# A Novel Trap Jamming Technique to Defeat Cognitive Radar

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# Presenter's Information

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- Bio: Dr. Taiwen Tang received his B.E. degree in electronic engineering from Beijing University of Posts and Telecommunications, Beijing, China, in 2001, his M.S. degree in electrical and computer engineering from the Colorado State University, Fort Collins, in 2003, and his Ph.D. in wireless networking and communications from The University of Texas at Austin in 2006. Dr. Tang is a researcher who has published over 40 journal and conference papers and has 16 US patents granted to date. He is currently a Defence Scientist at Defence Research and Development Canada (DRDC) – Ottawa Research Centre. He has 17 years of experience in wireless system baseband and digital intermediate frequency algorithm design and implementation and worked in various technology companies and several universities before joining DRDC in 2018.

# Outline

- There has been a growing research interest in the development of cognitive capabilities, such as
  - Cognitive radio utilizes the principle of dynamic spectrum access
  - Cognitive radar shares the fundamental principle and "perception-action" cycle of cognitive radio
- The cognitive technology leverages artificial intelligence and machine learning to enable autonomous, real-time adaptation to complex electromagnetic environments
- In this paper, a trap jamming technique is proposed, which intends to periodically disrupt cognitive radar's measurement capabilities
- The MATLAB experimental results showed that the proposed technique could disrupt and render cognitive radar ineffective

# Cognitive Radio

- Cognitive radio is a novel method of radio communication that enables more efficient use of the frequency spectrum
- It has emerged as a key technology that realizes the principle of dynamic spectrum
  - being capable of sensing and exploiting unused spectrum bands
  - allowing secondary users to access the licensed radio spectrum
- Thus, cognitive radios can increase the spectrum utilization and consequently spectrum efficiency

# Cognitive Radar

- The concept of cognitive radar was introduced by Simon Haykin in 2006 [5]. It has become a topic of regular interest at radar conferences
  - Cognitive radar enables optimal adaptation of the waveform and other parameters to the environment through received feedback
  - Previous knowledge and current measurements obtained from the radar channel are used to form a probabilistic understanding of its environment
  - Machine-learning techniques and other methods from the field of Artificial Intelligence (AI) allow for the automation of cognitive abilities
- As mentioned above, cognitive radar stems from cognitive radio and an interesting capability is that cognitive radar tries to predict the frequency band with the lowest jamming energy

# Electronic Countermeasure (ECM)

- ECM is a crucial element of Electronic Warfare (EW)
  - ECM includes techniques and technology to control the spectrum
  - Deceive, confuse, or jam radar or other electronic systems
  - ECM is commonly used to protect platforms, such as aircraft and ships.

# Jamming

- Jamming is a conventional method of EW
  - Transmitting interfering signals, such as, noise signals or false information
  - Deceiving the receiver of any electronic device
- There are two main techniques of jamming
  - Noise techniques
  - Deceptive techniques

# Noise Jamming

- The objective of noise jamming is to mask the actual signal by introducing an interference signal into the adversary's electronic system
  - Barrage jamming
  - Spot jamming
  - Sweep jamming
- Jammer, attacking the targeted radar need to be lined-up for main lobe jamming.
- Burn-through range shall be at minimum

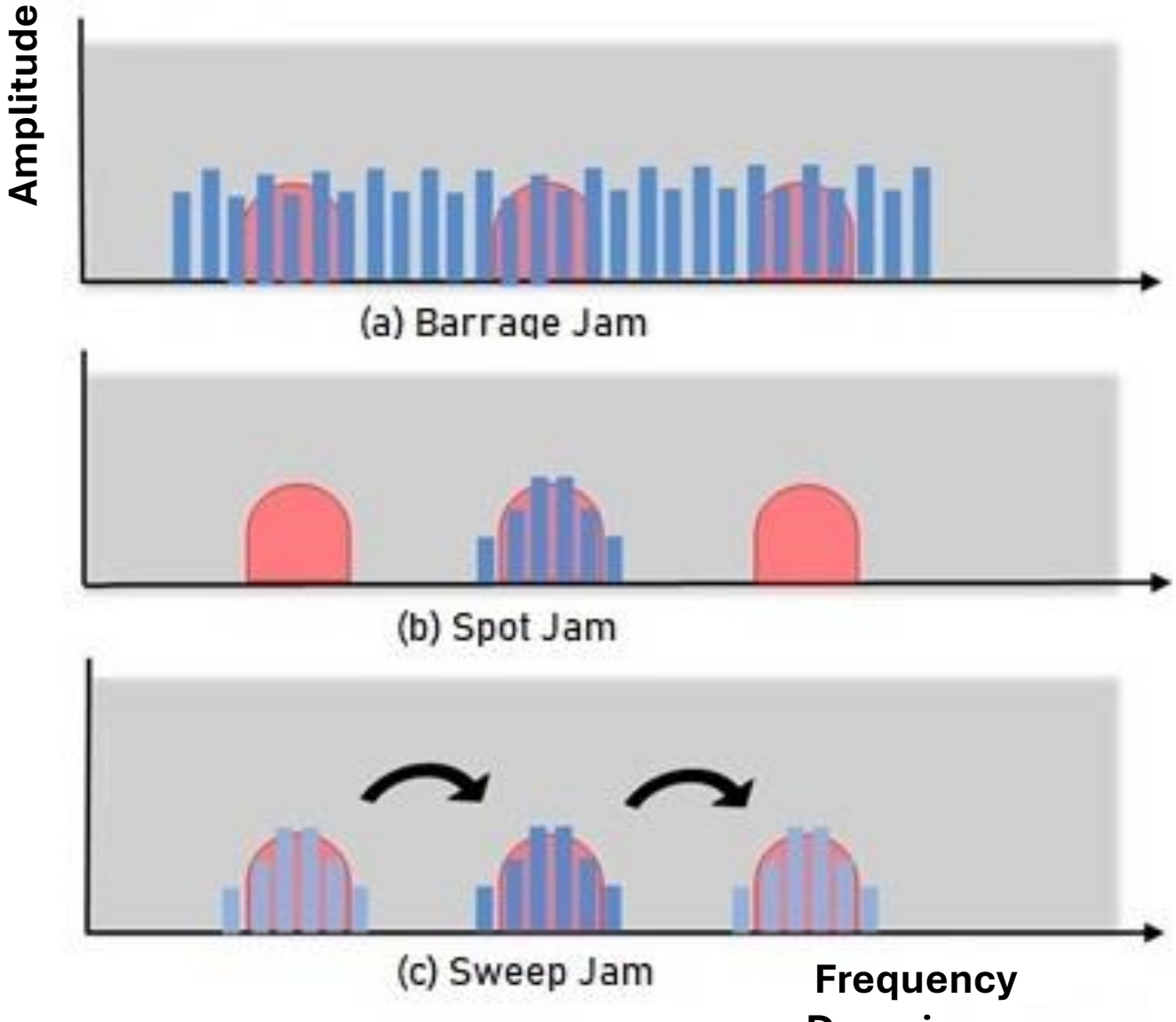



*Figure 1*

# Trap Jamming Technique

- Based on the property of cognitive radar that tries to predict the frequency band with the lowest jamming energy, a trap jamming technique is proposed that
  - Sets up spectrum holes,
  - Lures the cognitive radar jump into one of the spectrum holes, and
  - Generates a jamming signal to cover the spectrum holes
- Therefore, make the radar cannot continuously lock onto the intended target

# Frequency-Power Plot at Time *t*, with Trap Jam Signal

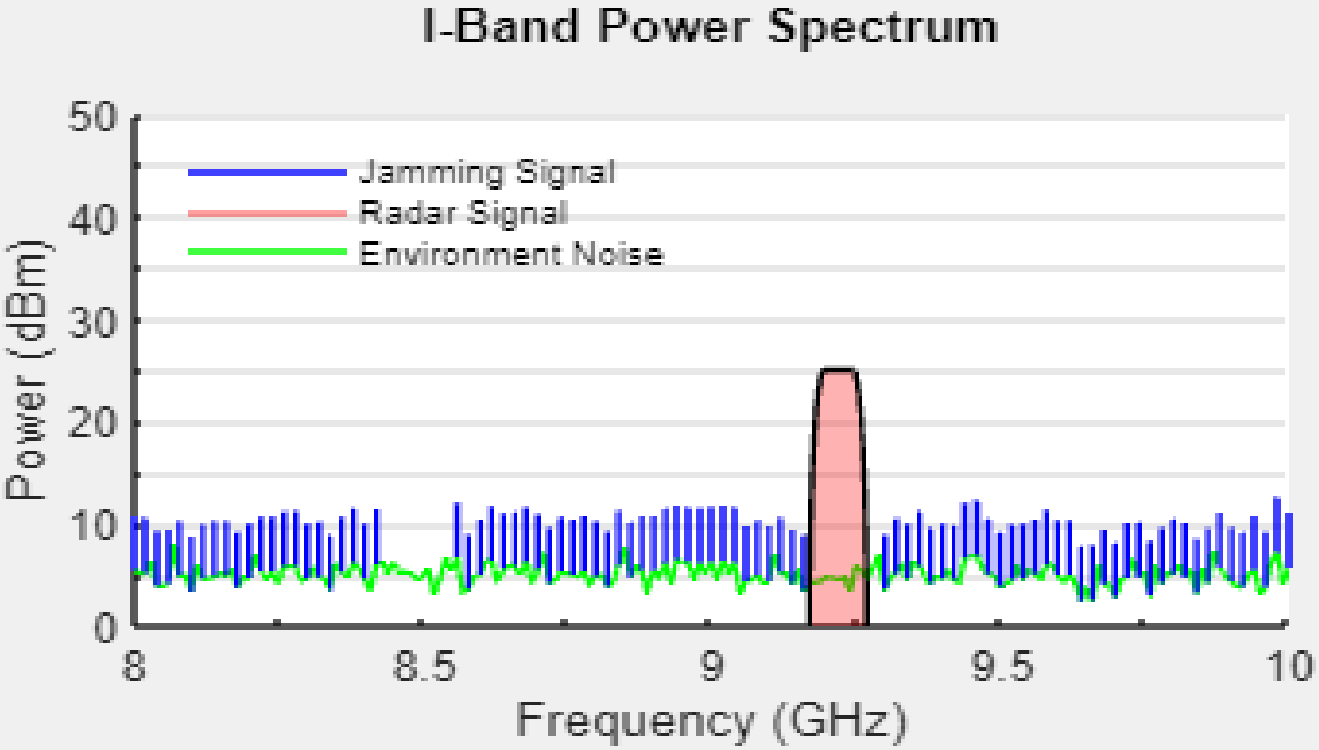



*Figure 2*

- As shown in Figure 2, the initial jamming signal transmitted at time *t* will be similar to a barrage noise jam, with the only difference being that there are two or three spectrum holes of bandwidth *b* that are not jammed
- The cognitive radar should find these spectrum holes and operate at one of them

# Frequency-Power Plot at Time $t + \Delta t$ with Spot Jam Signal

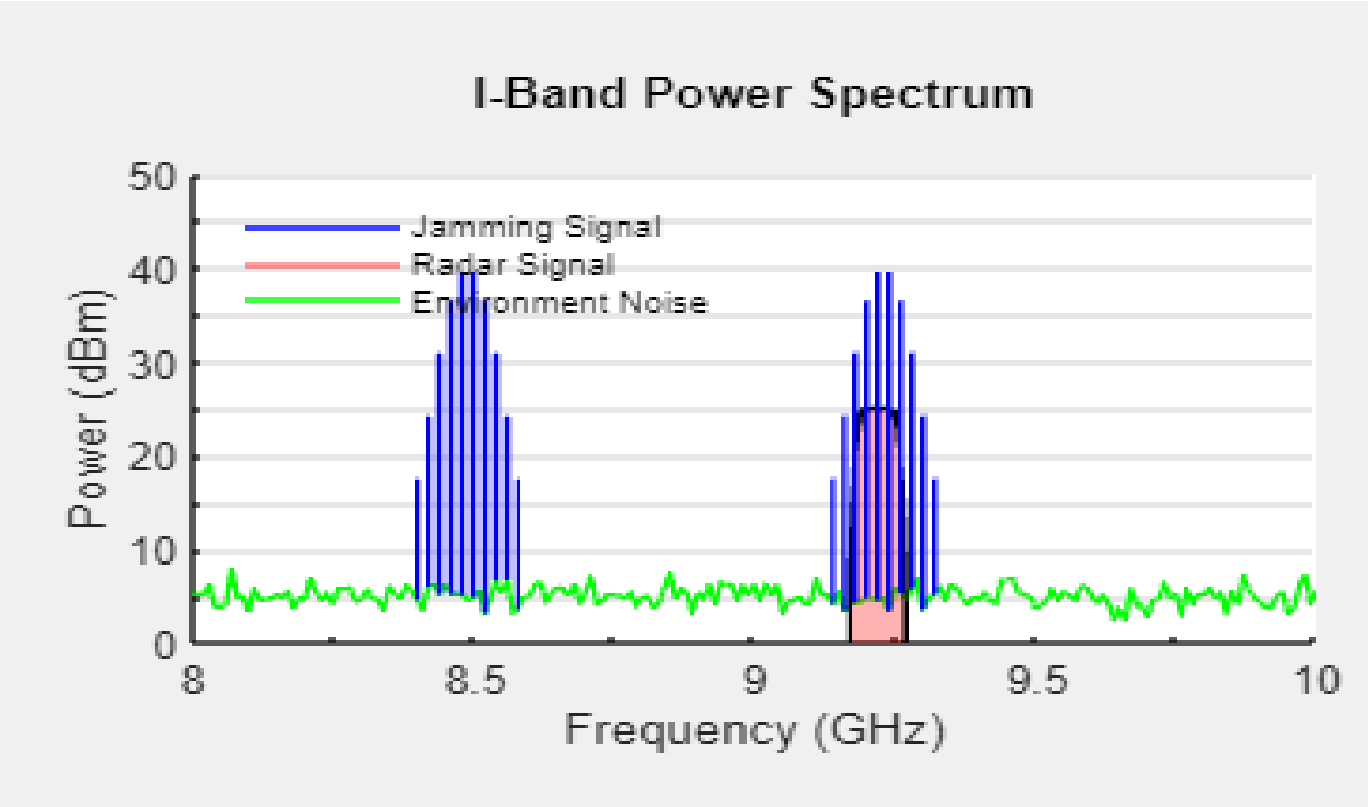



*Figure 3*

- At time $t$ plus an interval of $\Delta t$
  - The jamming signal will switch to spot jamming with power $P_J$ on the "trapped" sections of the frequency domain that were initially left without transmitted noise signals
  - $\Delta t$ intervals will be designated so that the cognitive radar will have ample time to find the trapped locations and start transmitting from them

# Method Summary

- The repetitive nature of this technique will continuously reset adversary radar into its search mode
- Advantages of this method include:
    1. No longer needing sophisticated Electronic Support Measures (ESM) to gain the exact parameters of the cognitive radar, which could then quickly change regardless;
    2. No need to use radar warning receiver to intercept radar energy from the target in every instance, therefore, uses less computational power;
    3. No needs to employ the ESM to identify the radar parameters to generate a spot jam.

# MATLAB Simulation

- A proof of concept MATLAB simulation was designed to demonstrate the trap jamming technique
  - Takes user inputs from the different radar and jammer parameters console, and stores them as variables
  - Then, evaluates the signals from both the friendly and adversary sides by using the radar and jammer equations in decibel (dB) form
  - The two-way link radar equation has been implemented

$$P_r = \frac{P_t G_t G_r \lambda^2 \sigma}{(4\pi)^3 R^4} \quad (1)$$

$$S = P_T + G_T + G_R - 20\log(f) - 40log(R) - 103.4 + \sigma \quad (2)$$

# MATLAB Graphical User Interface (GUI)

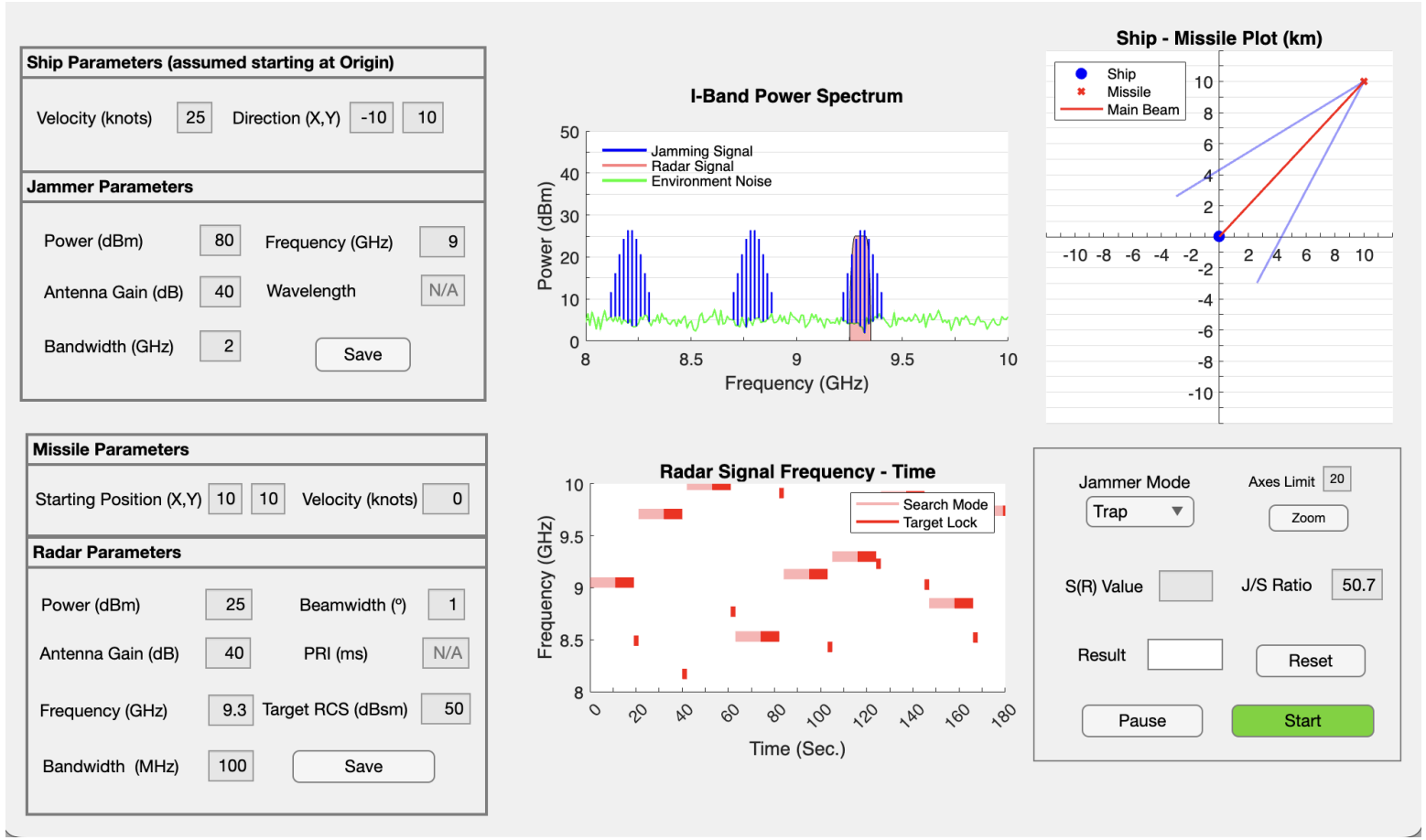
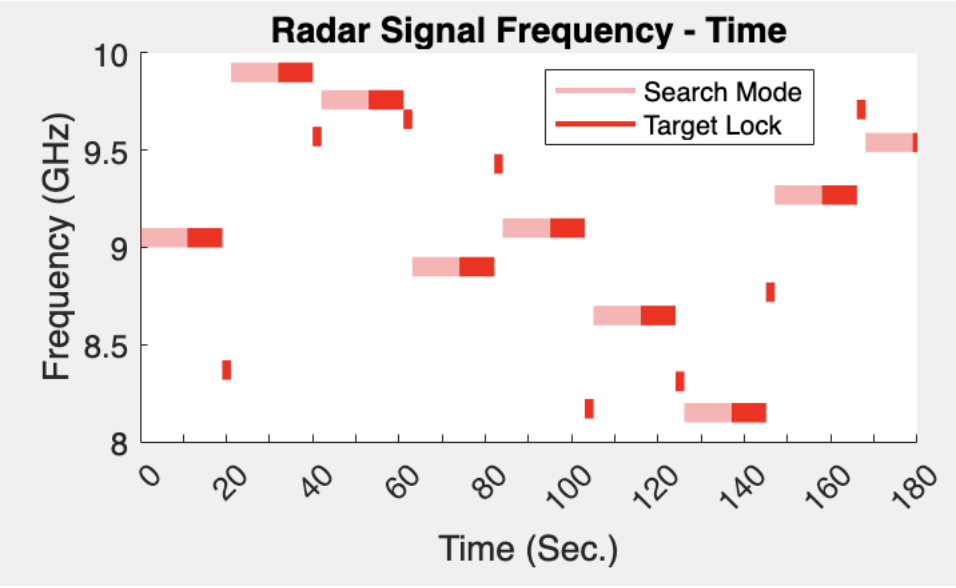


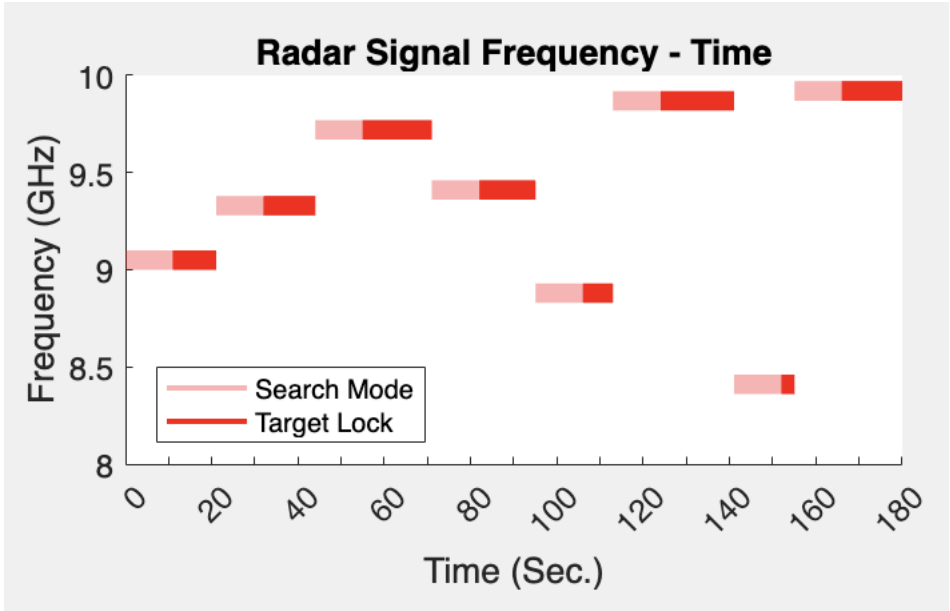

*Figure 4*

# Simulation Experiments

- Figure 5 shows a simulation result, which visualizes how often the cognitive radar is being allured to change its carrier frequency.




(a) The radar carrier frequency when the trap jamming method is used




(b) Same plot with the sweep jamming method simulated

*Figure 5*

# Conclusions And Future Work

- Targeting at the principle of dynamic spectrum that cognitive radar used, a novel trap jamming technique is proposed in this paper.
- The objective is to defend against cognitive radar system by making it unable to lock-on the intended target continuously.
- Possible future works include simulation supplemented with improvements, such as
  - Implementing artificial intelligence on the radar to have it learn ECCMs; and
  - Adding the other supporting countermeasures such as, chaff or decoys, to make the cognitive seeker lock onto the false targets, once the seeker is lured back to search mode.