Synthetic Aperture Radar

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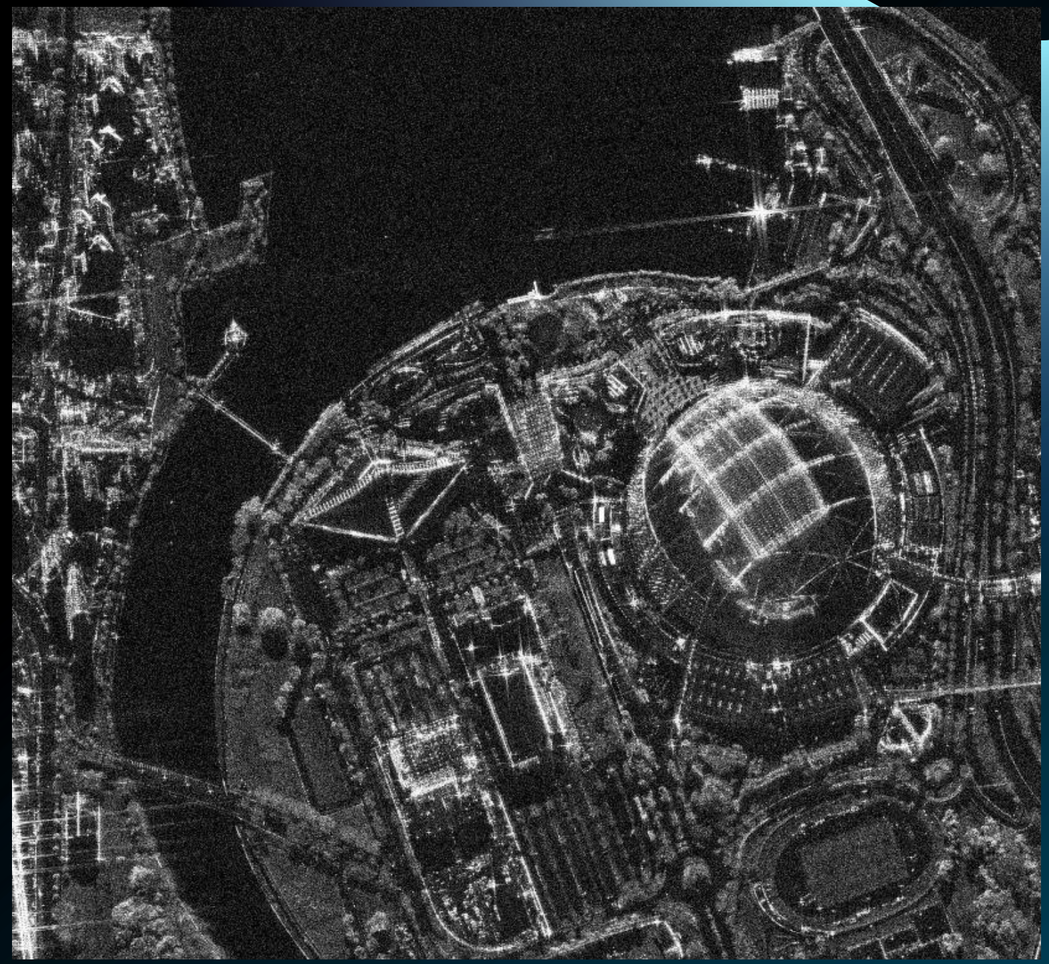
Outline

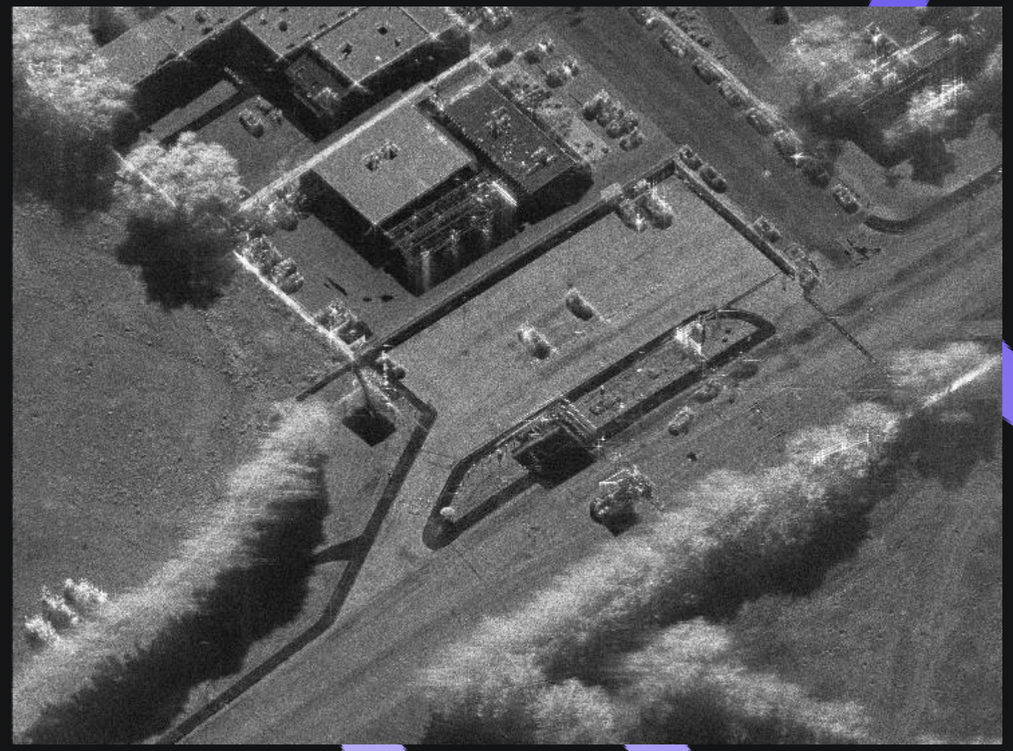
- Explanation
- Modes
- How it works
- The math
- Experiment 1: Shadowing
- Experiment 2: Movement
- Experiment 3: Aerial Data
- Applications



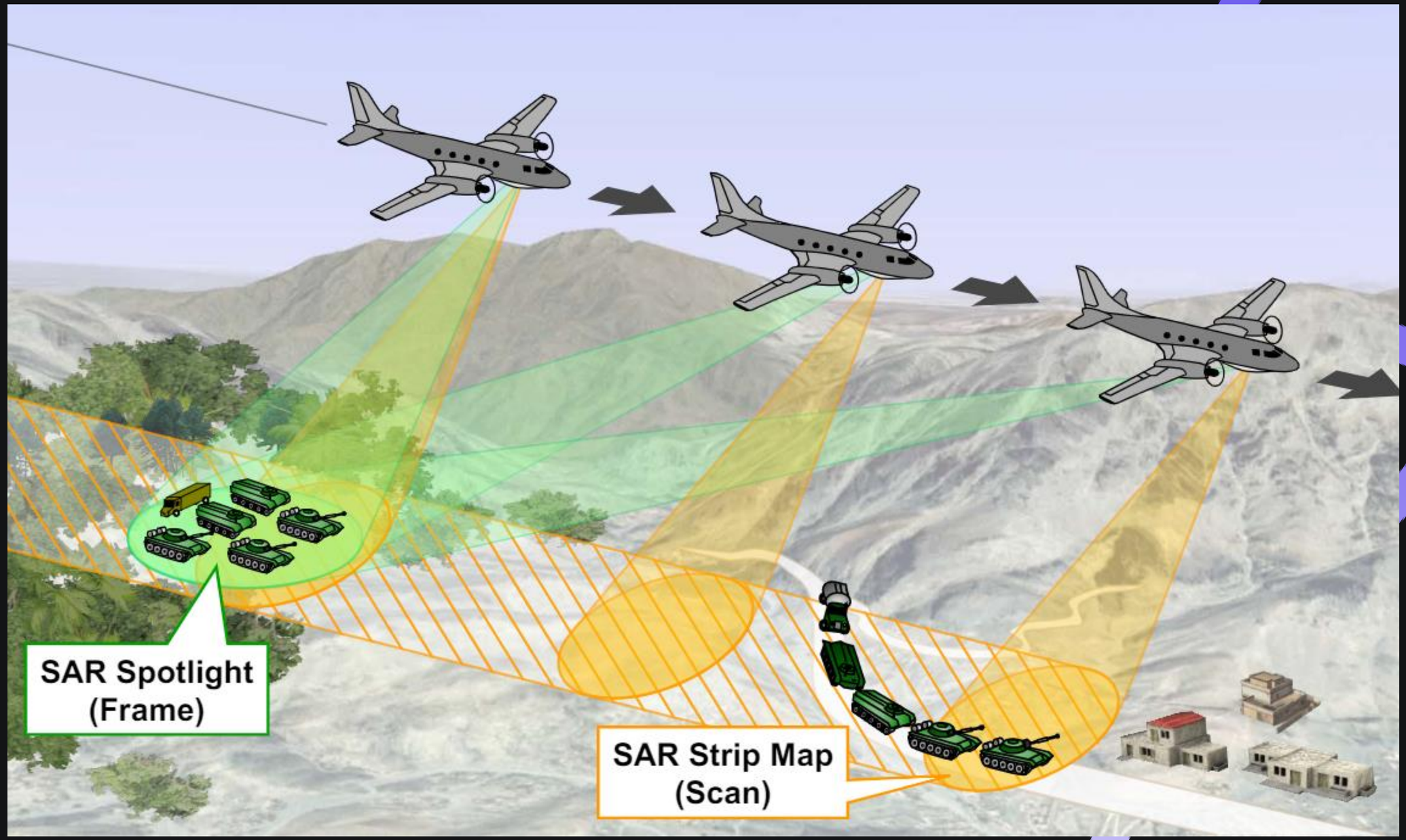
Maxar Technologies
https://www.maxar.com/maxar-intelligence/products/sar-imagery

What is Synthetic Aperture Radar?

- Collects data by taking multiple snapshots an area surroundings to recreate a model
- Unlike other modes, SAR can be used for detailed 2-D modeling

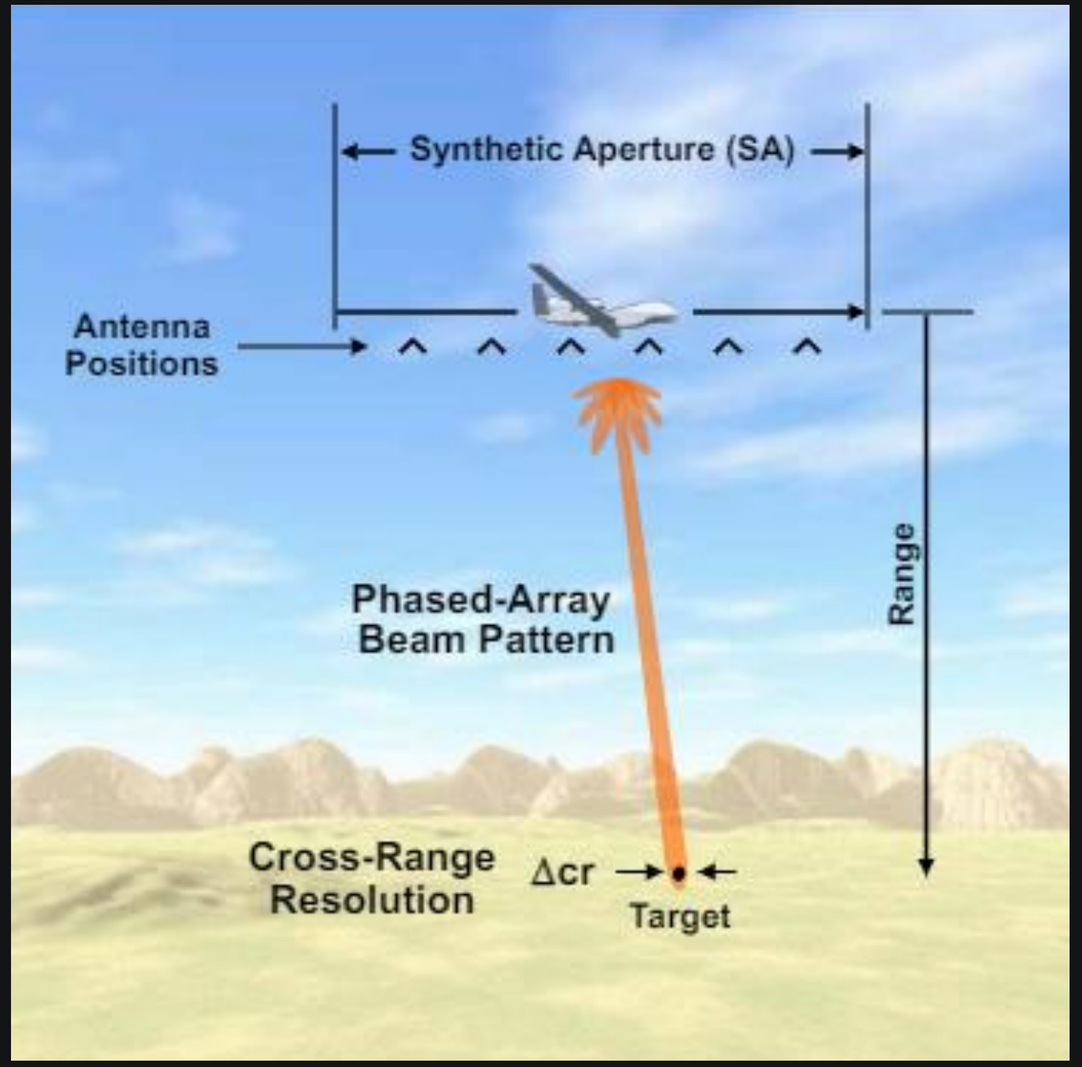


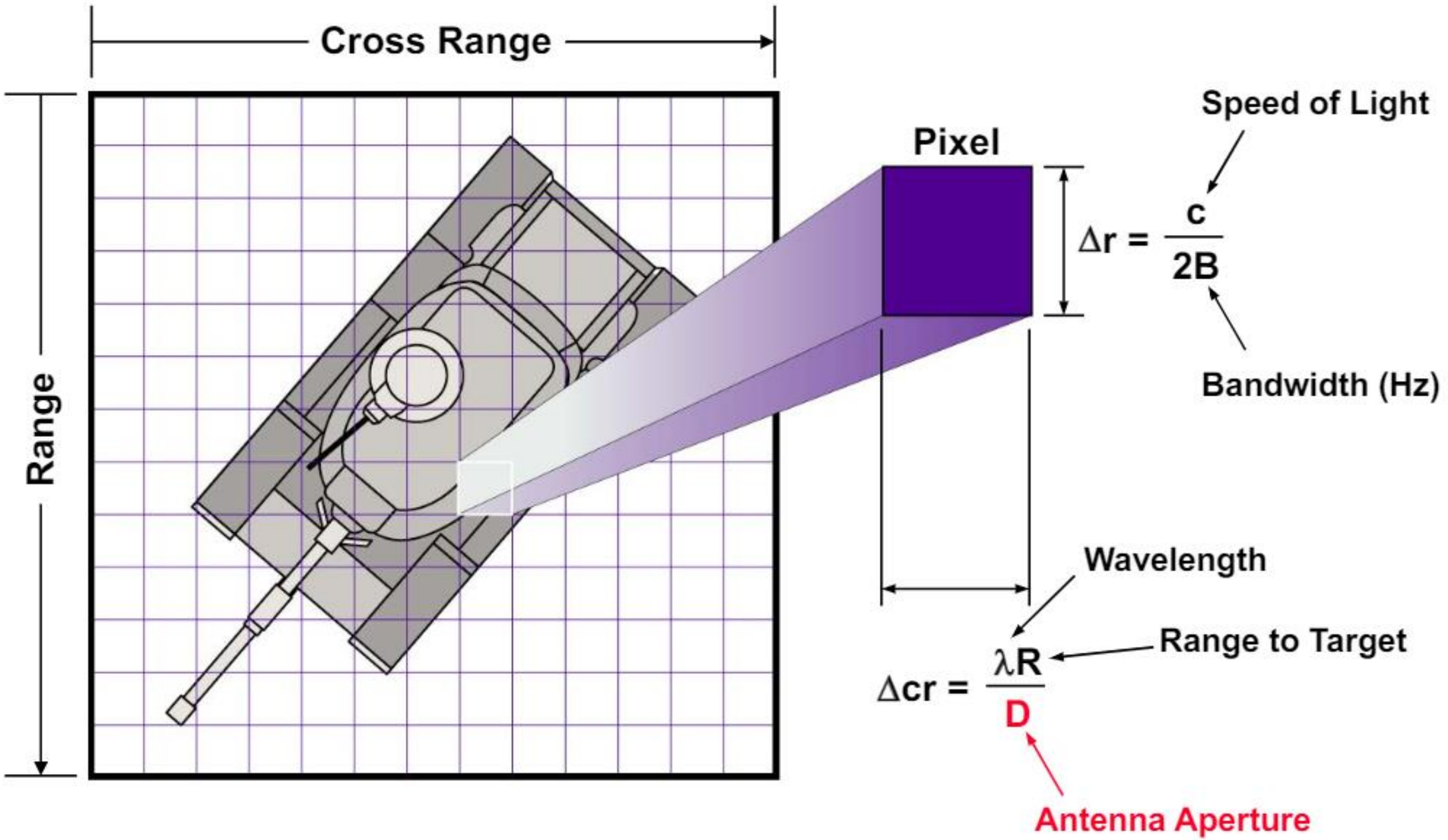
John Hodge
https://www.quora.com/What-is-the-difference-between-a-conventional-Radar-and-the-SAR


SAR Spotlight
(Frame)
SAR Strip Map
(Scan)

Crossrange & Downrange

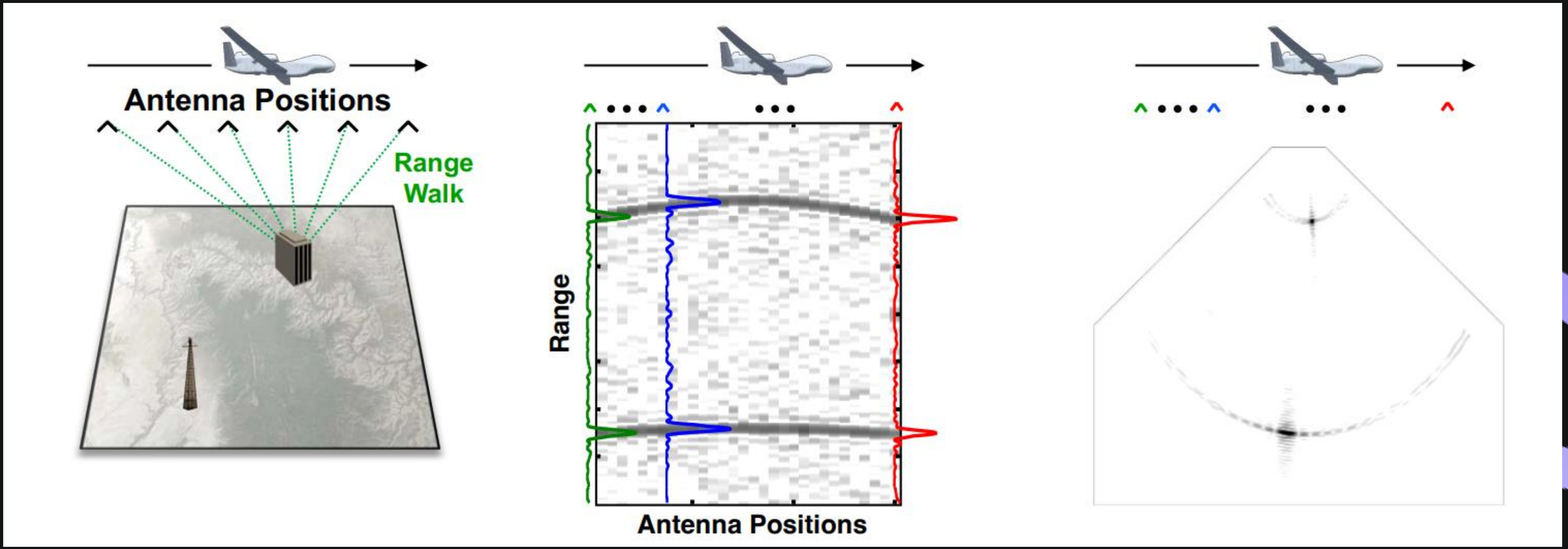
- Range: distance from the radar to the target
- Crossrange: field perpendicular to the range




Cross Range
Range
Pixel
Speed of Light
$\Delta r = \frac{c}{2B}$
Bandwidth (Hz)
Wavelength
Range to Target
$\Delta cr = \frac{\lambda R}{D}$
Antenna Aperture

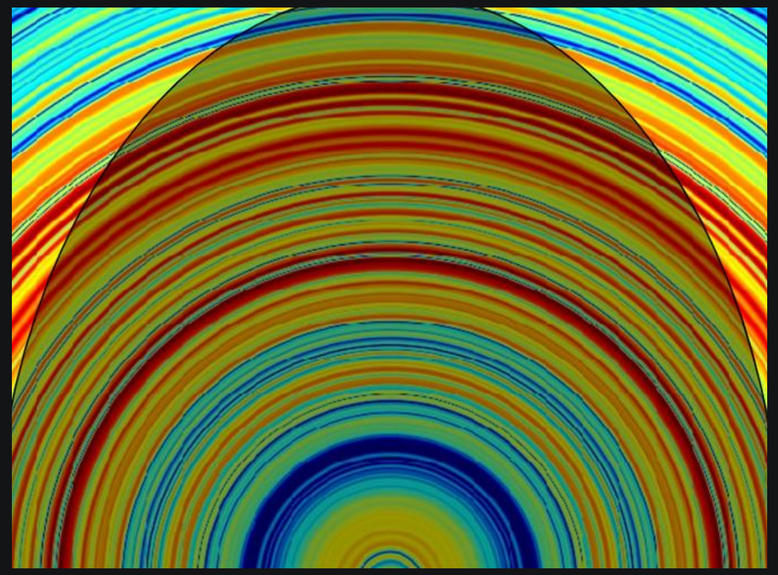
How our SAR works

- Takes a specific number of data captures
  - Appear as radar pulse compression returns
- Combines by back projection, like smear and add



Smear and Add:

1.



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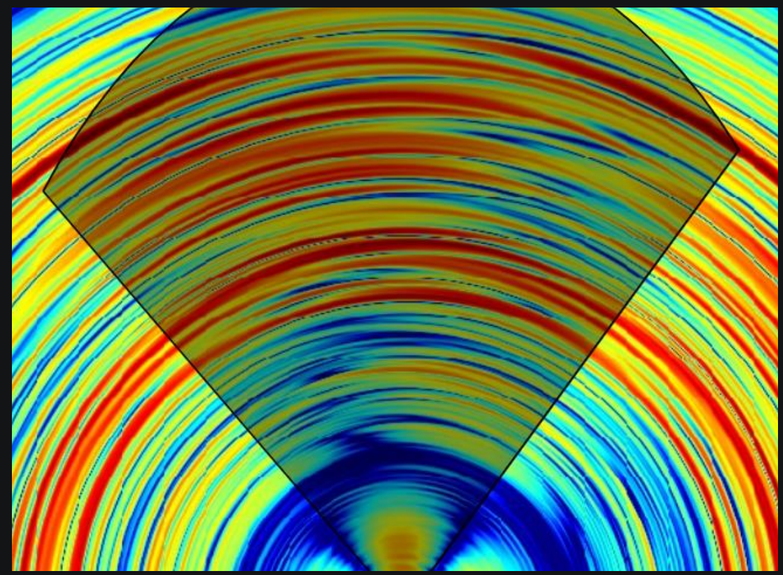

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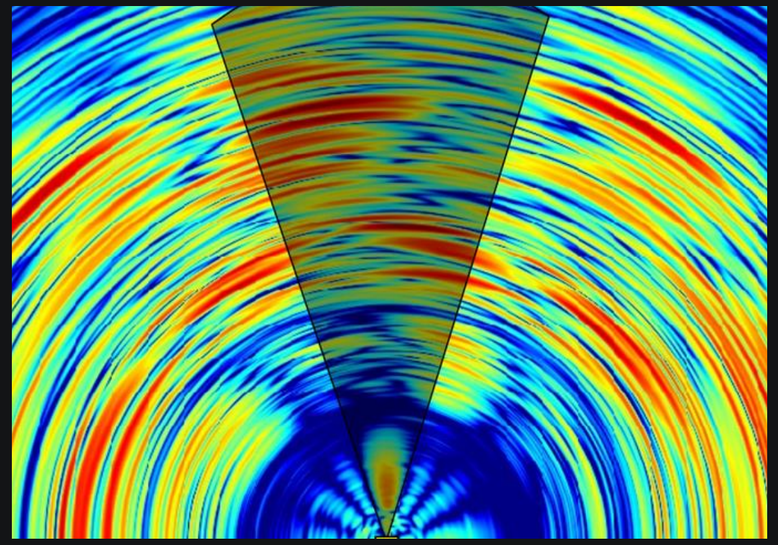

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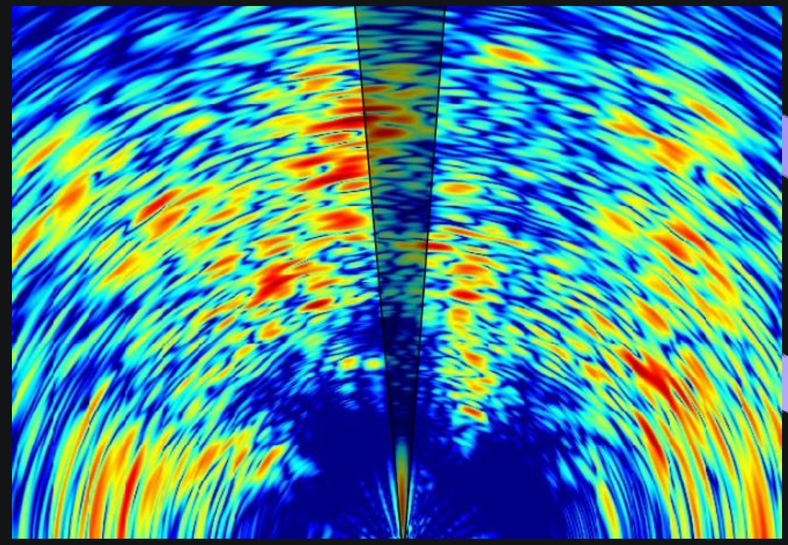
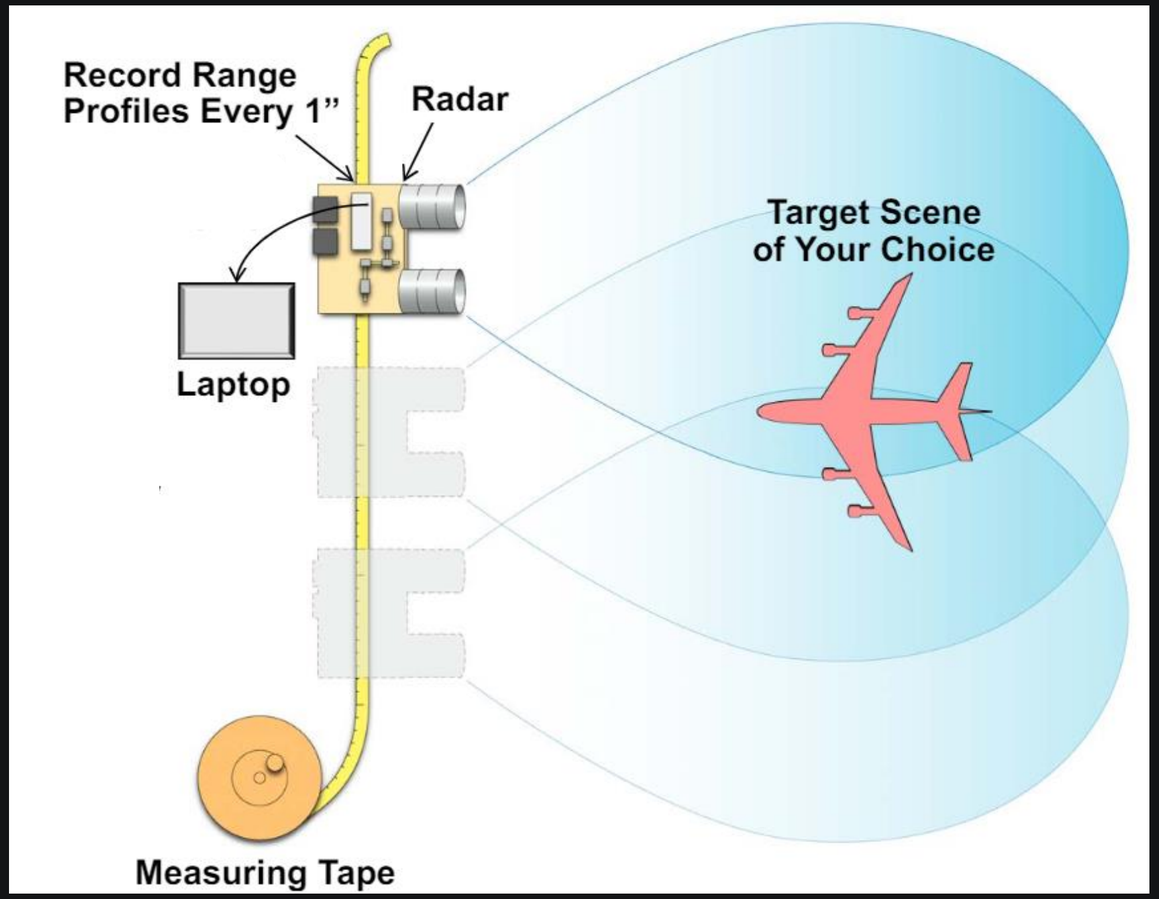
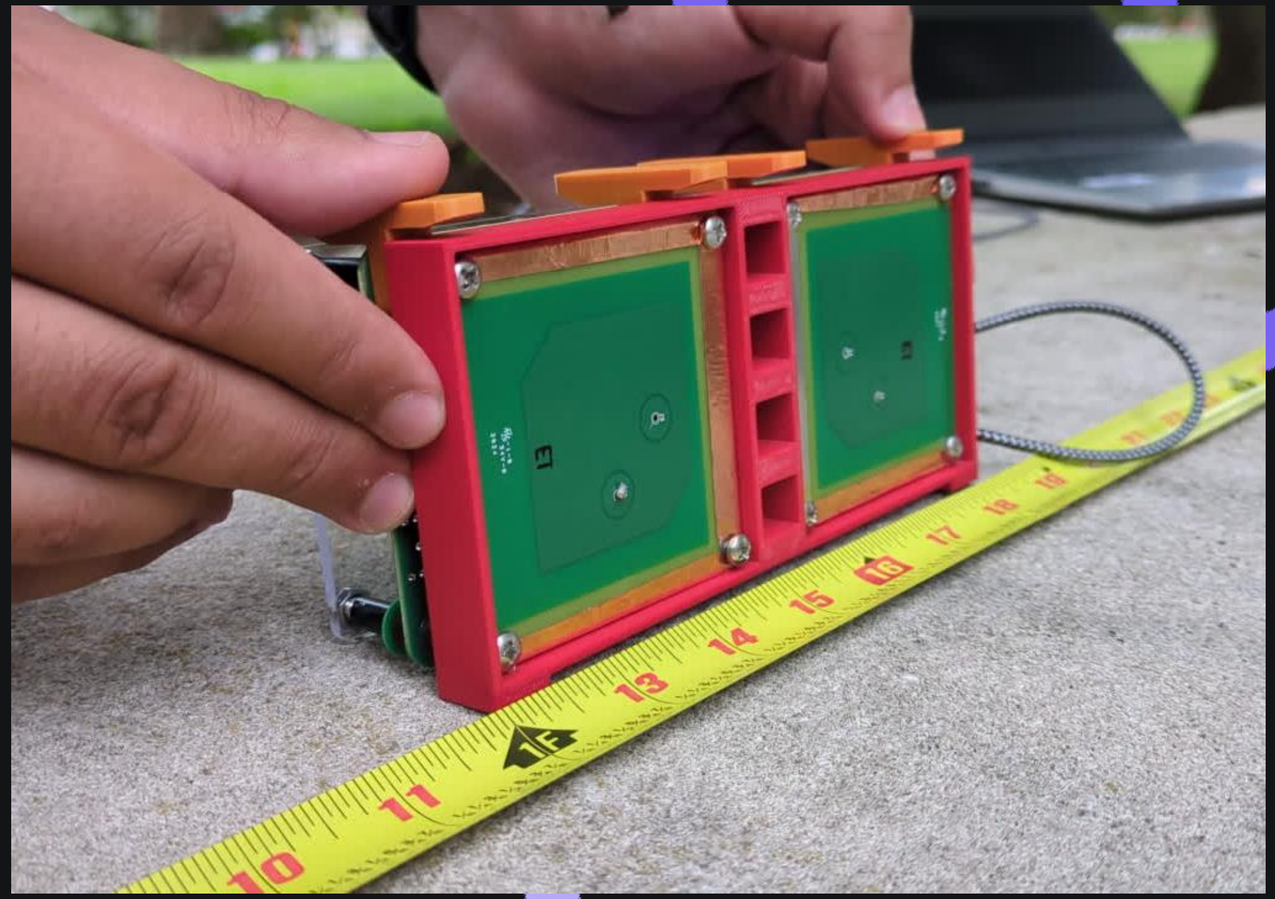



Record Range
Profiles Every 1”
Radar
Target Scene
of Your Choice
Laptop
Measuring Tape



Experiments

Finding the Limits of SAR

Settings

Mode	MTI
Voltage Gain	20
Bandwidth	300 MHz
SAR Step Size	60

Shadowing Experiment

1

Question:

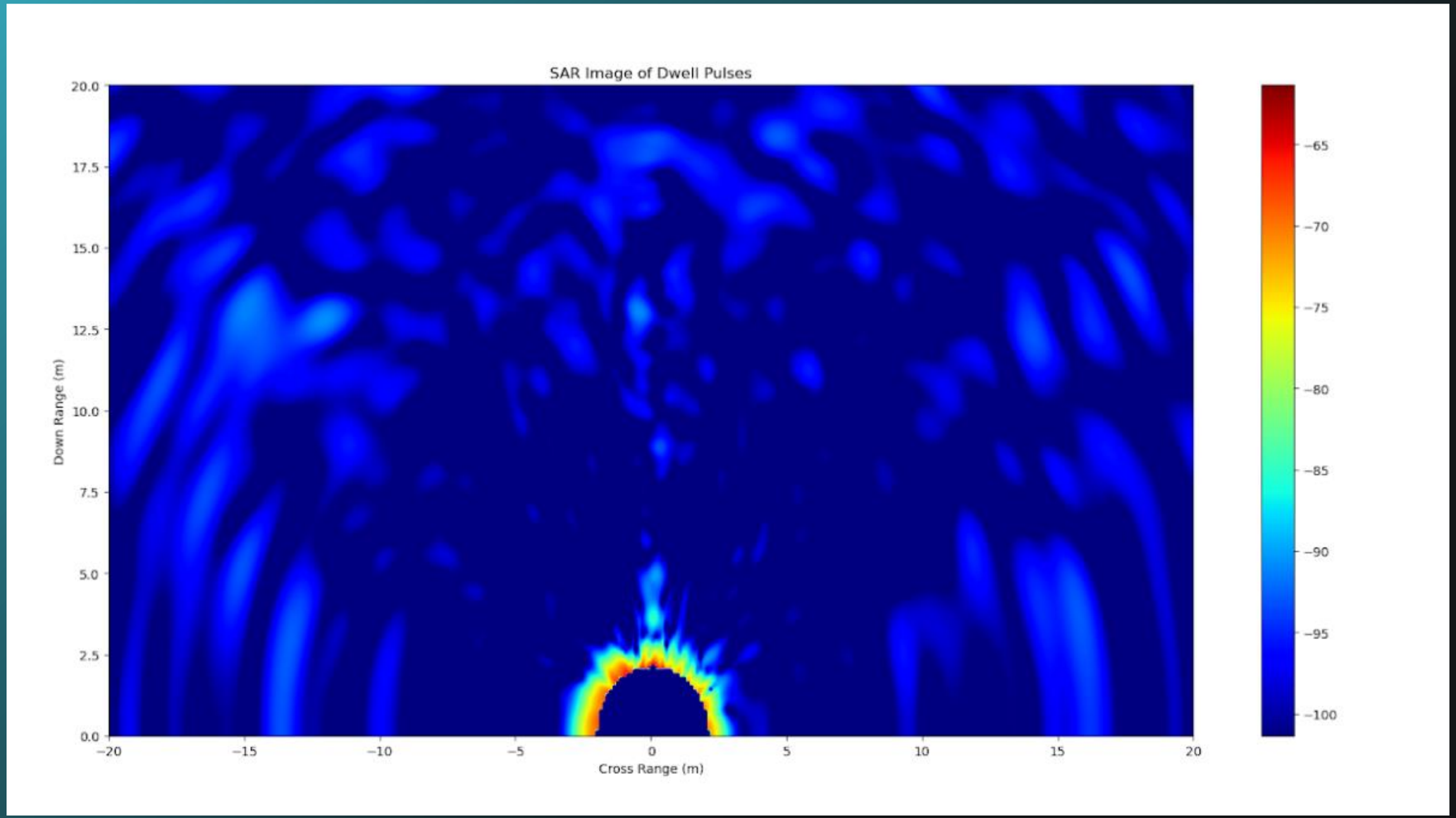
Will a large object prevent our radar from detecting a smaller object placed directly behind it?

Hypothesis:

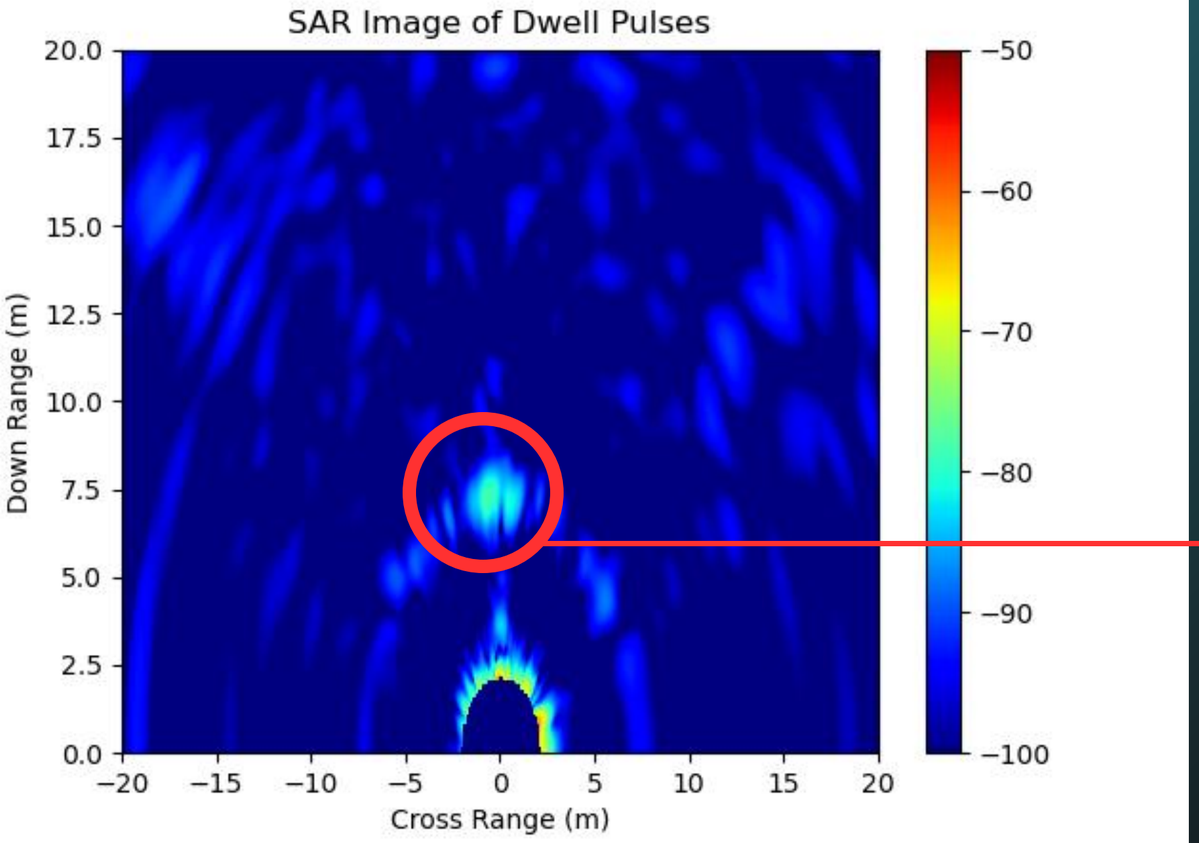
A large plastic trash can will block the detection of Wilson, because the trash can reflects most of the waves back to the radar.

Procedure

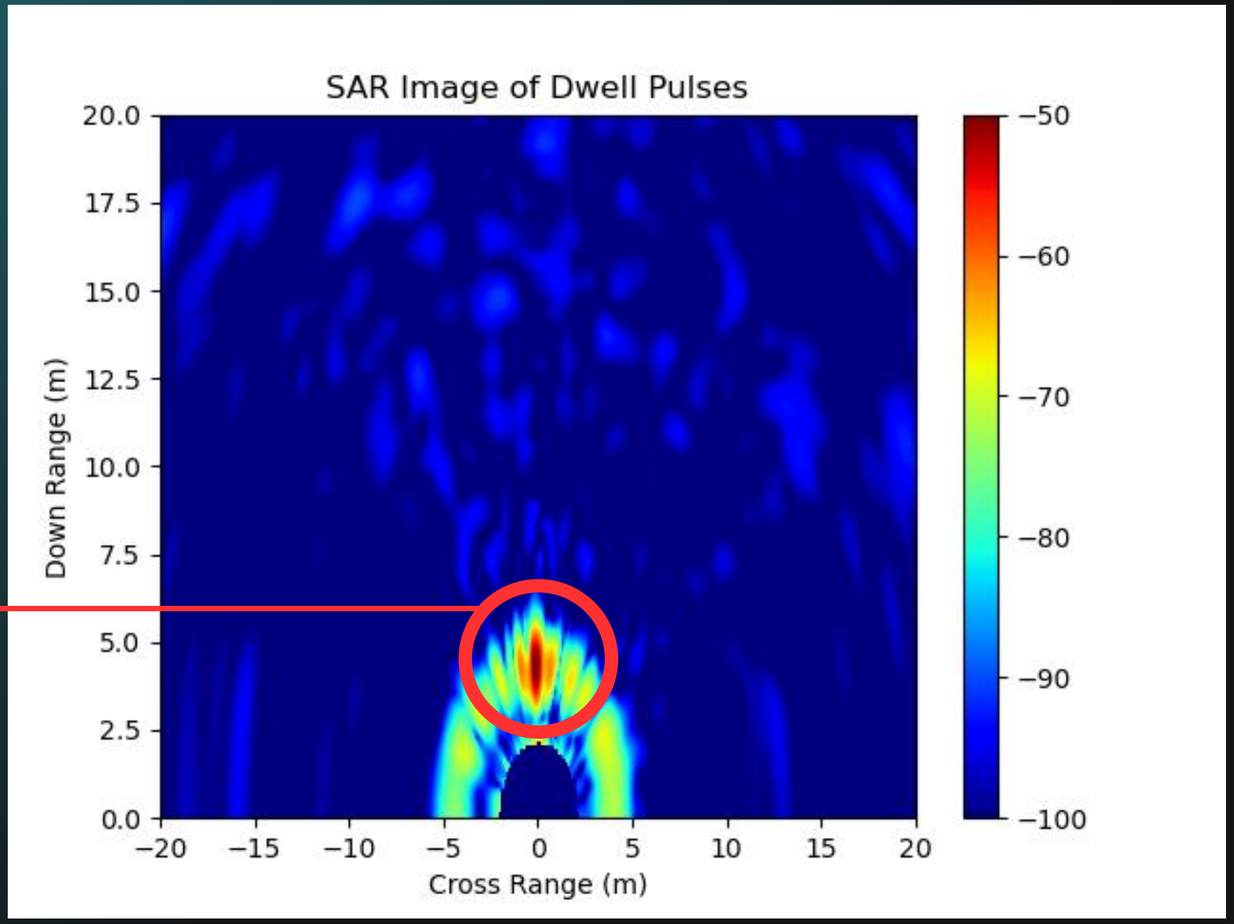
Empty Field (Control)



Just Wilson (Control)



Wilson & Trash Can



Application:

Reader's Digest
https://www.rd.com/article/what-do-airport-body-scanners-see/

Movement Experiment

2

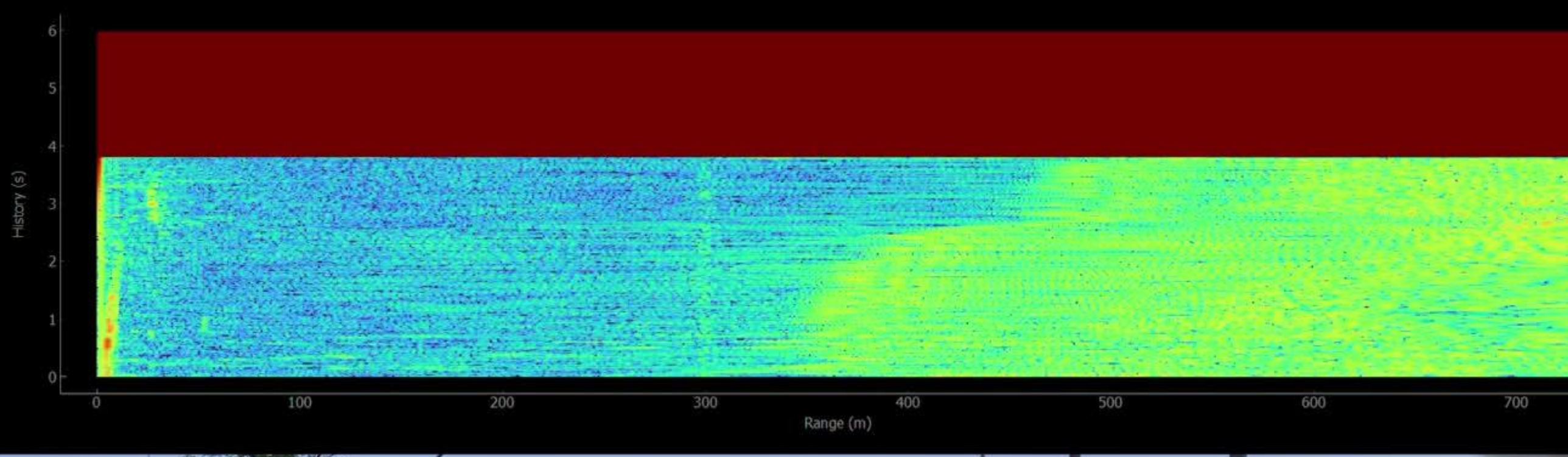
Question:

How does a moving object's speed affect its appearance on a SAR image?

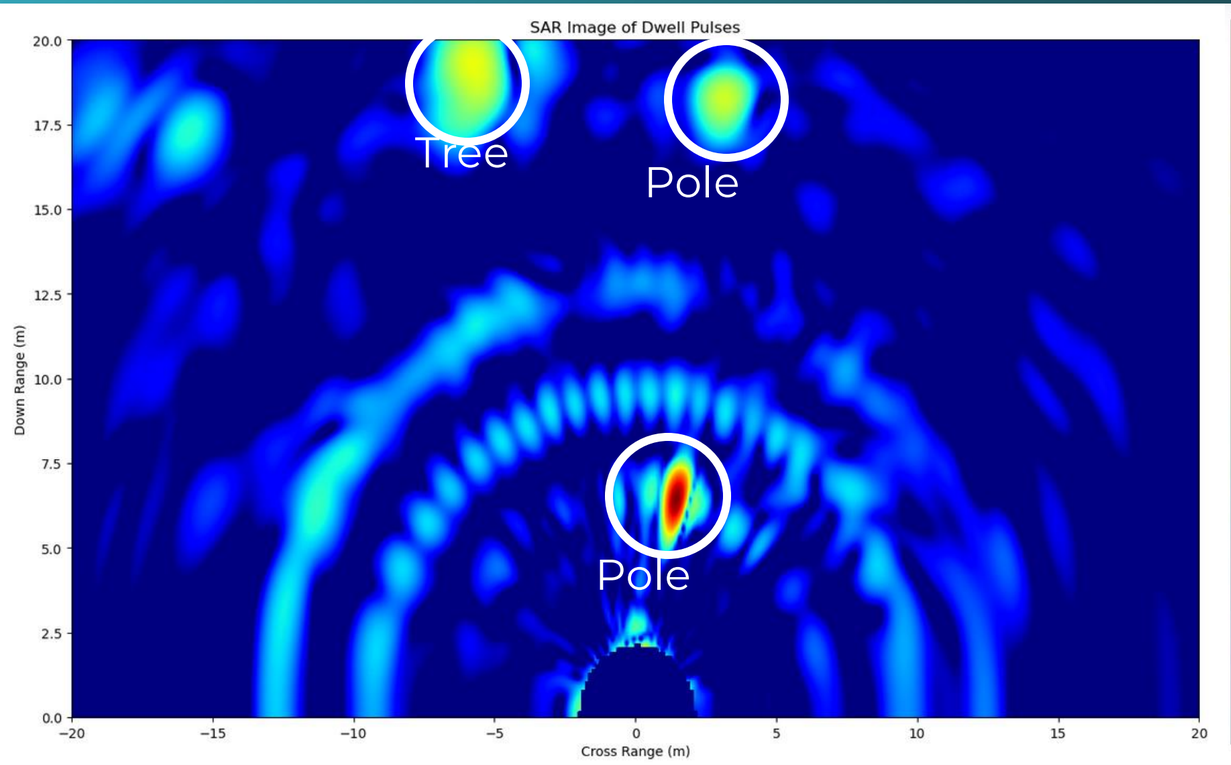
Hypothesis:

The faster a target moves, the weaker it will appear on a SAR image.

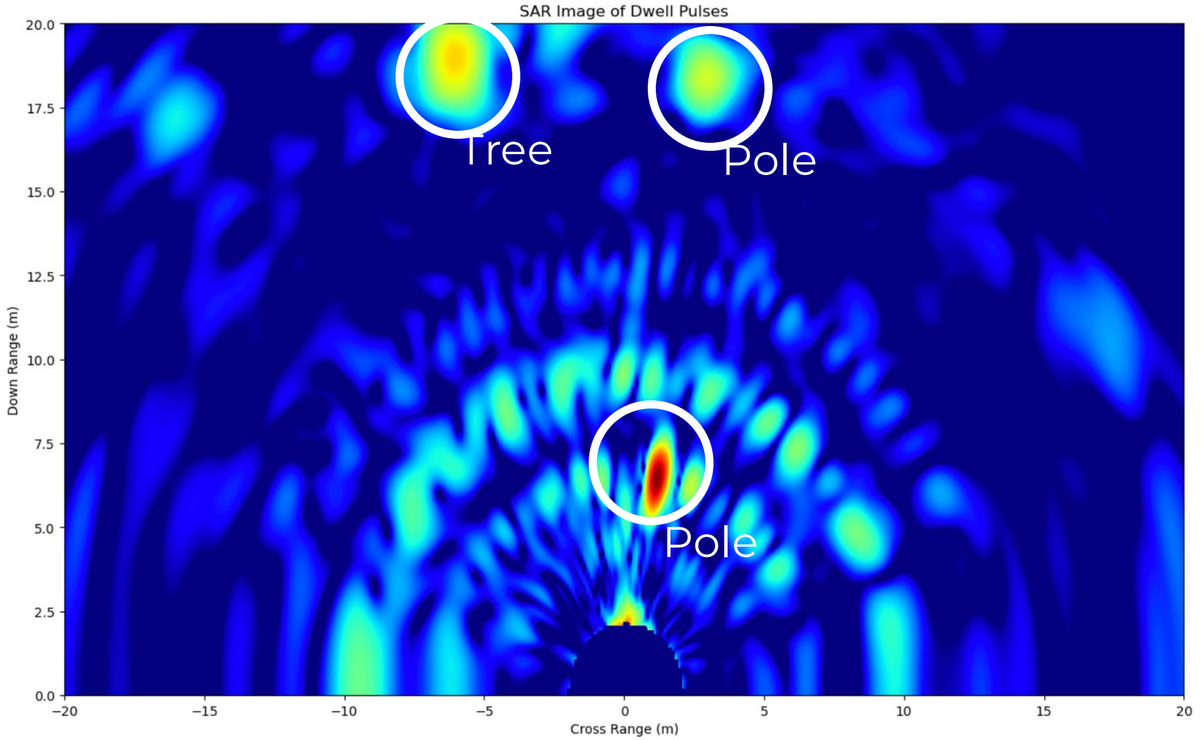
Procedure


History (s)
6
5
4
3
2
1
0
0
100
200
300
400
500
600
700
Range (m)

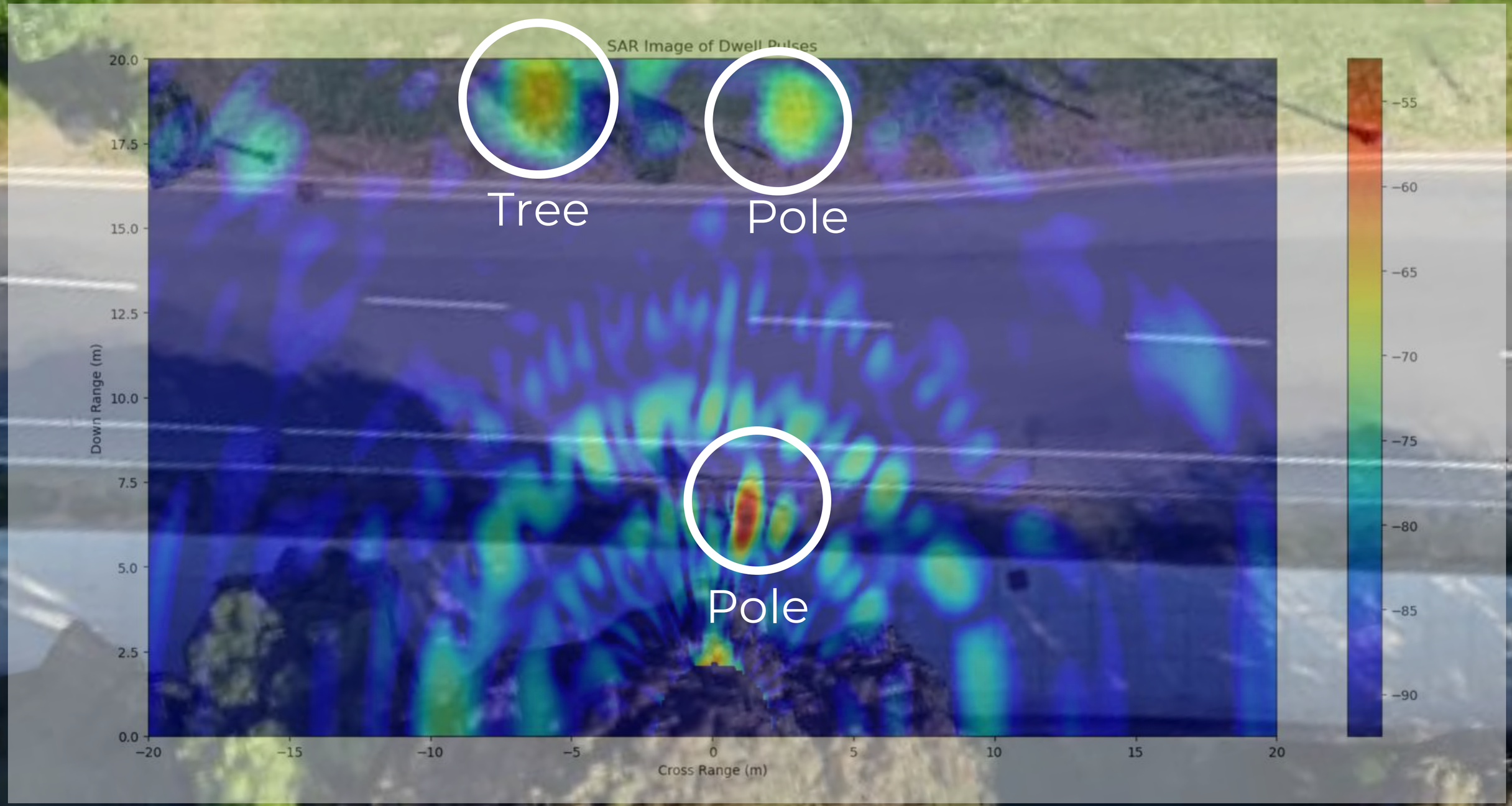
Fast Movement



Slow Movement



Overlay


SAR Image of Dwell Pulses
Tree
Pole
Pole
Down Range (m)
Cross Range (m)
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
−20
−15
−10
−5
0
5
10
15
20
−55
−60
−65
−70
−75
−80
−85
−90

Application:

Echoes radar Technology
https://www.echoes-tech.it/products/phoenix/

Airborne SAR

3

Question:

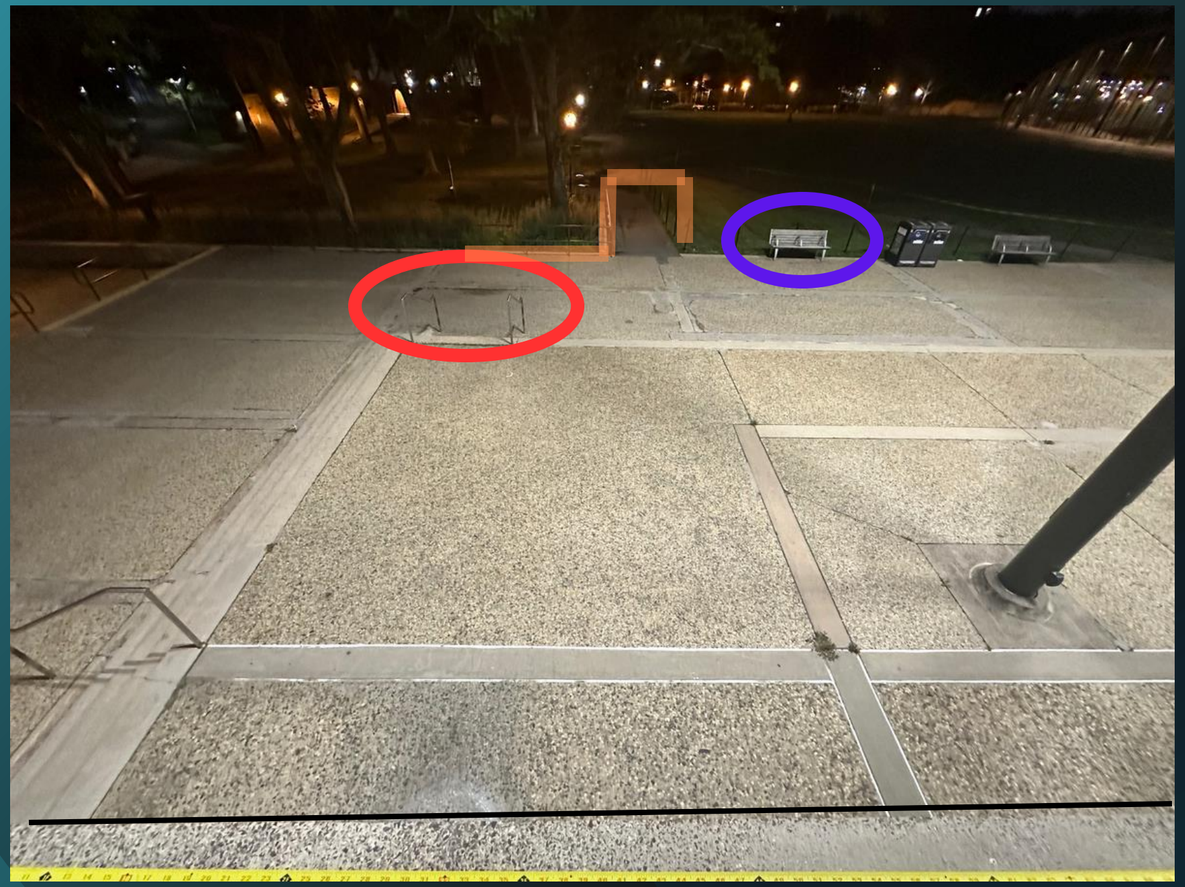
Can we replicate aerial SAR data using our handheld radar?

Hypothesis:

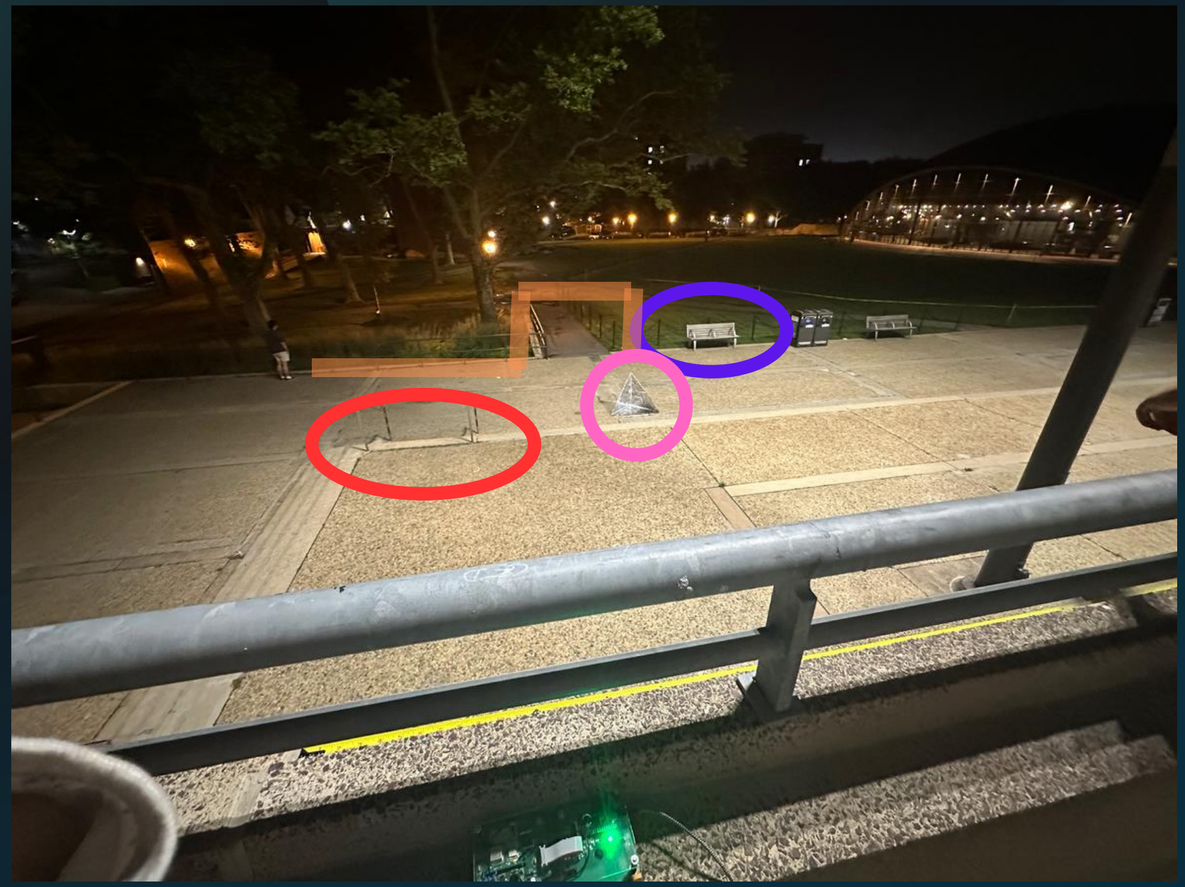
We will be able to capture useable aerial SAR data using our radar.

Procedure

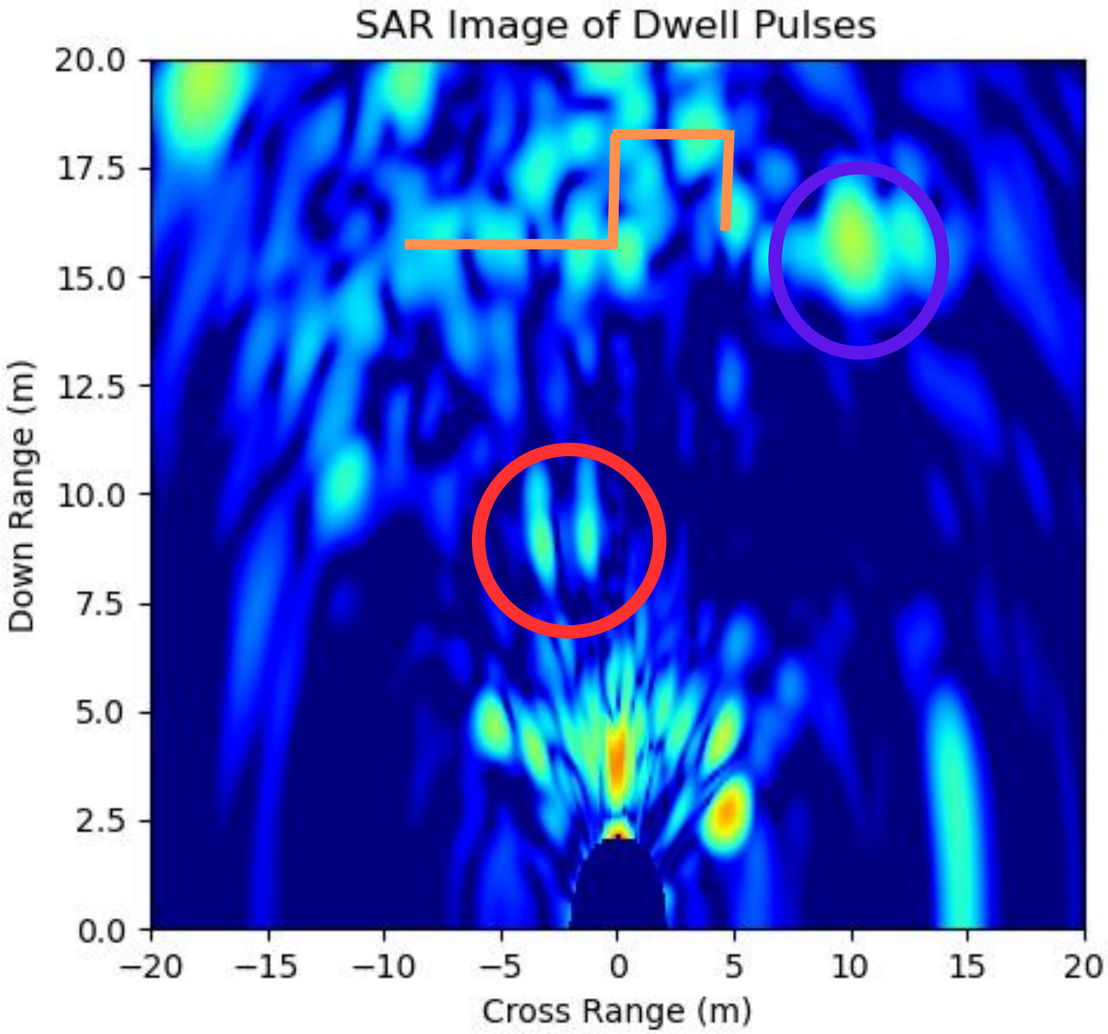
Without Reflector (Control)

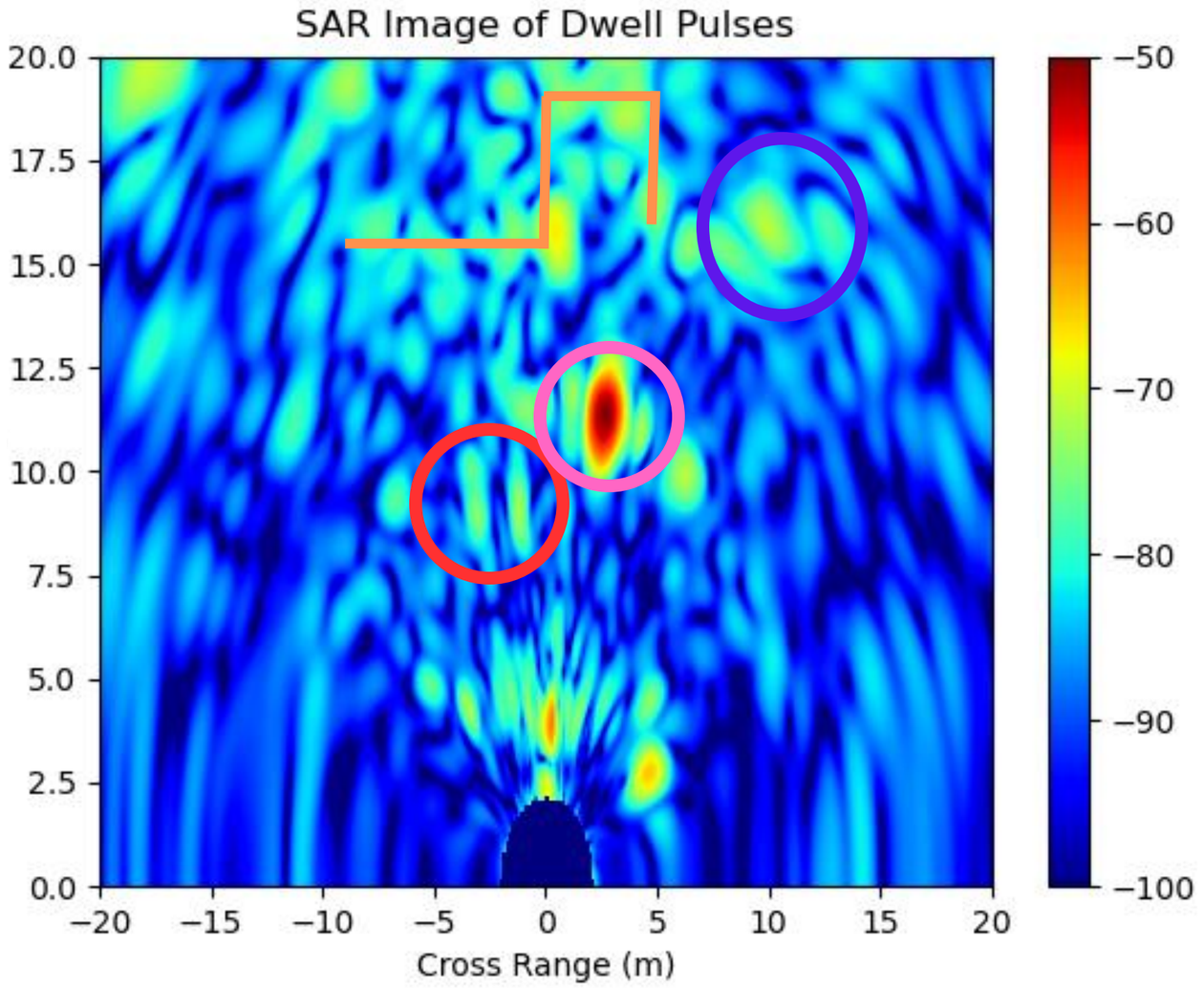


With Reflector

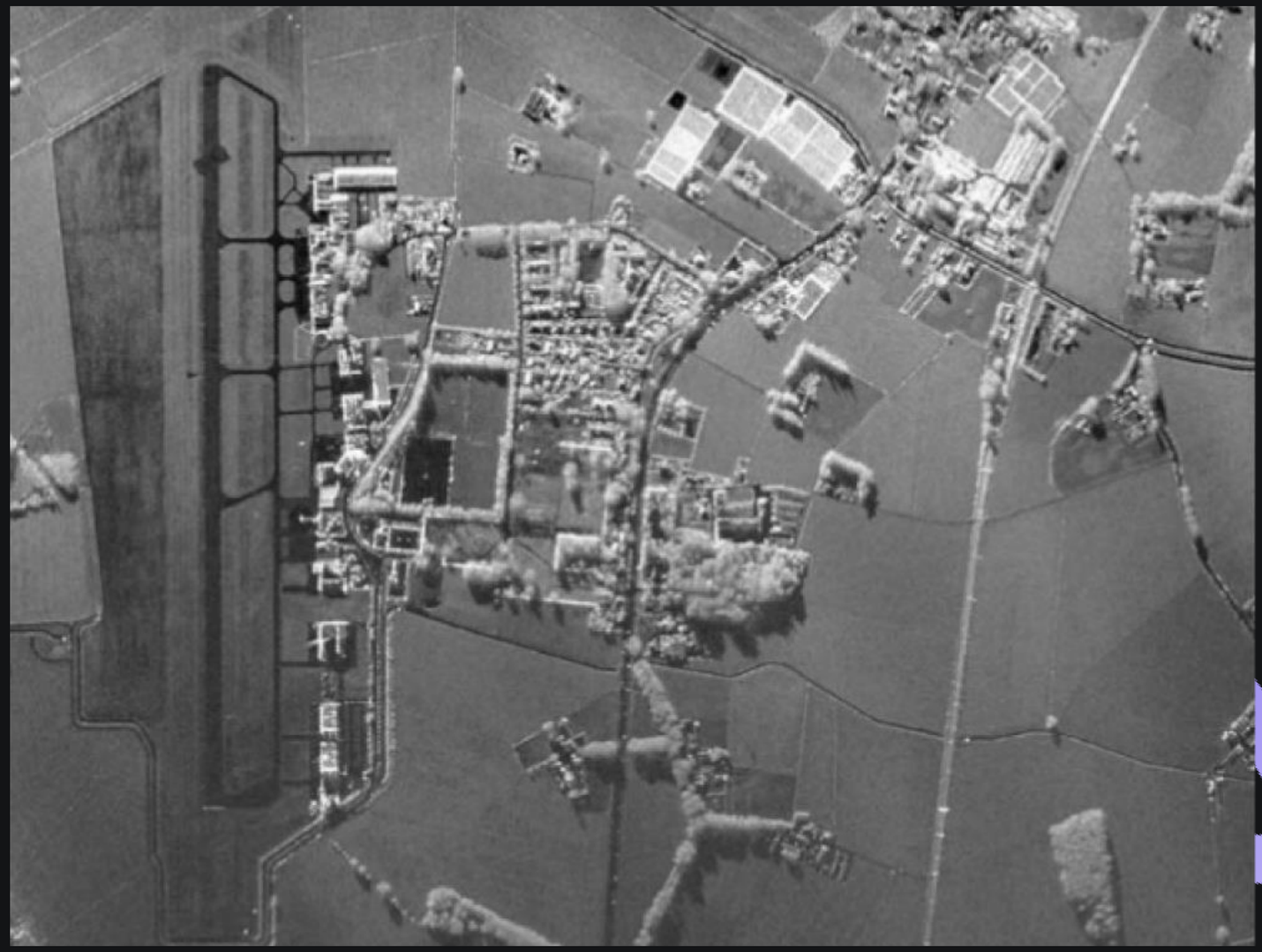


Without Reflector (Control) With reflector





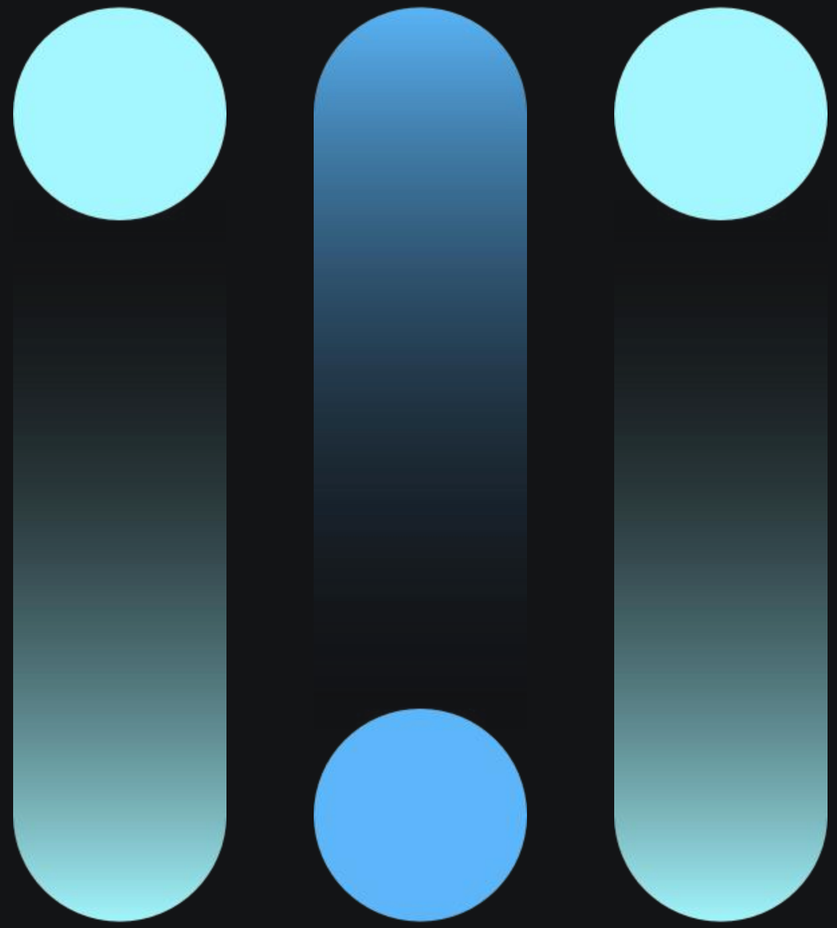
Application:



The Cove
https://ieeexplore.ieee.org/document/9046252

Conclusion

- SAR: Synthetic Aperture Radar
- Modes:
  - Strip Map and Spotlight
- Shadowing/blocking properties
- Fast movement blurs the resulting image
- Aerial data is best collected at an angle



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RADAR INTRODUCTION FOR STUDENT ENGINEERS