MURRAY STATE UNIVERSITY

CREATING A PRACTICAL EDUCATION IN SPACE CYBERSECURITY THROUGH ANTENNA DESIGN AND IMPLEMENTATION

CISSE 27TH COLLOQUIUM

by Clark Duncan, Randall Joyce, Spencer Bugg, Jason Marquardt, M

Introduction

- In February 2022, the U.S. saw one of the first state-sponsored attacks against a U.S. commercial satellite company, ViaSat.
- Researchers have found over the last decade, with the increase of deployed satellites, the number of cybersecurity-related events is matching this trend.
- How do we help bridge the gap in cybersecurity and satcom knowledge?
- How do we bring this into a course and implement the activities.

Research Goals

Practical Experience

Undergraduate and graduate level that exposes students to antenna design, satellite communication, and cybersecurity

SDR Use in the Classroom

Develop exercises for SDR use in the classroom

Reproducible Experience

Create a cost effective practical experience that can be repeated

What's out there?

Find out what Low Earth Orbiting satellites are available in West Kentucky

Education Objectives and Curriculum

Learning Objectives

Under Graduate

- Interpret antenna design requirements.
- Construct an antenna based on frequency requirements.
- Assemble and test antenna with an software defined radio.

Graduate

- Composing timing and targeting list for specific satellites.
- Assess traffic captures from satellite communications.

Education Objectives and Curriculum Cont.

Courses

- Undergraduate and Graduate- Independent Study
- Undergraduate- Introduction to wireless course.

Assignment Example

- Antenna Research

  Go out online and research an antenna design that can be used to capture radio frequency on the 243-270 MHz range. Please write a synopsis of your finding and reasoning for selecting this design and provide a link and require materials.

DESIGN

Trial and Error

Using the article Hunting for Space Radio Pirates on the US Military Fleet SATCOM Satellites as a reference, the frequency range 243-270 MHz was identified as the communication range utilized for pirate communications.

- Veins were created.
- 3d Printed mounting brackets

Antenna Phases

Antenna 1 and 2

- Considered several designs
- Turnstile was chosen
- Several DIY projects have utilized this design
- Same design as Antenna 3 (production)
- RF range centered at 255.55 Mhz

Antenna Phases cont.

TSE Antenna 3

The antenna that was procured was a TSE brand Light Weight TACSAT 03. This model was designed for a frequency range very similar to the other student-built antennas (243-318 MHz).

L-Com Mesh Antenna 4

L-Com mesh dish antenna was designed for 2.4 Ghz Wi-Fi. This antenna gave the team the capability to receive signals from other frequencies. The mesh dish could cover frequencies from 1 to 3 GHz.

SDR and Targeting

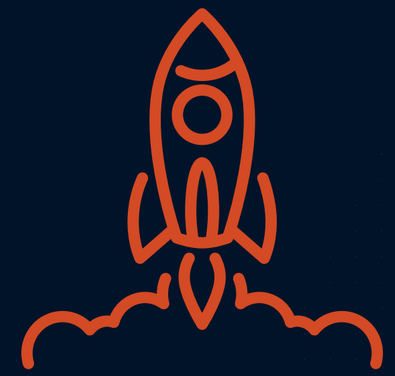
Target List							
Satellite Name	NORAD ID	Country of Origin / Owner	Type	Orbit Type	Freq 1	Freq 2	Freq 3
Galileo 10	40890	France	Navigation	MEO	1575.42	1176.45	1207.14
Galileo 15	41859	France	Navigation	MEO	1575.42	1176.45	1207.14
Globalstar M065	32266	Kazakhstan	Communication	LEO	2493	2485.62	2488.08
Navstar 49	26605	United States	Navigation	MEO	1575.42	1227.6	1176.45
Cosmos 2436	32395	Russia	Navigation	MEO	1202.025	1600.995	1248.06
Navstar 71	40105	United States	GPS	LEO?	1575.42	1227.6	1176.45
Cosmos 2456	36111	Russia	Navigation	MEO	1202.025	1600.995	1248.06
Galileo 11	41175	France	Navigation	MEO	1575.2	1176.45	1207.14
USA 217	37222	United States	Military Coms	?	400.18		
Oscar 25	19419	United States	Military Coms	LEO	399.968	149.988	
UniSat-5	39421	Russia / Italy	Exp / Amateur Radio	LEO	437.175	437.425	
UniSat-6	40012	Russia / Italy	Cube / Amateur Radio	LEO	437.421		

Results

- They found that it was harder to set the direction, and the capture timing was critical to see the satellite communications successfully.
- The majority of received transmissions came from Antenna 4 (mesh dish) around 1 GHz. This received traffic was highly variable in signal quality.
- Another area that needs more research is how higher-end software defined-radios would work in Western Kentucky since these software-defined-radios would have a better frequency range since we used a low cost SDR.

CONCLUSION

- Great practical experience
- Setup and capturing is hard
- Good exercise to implement in the classroom and works great for a independent study project.



THANK YOU

QUESTIONS