Deployable Weather Radar, "EAGLE RADAR" , Upgrade: For effective use of "limited" frequency allocation

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    + Frequency allocation in any of countries
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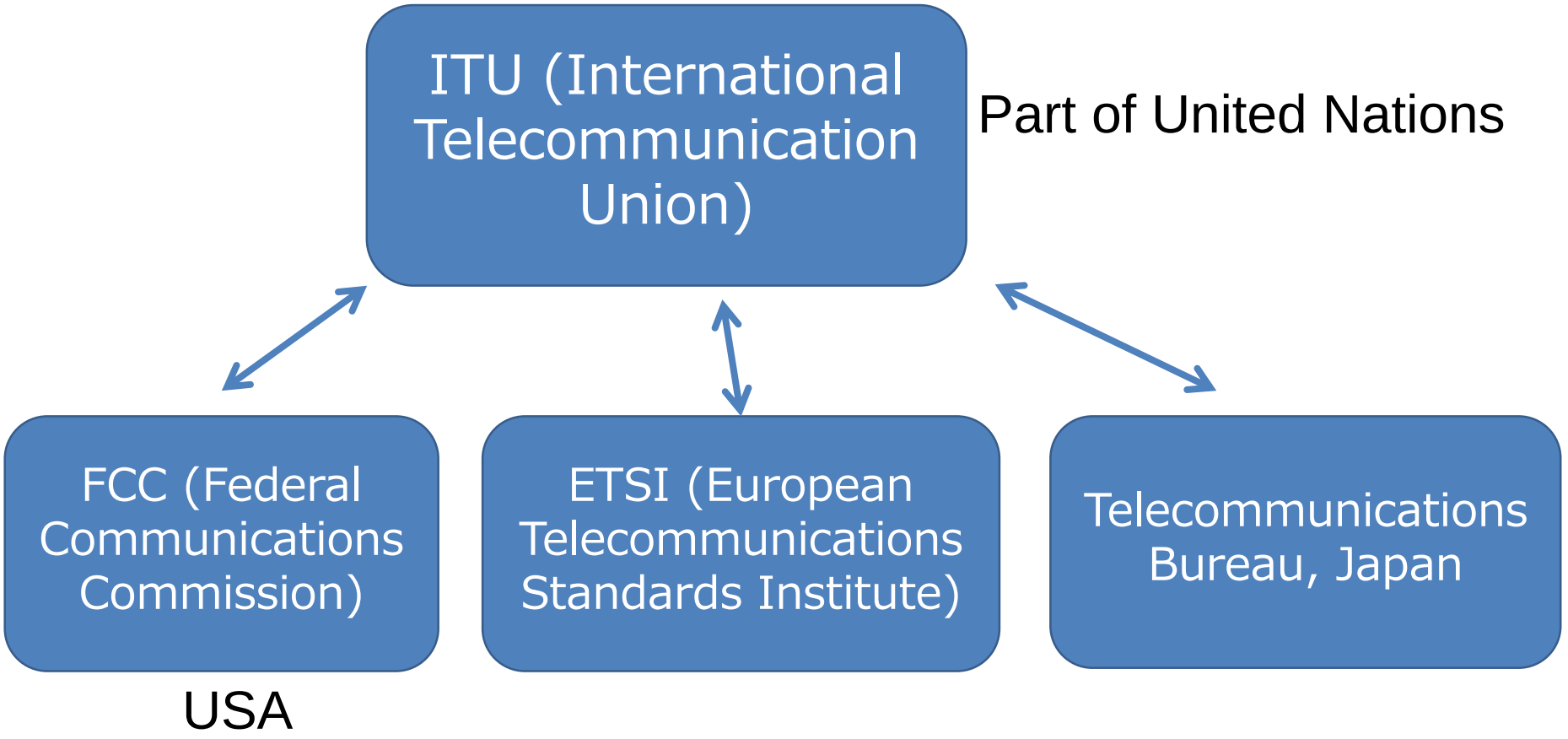
Motivation

- In order to deploy our radars into any of countries, radar frequency should be the same, but not…
  - **The frequency allocations in countries are very different**

Motivation



- **Each country have their own rules about FA**
- **ITU organizes the rules and enlightens each country**
- **ITU's rules are basically assigned to the local rules**

Motivation

- In order to deploy our radars into any of countries, radar frequency should be the same, but not…
  - **The frequency allocations in countries are very different**
- ITU's functions are:
  - **Prioritize usage of frequency band. Ex.) 9.3-9.5GHz**
    + Radio-allocation service (Marine & Airborne)
    + Radio-determination service (Weather radar)
- If Wx-radar interferes Marine radar, Wx-radar cannot get frequency allocation and stop to transmit!
- Our radars never interfere in both Marine and Airborne radars AND undergo interferences from both…

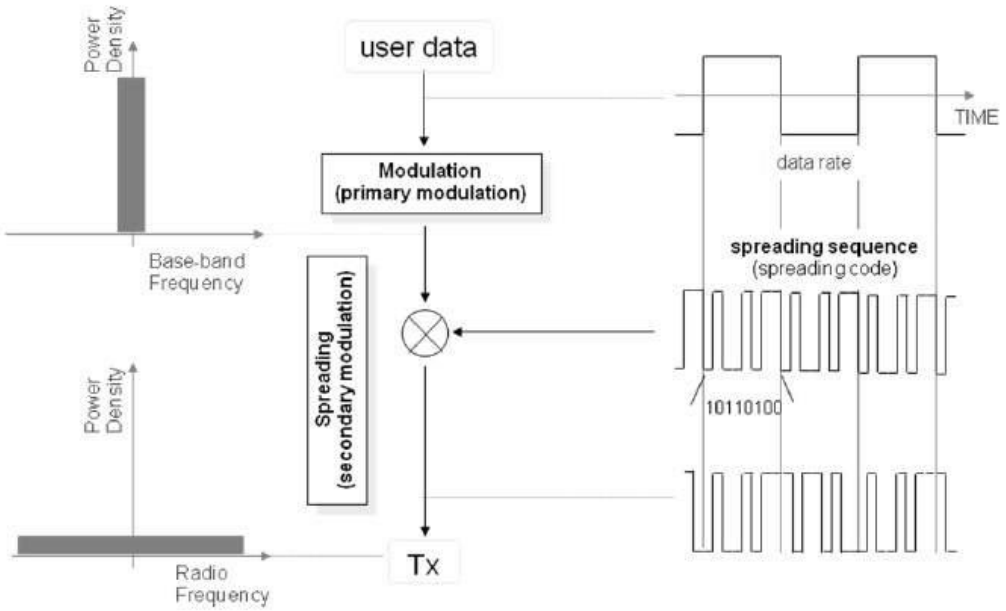
Motivation

- Additionally, ITU has no rules about X-band Solid-state transmitter, 9.7-9.8GHz fq-band usage Japan uses for Wx-radars
- We have to submit our band-plan to ITU through WMO*, easy to deploy*!!!

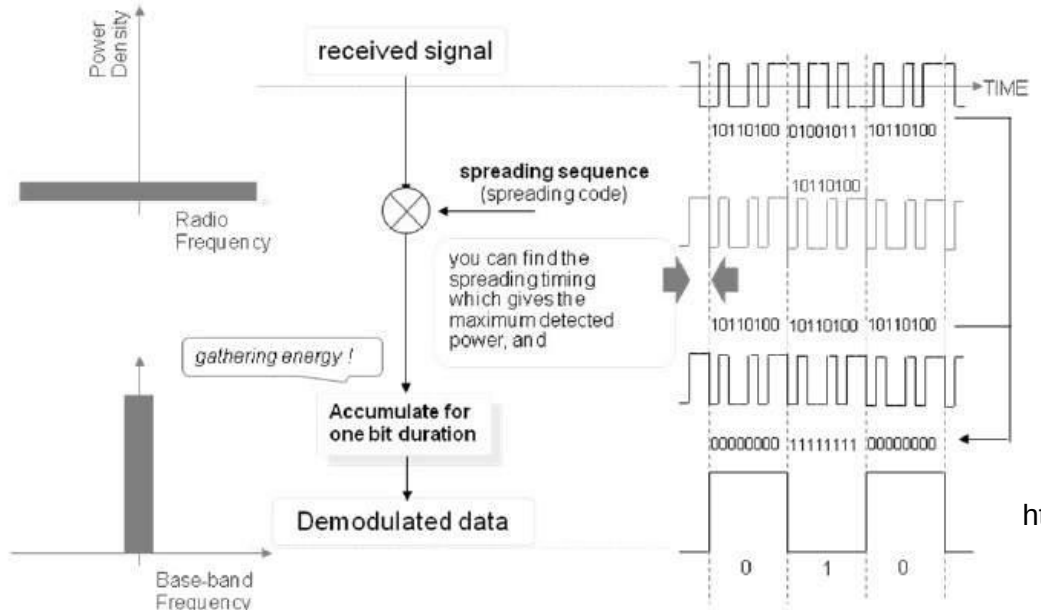
Motivation

- Our radars never interfere in both Marine and Airborne radars AND undergo interferences from both…
  - **Typically, Wx-radar uses no-modulation / (Non-)Linear frequency modulation**
  - **For example, cellular phones use “Code Divided Multiple Access (CDMA)” w/o interferences each other**
  - **How about applying CDMA into each pulse???**

What is CDMA?



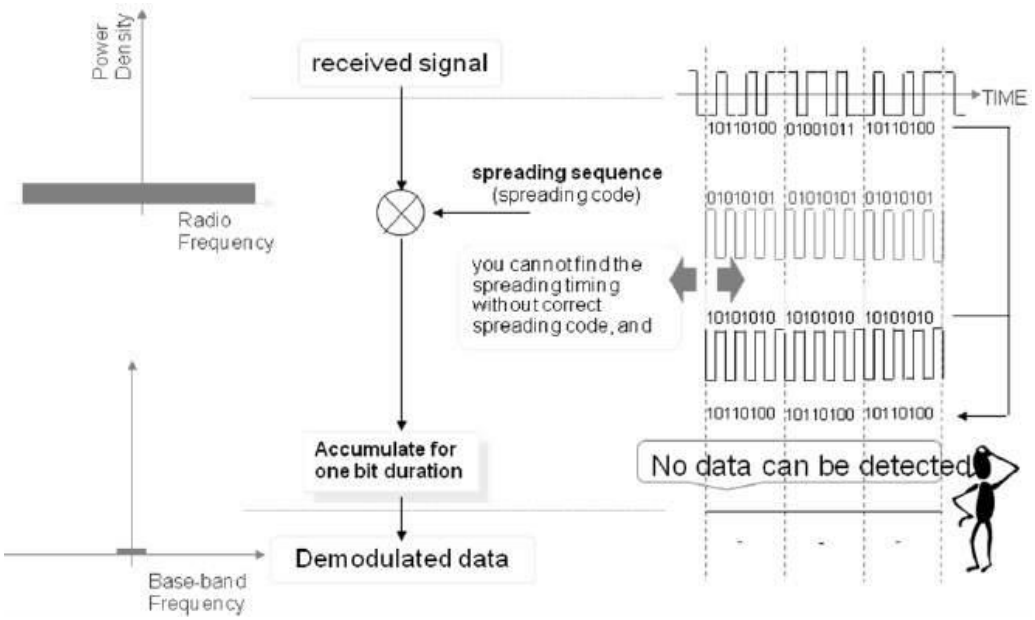
Modulation Process



Demodulation Process

https://www.tutorialspoint.com/cdma/cdma_spread_spectrum.htm

What is CDMA?



Demodulation of different-coded signal

- CDMA will help to decode only code-matched signal, non-decode others
- CDMA has many code sets and we can change the code in each pulse (c.f. barker code)

Applications of code modulation into Radar

- Many researches have conducted, using barker code (gold sequence (Cai et al., 2010) and polyphase (Qazi and Fam, 2015)
- Application for weather radar (Mudukutore et al., 1998, Nguyen and Chandrasekar, 2014)
  - **Barker code (Mudukutore 1998)**
- No application for Wx-radar has been conducted using CDMA code

Objective

- Effectiveness of code modulation for Wx-radar
  - **CDMA, using GPS Course / Acquisition (C/A) code**
  - **32 code sets used for GPS**
- Range sidelobe depression & Doppler shift resolution (Autocorrelation)
- Interference between different codes, code and no-modulation, and code and LFM
  - **Frequency allocation, especially in Japan**

Simulation

- Characteristics of matched filter between different modulations
  - **Freq. 9.47GHz, PW. 20us,**
  - **GPS codes: Nr 22 and 1, code length. 1023, sampling freq. 51MHz,**

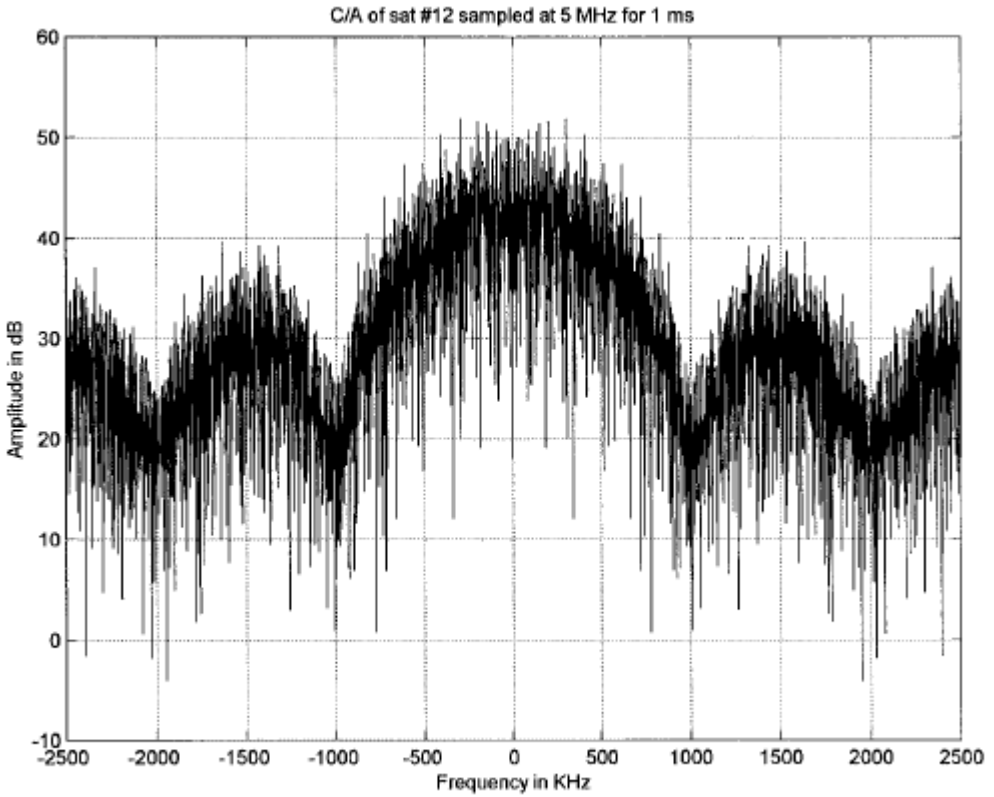


FIGURE 5.2 Spectrum of a C/A code.

Barker code (rep) and No-modulation

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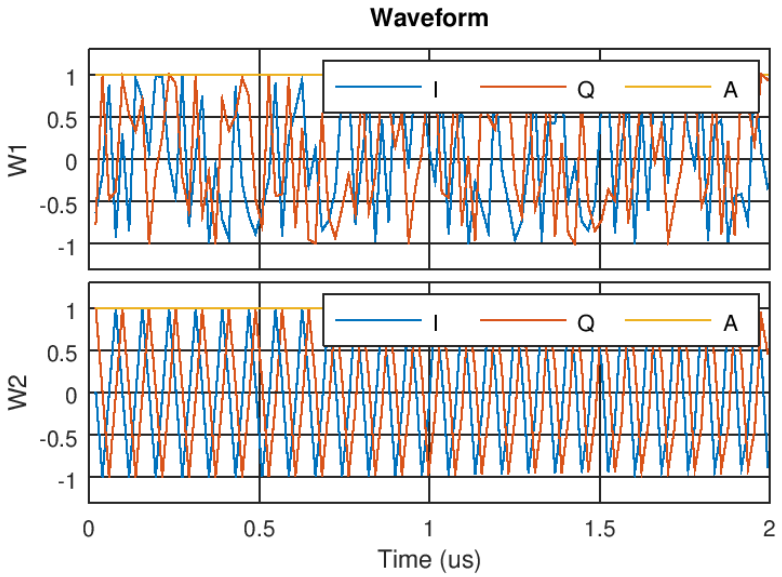

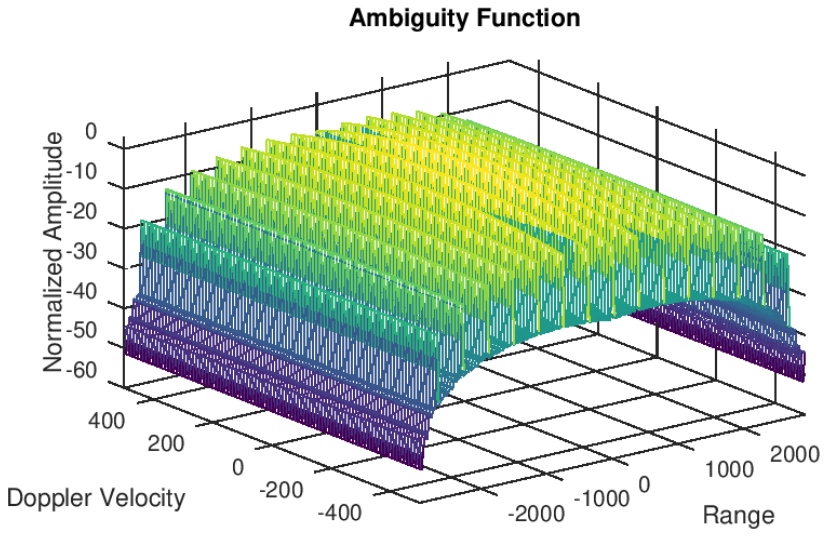

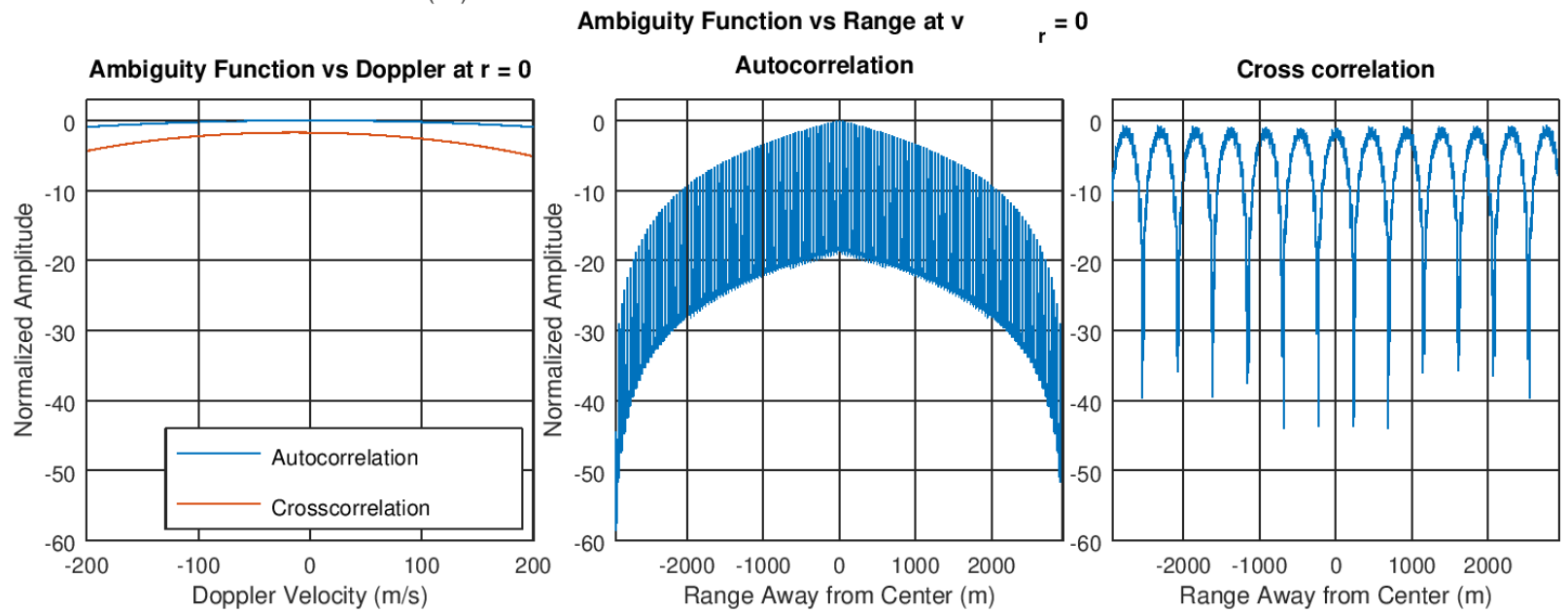

GPS code (22) and No-modulation

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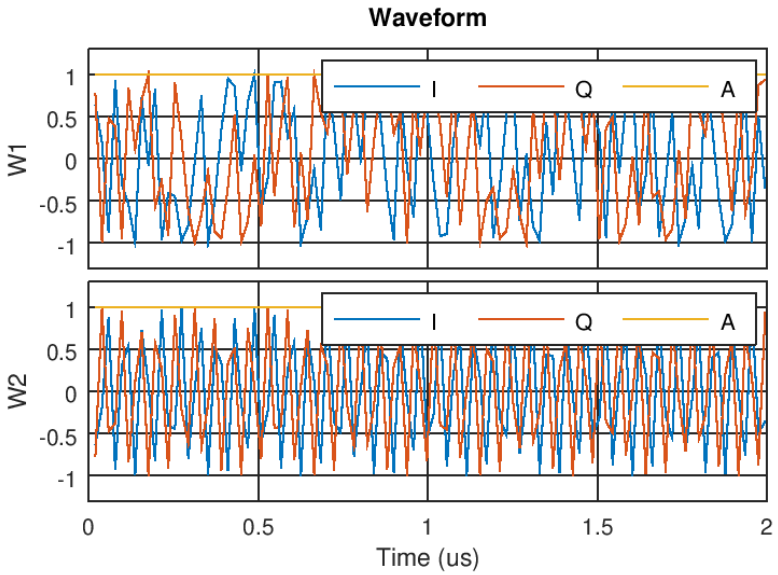

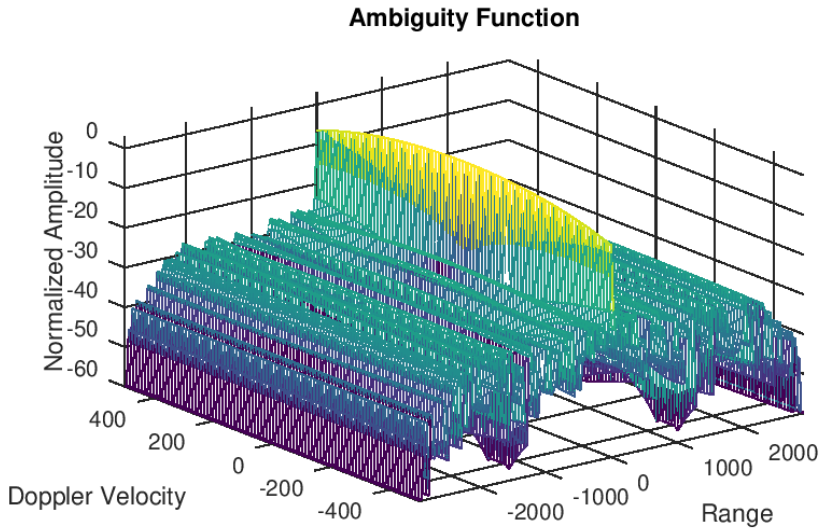

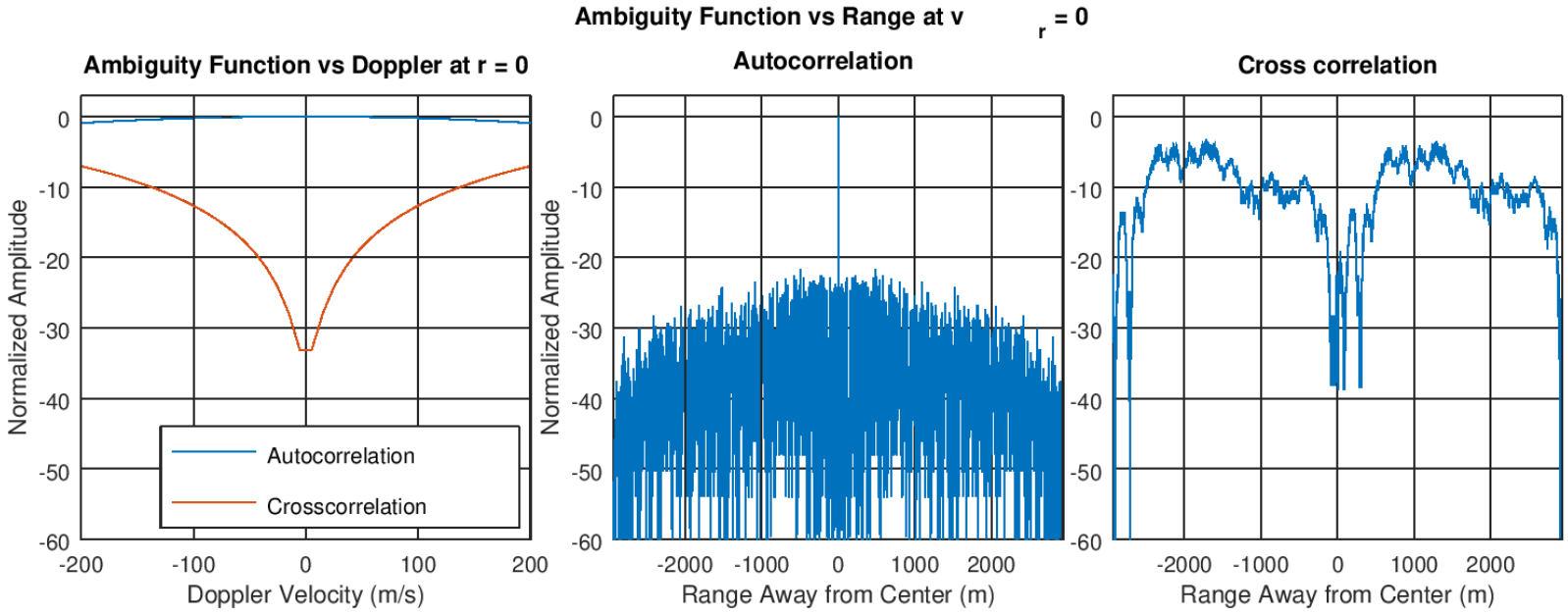

GPS code (22) and LFM

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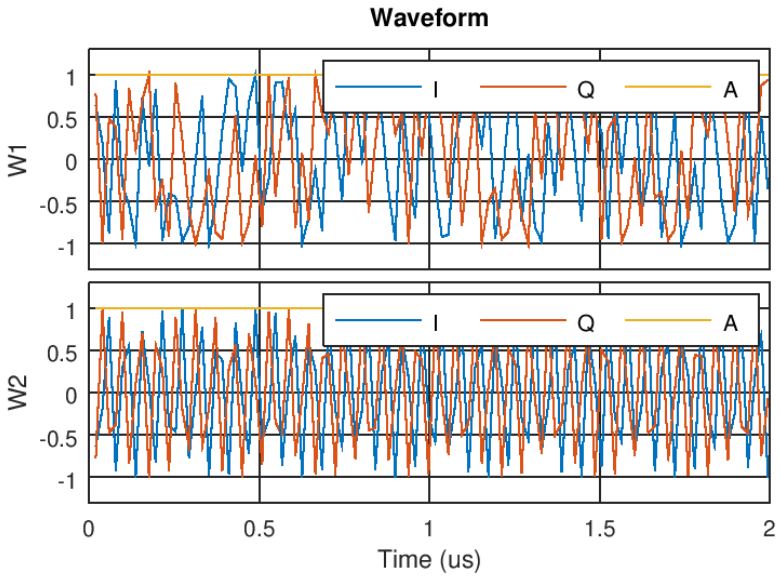
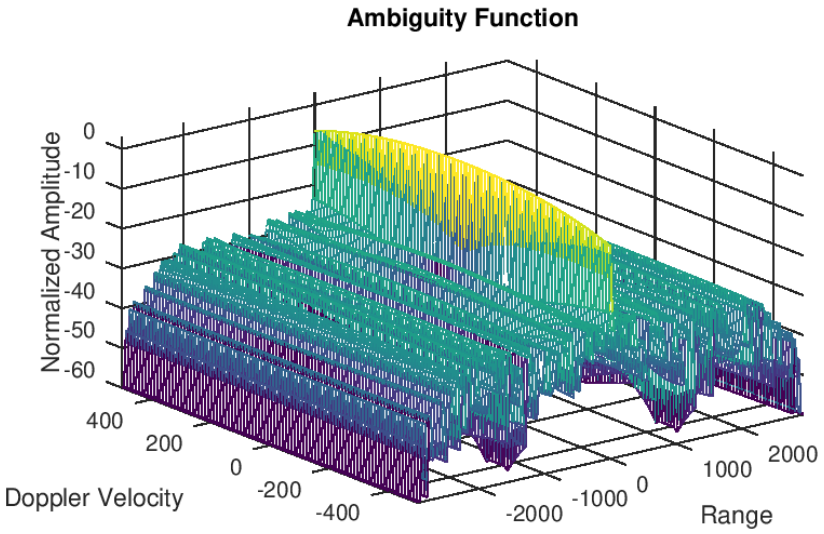
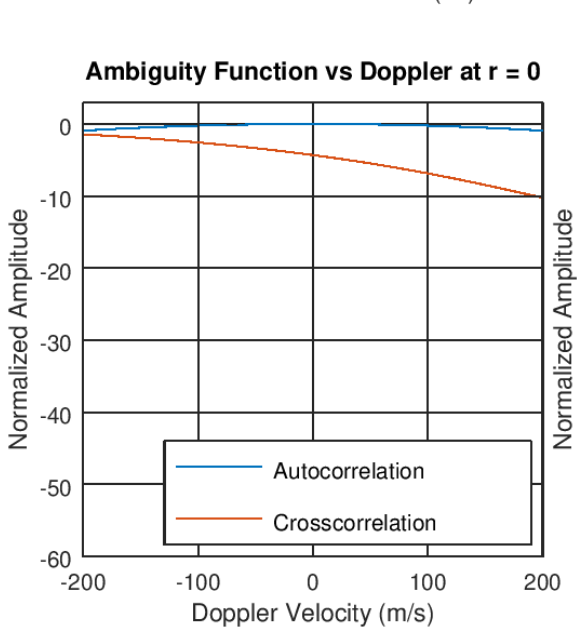
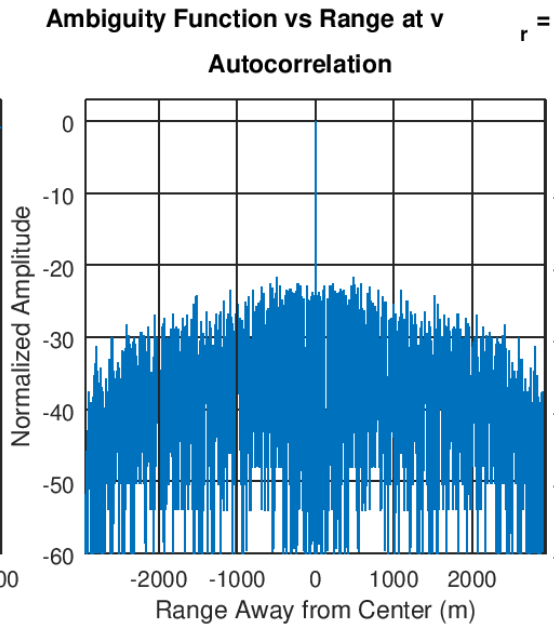
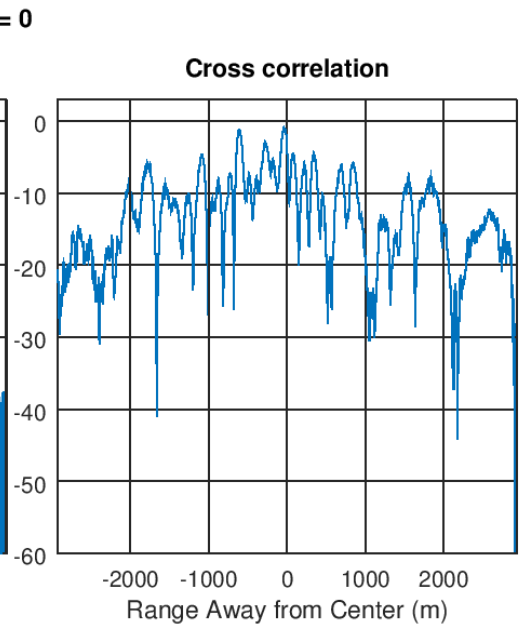


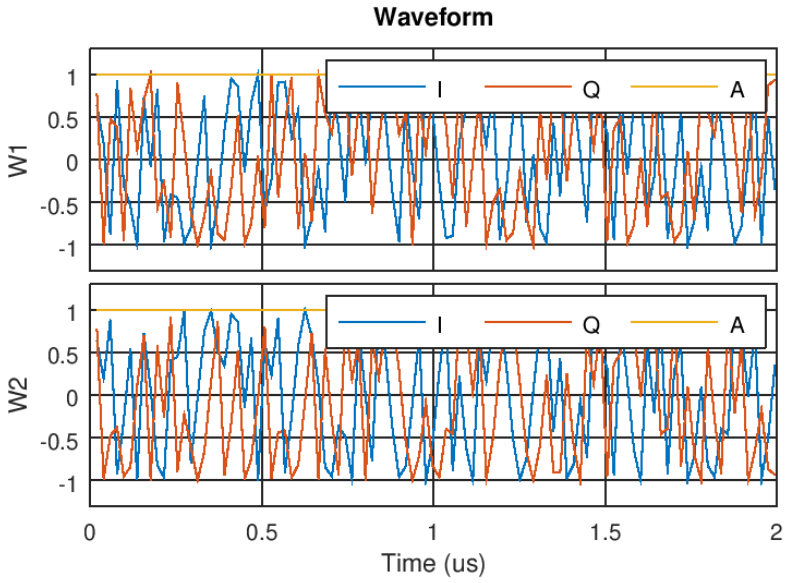


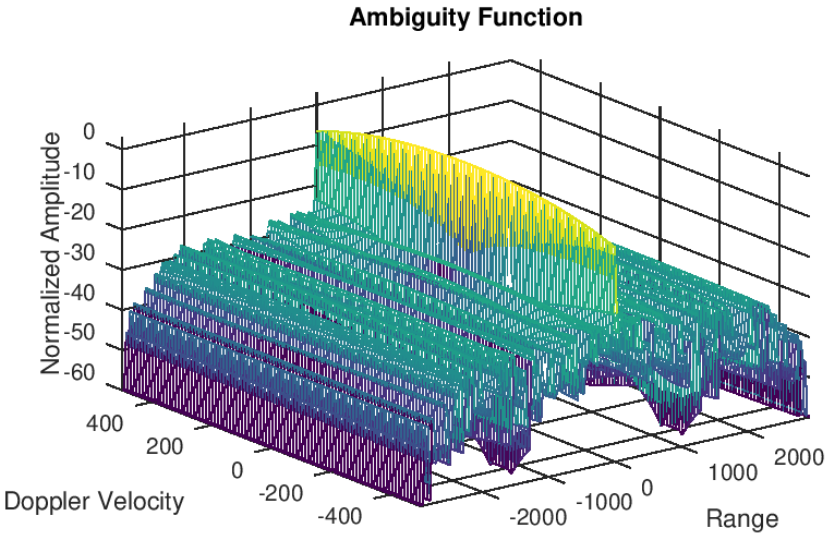


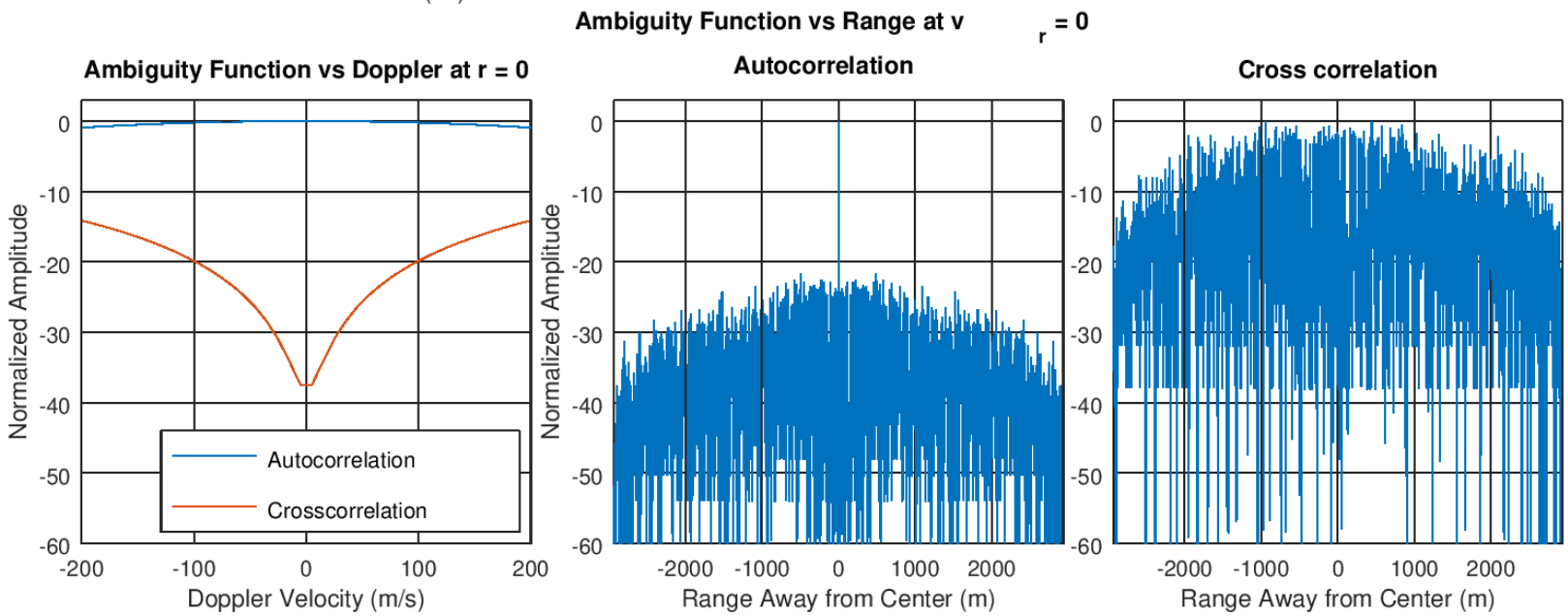




GPS code (22) and code (1)







Concluding remarks

- Good range sidelobe suppression w/ GPS code
- Large interference from other modulation…
  - **GPS jamming**
- Limited bandwidth due to frequency allocation (~20 MHz)

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