Video Synthetic Aperture Radar (ViSAR)

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The problem: Engaging maneuvering ground targets through clouds

Electro-optic sensors cannot provide accurate air-to-ground targeting through clouds due to loss of contrast – a physics problem.

- In Kosovo, air support could attack ground forces in only 24 of 78 days due to cloud cover.

Existing radar systems can penetrate clouds but frame rates are too low (<0.1 Hz) to provide targeting against maneuvering targets – a technology problem.

Percentage of times cloud ceiling < 1km occurs for selected locations.

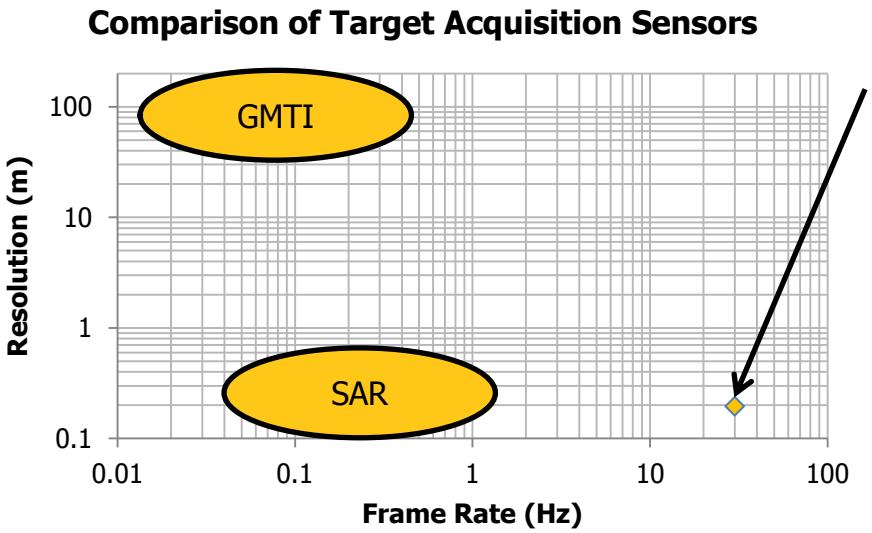
Region	Winter	Summer
Korea East Coast	23	56
South Korea	24	40
Dinaric Alps	41	23
European Highlands	57	26
European Lowlands	52	24
Mideast Desert	19	2

Table 62 from "Comparison of Infrared and Millimeter-Wave Imager Performance in Adverse Weather Conditions," Brian Riely, ARL-TR-1301, December 1997

Demonstrate a RF cloud penetrating sensor in a gimbaled mount for use on a variety of platforms for ranges up to 10 km.

Program Goal: Develop and demonstrate an RF targeting sensor that will operate through clouds as well as current IR sensors do in clear weather.

Can we develop a RF sensor to image a scene and track the maneuvering targets?

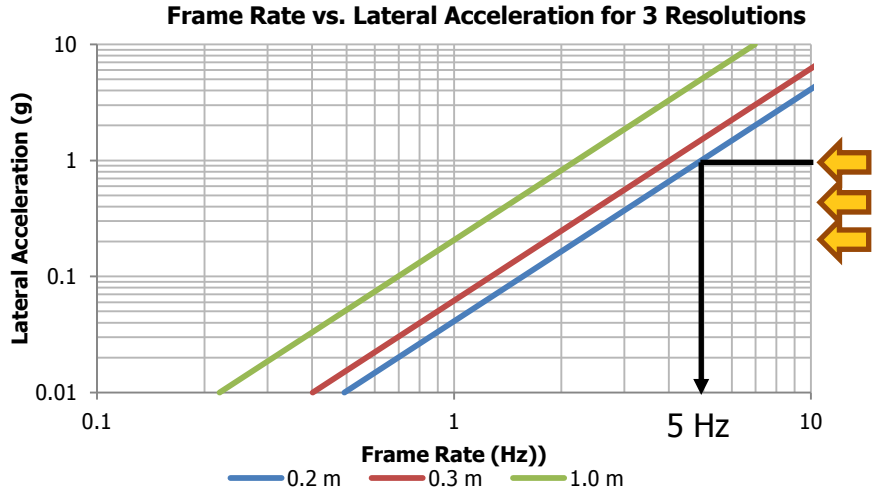


Our design goal: 0.2m resolution over a 100m Field of Regard (FOR).

For SAR:

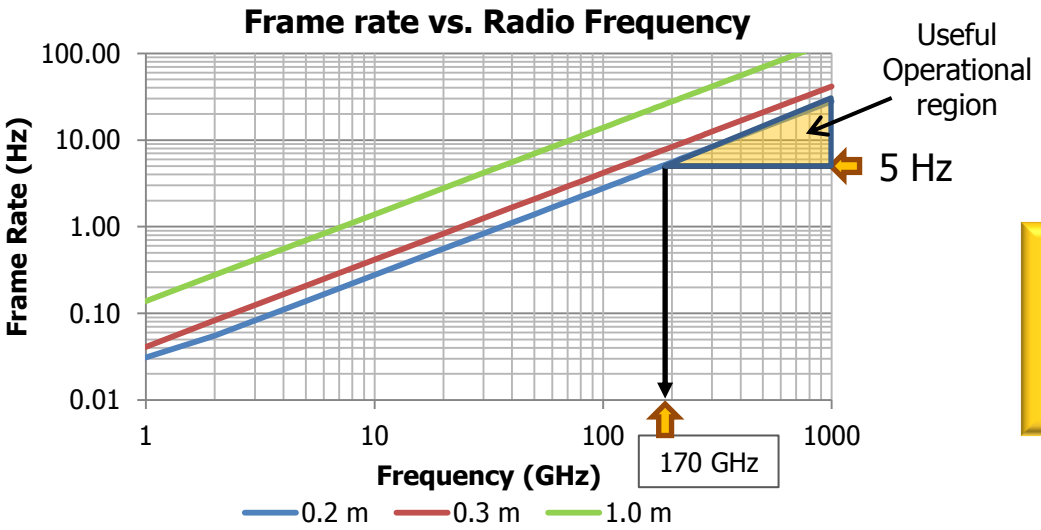
$$\text{Frame Rate} \propto \frac{\text{Velocity} * \text{Resolution}}{\text{Range}} * \text{Frequency}$$

What Frame Rate is needed to track Maneuvering ground targets?



We need to exceed 5 Hz frame rate while matching the resolution of the current IR Targeting Systems.

What RF band can provide the same resolution and frame rate as infrared but through clouds?

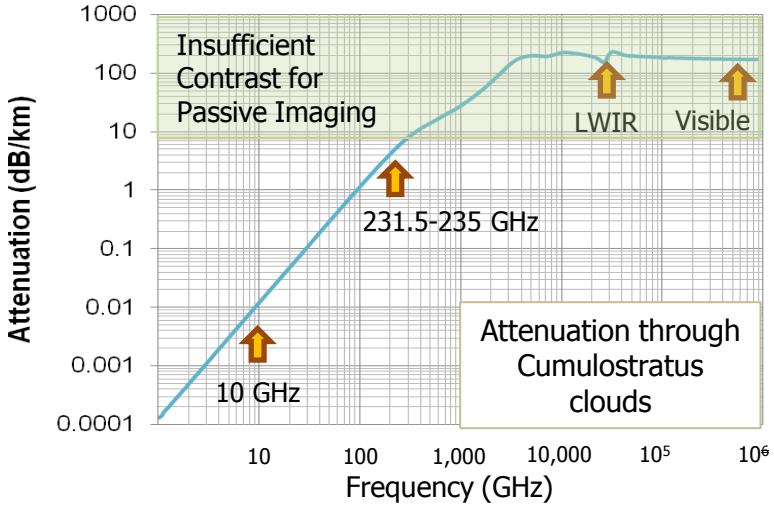


Meeting our Goals would require a SAR frequency over 170 GHz to exceed the 5 Hz frame rate.

Can the clouds be penetrated above 170 GHz?

Attenuation from the clouds reduces the contrast between the target of interest and the background.

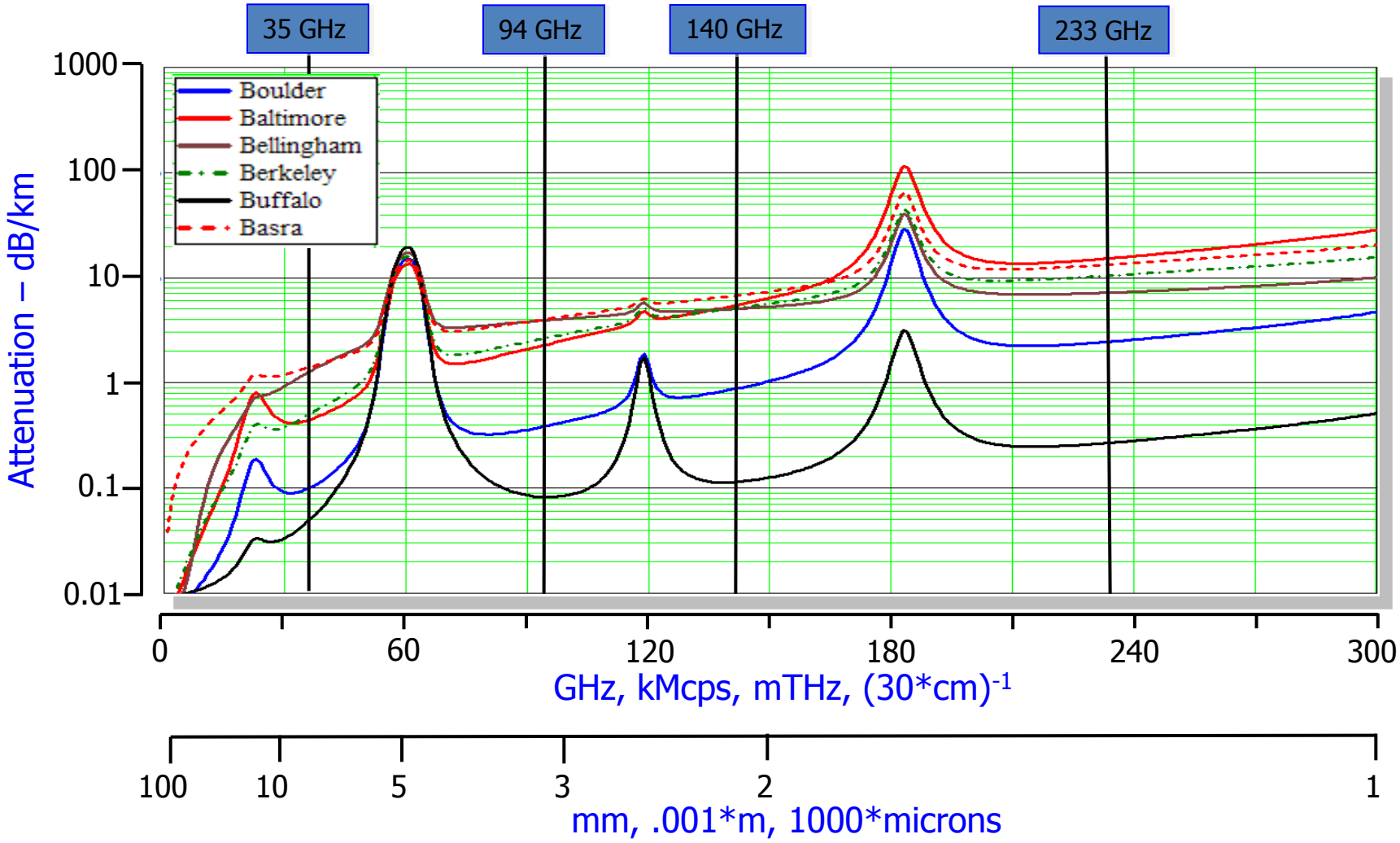
The first radiolocation band above 170 GHz is 231.5-235 GHz.
We will next examine a technical challenges for a SAR operating in that frequency band.



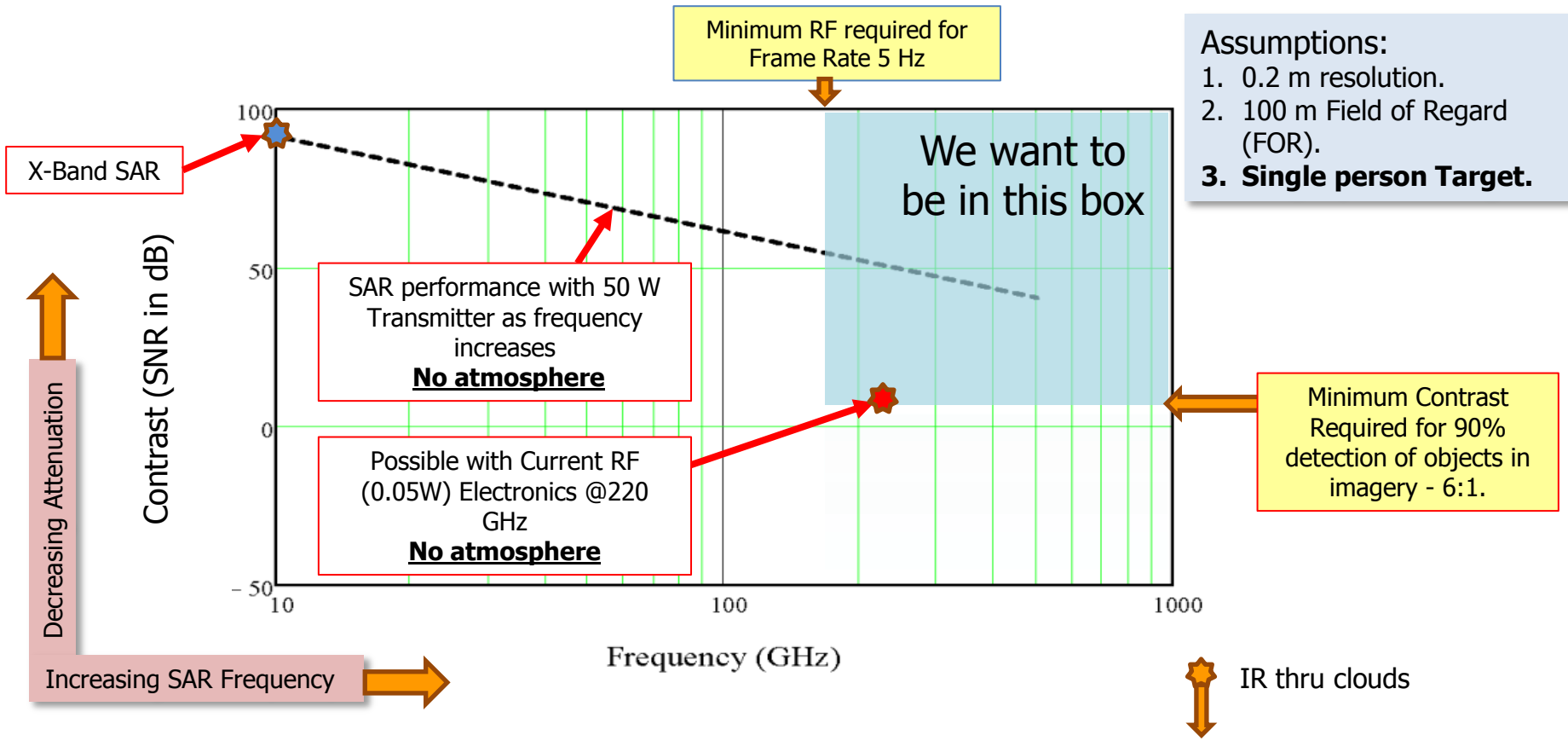
There are many forms of natural obscurants

The Six "Bs" of MMW Attenuation

Typical weather conditions for different geographic locations



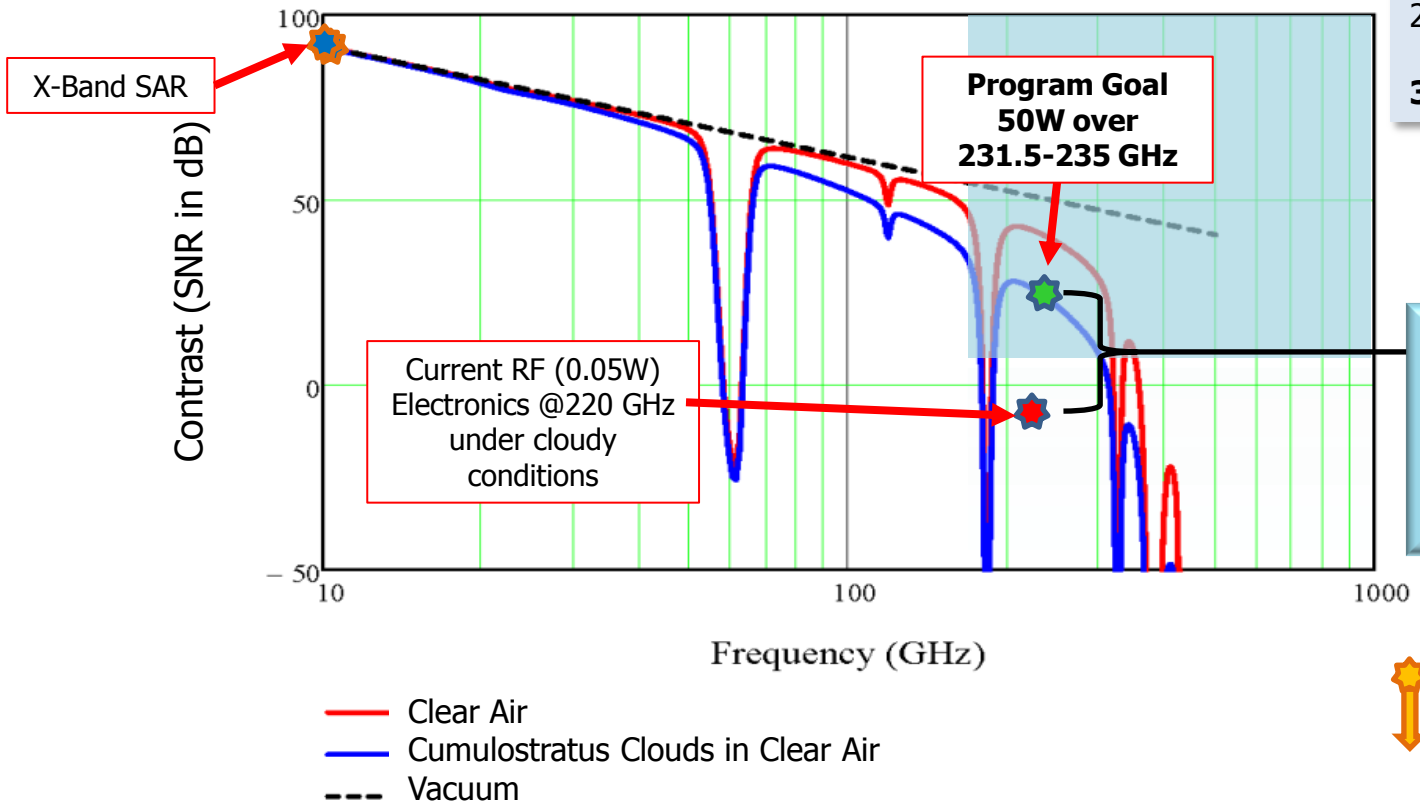
Target contrast and SAR frequency for targeting



We will now look at performance with the introduction of a realistic atmosphere.

Challenge: Achieve a 30 dB increase in transmitter power and/or receiver sensitivity

Assumptions:
1. 0.2 m resolution.
2. 100 m Field of Regard (FOR).
3. **Single person Target.**



Increase in contrast achieved through improved Technology.

Operating around 230 GHz has other benefits:
Antenna size is inversely proportional to frequency,
SAR image formation processing requirements are reduced. (Backup #1)

Elements of the program

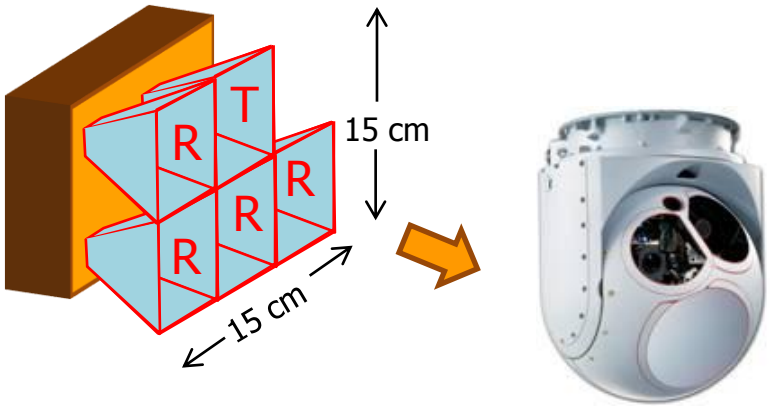
Flyable electronics:

1. Medium power amplifier with bandwidth greater than the radiolocation band.
2. Integrated receiver and exciters operating over 231.5-235 GHz replacing large waveguide structures.
3. High power objective system amplifier which combines the medium power amplifier with a vacuum electronic power booster.

Phenomenology experiments and a system simulation:

1. Measurement of clutter backscatter and Doppler spreading to support scene modeling.
2. Analysis of Doppler from humans at appropriate frame rates to aid in ID of targets.
3. Scene simulator to include moving targets, aircraft dynamics, and weather for testing processing functions.
4. Investigation of new algorithms taking advantage of high frame rates.

Develop a prototype SAR to replace IR Targeting Systems



1. Potential solution: integration of one transmit antenna and four receive antennas which should fit within a typical EO/IR Gimbal for flight testing of the concept.
2. Potential for an RF tag so the Forward Observer can be identified in the Field of Regard.
3. Demonstrate this capability on an AC-130J or surrogate.

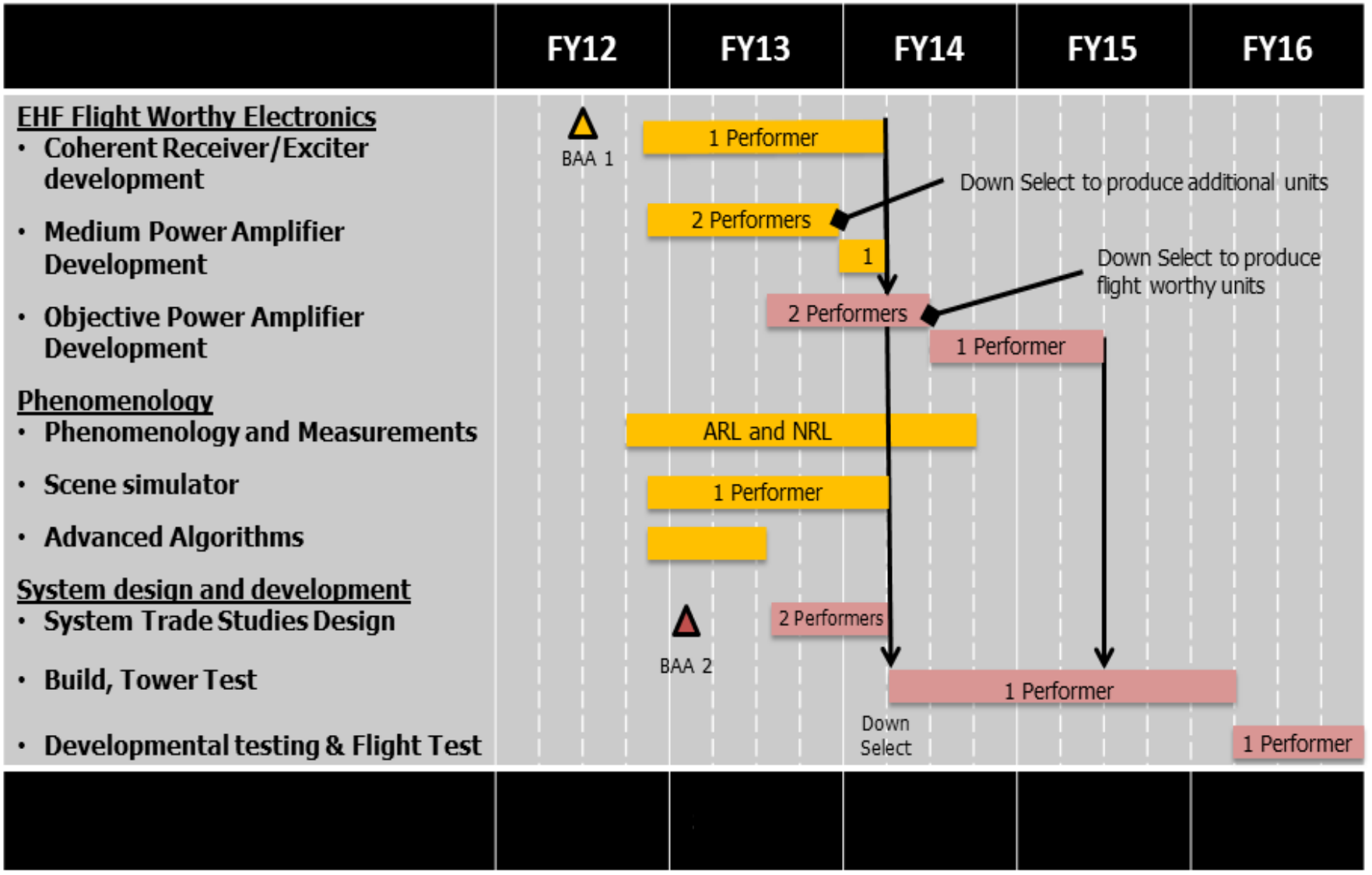
Outcomes and transition opportunities

Outcomes:

- Clouds can be your friend! – We begin to use them for protection.
- Establish the kill chain under conditions where no capability previously existed.
  - Potential 3X increase in weapons availability based on documented cloud cover in regions of the world

The AC-130 is the proposed flight test platform for demonstration of the key technologies. These techniques are extendable to other platforms and scenarios. (Backup #2)

ViSAR program plan



Estimated ViSAR Key Dates	
BAA Release	4/30/12
Proposer's Day	4/30/12
Abstracts Due	5/10/12
Final Q&A Posted	5/18/12
Proposals Due	6/18/12
Notification of Selection	~7/20/12
Contract Award	Sept-Oct 2012

Additional Questions

Please submit any outstanding questions you have to our BAA inbox at:

DARPA-BAA-12-41@darpa.mil

Thank you for your time and interest in ViSAR, we look forward to hearing your ideas.

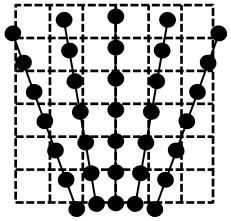
Backups

Backup #1

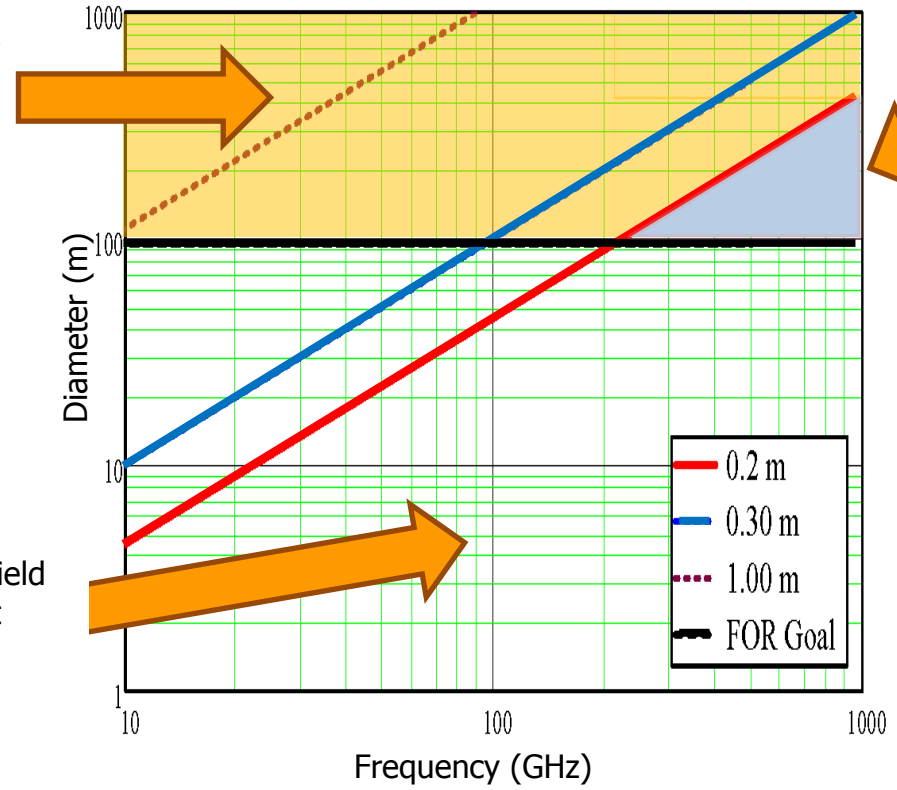
$D_0=4\rho^2/(1.2*\lambda)$ [Carrara]
Where ρ is the SAR resolution , and λ is the wavelength

Diameter of maximum scene size for rectangular processing

Region where Polar format processing required.

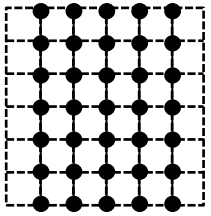


Requires two one-dimensional interpolations



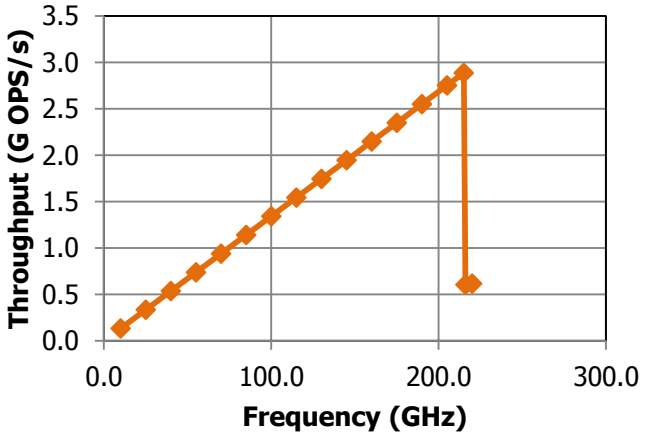
Region where Field of Regard is not satisfied

Region where Rectangular processing is sufficient.



No interpolations Required

At 230 GHz, processing can be done using the simpler rectangular algorithm



Resultant Throughput for SAR image formation (pre receive channel)

Reference: Carrara, Walter G, Ron S. Goodman, Ronald M. Majewski, *Spotlight Synthetic Aperture Radar, Signal Processing Algorithms*, Artech House, Boston, 1995

Backup #2

Target Contrast vs. Range to Target