#### Mitigating Wrong Way Driving at Rural Interchanges Using Intelligent Transportation Systems

DO

NOT

ENTER

WRONG

WAY

UGRADS, April 27, 2018

NORTHERN

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#### **IMPORTANCE**

- From 2004 to 2011 an annual average of 350 people die in 270 crashes nationally [1].
- Drivers who are impaired, distracted, or confused
- 44% of fatal incidents occur in rural areas and 56% in urban areas [2].

#### Why Rural Areas?

- No effective solution implemented yet.
- 44% of fatal wrong way accidents happen in rural areas.





✓ Detect and alert the wrong-way driver (WWD)

system

- Warn oncoming right-way drivers of oncoming WWD using Dynamic Messaging Signs
- Alert ADOT of WWD in hopes of correcting the WWD
  Utilize Intelligent Transportation Systems for WWD

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#### Area of Prototyping

- Rural Interstates
  - Interstate 17
- ➢ Exit Ramp 333
- Intersection of Interstate-
  - 17 & Mountainaire Rd.
  - ➢ Kachina Village



#### PROJECT LOCATION

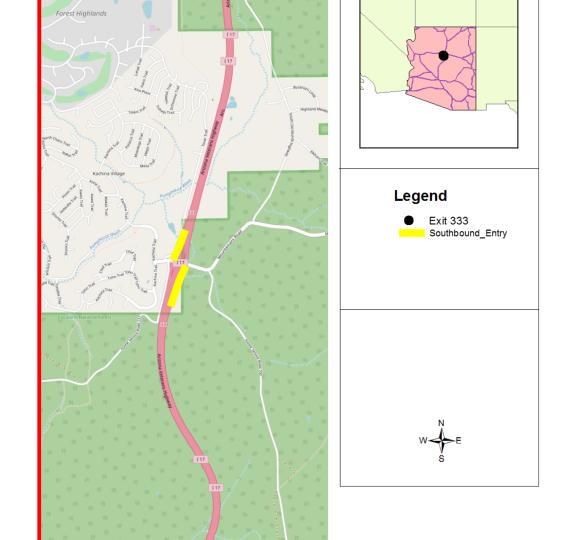
9.0 miles south of Flagstaff

> Interstate -17 Mile 334.14

I-17 and Mountainaire Rd.

- Exit Ramp 333

Kachina Village – South of Flagstaff



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#### **PROJECT SCOPE**

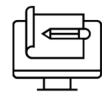


Detection System



Communication System





Testing & Prototyping



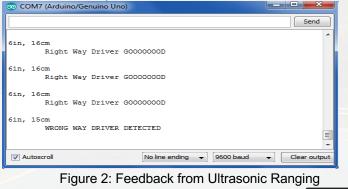
#### **Design Process**



- Ultrasonic Ranging Module
  - Replaced magnetometers to
    Ultrasonic (Radar) technology
  - Provides 2 cm to 400 cm of non-contact measurement
  - Ranging accuracy up to 3 mm
  - Connected to Arduino UNO



Figure 1: Ultrasonic Ranging Module on Prototype. Photo by Hashem Albhrani.



Module. Photo by Hashem Albhrani.

## Design Process

- Camera
- Filtering out unnecessary information
- Finds objects that needs to be detected and highlights them
- Establishes two regions of interest (ROI) to detect direction
- Once the object has passed the boundaries of the ROI then it recognizes the object as going the wrong-way

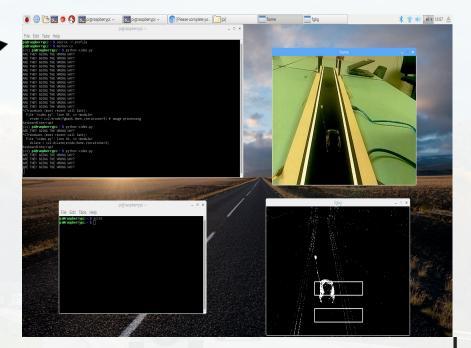


Figure 3: Screenshot showing camera detecting vehicle. Photo by Timothy Fisher.

# Final Design



(10)

- > 5 Megapixel camera
- Uses computer vision
- Ultrasonic Ranging Module
  - Similar to radar detection
  - Can detect distance and movement



Figure 4: Camera Module .



Figure 5: Ultrasonic Sensor (Radar Technology).

#### Hashem 11



# Design Process

- Warning
  - Found a way to increase visibility of warnings.
  - Follow MUTCD with commercially available products
  - Research previously used methods
  - Alert both right and wrong way drivers.

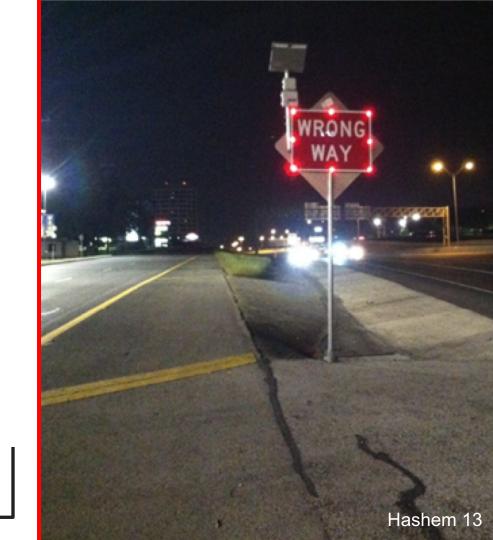


## **Final Design**



#### Warning

- WRONG WAY Sign
  - Added LEDs for greater visibility
  - Construction documents for manufacturing
- Dynamic Messaging Sign
  - LCD display
  - Displays warning message: "WRONG WAY DRIVER USE CAUTION!"





## Design Process

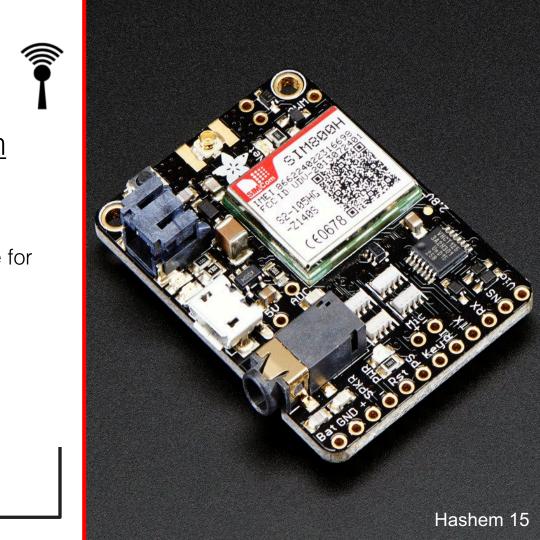
- Communication
  - Research available signal in designated area.
  - Conduct a decision matrix for the method used





#### **Communication System**

- Global System for Mobile communication (GSM) – 2G module for Raspberry Pi
- Connected to a cellular carrier
- Sends SMS messages to ADOT for response





# Design Process

- Power
  - Research available natural resources in designated area
  - Research best type of batteries
    for off grid applications
  - Conduct a decision matrix for the best method used







- 246 days of the year are sunny [3]
- Utilizing solar power
- Using "Lead Acid" batteries for inclement weather and night conditions
- Powering Raspberry Pi, GSM board, ultrasonic, and Arduino



#### SYSTEM OVERVIEW

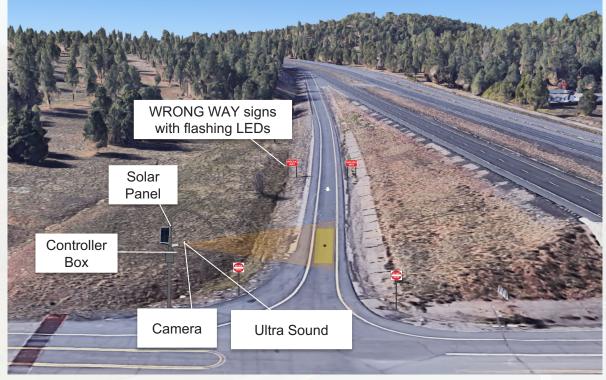


Figure 6: Key components of the system. Photo by Zakary Jenkins.

## Hardware Diagram

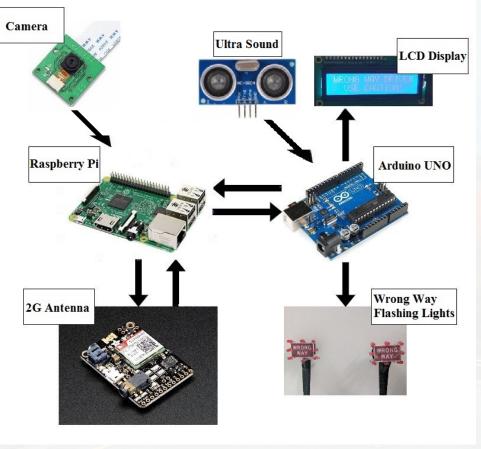
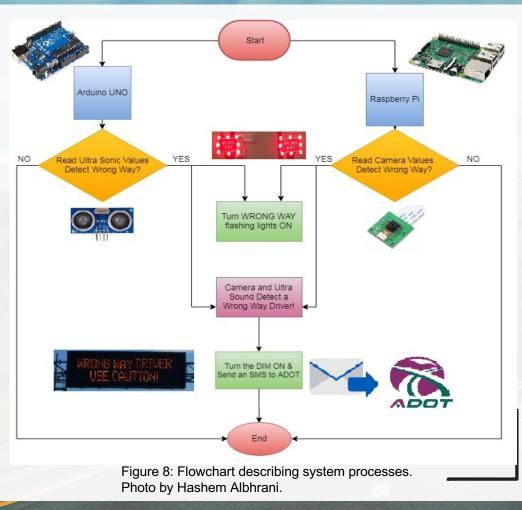


Figure 7: Hardware Diagram describing system connections. Photo by Timothy Fisher

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## SYSTEM OVERVIEW



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## Final Design Prototype

- Characteristics
  - ➤ 1:64 scaled exit ramp
  - > Shoulders
  - > WRONG WAY signs
  - Model made of wood
- Equipment
  - Raspberry Pi 3
  - Arduino Uno
  - Ultrasonic Ranging Module
  - Camera
  - Model Car
  - Cables and Accessories



#### PROTOTYPE COMPONENTS

- Raspberry Pi
  - Currently running on Linux OS Debian
    variant called Raspian
  - ➢ Microcomputer
  - Does basic non-intensive calculations
  - Connected to camera and uses
    OpenCV in conjunction with Python



Figure 9: Raspberry Pi Microcomputer.



Figure 10: James working on assembly and configuration. Photo by Hashem Albhrani.

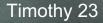


#### PROTOTYPE COMPONENTS

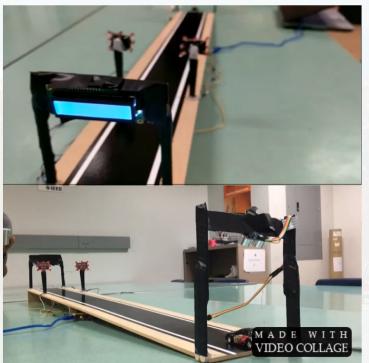
- Arduino Uno
  - Microcontroller
  - Connects modules and gathers information
  - Not a computer, it reads and relays information coming from Ultrasonic Ranging Module
  - Powering the dynamic messaging sign displaying "WRONG WAY DRIVER USE CAUTION!" and WRONG WAY sign with flashing LEDs



Figure 11: Arduino Uno Microcontroller.







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#### PROJECT BUDGET

	Staff	Hour	ly Rate (\$/Hr)	<b>Projected Billing Hours</b>	Pro	jected Total Cost	<b>Actual Billing Hours</b>	Actua	l Total Cost
	Project Engineer	\$	120.00	58	\$	<mark>6,960.00</mark>	50	\$	6,000.00
	Civil Engineer	\$	84.00	94	\$	7,896.00	110.5	\$	9,282.00
Personnel	Electrical Engineer	\$	97.00	119	\$	11,543.00	126	\$	12,222.00
	Lab Technician	\$	<mark>69.00</mark>	80	\$	5,520.00	110	\$	7,590.00
	Administrative Assistant	\$	37.00	49	\$	1,813.00	53	\$	1,961.00
	Intern	\$	20.00	181.5	\$	3,630.00	205.5	\$	4,110.00
Total Personnel			-	581.5	\$	37,362.00	655	\$	41,165.00
Equipment						\$1,700.00			\$306
Testing Expenses						\$500			\$0
				Projected Total	\$	39,562.00	Actual Total	\$	41,165.00



## SCHEDULE

2.0 Detection Design	Original Dates	Actual Dates		
2.2 Technical Specs for Chosen Type	1/30 – 2/5	2/26 - 3/1		
2.3 Parts Requisition	2/6 – 2/7	3/1 – 3/20		
2.4 Assembling & Testing	2/8 – 2/13	4/23 - 4/26		
4.0 Communications	Original Dates	Actual Dates		
4.2 Parts Requisition	2/5 – 2/6	4/26 - 4/30		
4.3 Testing	2/7 – 2/13	4/25 – 4/26		
6.0 Prototyping	Original Dates	Actual Dates		
6.1 Assembly	3/16 – 3/22	3/3 - 4/25		
6.2 Testing	3/23 – 3/29	4/25 – 4/26		
6.3 Final Design	3/30 – 4/5	4/26		

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# QUESTIONS?

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#### References

 S. Simpson and R. Karimvand, "Automatically Detecting Wrong-way Drivers on the Highway System," 22nd ITS World Congress, 2015.

- [2] F. Baratian-Ghorghi, H. Zhou and J. Shaw, "Overview of Wrong-Way Driving Fatal Crashes in the United States", ResearchGate, 2014.
- [3] "Flagstaff, Arizona Climate", Bestplaces.net, 2018. [Online]. Available: https://www.bestplaces.net/climate/city/arizona/flagstaff. [Accessed: 27- Apr- 2018].

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[B] Freewayjim, Vehicles come to a stop on the Seventh Street exit off Interstate 10 near downtown Phoenix. Available <u>https://www.youtube.com/watch?v=el3ILaTUZ\_M</u> . [Accessed: 30- Nov- 2017].

[C] N. Tonelli / Flickr, Spreading roads with brine from oil and gas operations might be dangerous, scientists say, but states still consider it a safe way to recycle the material. Available <u>http://www.newsweek.com/oil-and-gas-wastewater-used-de-ice-roads-new-york-and-pennsylvania-little-310684</u>. [Accessed: 30- Nov-2017].

[D] Google Maps, <u>https://maps.google.com/</u> . [Accessed: 30- Nov- 2017].

[E] Dachshundlover2014/ Reddit, View of Sedona from End of the World, Flagstaff, AZ. Available <u>https://www.reddit.com/r/EarthPorn/comments/3ange0/view\_of\_sedona\_from\_end\_of\_the\_world\_flagstaf</u> <u>f\_az/</u>. [Accessed: 30- Nov- 2017].

#### **References - Pictures**

[F] A. Stark/ Flickr, "Mini Stack" Interchange of Interstate 10, Loop 202, and State Route 51 (1). Available https://www.flickr.com/photos/squeaks2569/5179659067/. [Accessed: 30- Nov- 2017].