SHIFT TECHNOLOGIES

ERadar

Emergency Response Portable Radar System

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Outline

1. Background and Motivation
2. Project Overview
3. Product Specification
4. Field Tests
5. Project Management
6. Future Work and Acknowledgements

Background and Motivation

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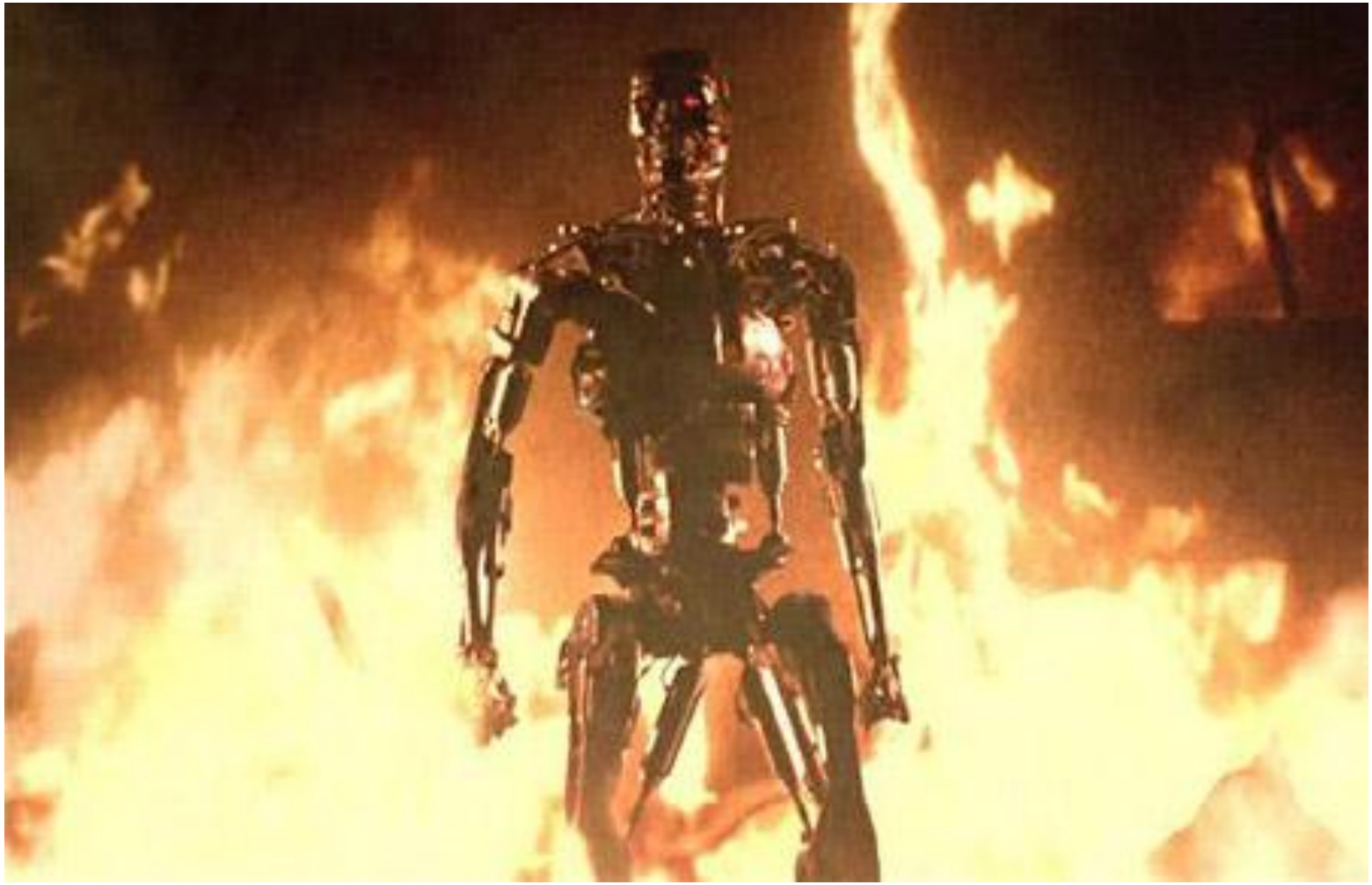

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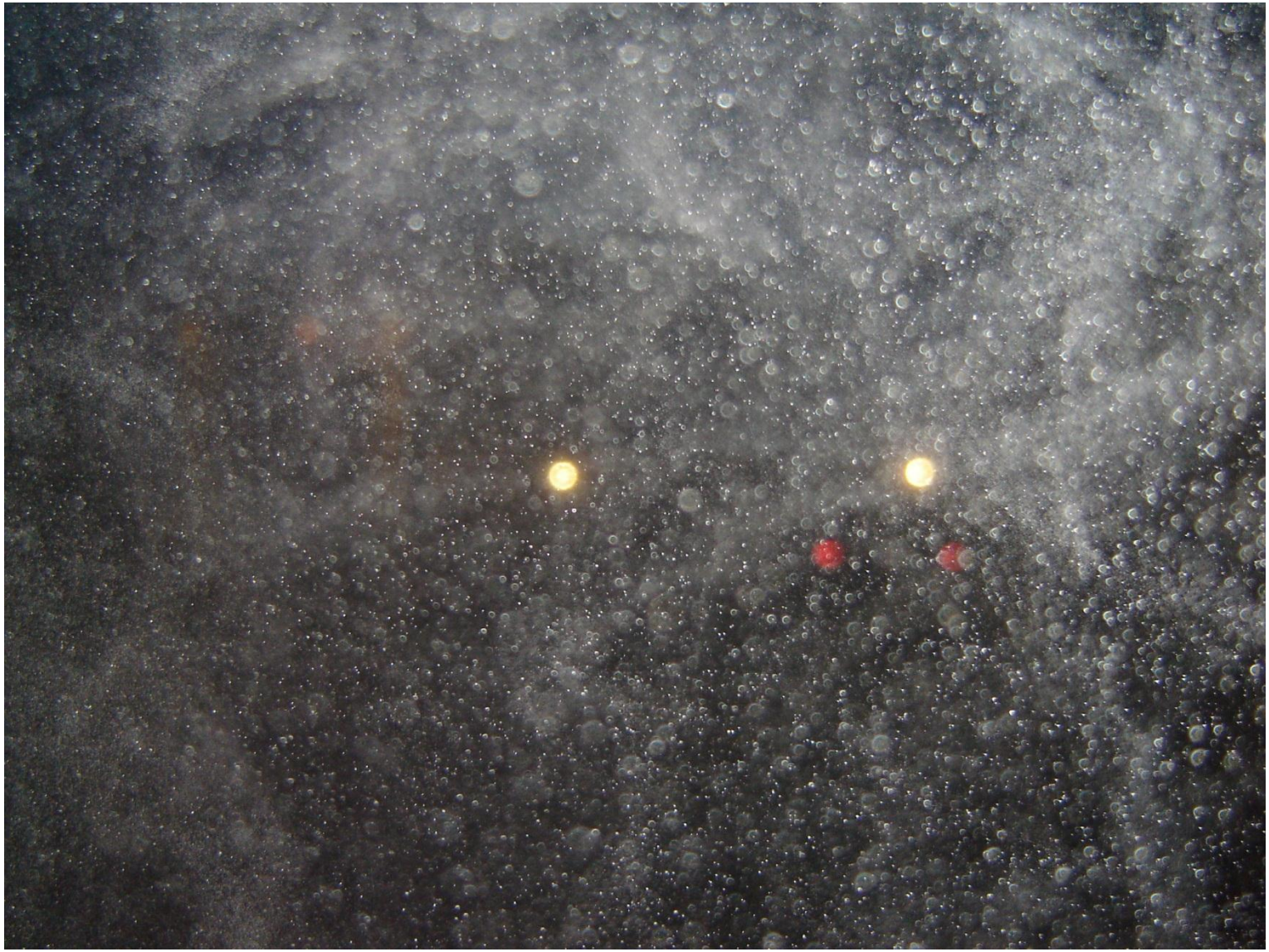

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Background and Motivation

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Firefighters

- Over 32,000 firefighters injured in the US in 2010 (National Fire Protection Association)

Search & Rescue Personnel

- Respond to over 1000 calls in BC alone each year
- Volunteers spend a combined total of over 120,000 hours during these searches (Emergency Management BC)

Background and Motivation

How can we protect emergency response personnel and victims?

Method	Pros	Cons
Infrared Imaging	• compact and portable • medium range • proven results	• expensive • potential to mask insensitive objects
LIDAR Technology	• can produce 3-D images	• low range • complex system • requires unimpeded path to target for light to travel

Neither are viable options for our desired application

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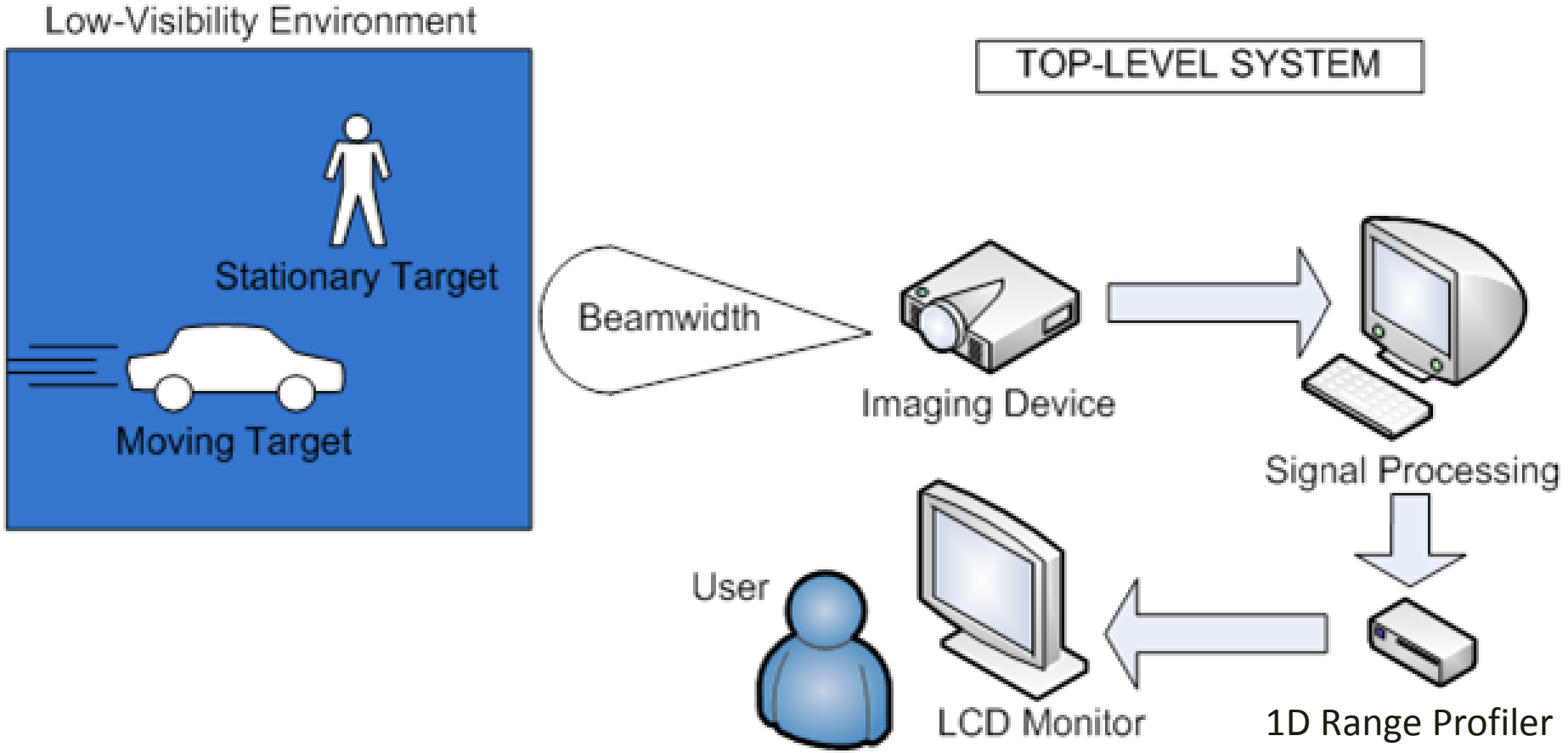
*ER*adar

Frequency-Modulated Continuous Wave Radar

Project Overview



Our Radar System Is…

- Powered by two 6 *V* battery packs
- Durable
- Lightweight (1.9 *kg*)
- Uses an iPhone app to interpret return echo
- Utilizes low-budget antennas (“Cantennas”)
- Safe and Efficient

Typical Transmission Power Output (TPO) – 18.5 dBm (70.7945 mW)
6V Supply Line – 154.5 mA (0.927 W)
12V Supply Line – 31.2 mA (0.374 W)

Project Specification

FMCW Radar Theory

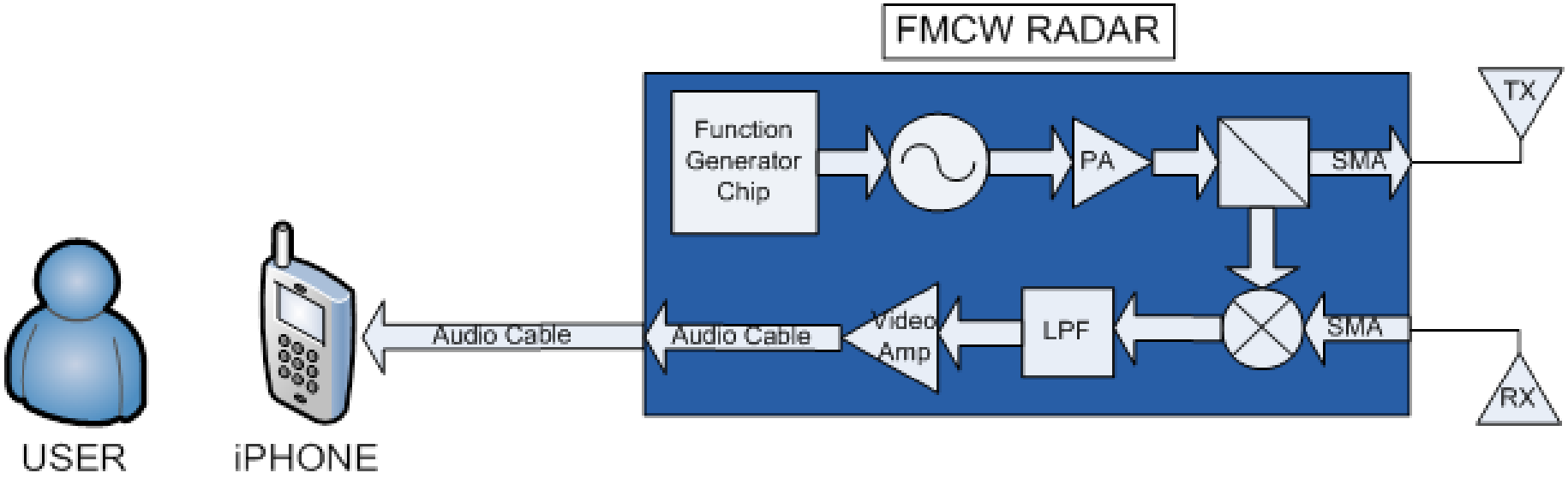
Signal Processing Algorithms

Firmware and Interfacing

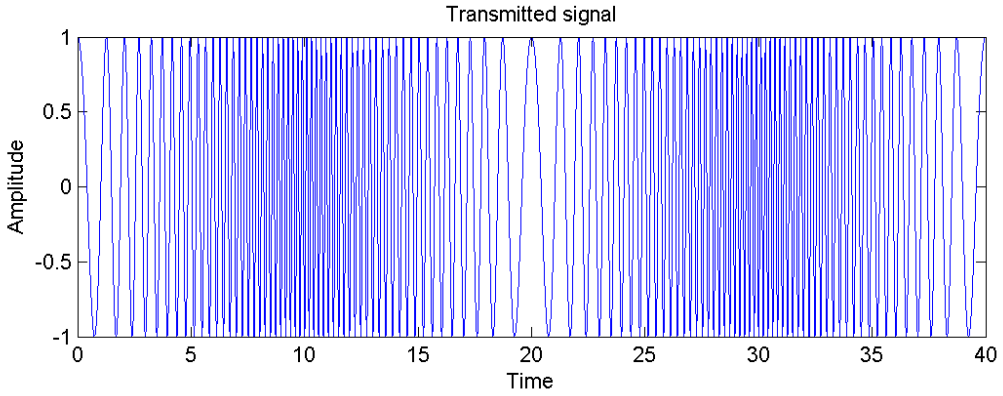
Radar Hardware

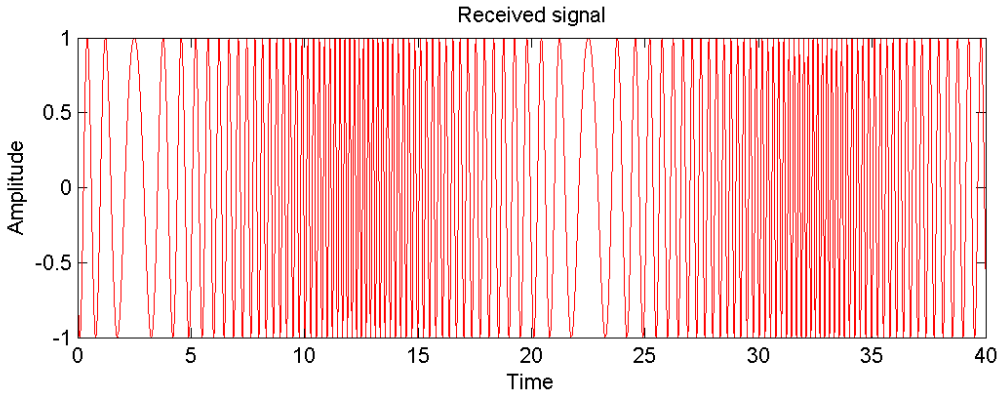
Hardware Packaging

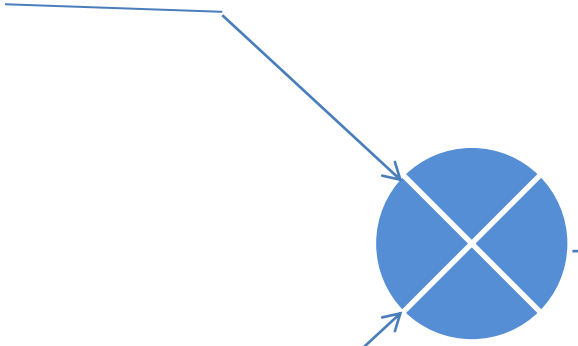
FMCW Radar Theory



FMCW Radar Theory

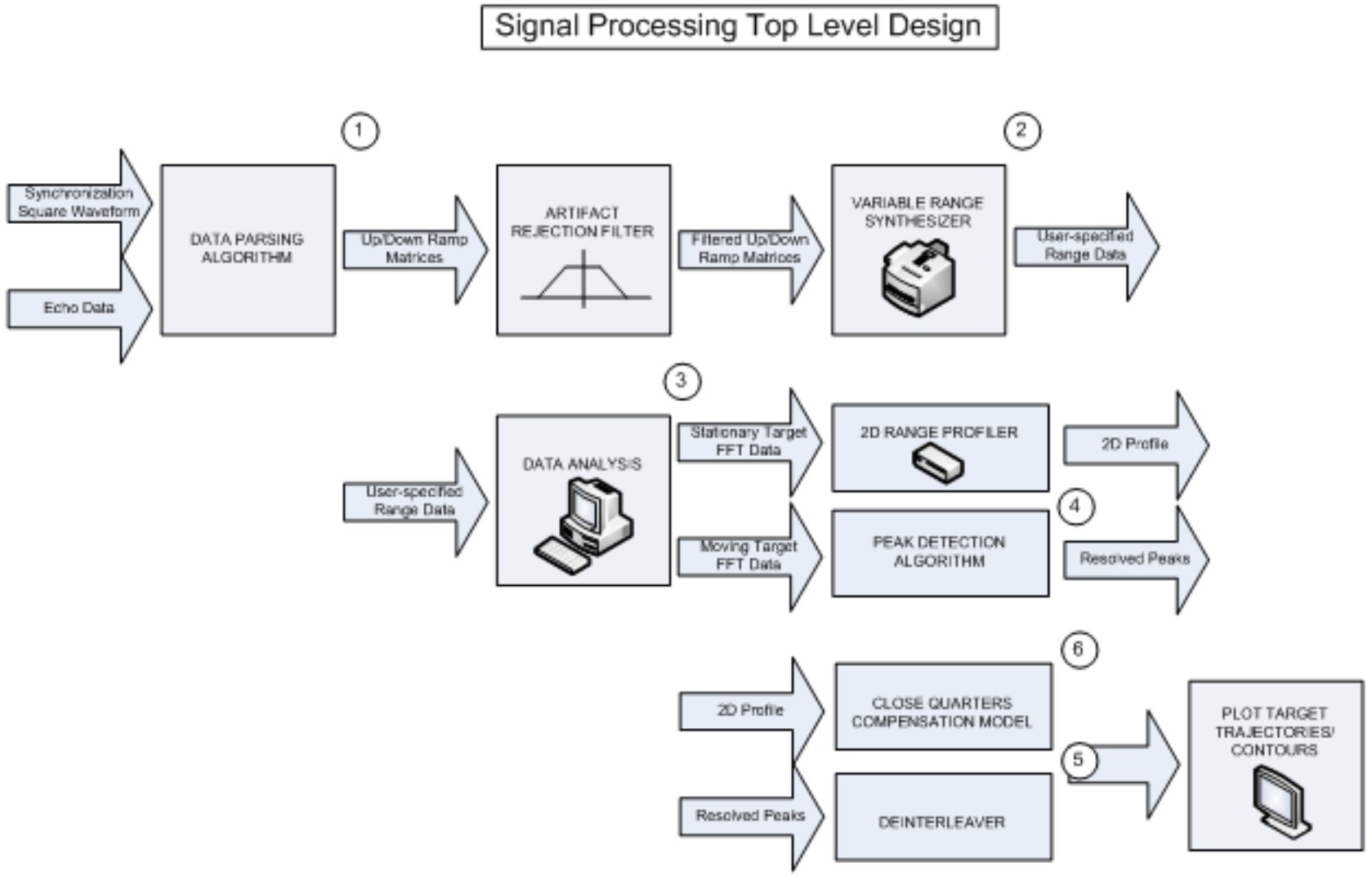




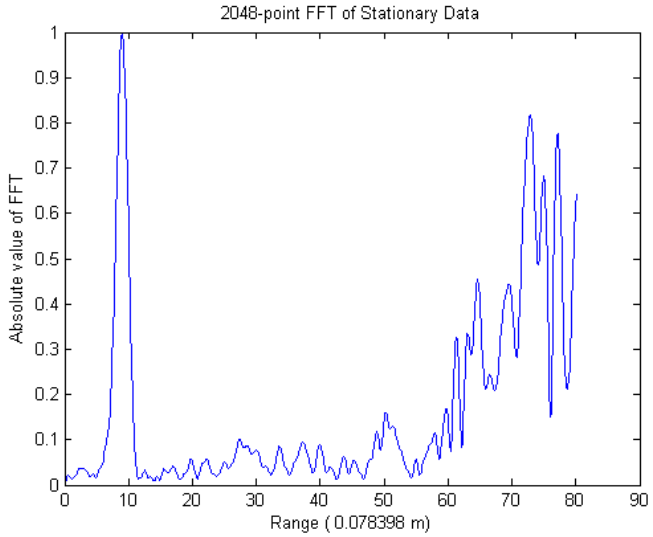


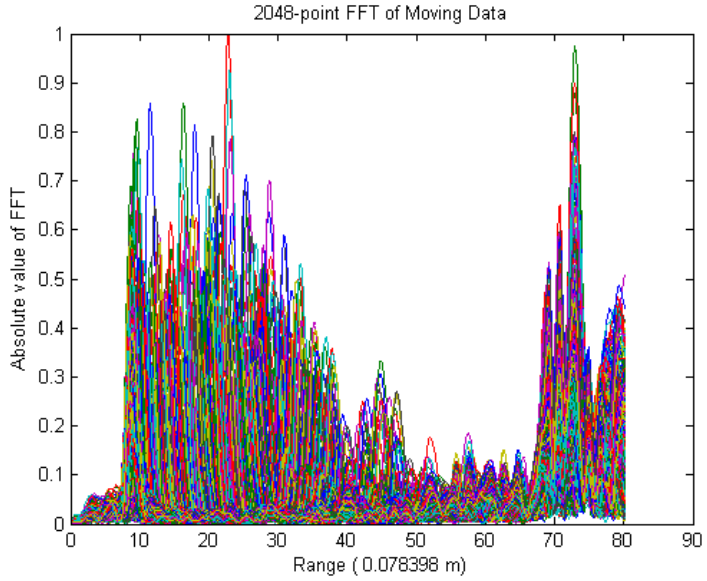
to processing

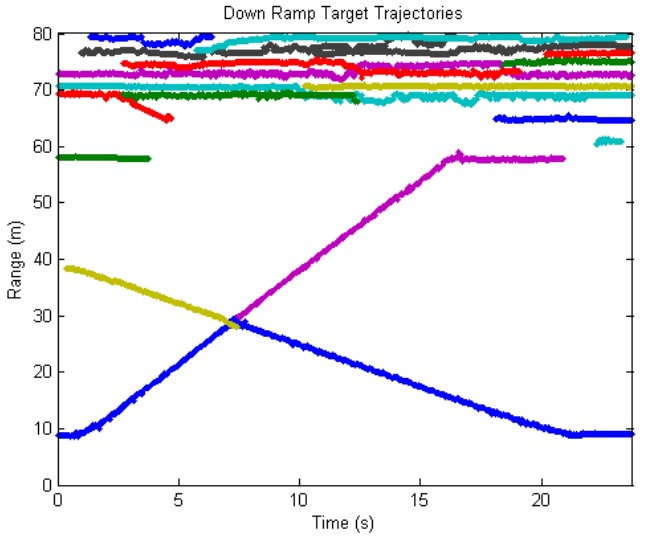
Signal Processing Algorithms



Signal Processing Algorithms







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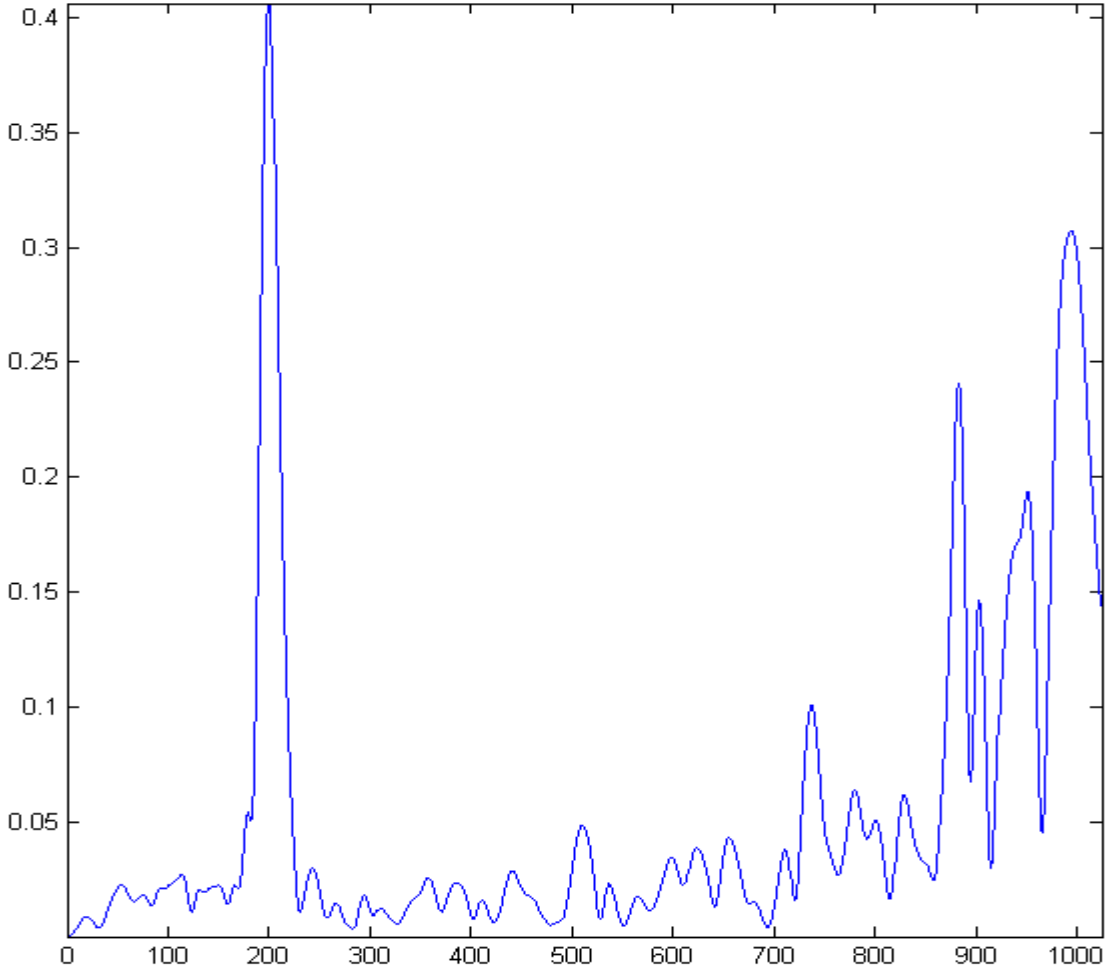
Signal Processing Algorithms



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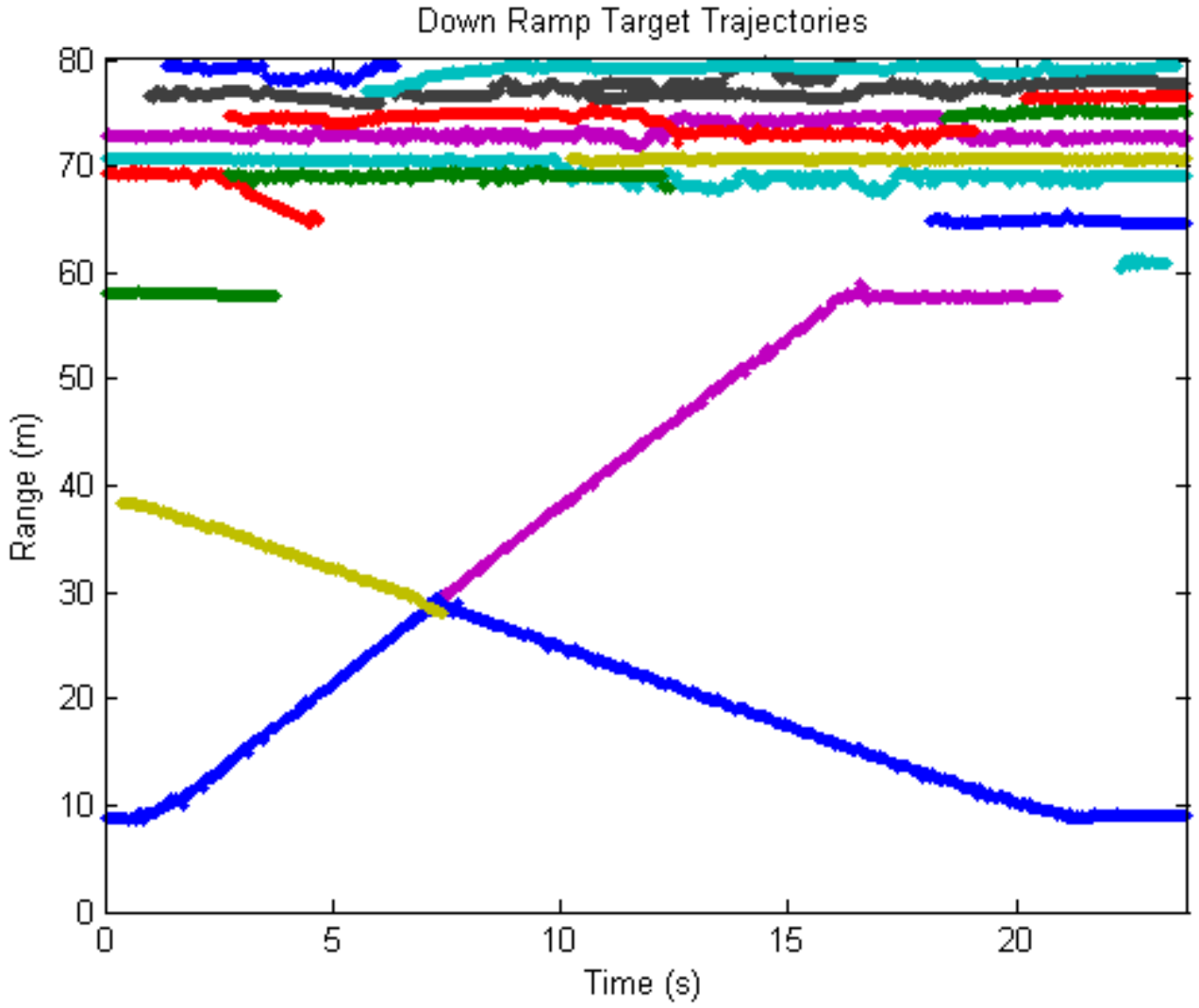


Portable HUD and Interfacing

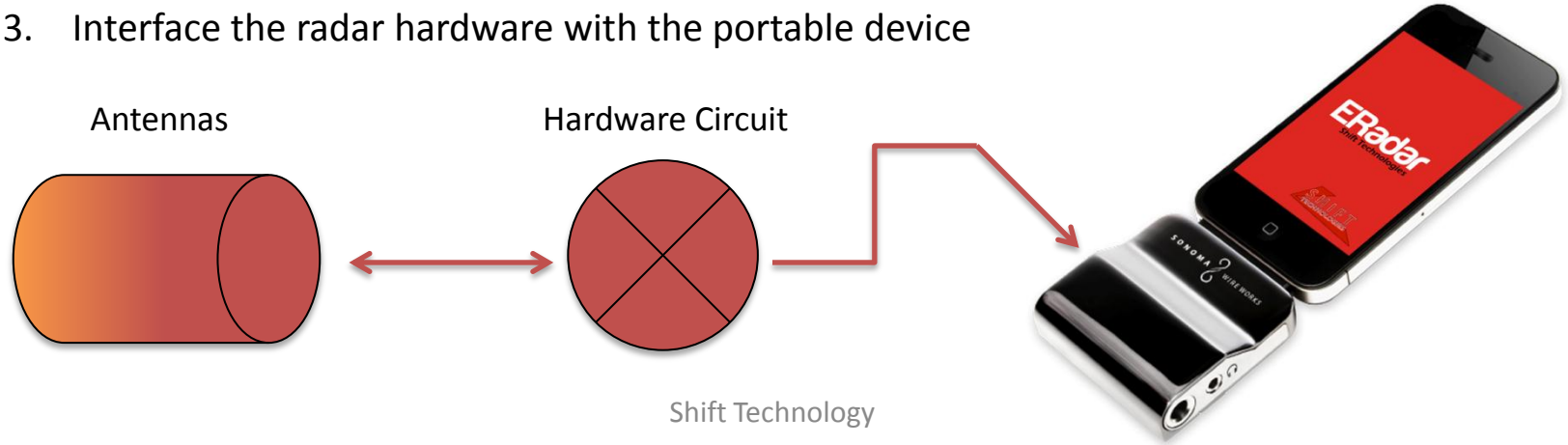
Summarized in three major components:

1. Build a graphics user interface (GUI) application

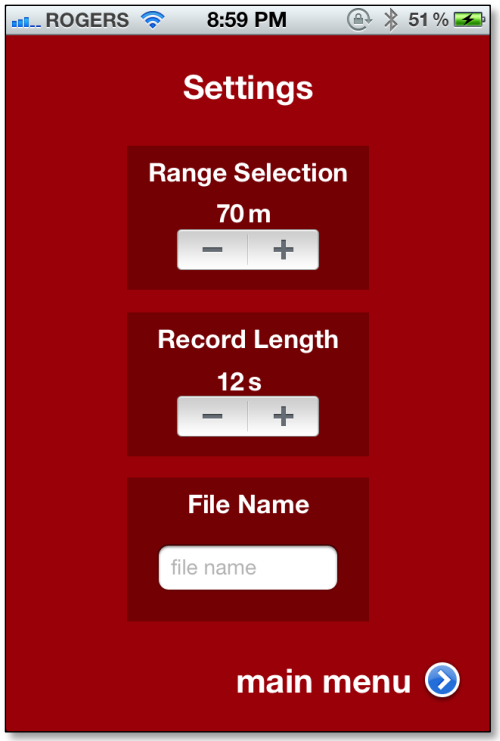
2. Convert MatLab radar algorithms into Objective-C

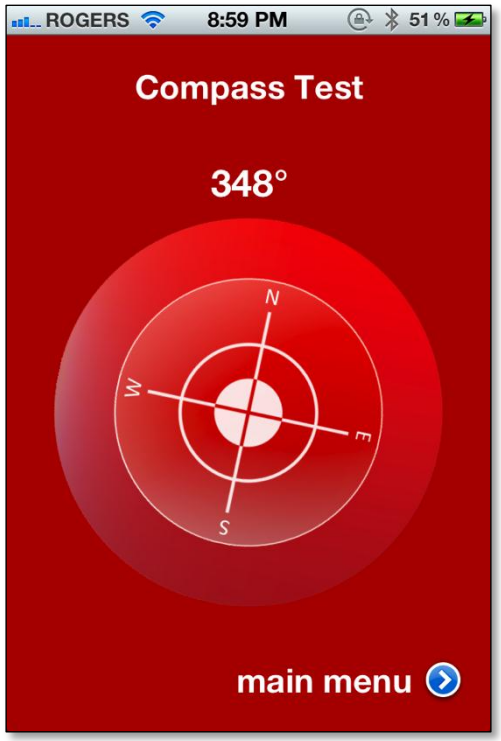
MathWorks®

3. Interface the radar hardware with the portable device

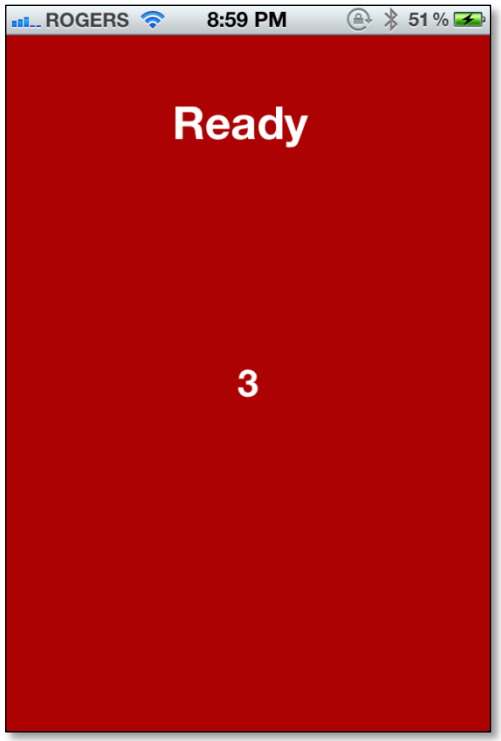


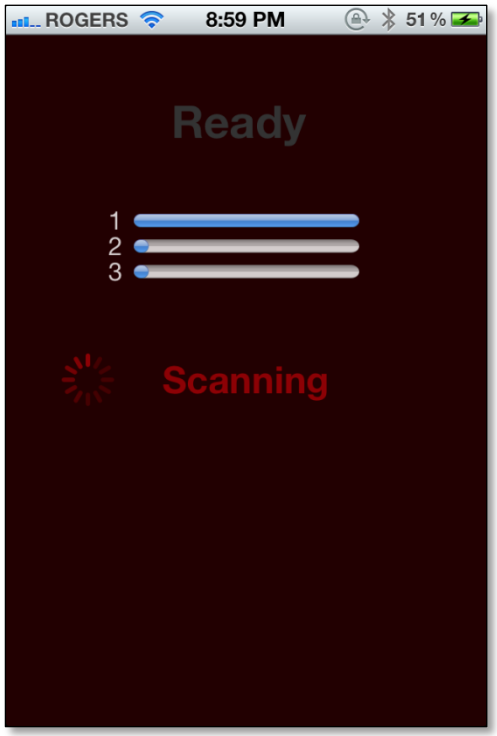
The Application GUI:

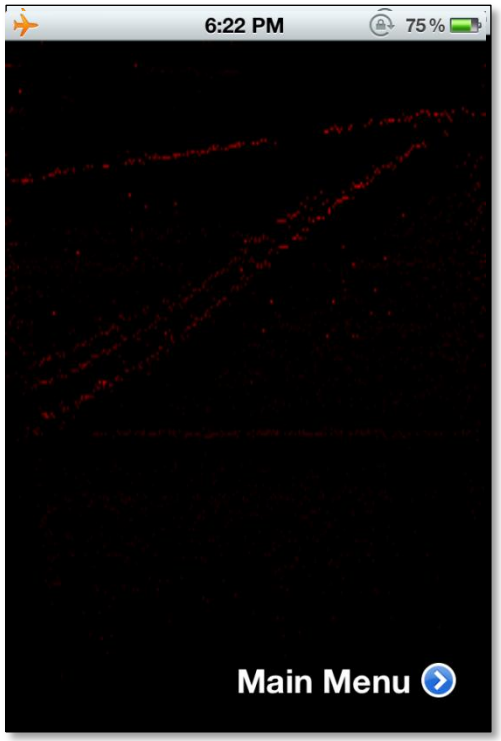




The Application GUI:







Portable HUD and Interfacing

Converting the Code:

- A significant amount of work is required to convert MatLab's proprietary functions into iOS compatible objective-C Code

There were a total of **1915** lines of code written for the iOS GUI

Matlab FFT usage

```
NFFT = 2^nextpow2(L);
Y = fft(y,NFFT)/L;
```

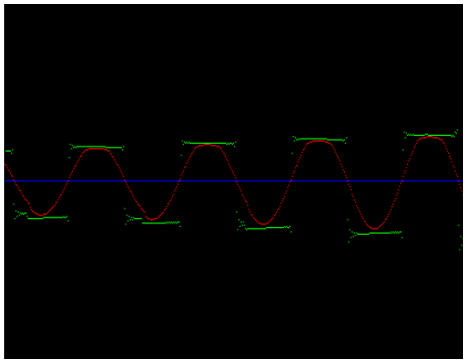
Objective-C iOS Equivalent

```
FFTWeights = vDSP_create_fftsetup(11, FFT_RADIX2);
DSPSplitComplex  input;
input.realp = (float*)malloc(1024*sizeof(float));
input.imagp = (float*)malloc(1024*sizeof(float));
vDSP_hamm_window(window, 1024, 0);
vDSP_vmul(samples, 1, window, 1, hammedSamples, 1, 1024);
vDSP_ctoz((DSPComplex *) hammedSamples,2,&input,1,512);
vDSP_ctoz((DSPComplex *) samples,2,&input,1,1024);
vDSP_fft_zrip(FFTSet, &input, 1, 11, 1);
input.realp[0] = 0.0;
input.imagp[0] = 0.0;
float  zvabs[1024];
vDSP_zvabs(&input, 1, zvabs, 1, 1024);
```

Portable HUD and Interfacing

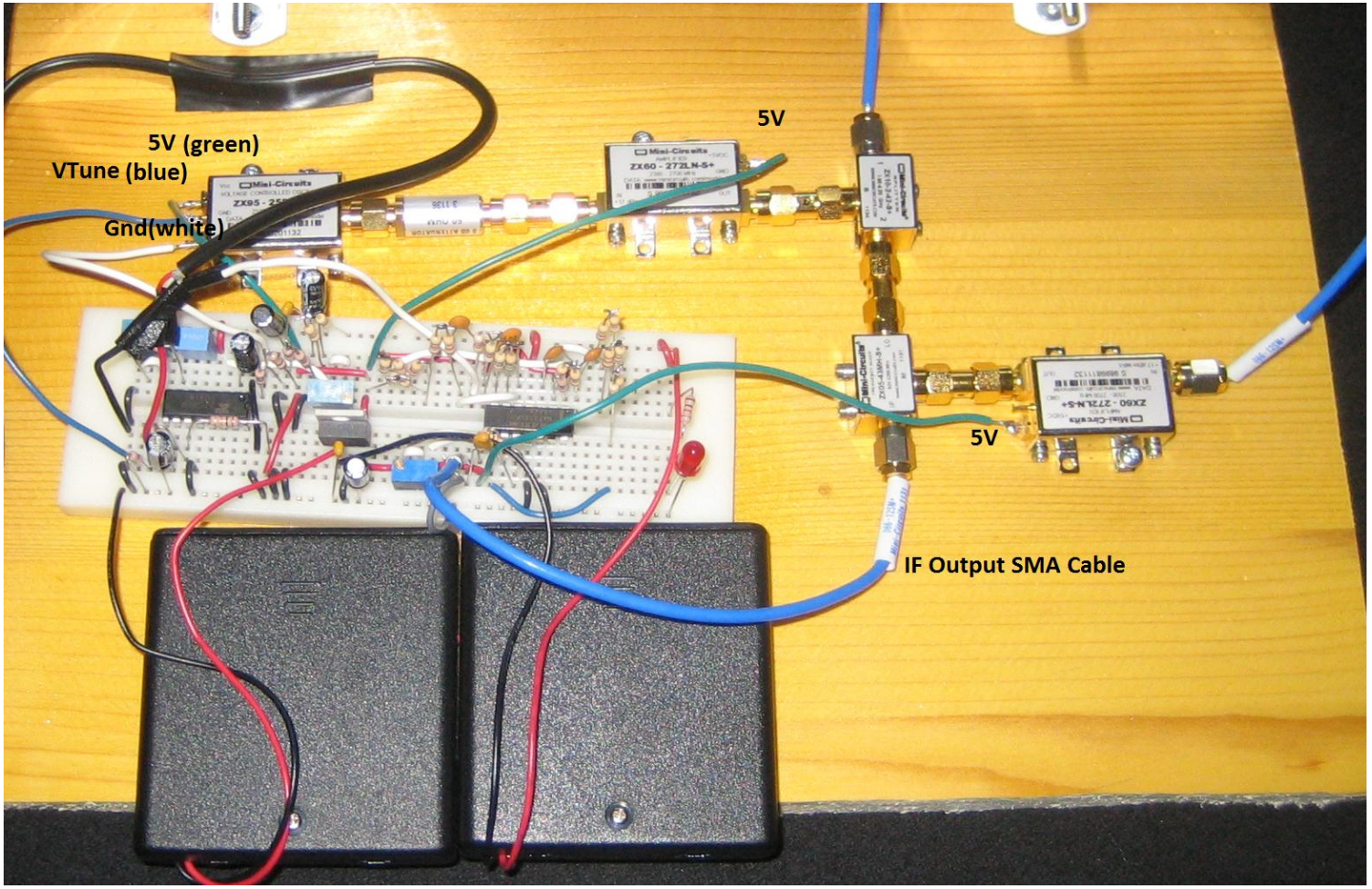
GuitarJack:

- Radar data consists of two separate and simultaneously sampled signals.
- Currently, none of Apple's portable devices can capture more than a single channel of audible input.
- Purchased off the shelf audio input accessory GuitarJack for apple devices to sample two channels of audible input simultaneously.



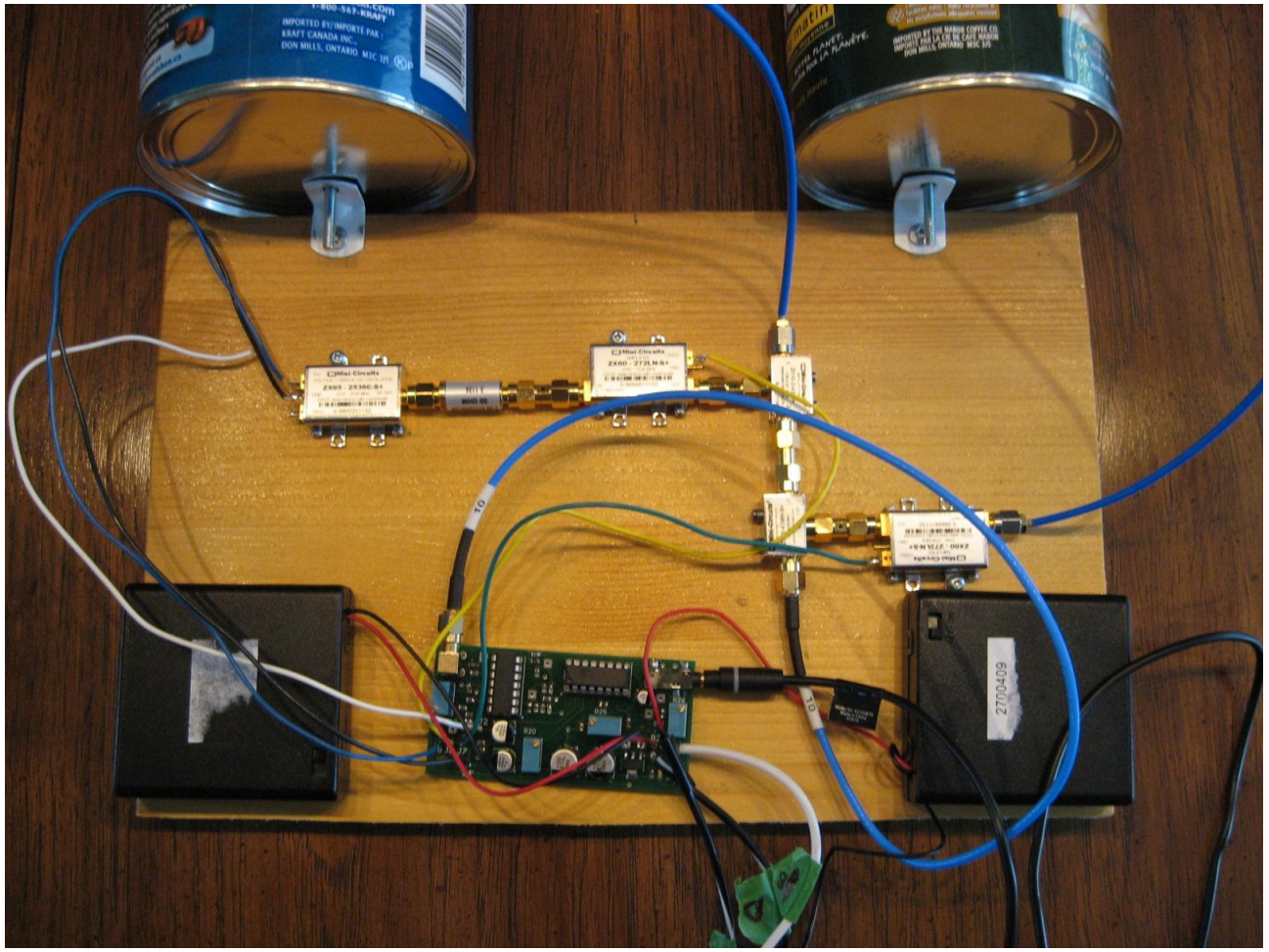
Radar Hardware

What we started with…



Radar Hardware

…what we ended with.



Hardware Packaging

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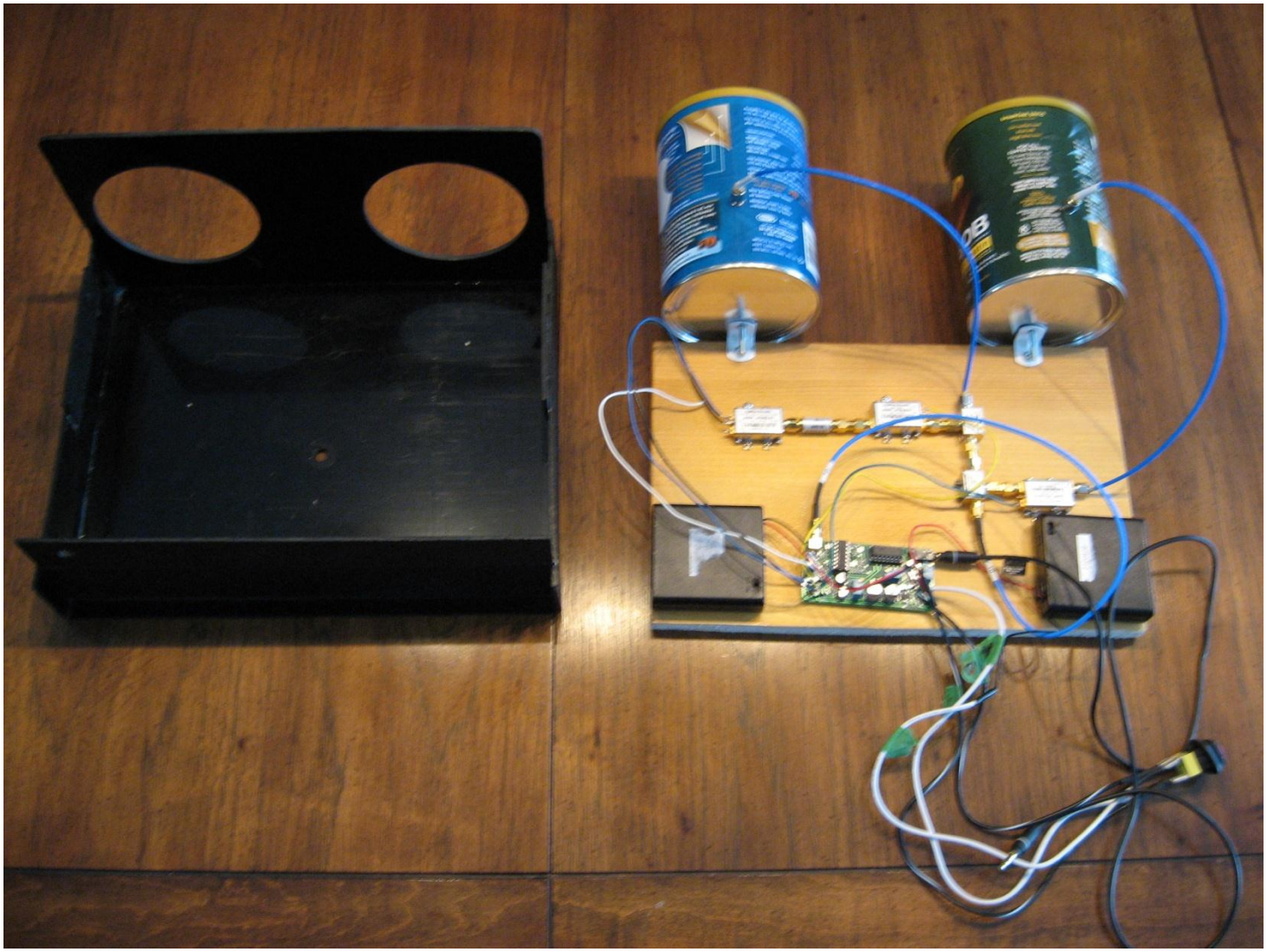
Hardware Packaging



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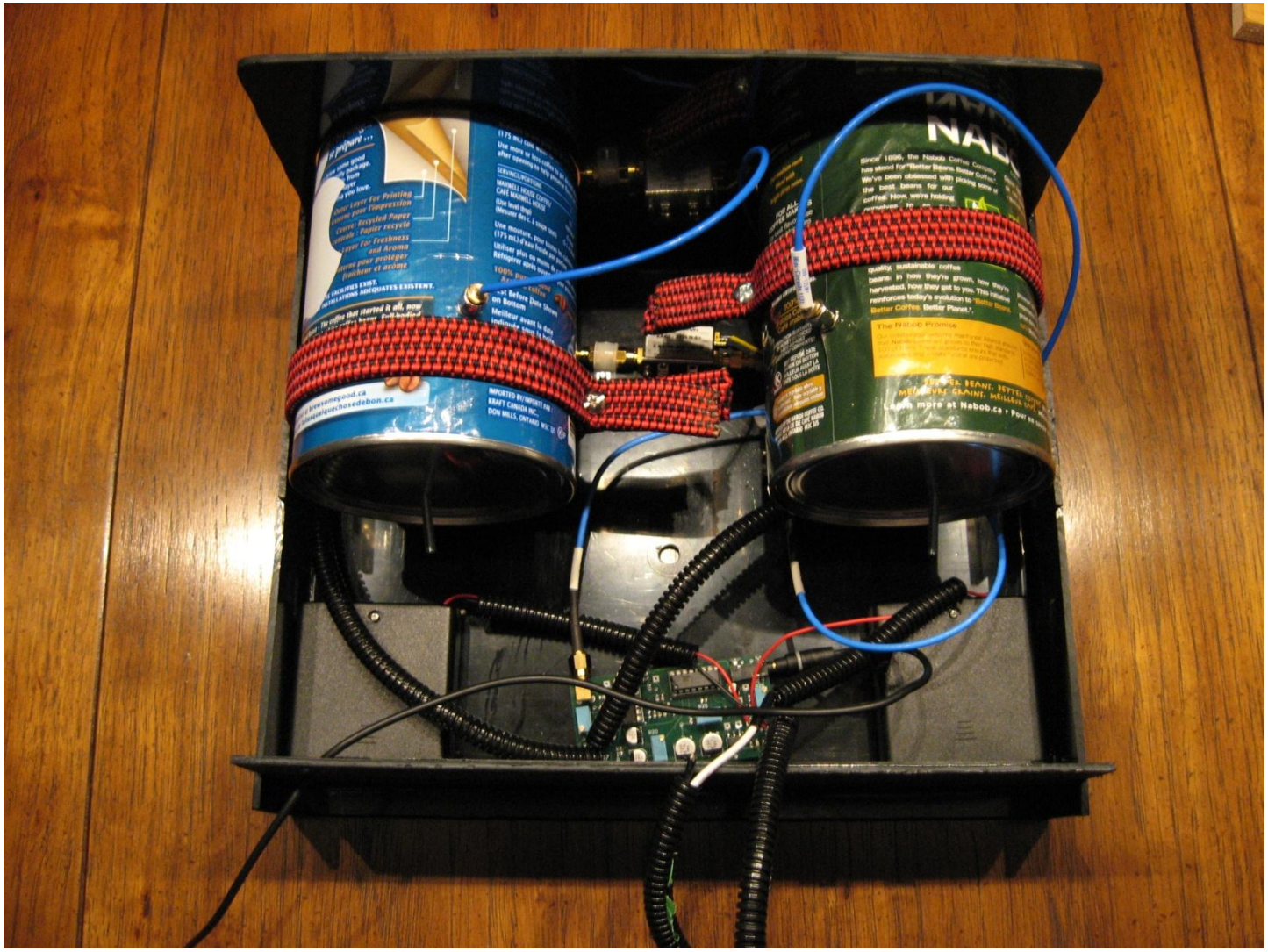

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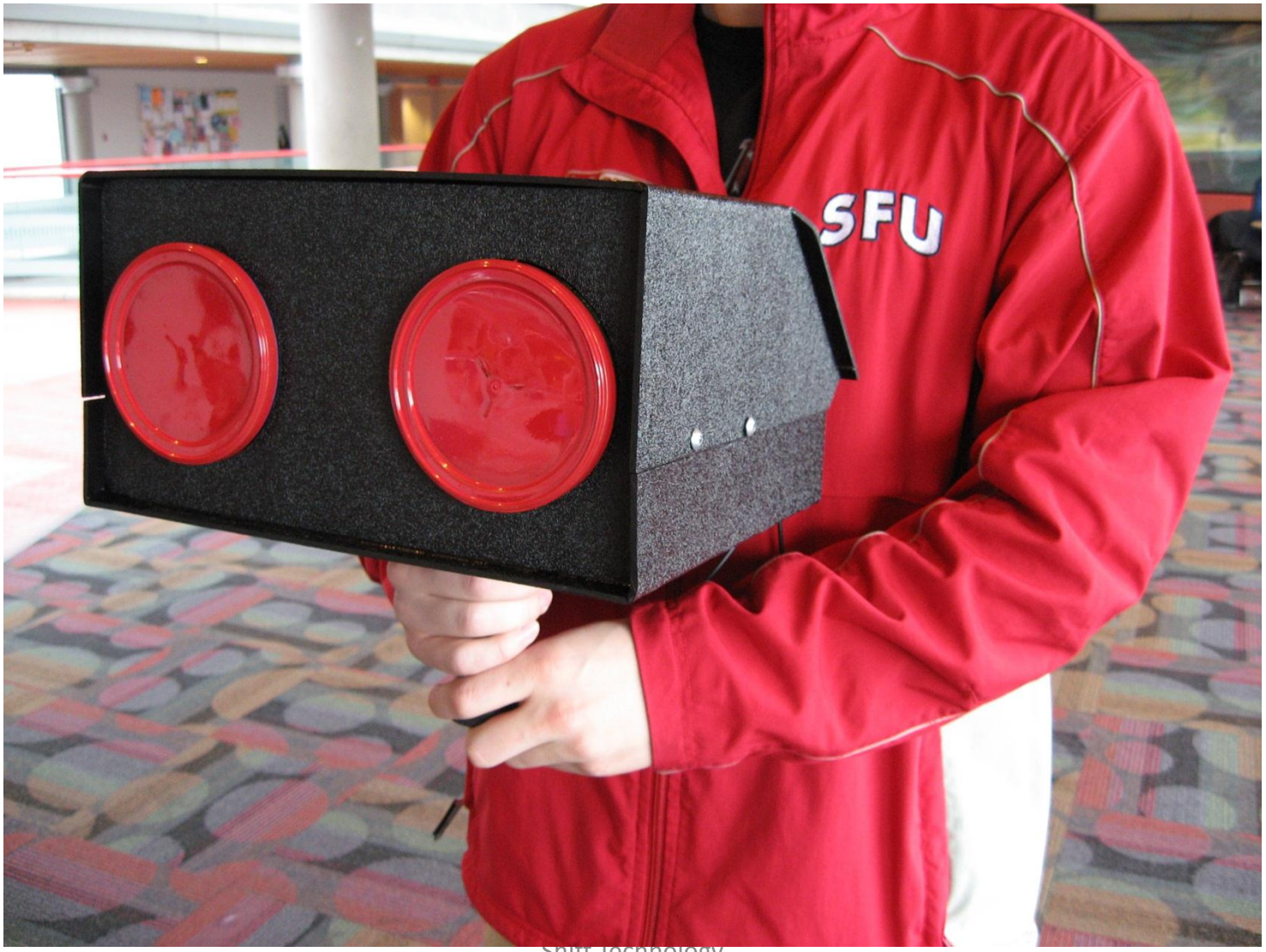

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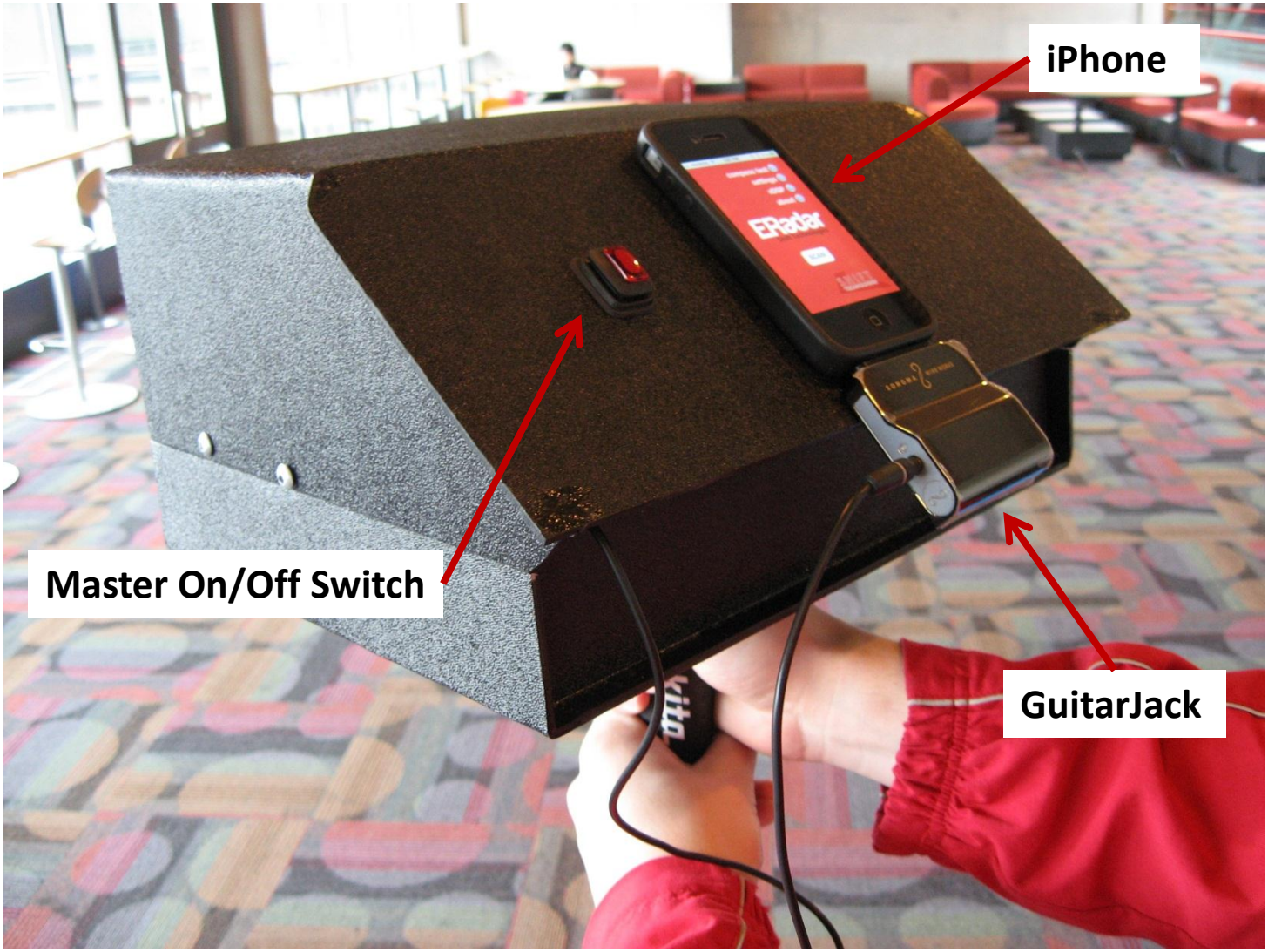

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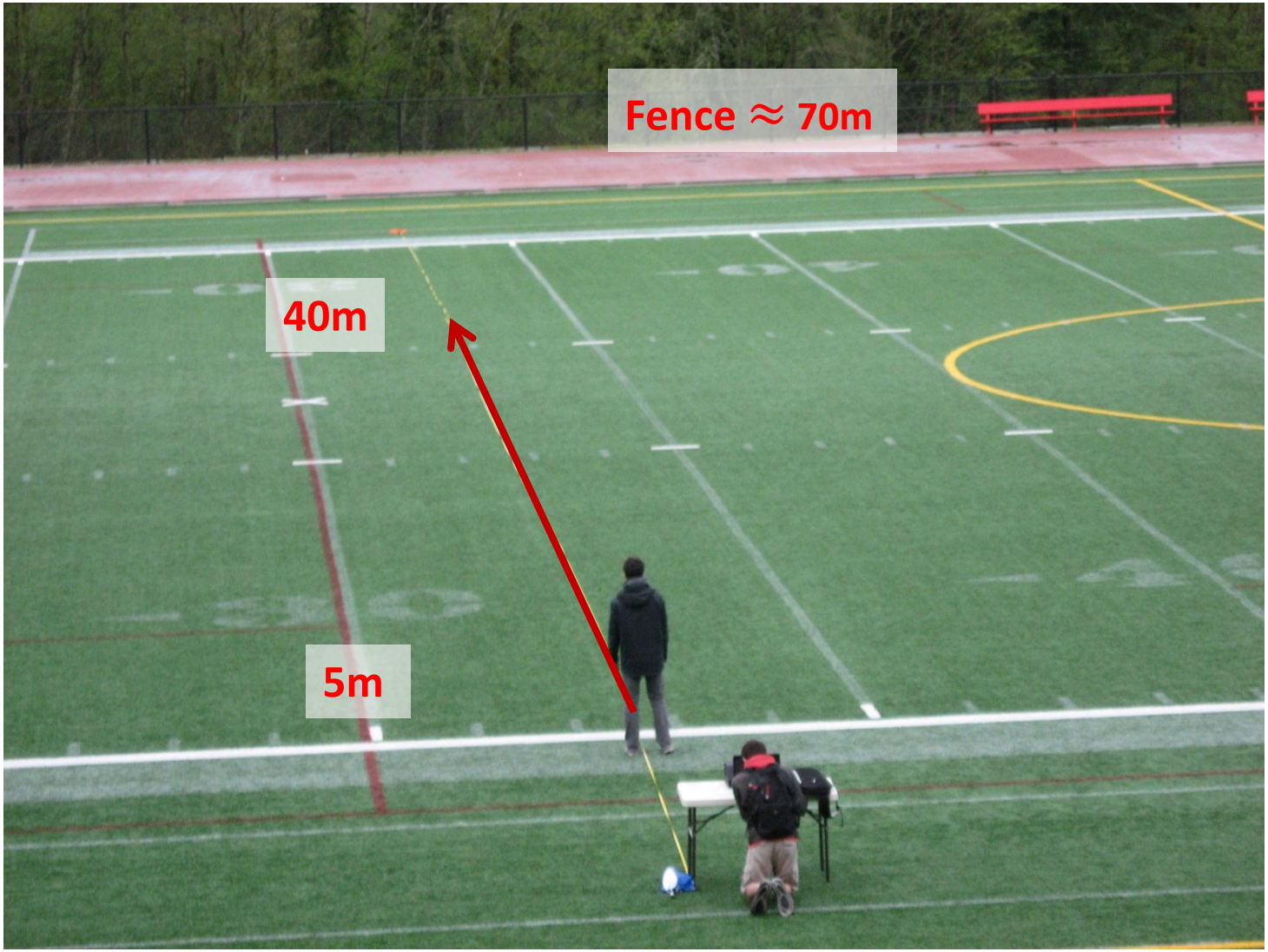
Field Tests

Field Trial #1 – Single Target, 5m to 40m, Light Rain



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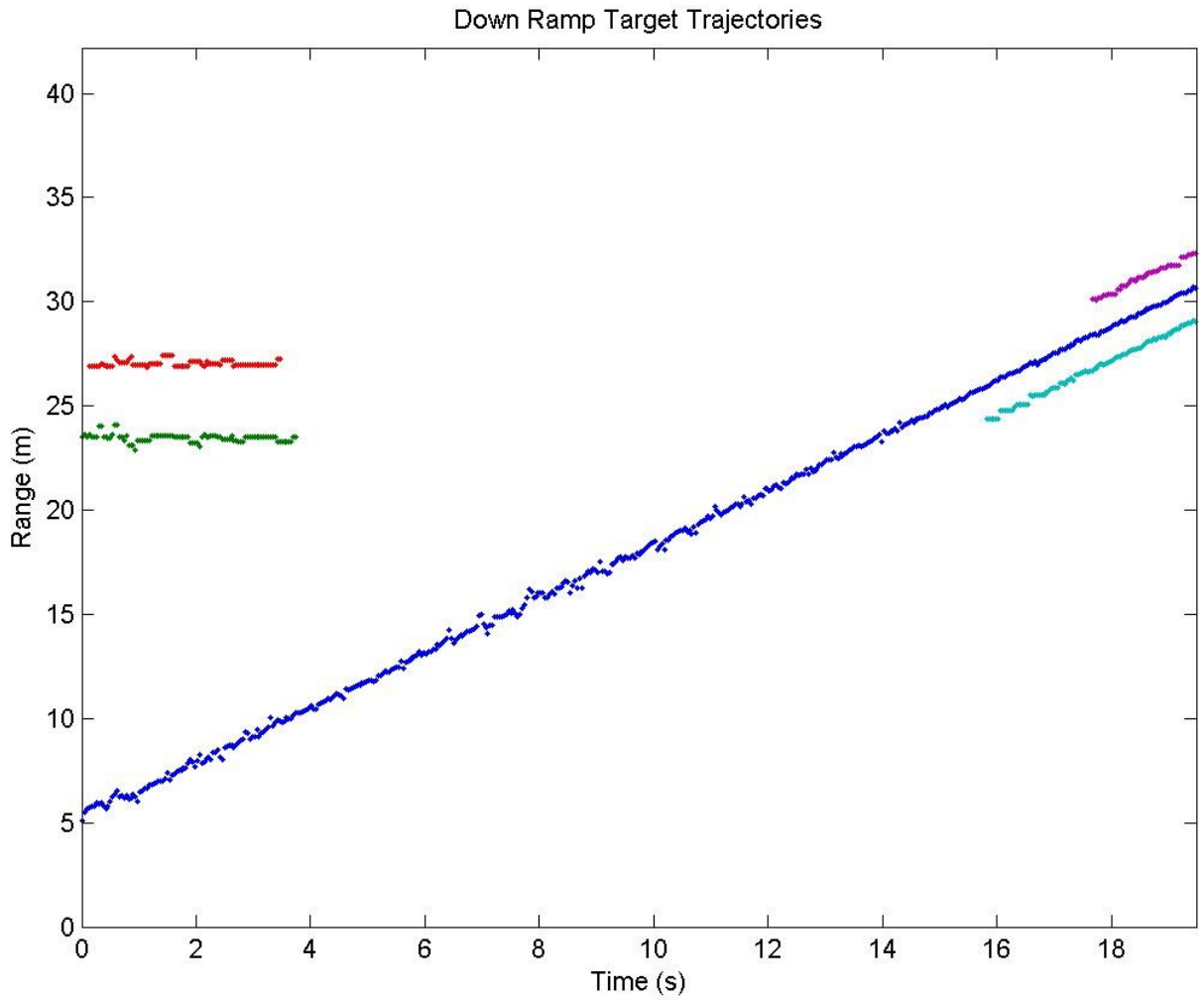

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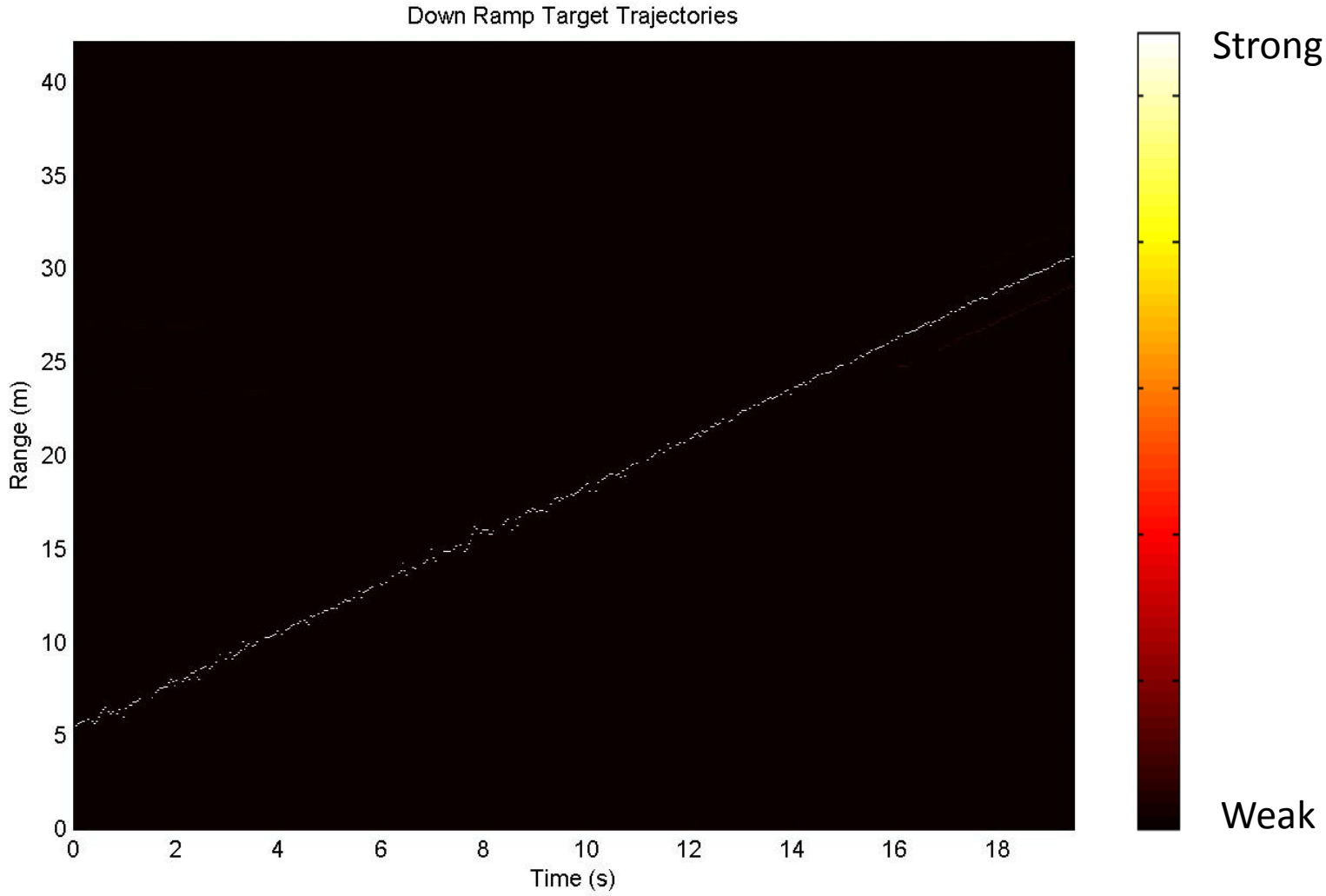

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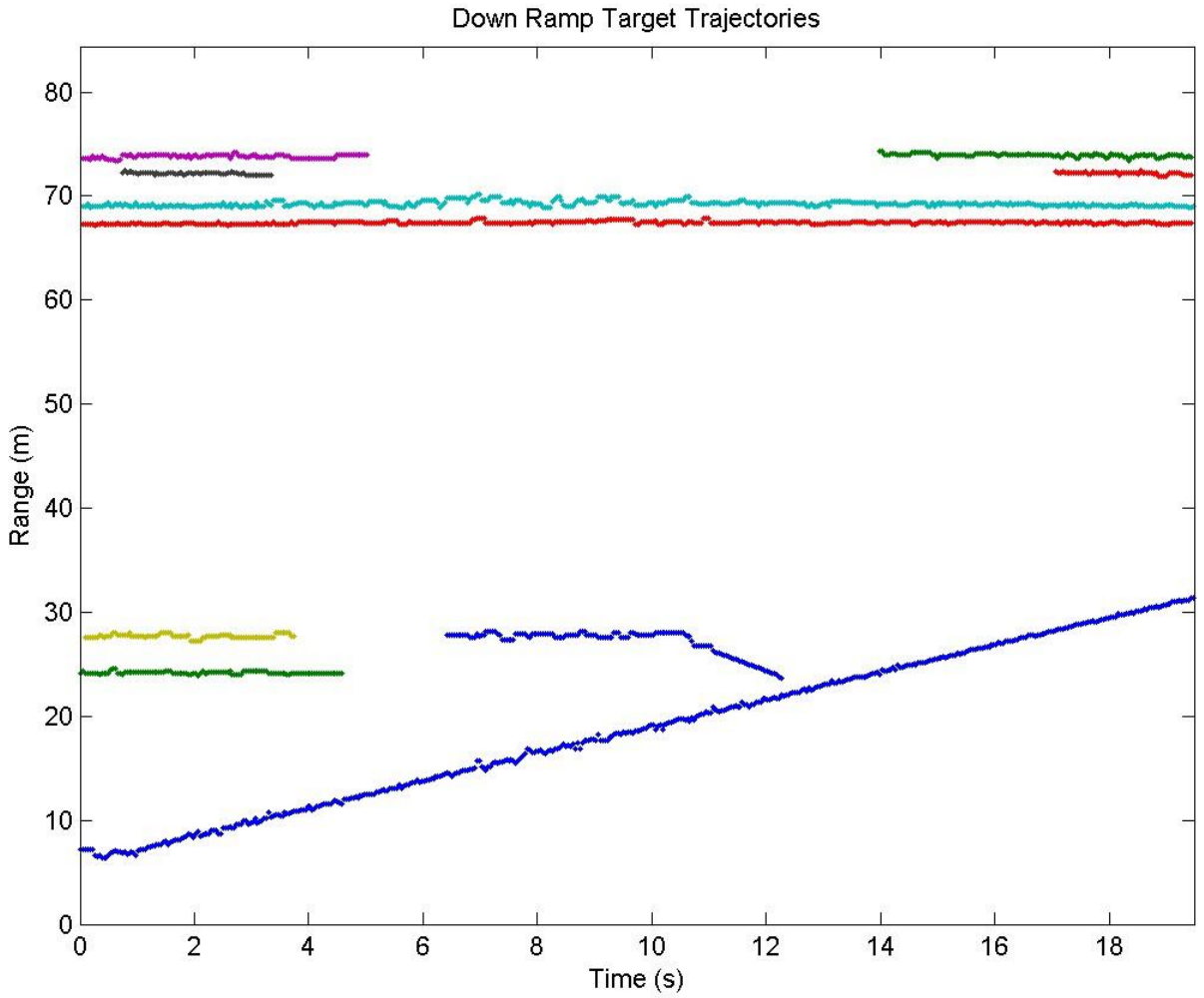

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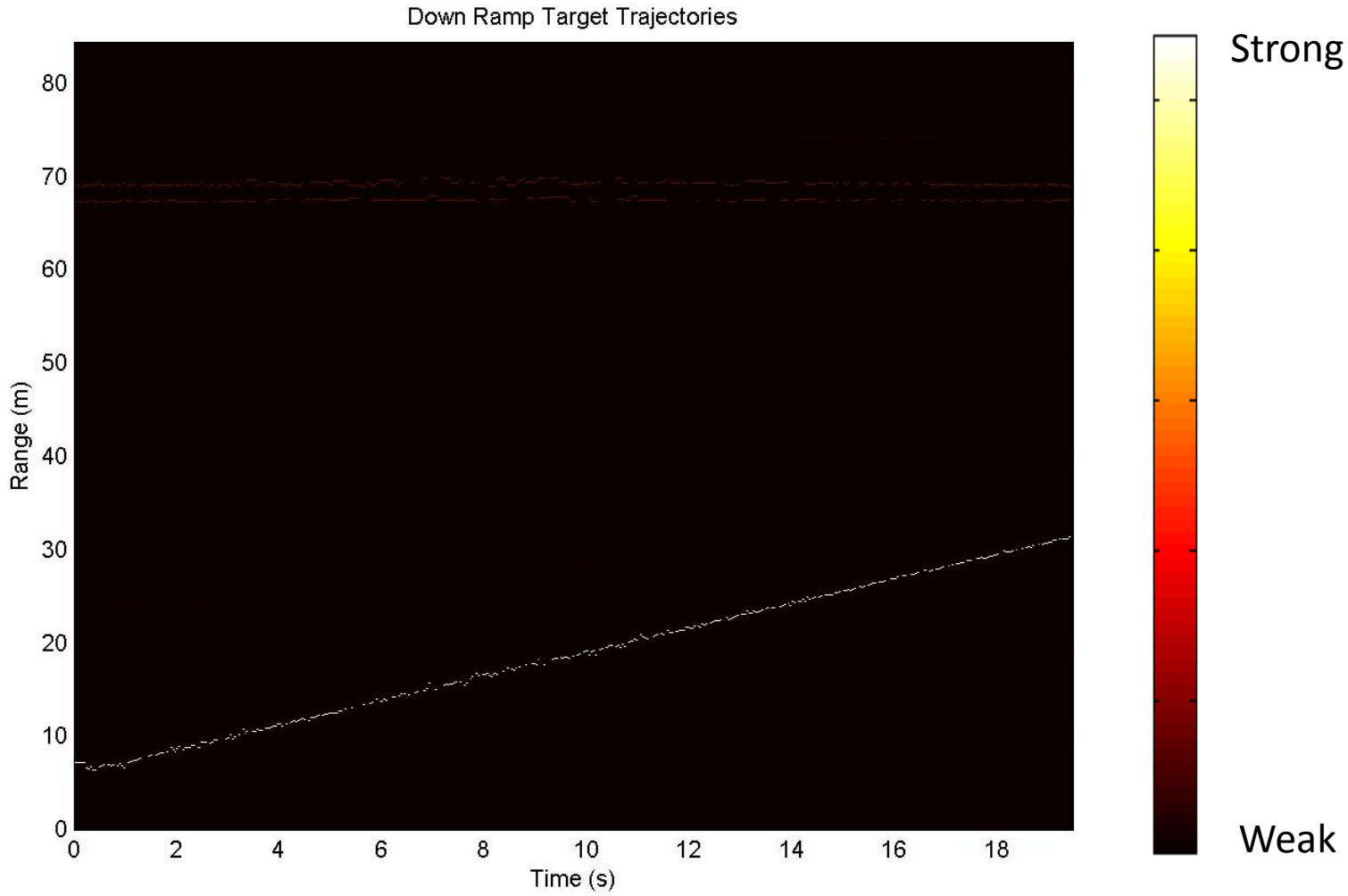
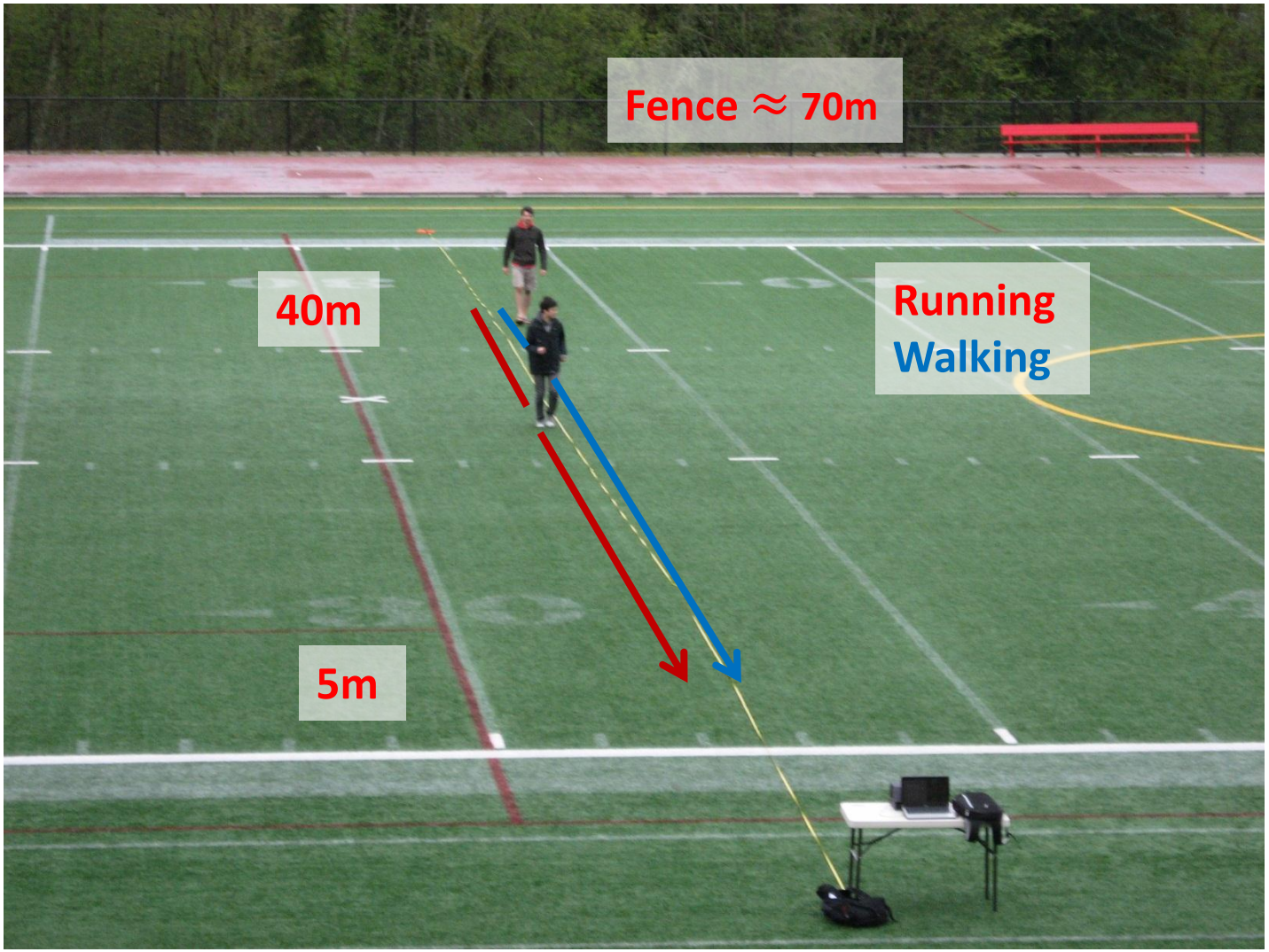


Field Trial #2 – Multi-Target, 40m to 5m, Light Rain



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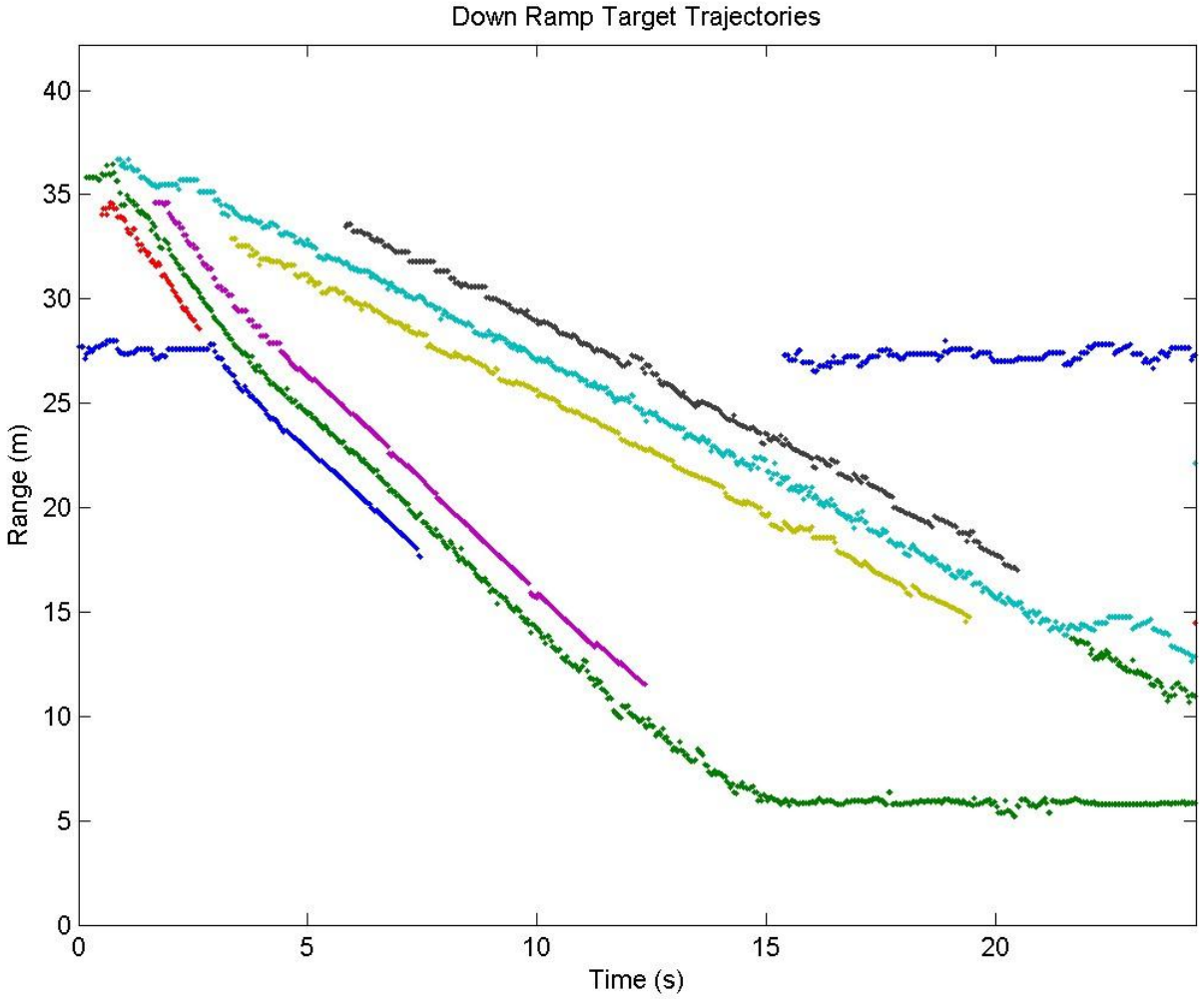

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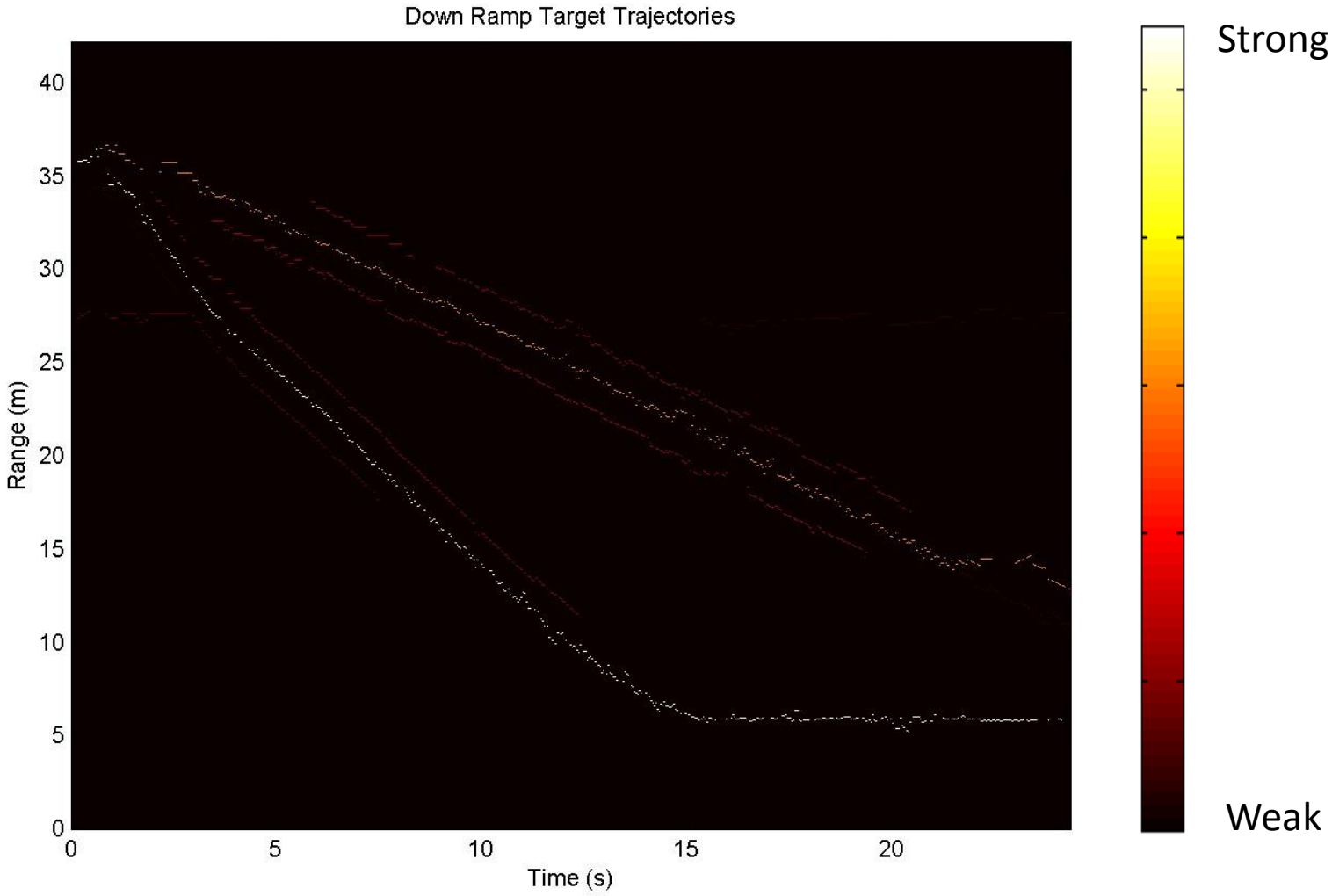

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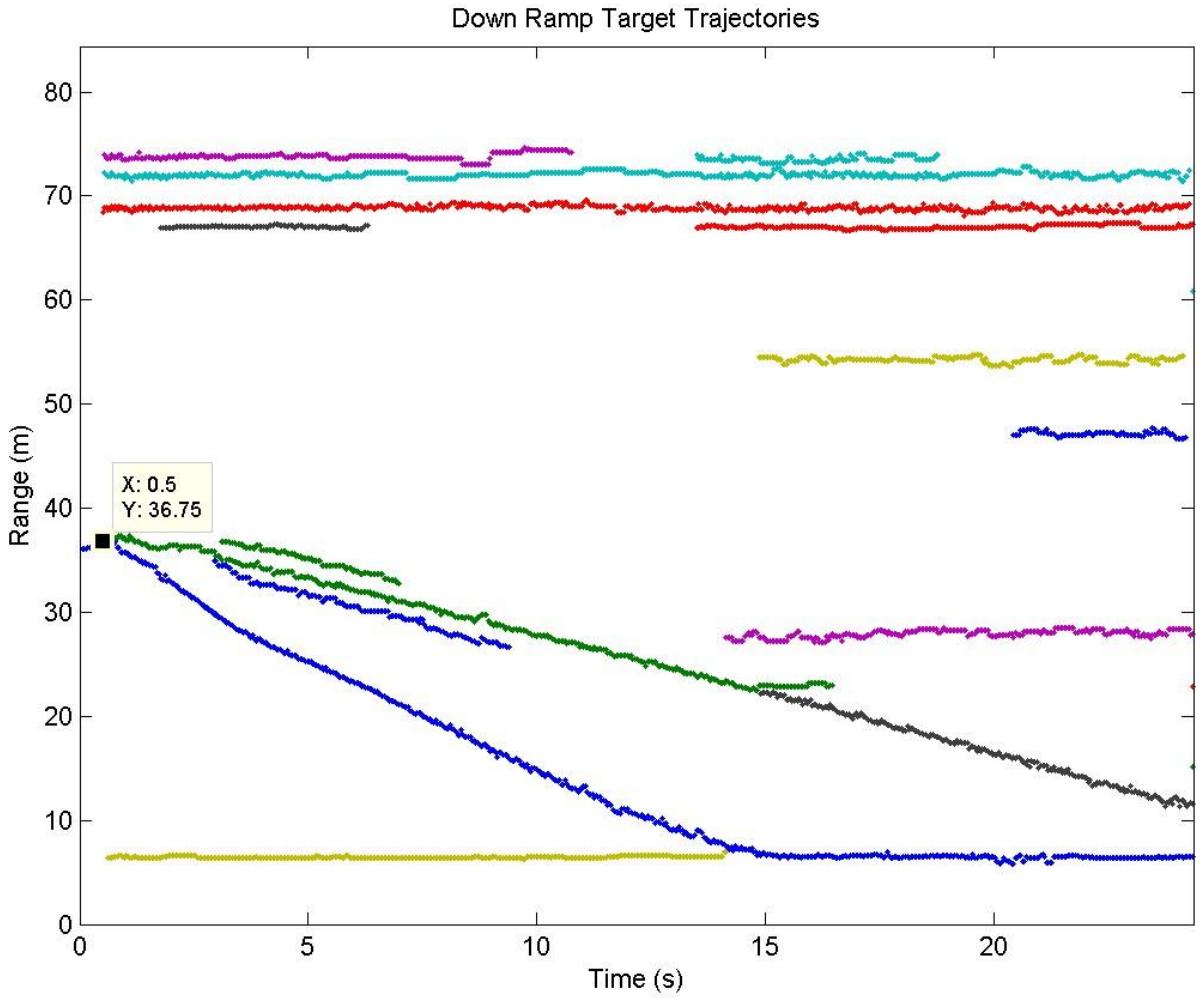

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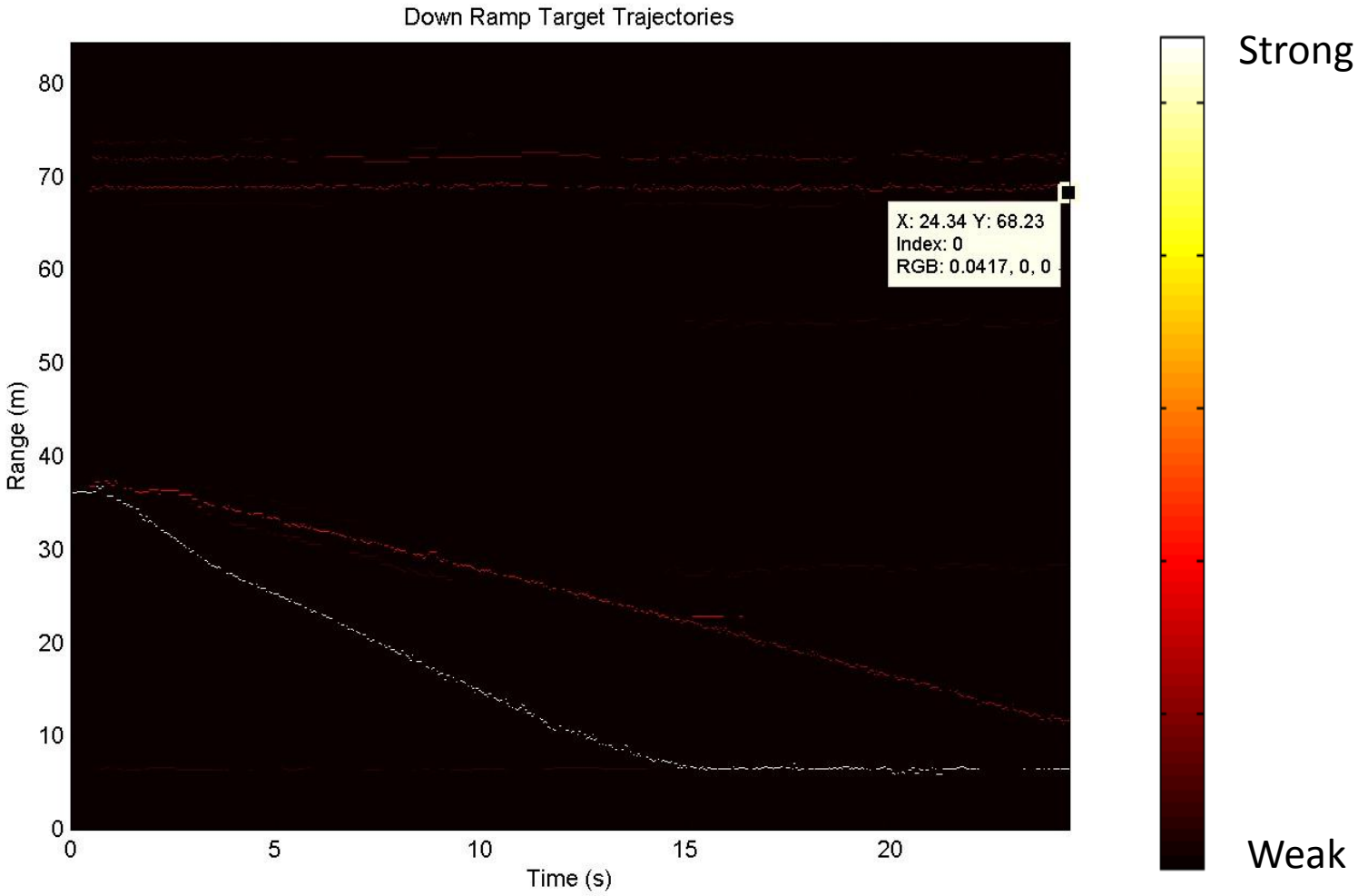
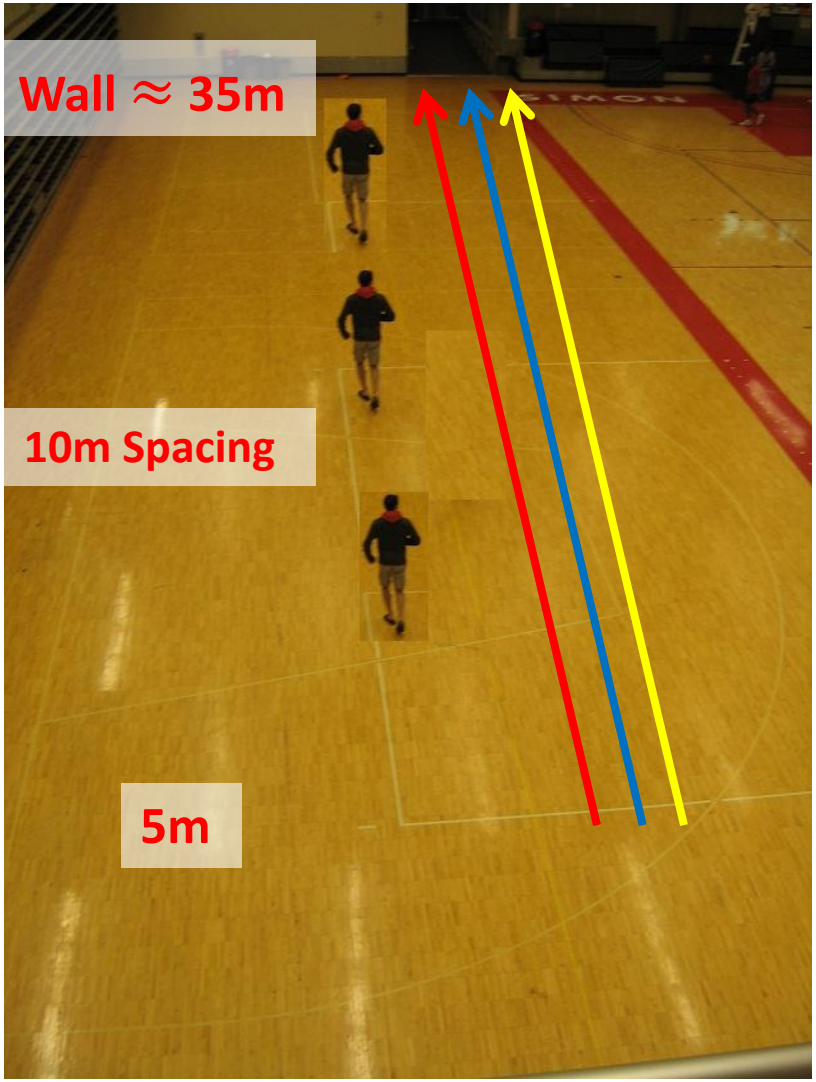


Field Trial #3 – Multi-Target, 5m to 35m, Gym



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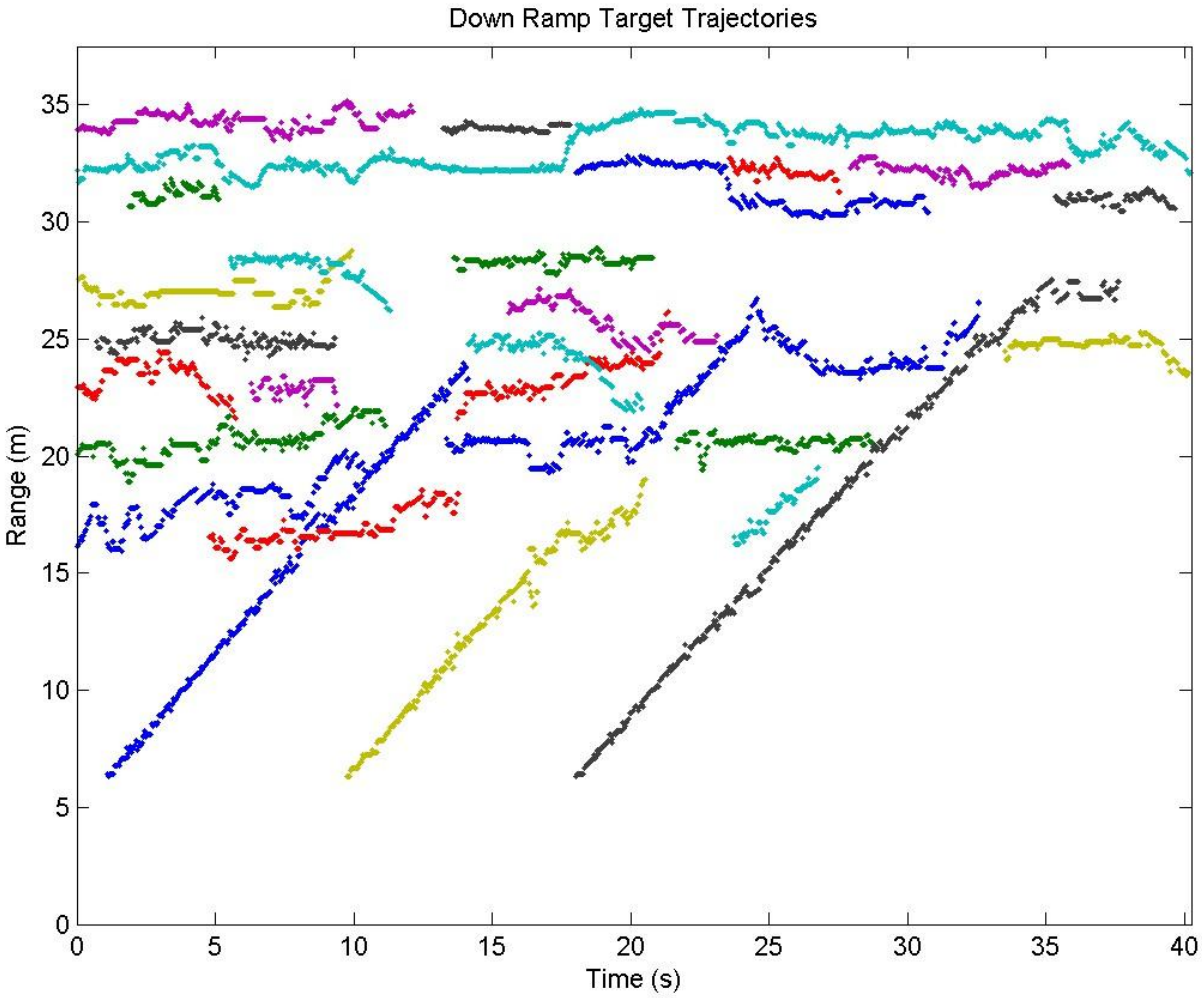

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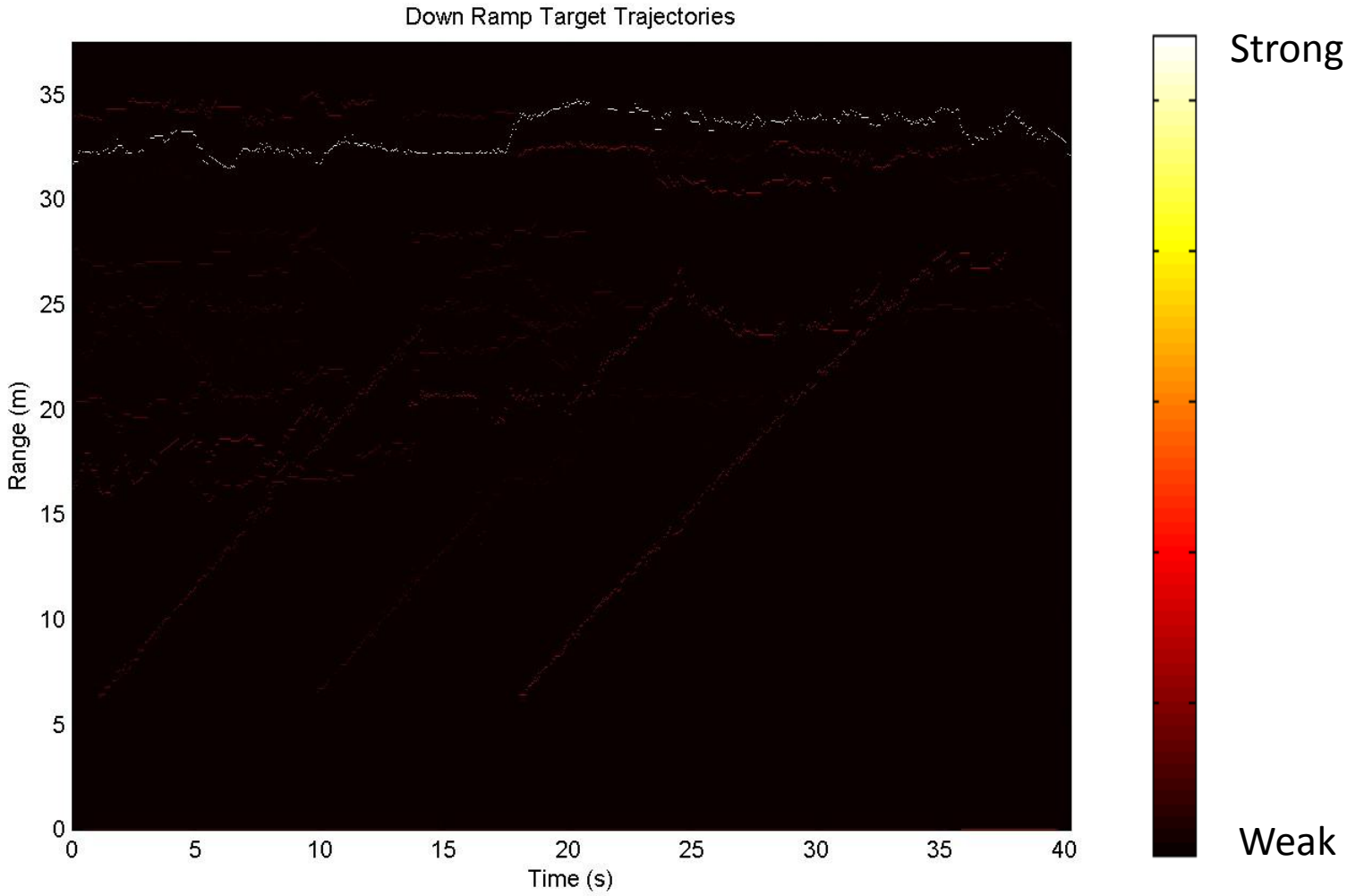

Project Management

Division of Labour

	Mehdi	Steve	Borna	Laurent	Nelson
Signal Processing - Deriving Algorithms - MATLAB	X				X
iOS Interfacing and Firmware - GUI - Objective-C Conversion			X	X	
Radar Electronics - Breadboard - PCBA	X	X			X
Hardware Packaging - Casing		X			

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Budget

Required Materials	Projected Cost	Realized Cost
Coffee Can Radar Kit	**$400**	**$292.48**
- Portable Radar System (MIT) [1]		
iOS Developer's Software Kit	**$100**	**$110.88**
- Apple iOS Developer's Program		
PCB Layout Costs	**$200**	**$183.63**
- PCB (AP Circuits)		$114.20
- PCB Components (Digikey)		$69.43
Hardware Packaging of Radar	**$50**	**$53.83**
- Case material (ABS Plastic)		$10.00
- 4" Holesaw, miscellaneous tools		$19.61
- Bungee cords, adhesive velcro, split sleeved tubing		$24.22
Unexpected Costs	**N/A**	**$187.60**
- GuitarJack		$167.65
- Express Shipping (Broken GuitarJack)		$19.95
Totals:	**$750**	**$828.42**

SHIFT TECHNOLOGIES

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Hardware Packaging of Radar	**$50**	**$53.83**
- Case material (ABS Plastic)		$10.00
- 4" Holesaw, miscellaneous tools		$19.61
- Bungee cords, adhesive velcro, split sleeved tubing		$24.22
Unexpected Costs	**N/A**	**$0**
Totals:	**$750**	**$640.82**

SHIFT TECHNOLOGIES

Timeline

Item	Proposed	Implemented
MIT Coffee Can Radar Built	January 1	January 8
Signal Processing – MATLAB Variable Range, 1-D Range Plot Interpolation	January 22	January 29
iPhone – Graphical User Interface	January 22	January 24
iPhone – Interface with Compass	January 30	January 24
MATLAB to Objective-C Code (1-D Range Plot)	February 11	April 21
Case Construction	February 16	February 23
Signal Processing – MATLAB 1-D Real Time Interpolation	March 12	April 22
Packaging of all Components inside of Case	April 1	April 20
Signal Processing – MATLAB 2-D Range Plot Interpolation	April 1	Not Implemented
MATLAB to Objective-C Code (1-D Real Time)	April 5	Not Implemented
MATLAB to Objective-C Code (2-D Range Plot)	April 8	Not Implemented
Completed Testing	April 10	April 25

What We Learned

- Software milestones are the hardest deadlines to meet
- iOS Software Development Kit is a powerful tool
- FMCW radar theory
- Target locking
- Altium Designer is a valuable tool in designing PCBs
- Organization = Less Stress

Future Work

- Antennas with smaller beam-width
- Eliminate memory allocation errors on iPhone
- 1-D Real Time on iPhone
- 2-D in MATLAB and on iPhone
- Better distinguishing between Humans and Inanimate Objects
- Interfacing device with larger screen and stereo input

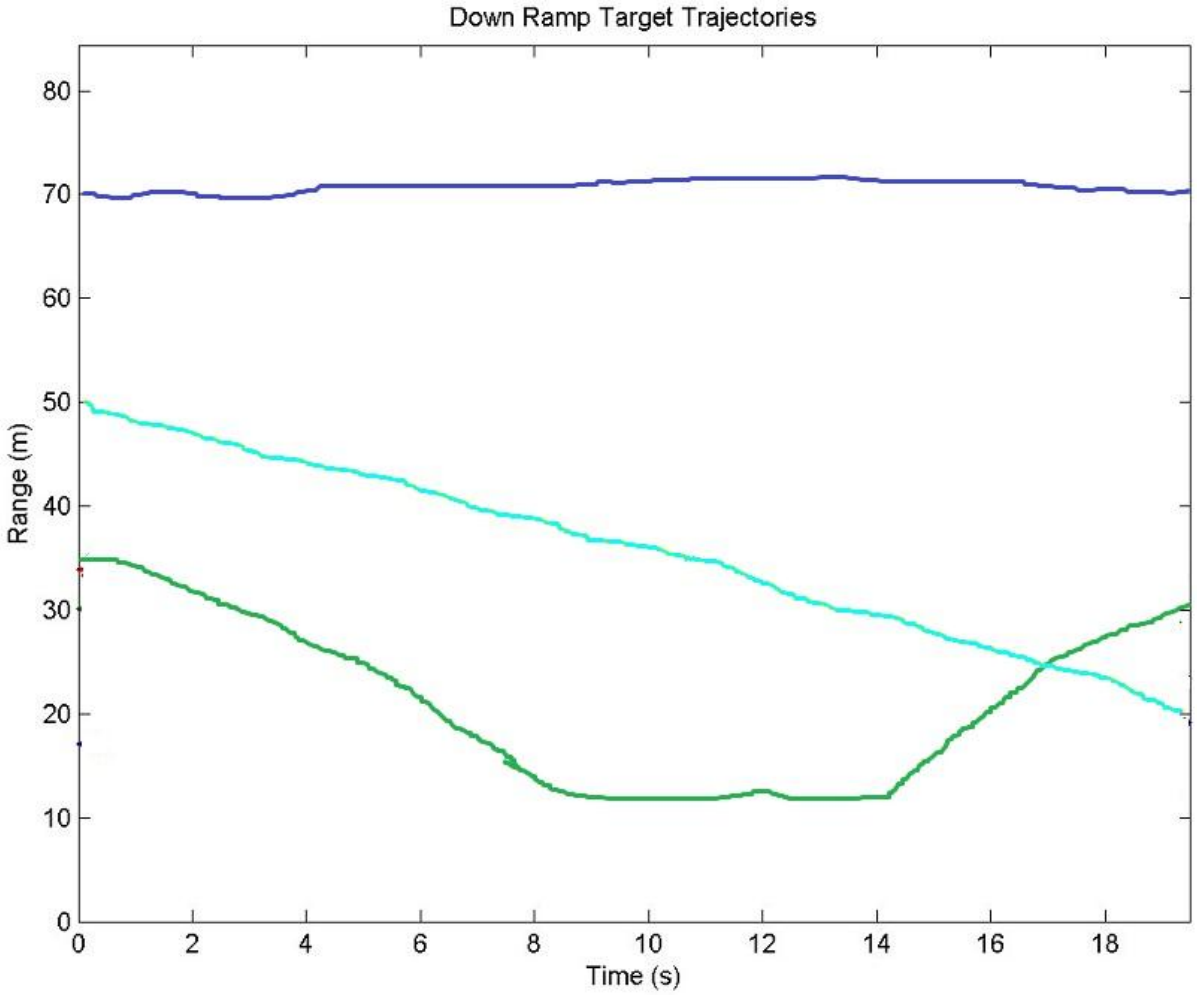
Acknowledgements

- Dr. Gregory Charvat
  - MIT Portable Radar
- Dr. Peter Fox
  - Consultant at Kongsberg Mesotech Canada
- Mr. Rob Sabo and Mr. Chris MacDicken
  - Access to shop facilities at Centennial Secondary School
- Dr. Shawn Stapleton
  - Testing
- Connie Drewbrook
  - Testing

Questions?

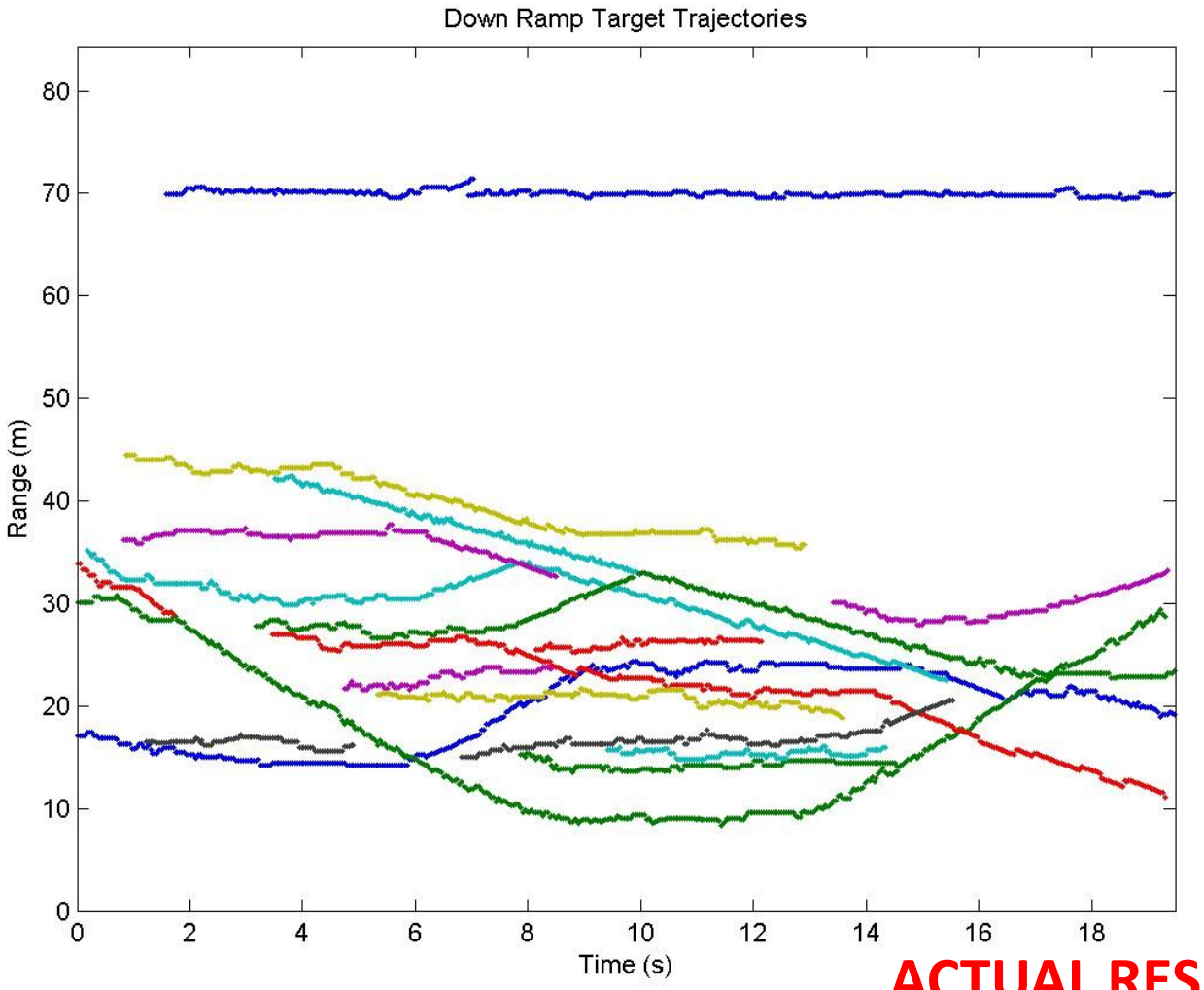
Field Trial #4 – Multi-Target, Crossing Paths, Heavy Rain

Field Trial #4 – Multi-Target, Crossing Paths, Heavy Rain



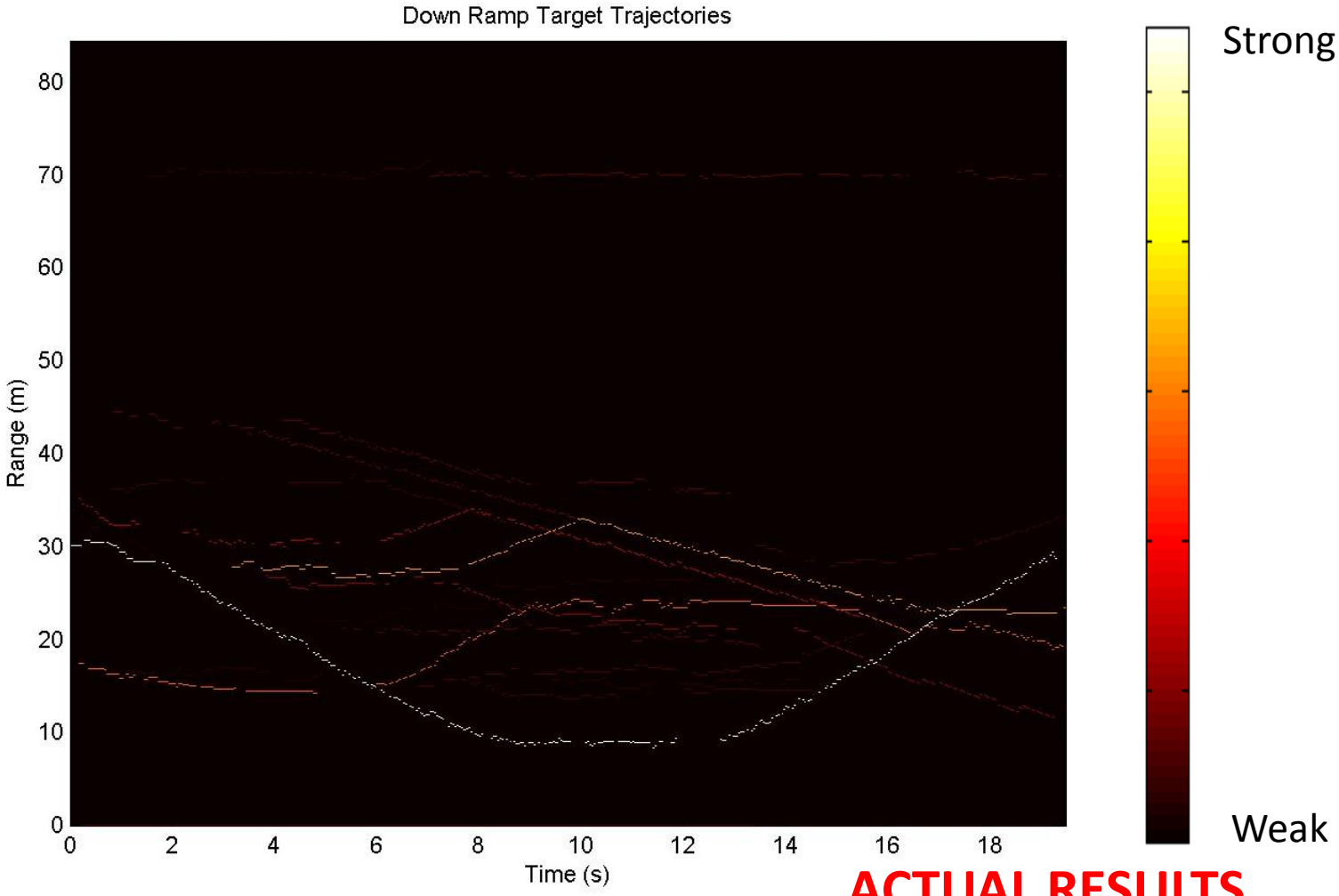
EXPECTED RESULTS

Field Trial #4 – Multi-Target, Crossing Paths, Heavy Rain



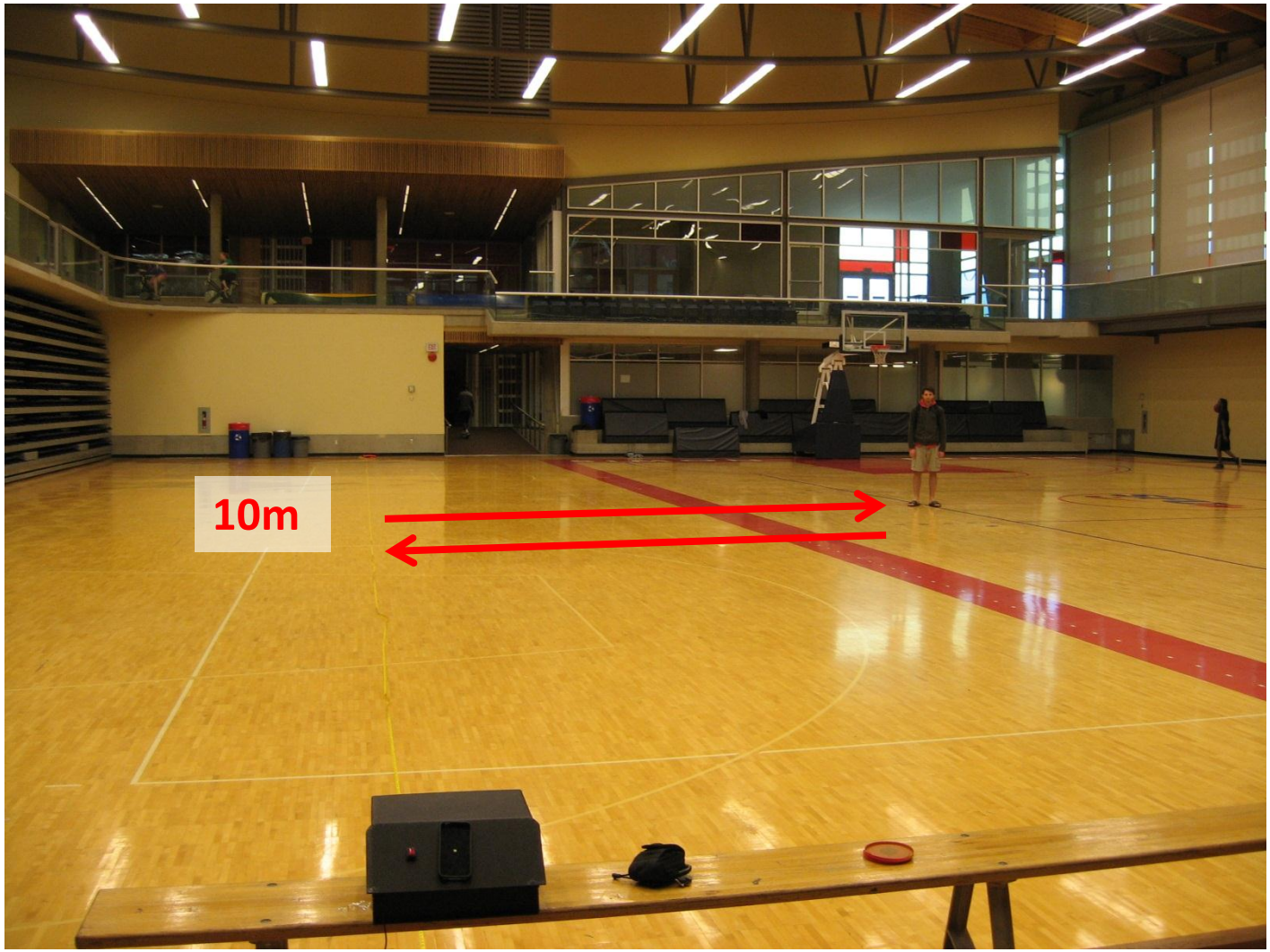
ACTUAL RESULTS

Field Trial #4 – Multi-Target, Crossing Paths, Heavy Rain

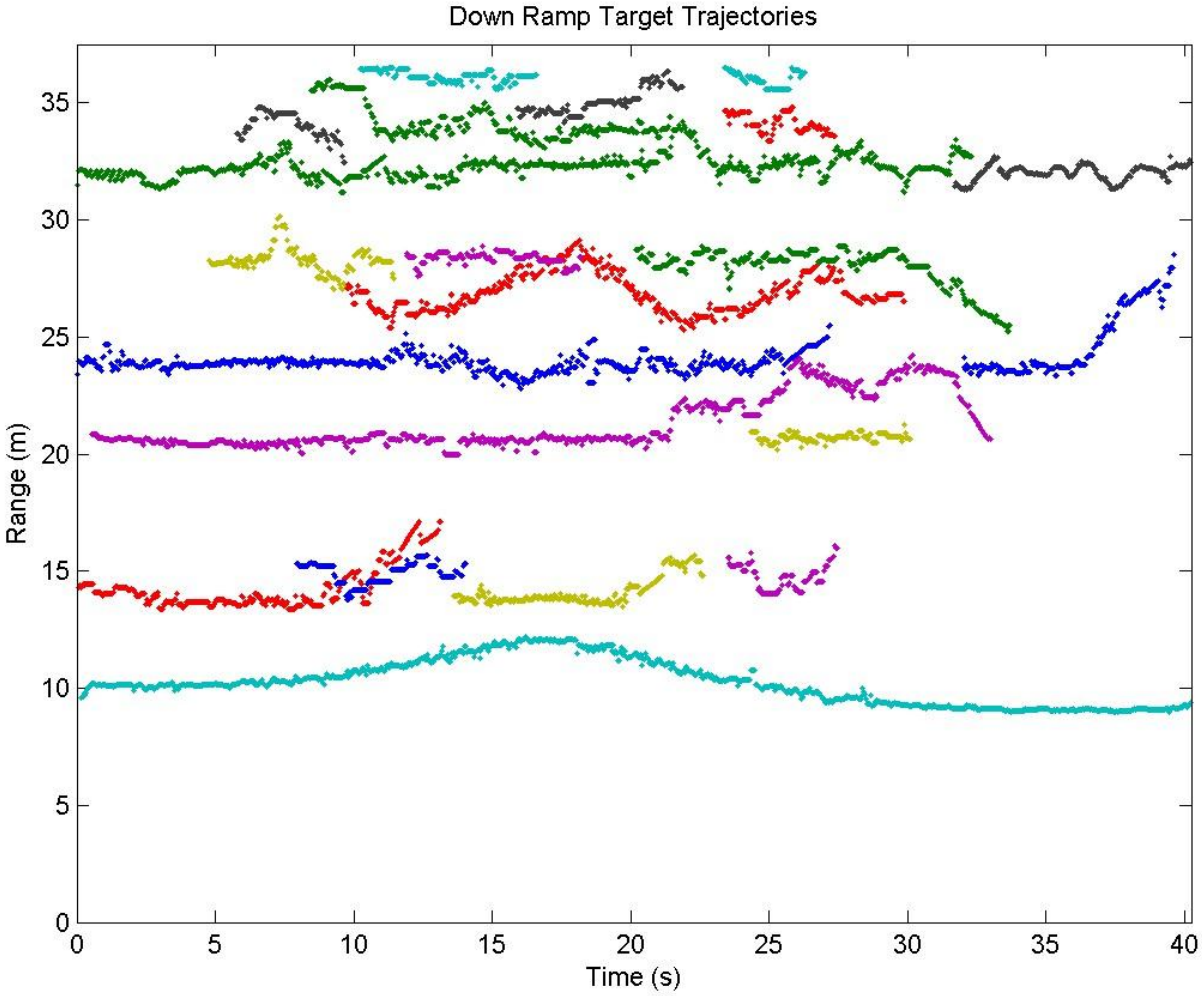


ACTUAL RESULTS

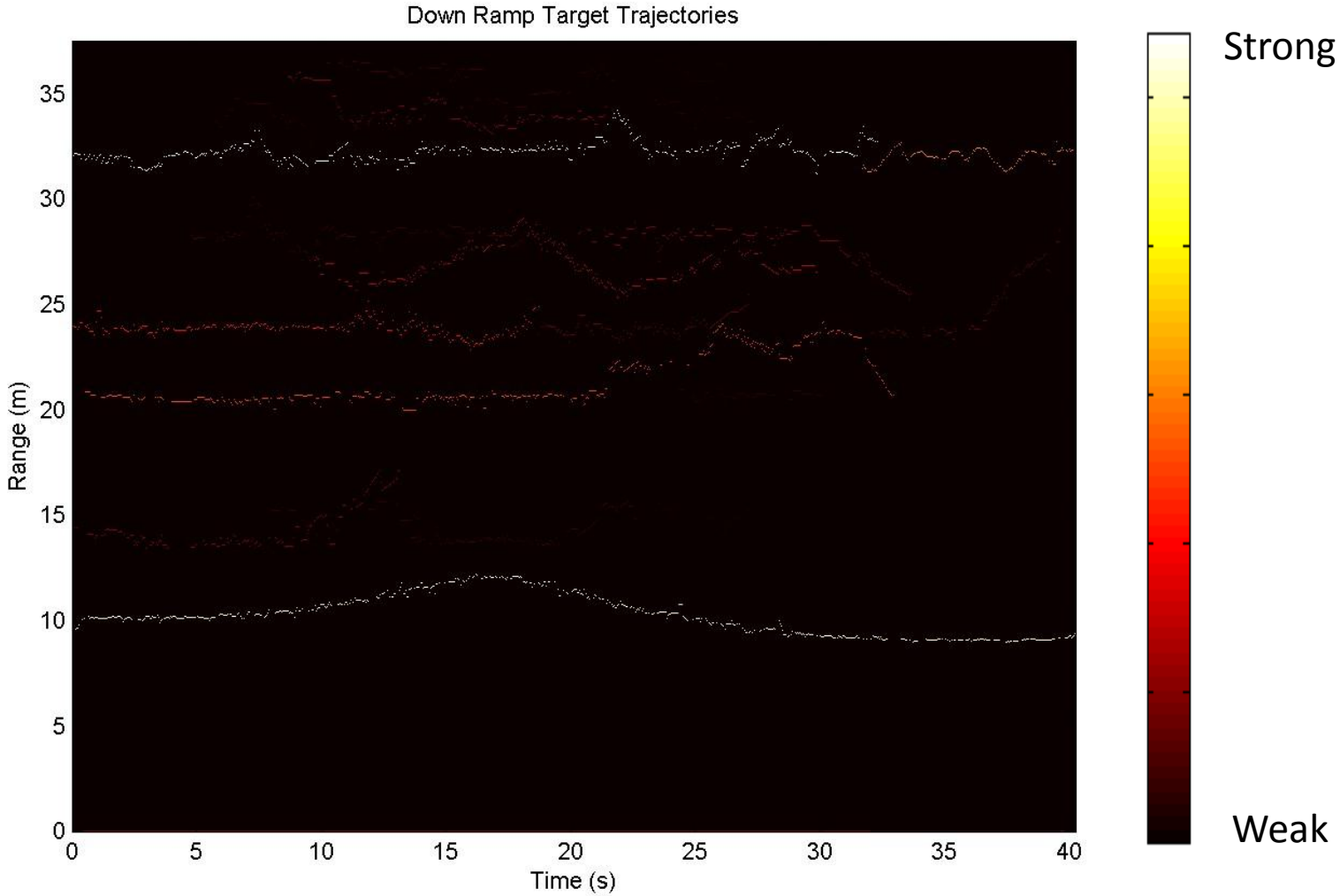
Field Trial #5 – Single Target, Cross-Range Walk, Gym



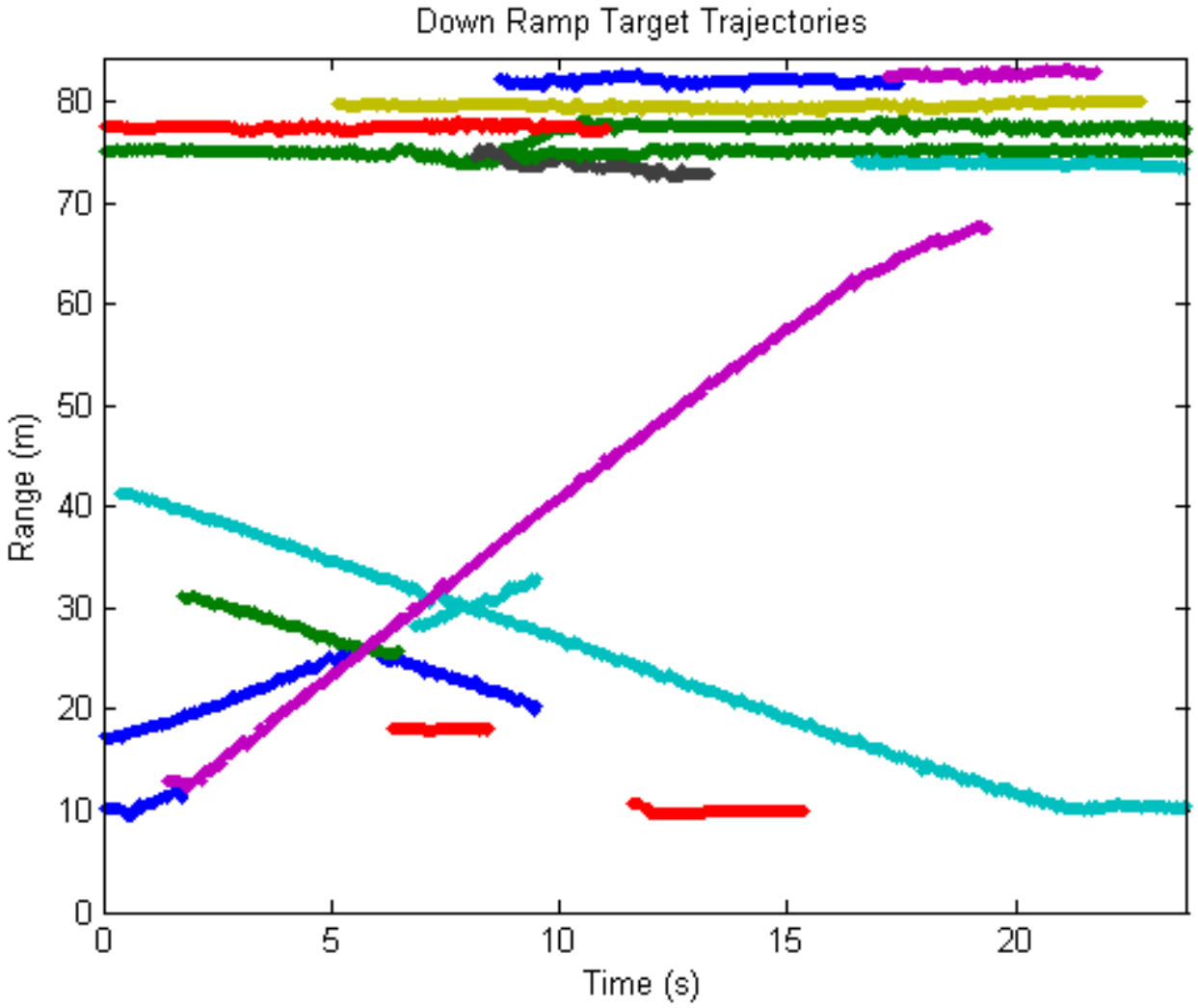
Field Trial #5 – Single Target, Cross-Range Walk, Gym



Field Trial #5 – Single Target, Cross-Range Walk, Gym



Field Trial #6 – Multi-Target, Criss-Cross, Park



Field Trial #6 – Multi-Target, Criss-Cross, Park