UWB SAR

Ultra-Wideband Synthetic-Aperture Radar

Final Presentation

Thu Truong, Michael Jones, George Bekken

Outline

- Team
- Senior Design Goal
- UWB and SAR
- Design Specifications
- Design Constraints
- Technical Approach
- Work Breakdown Structure
- Schedule
- Budget
- Open Floor

Team

Thu Truong
Graduation: May 2013

George Bekken
Graduation: May 2013

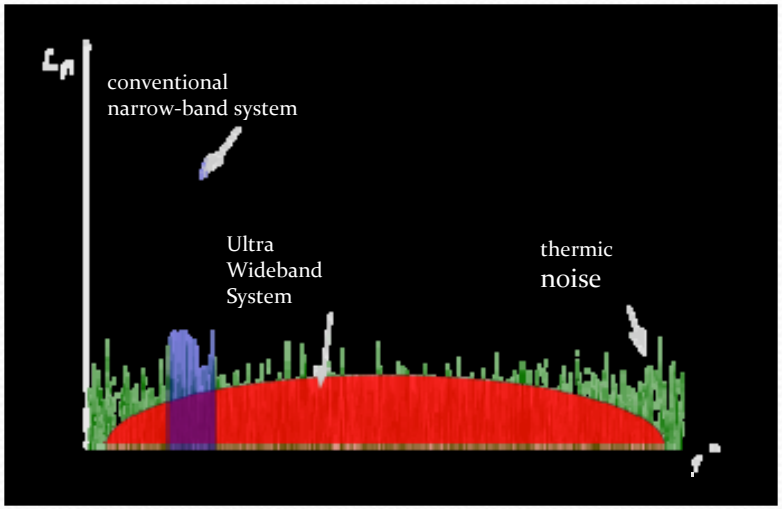
Michael Jones
Graduation: December 2012

Senior Design Goal

- Indoor radar imaging
- Combine ultra-wideband technology and synthetic aperture radar
- “See-through-wall”

UWB – What is it?

- Ultra Wideband Radio
  - Uses wide frequency bandwidth
  - Low power spectral density
  - Almost no regulation
    - Don't need a license to use
    - Can use indoors
    - Can safely use around people

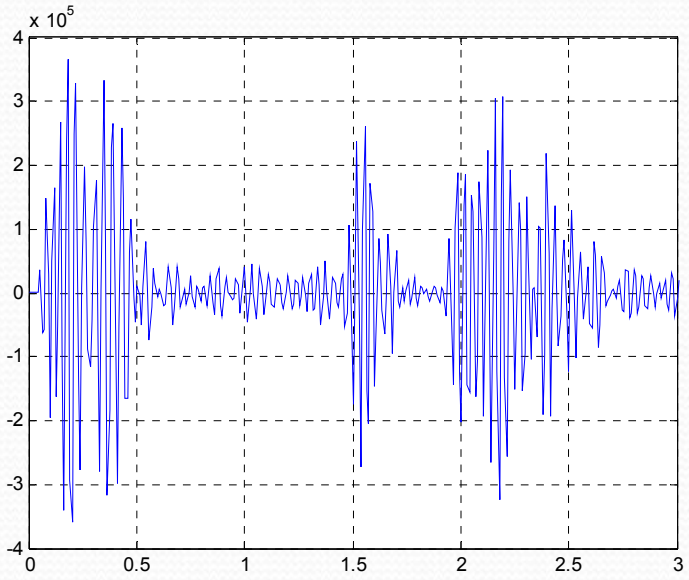


Our Radar

- PulsOn 410 module
  - Developed by Time Domain
  - 4.3 GHz center frequency
  - Transmits across 2.2 GHz bandwidth

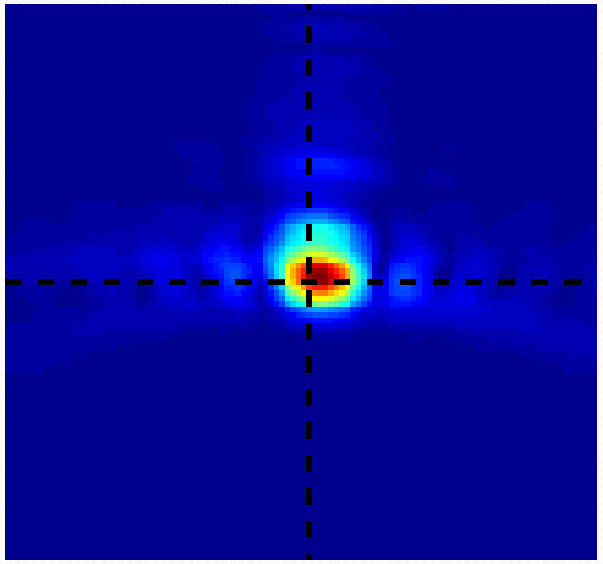
Radar Scans

- Radar Signal
  - Pulsed output for this project
- Transmit pulse
- Wait
- Receive pulse
- Correlate time to distance
- Can find objects by increased power (spike) on scan



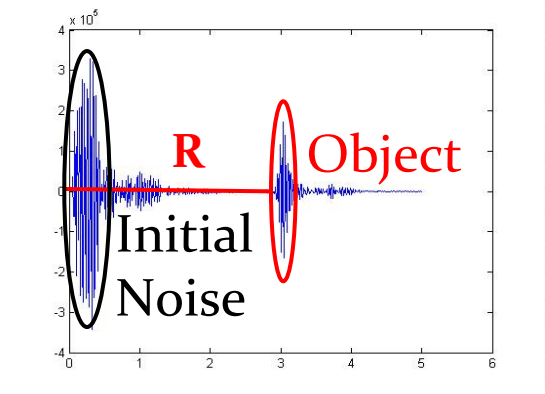
Radar Imaging

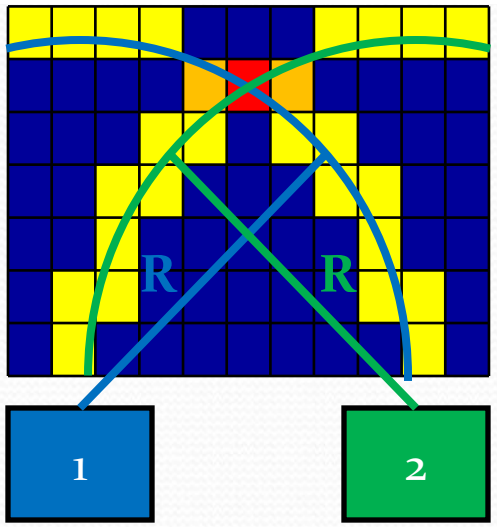
- Radar scan is one dimensional
- Want a two dimensional image
- Combine several scans
  - Precise location of each scan
  - More scans improves image quality
- Type of imaging
  - SAR
    - Moving radar
    - One set of antennae
    - Combine scans from different locations

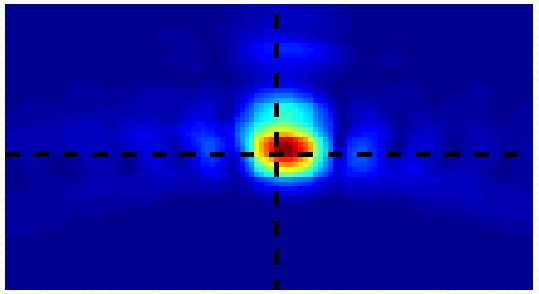


SAR – How It Works

- Take scans at different positions
  - Need to know the distance between two scans as precisely as possible
- Create an imaging grid
  - Calculate distance between radar and each grid point
  - Map out scan into grid points
- Overlay scans on each other
  - Values are added together to form relative intensity plot
  - More scans make the image more clear







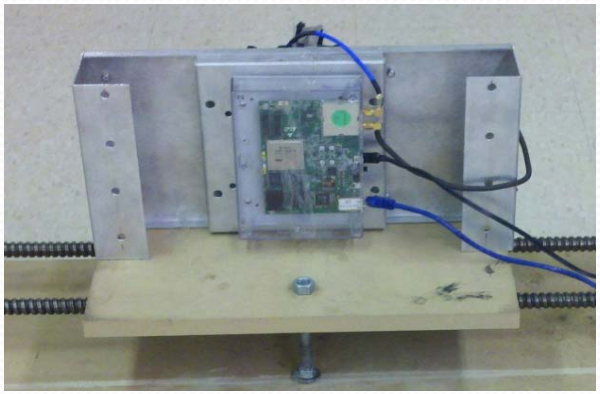
Design Constraints

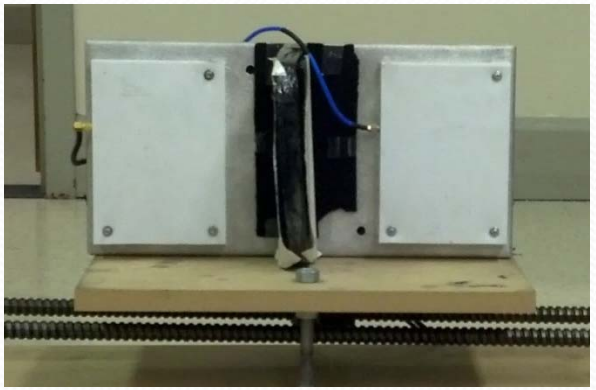
- High Initial Cost
- Cluttered Environment
- Legal and Health Issues
  - Will radar be legal?
  - Will radar be safe?

- Social Issues
  - Advantages
    - Search and rescue missions
    - Hostage negotiations
  - Disadvantages
    - Low power
    - Limited range

Design Specifications

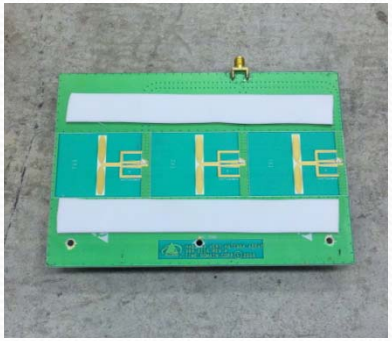
- Software
  - MATLAB Code
  - Stepper Motor Driver Code
  - Autohotkey Code
- Hardware
  - Radar
  - Antenna Type
  - Housing or No Housing?
  - Track





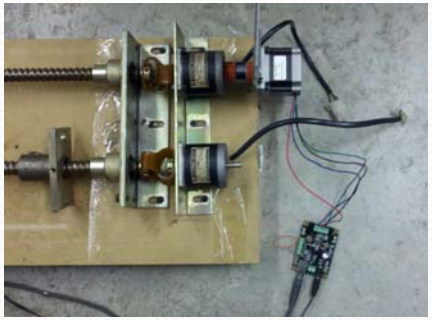
Our Journey

- Suppressing initial noise



- Different antenna types

- Mobile platform



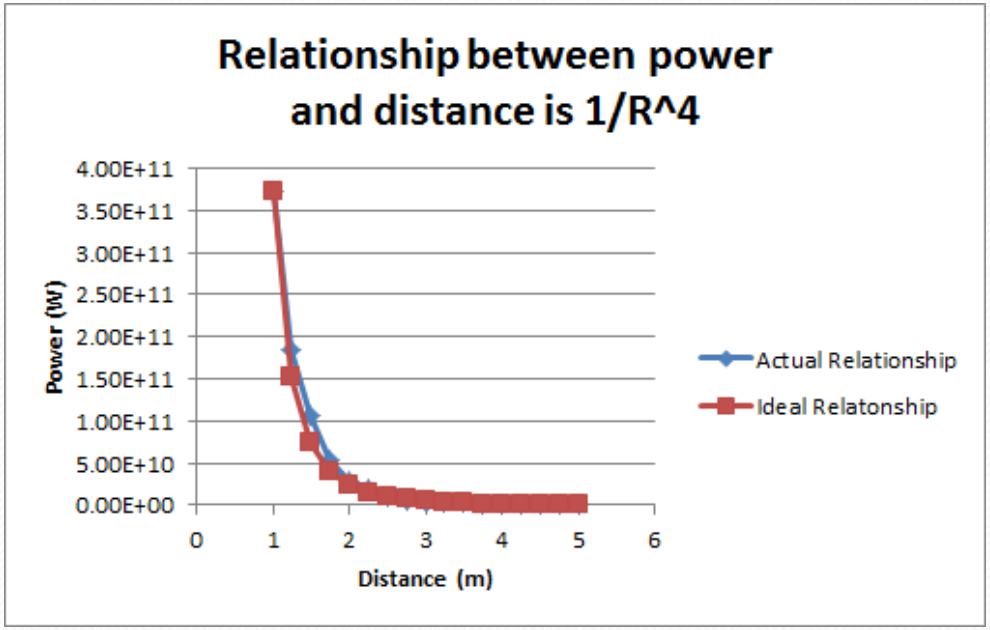
Radar Range Equation

$$P_r = \frac{P_s * G^2 * \sigma * \lambda^2}{(4\pi)^3 * R^4}$$

- P_r = received power (W)
- P_s = transmitted power (W)
- G = antenna gain (dB)
- σ = radar cross section of target (m^2)
- λ = wavelength of signal (m)
- R = distance of target from radar (m)

Normalized Power vs distance

Distance	Actual	Ideal
1	1/1	1/1
2	1/13.3	1/16
3	1/104	1/81



Down Range Resolution

- Down Range Resolution is calculated as:

$$\Delta r = \frac{c}{2B}$$

- Where c = speed of light (3.0×10^8 m/s)

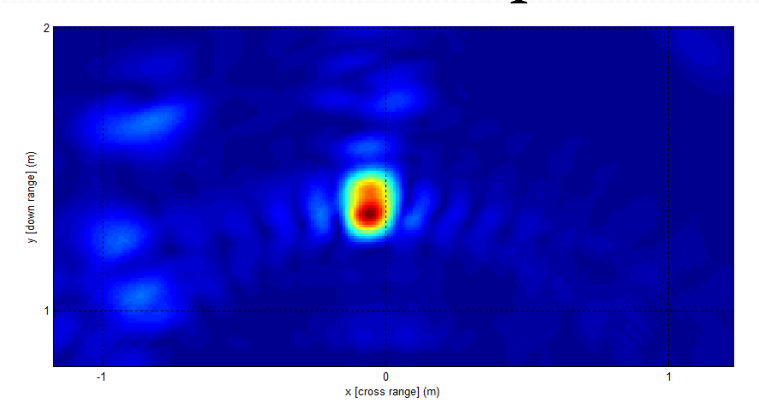
  B = bandwidth (2.2 GHz)

- For the PulsOn 410, the down range resolution is

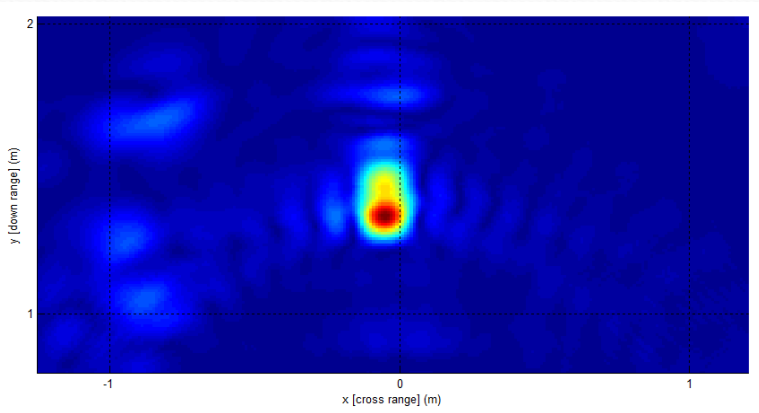
$$\frac{3.0 * 10^8 \, m/s}{2*(2.2*10^9 \, Hz)} = 6.82 \, cm$$

Down range resolution

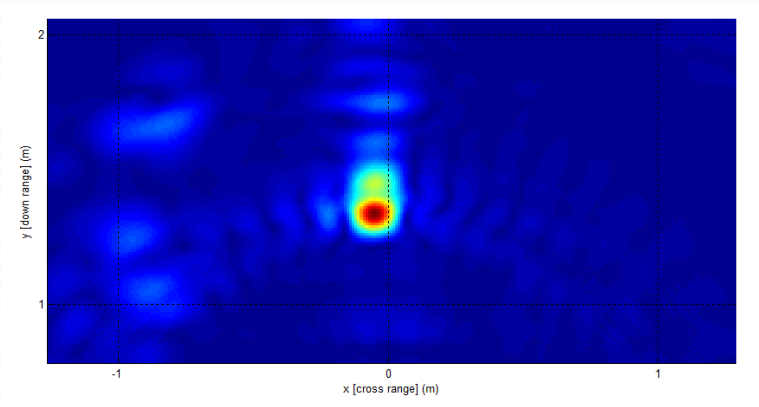
At 3 cm apart



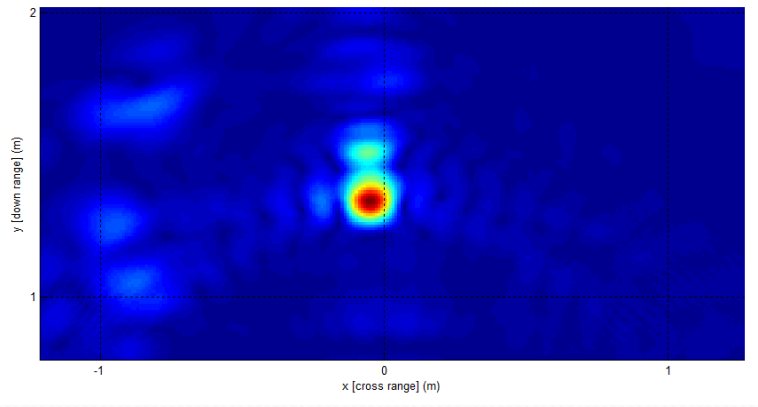
At 6 cm apart



At 7 cm apart



At 10 cm apart



Cross Range Resolution

- Cross Range Resolution for SAR is calculated as:

$$\Delta cr = \frac{\lambda R}{2 \times SA}$$

- Where λ = wavelength of signal (0.069767m)

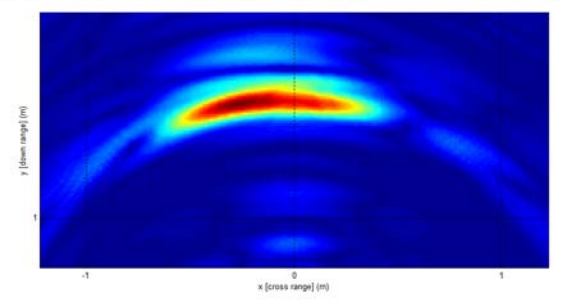
  R = Range of target

  SA = synthetic aperture created by moving radar

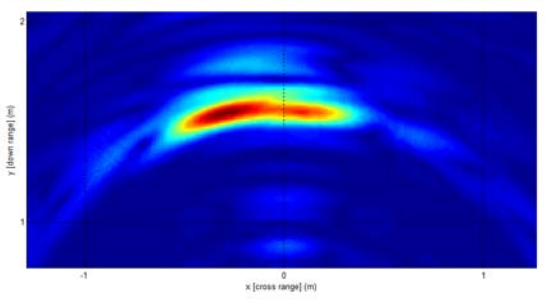
- By increasing the synthetic aperture, you can improve the cross range resolution (resulting in a clearer image)

For R=1.5m and Δcr = 35cm

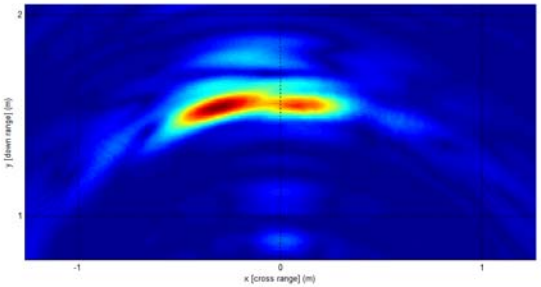
SA = 11 cm



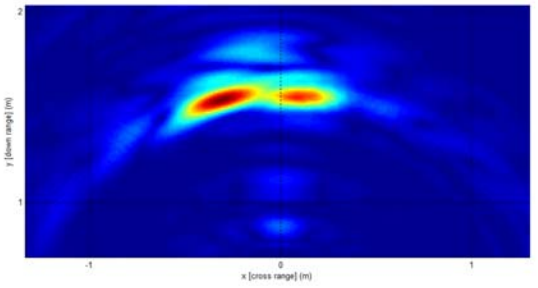
SA = 13 cm



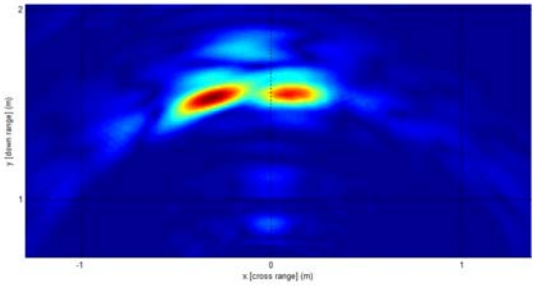
SA = 15 cm



SA = 17 cm

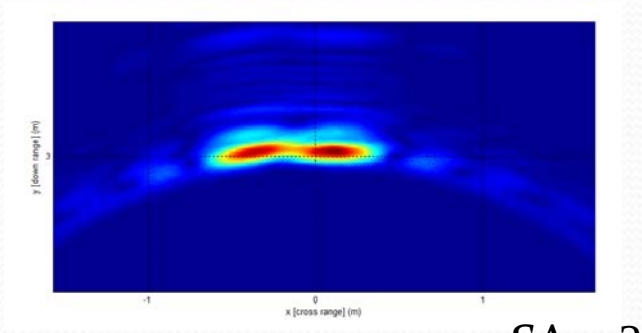


SA = 19 cm

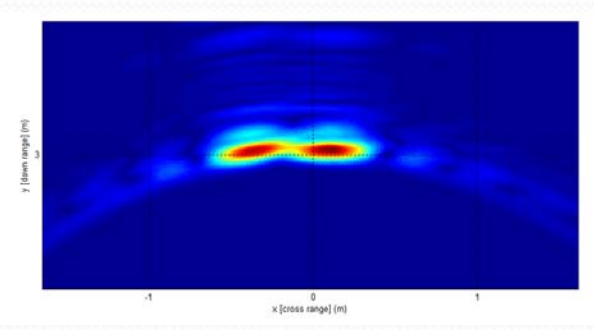


For R=3.0m and Δcr = 35cm

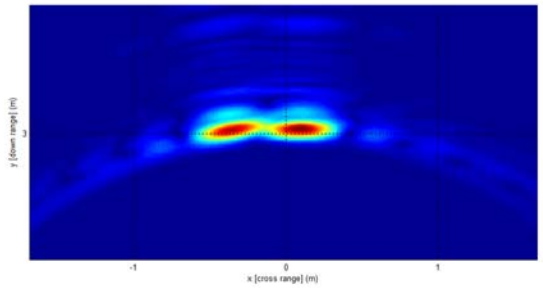
SA = 26 cm



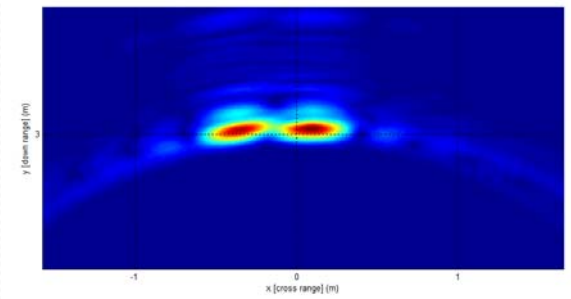
SA = 28 cm



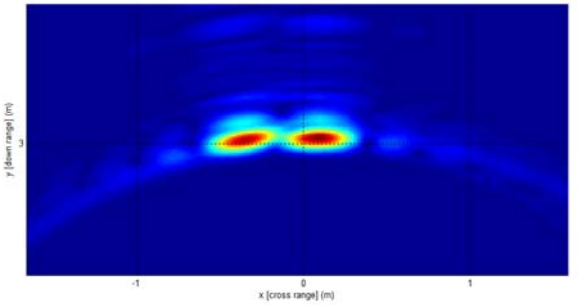
SA = 30 cm



SA = 32 cm

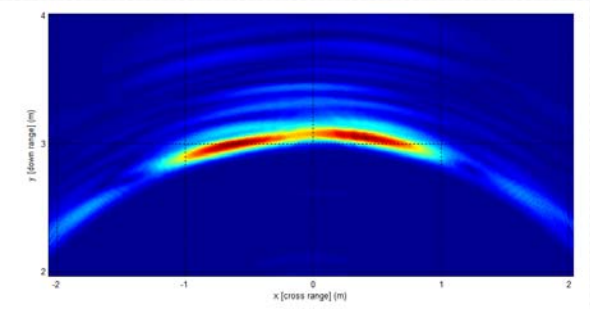


SA = 34 cm

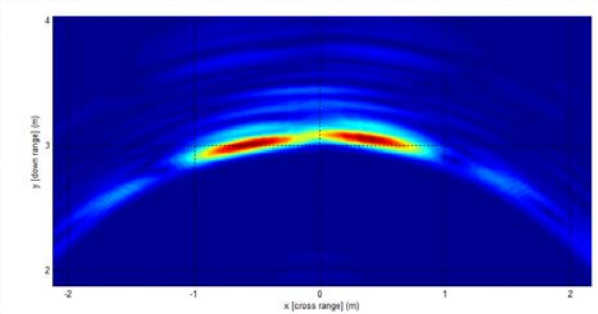


For R=3.0m and Δcr = 70cm

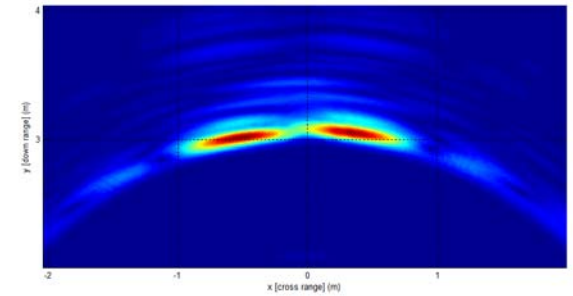
SA = 11cm



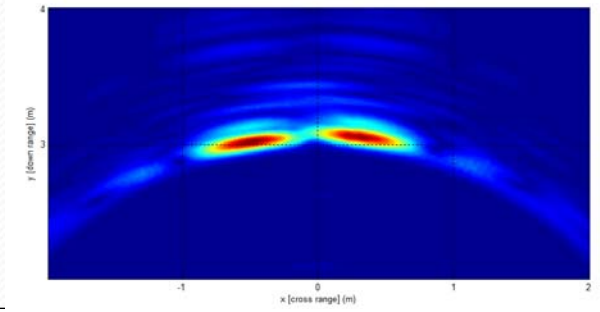
SA = 13cm



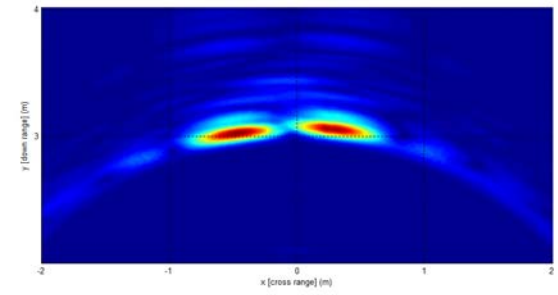
SA = 15cm



SA = 17cm

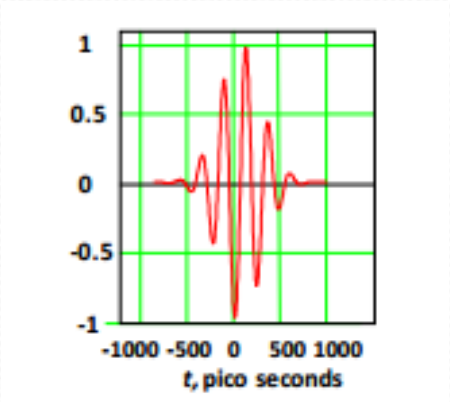


SA = 19cm



The Sidelobe Phenomenon

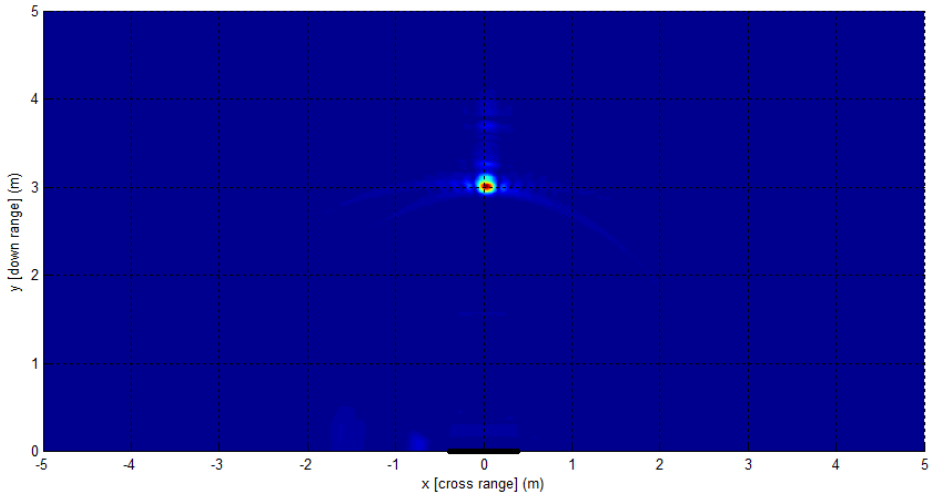
- Distance between scans affects sidelobe appearance



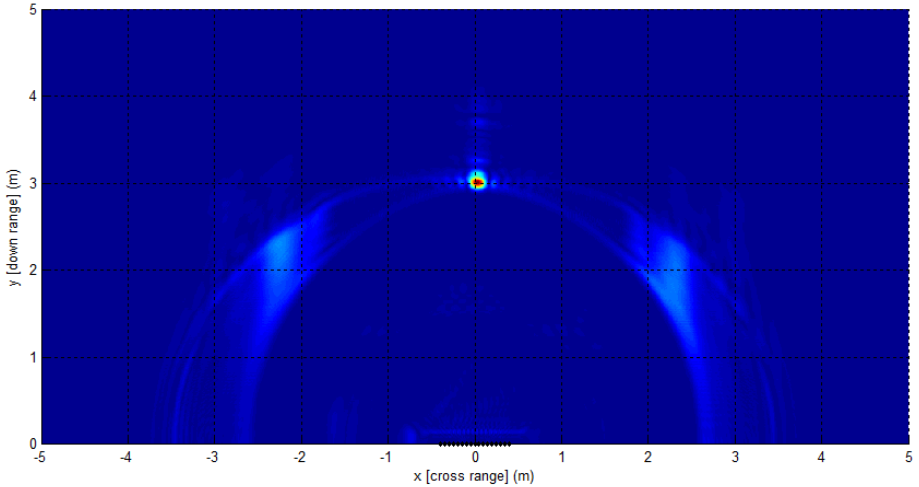
- Greater distance between two pulses results in phase differences that create destructive and constructive interference

Metal Sphere at 4 m

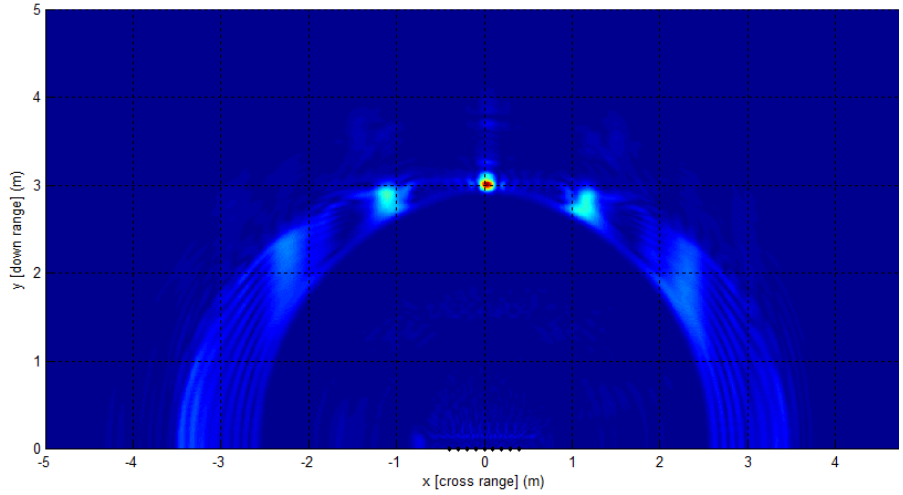
Scans every 1 cm



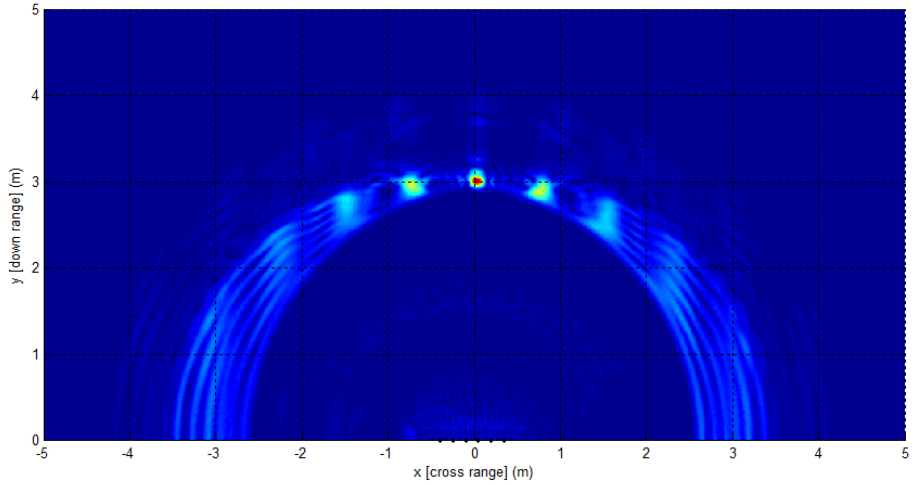
Scans every 5 cm



Scans every 10 cm

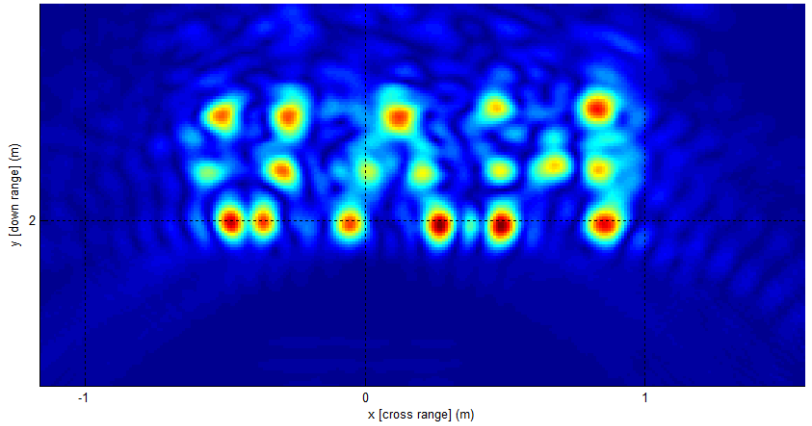


Scans every 15 cm

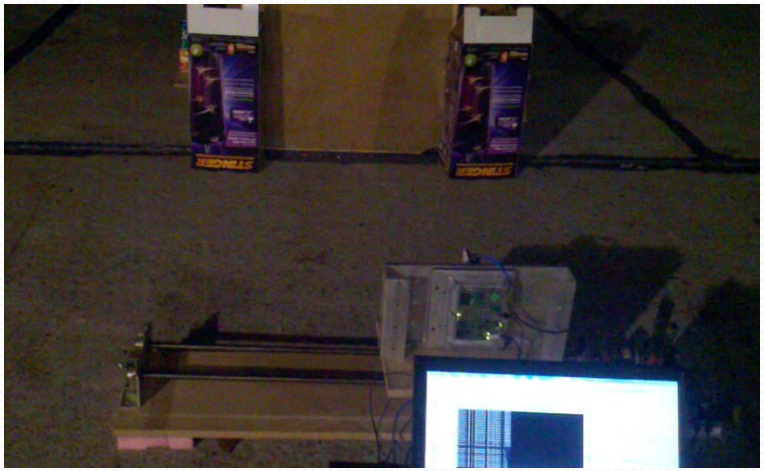


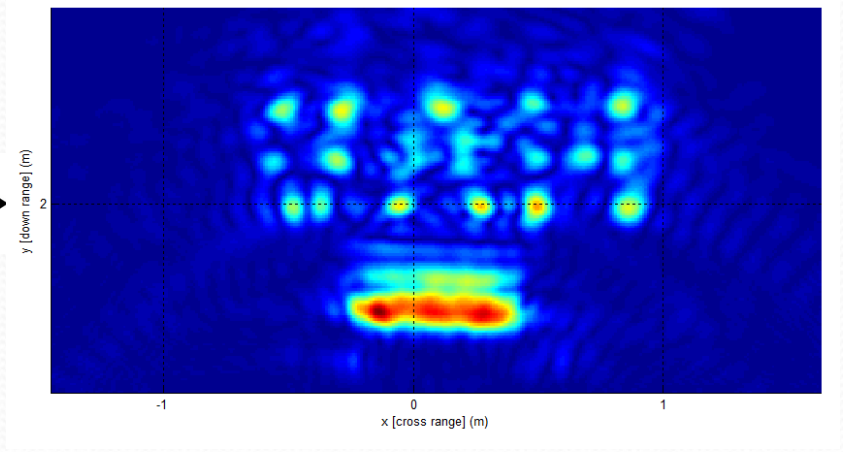
Spelling out UAH

- Aluminum cans

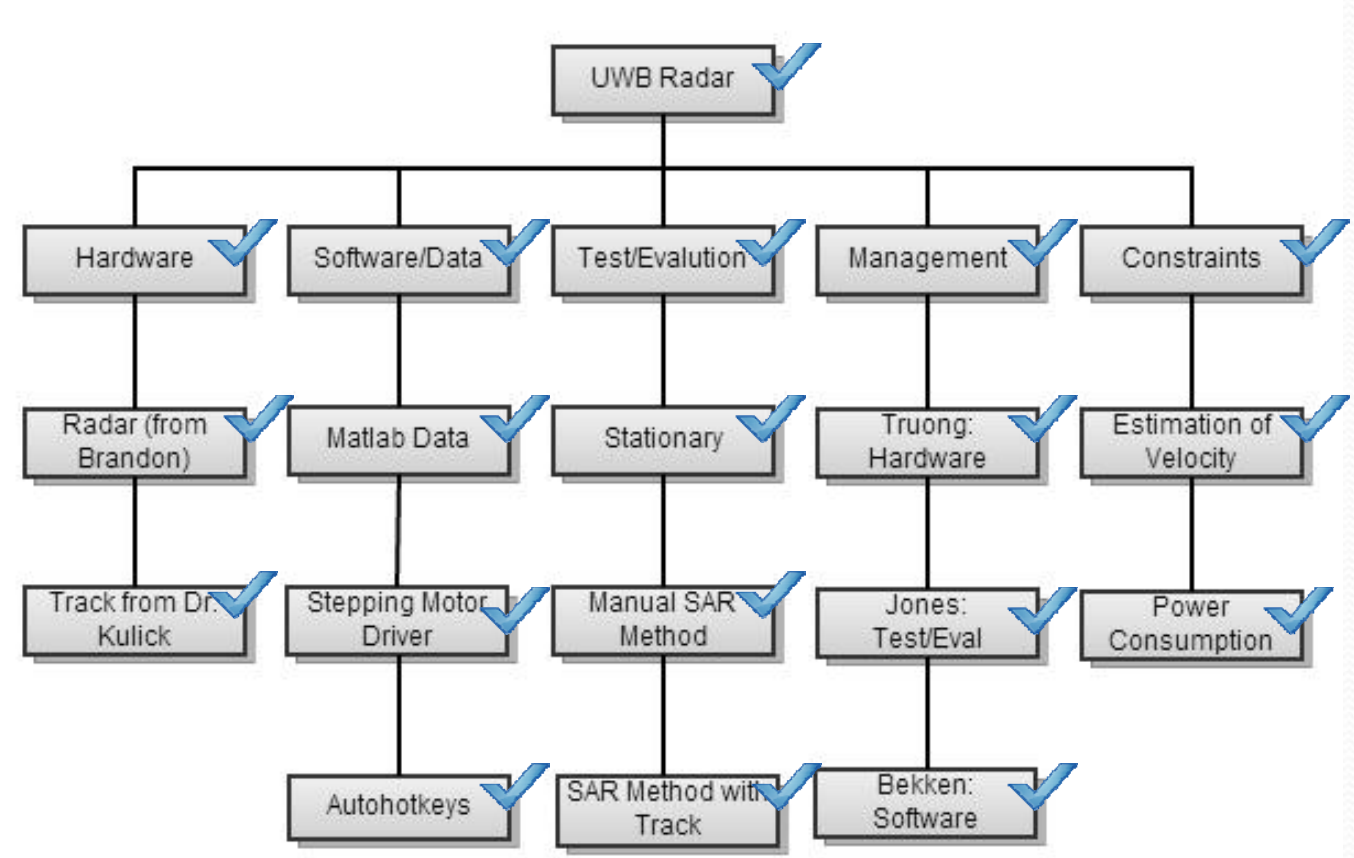


Adding drywall





Final Work Breakdown Structure (WBS)



Final Schedule

Month	August	September				October					November			
Week	27	4	10	17	24	1	8	15	22	29	5	12	19	26
Project	X													
Research		X	X	X	X									
Project Summary		X												
Project Proposal		X	X											
Stationary Radar				X	X	X	X	X						
Stationary Software				X	X	X	X	X						
Preliminary Design								X						
Synthetic Aperture Radar									X	X	X	X		
Synthetic Aperture Radar Design									X	X	X	X		
Test Functionality								X	X		X	X		
Improvements												X	X	X
Final Presentation													X	X

Final Expenditures

Materials	Estimated Cost	Payment Method
UWB Radar	$1,500	Loaned by Brandon
Poster Board Display	$120	Bought by the group
Mobile Track	$100	Loaned by Dr. Kulick
Stepper Motor and other Track Accessories	$87	Bought by the group
Detected Materials	$10	Bought by the group
Tape Measure	$3	Bought by the group

Open Floor

- Questions?
- Comments?
- Have a great day!

Special Thanks To:

- Dr. Corsetti
- Brandon Dewberry
- Time Domain
- Dr. Joiner
- Dr. Kulick
- Professor Hite