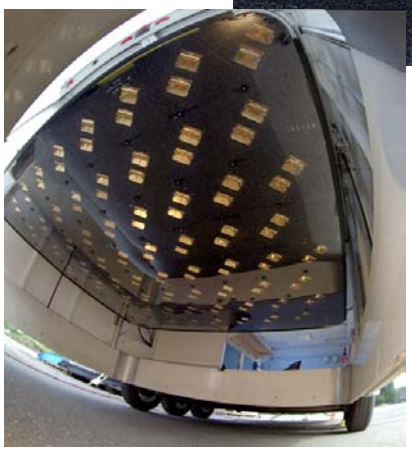


Instrumentation &
Control Systems
Development

Field Support
Installation/Electronics

Summary





We would like to participate

- **Patented technology**
- **Resources**
  - **Management experience**
  - **Technical talent**
  - **Advanced engineering facilities**
- **Experience in:**
  - **Microwave system development**
  - **GPR arrays & SAR imaging**
  - **Communications**
  - **Diagnostic & Instrument Devp't**
  - **Commercializing when complete**