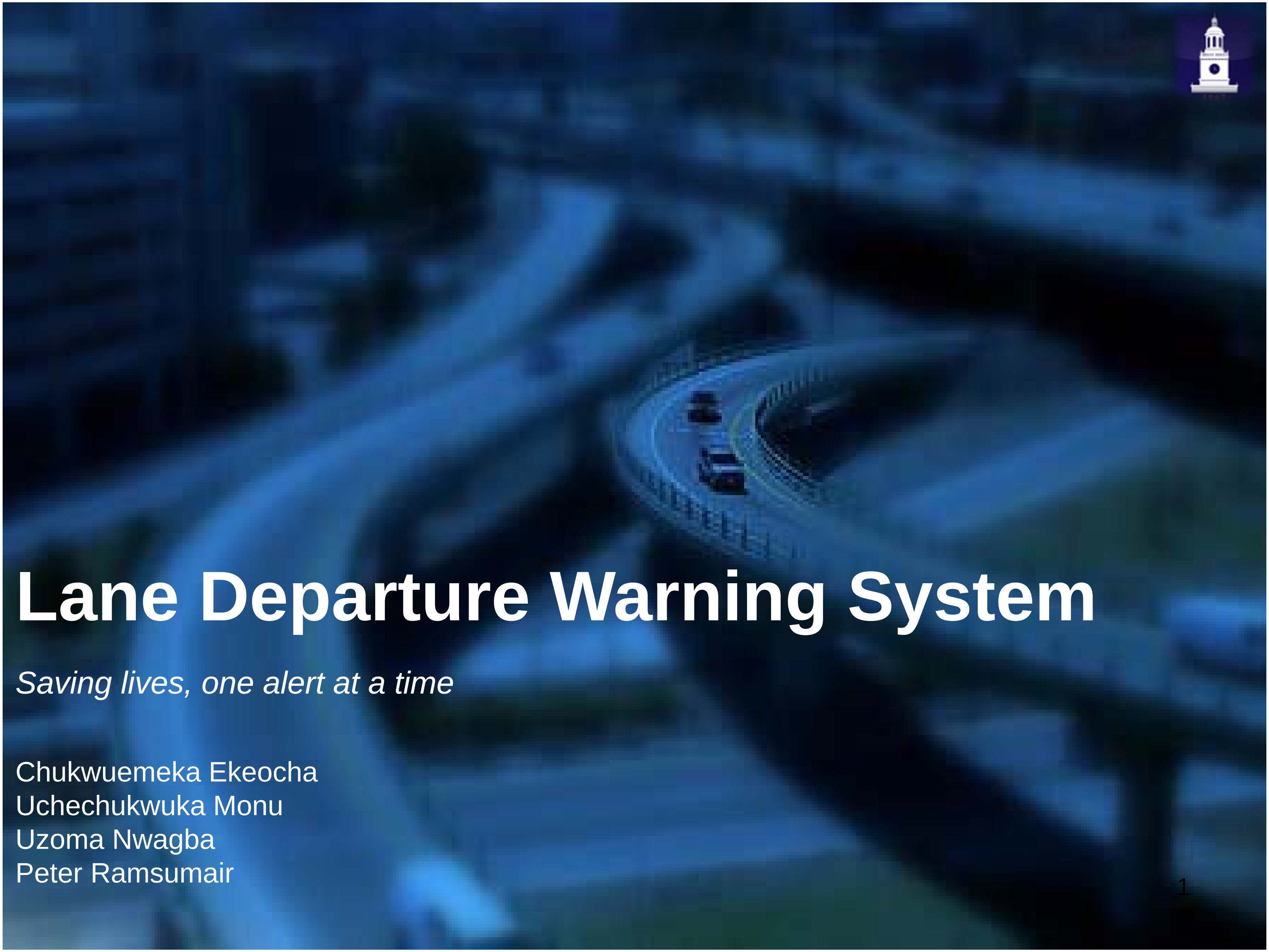

Lane Departure Warning System

Saving lives, one alert at a time

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Overview

1. Problem formulation
2. Performance criteria
3. Solution generation
4. Implementation plan
5. Performance evaluation
6. System functionality
7. Learning experience
8. Acknowledgements
9. Questions

Problem Formulation

- Run-Off-Road (ROR) accidents are a leading cause of deaths on US roads and highways (1,550 fatalities, 71,000 injuries a year)(1)

- Design a lane departure warning system that provides a quick and effective alert to the driver to take a corrective action when car drifts unintentionally

- Main design components:
  - Input: Monitoring environment
  - Control Unit / Data Unit: Interpret the data from monitoring
  - Output: Alert system for the driver in the event of a lane drift


Input

Control Unit / Data Unit

Output

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(1) - National Highway Traffic Safety Administration

Performance Criteria

Performance

- Issue directional warning within 1 second
- Detect vehicle position relative to visible lane boundaries using an input data stream from 6 infrared sensors
- Should not issue warning if the turn signal is activated
- Functionality for
  - Solid and dashed painted lines
  - Single and double painted lines
  - Yellow and white painted lines

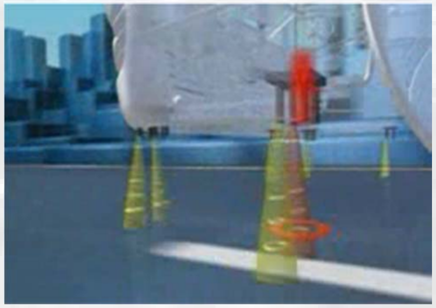
Safety and Compliance

- Perform a self-test within 30 seconds of starting the vehicle
- Adhere to all NHTSA (1) safety standards (crash avoidance, simplicity of use)
- Meet the electrical requirements of SAE standards J1455 / J1113

(1) - National Highway Traffic Safety Administration

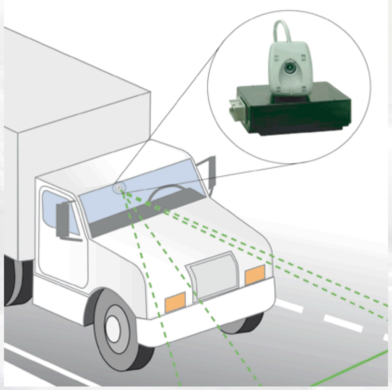
Solution Generation - Input

Infra-red technology



- Constant bombardment of road with IR rays
- To leverage wavelength difference in reflected beam based on color of material hit (road or lane mark)
- Multiple sensors help determine extent of drift

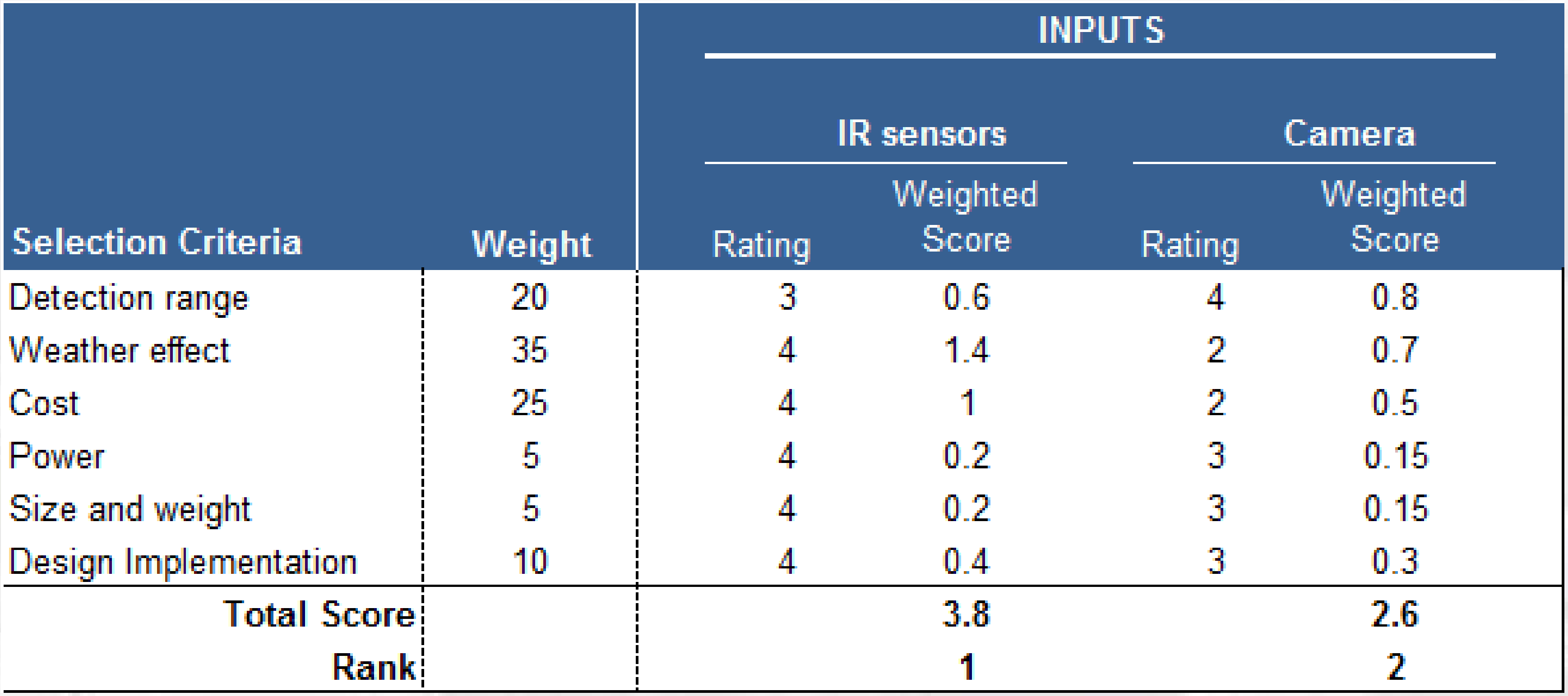
Camera technology



- Vision based system that uses camera sensors as the lane trackers
- Uses image recognition software and proprietary algorithms to determine when a vehicle drifts

Top Design Selection - Input

Input Component - Decision Matrix



		INPUTS			
		IR sensors		Camera	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score
Detection range	20	3	0.6	4	0.8
Weather effect	35	4	1.4	2	0.7
Cost	25	4	1	2	0.5
Power	5	4	0.2	3	0.15
Size and weight	5	4	0.2	3	0.15
Design Implementation	10	4	0.4	3	0.3
Total Score			**3.8**		**2.6**
Rank			**1**		**2**

Solution Generation - Control Unit

NetFPGA

- Uses 4 RJ-45 network ports for interface with wire-speed processing on all ports using FPGA logic

Basys system board

- Allows various interfaces - USB port, 4 6-pin Pmod connectors, VGA,PS/2

Spartan 3E Starter Board

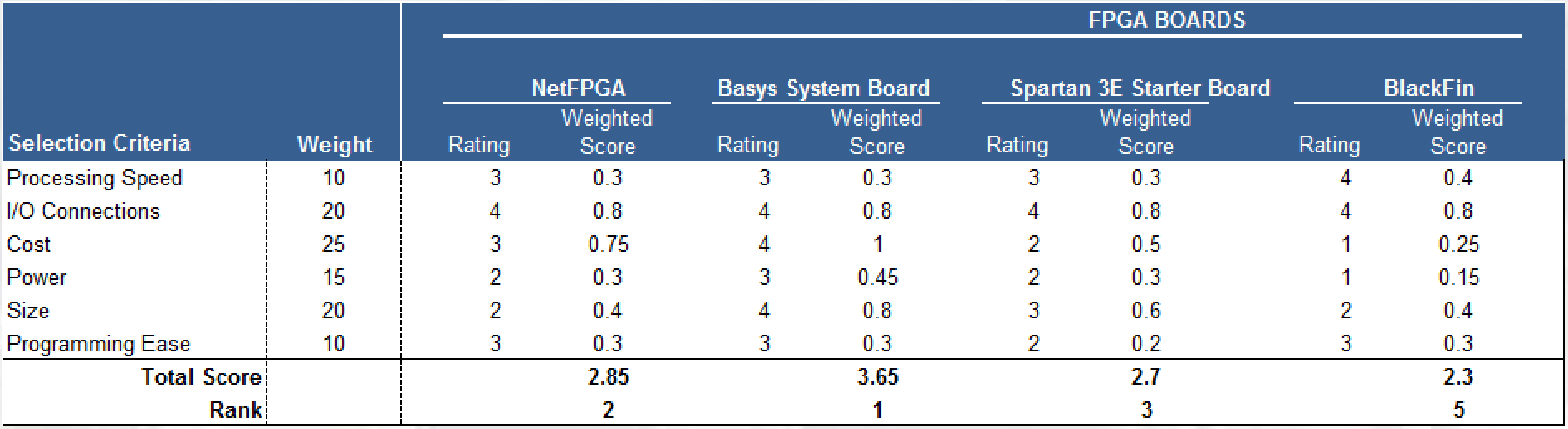
- Added functionality of SMA connector for high-speed clock input

Blackfin processor

- Allows access to Blackfin and FPGA pins for off-board connections and probing

Top Design Selection – Control Unit

Control Unit - Decision Matrix



		FPGA BOARDS							
		NetFPGA		Basys System Board		Spartan 3E Starter Board		BlackFin	
Selection Criteria	**Weight**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Processing Speed	10	3	0.3	3	0.3	3	0.3	4	0.4
I/O Connections	20	4	0.8	4	0.8	4	0.8	4	0.8
Cost	25	3	0.75	4	1	2	0.5	1	0.25
Power	15	2	0.3	3	0.45	2	0.3	1	0.15
Size	20	2	0.4	4	0.8	3	0.6	2	0.4
Programming Ease	10	3	0.3	3	0.3	2	0.2	3	0.3
Total Score			**2.85**		**3.65**		**2.7**		**2.3**
Rank			**2**		**1**		**3**		**5**

Solution Generation - Output

Light Emitting Diodes (LEDs)

- LED arrows to provide a visual driving alert

Seat Vibrators

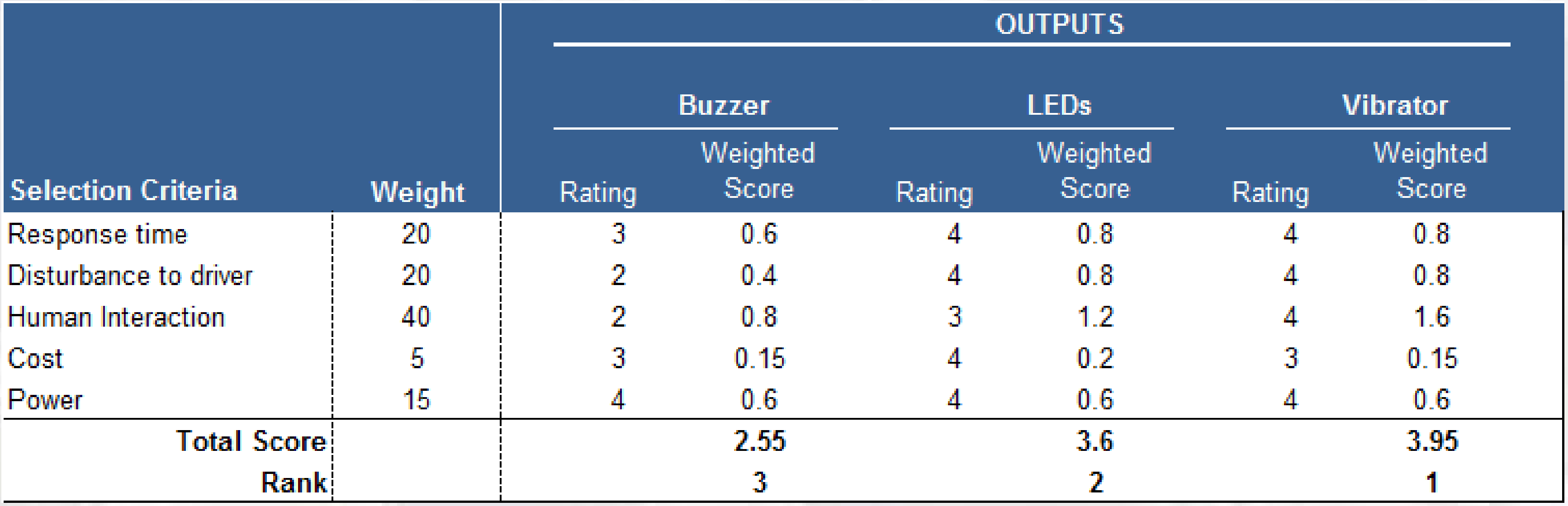
- Two sets of vibrators built into driver's seat (one set on each side—left and right)

Buzzers

- Buzzer built in to provide audio alerts

Top Design Selection – Output

Output Component - Decision Matrix



		OUTPUTS					
		Buzzer		LEDs		Vibrator	
Selection Criteria	**Weight**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Response time	20	3	0.6	4	0.8	4	0.8
Disturbance to driver	20	2	0.4	4	0.8	4	0.8
Human Interaction	40	2	0.8	3	1.2	4	1.6
Cost	5	3	0.15	4	0.2	3	0.15
Power	15	4	0.6	4	0.6	4	0.6
Total Score			**2.55**		**3.6**		**3.95**
Rank			**3**		**2**		**1**

Final Solution

Input - Infra-red

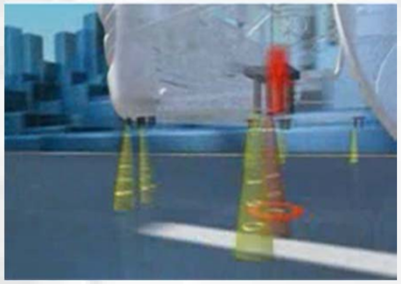
- Constant bombardment of road with IR rays
- Multiple sensors help determine extent of drift

Control Unit - Basys board

- Allows various interfaces – USB port,4 6-pin Pmod connectors VGA,PS/2

Output - Seat vibrators and LEDs

- Seat vibrators built into seat
- LED arrows to provide a visual driving alert



Implementation Plan

Task layout

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
8-Feb	15-Feb	22-Feb	1-Mar	8-Mar	15-Mar	22-Mar	29-Mar	5-Apr
1) Order Parts	1) Develop LDWS system algorithm	1) Use VHDL to develop the input module	1) Construct demonstration set	1) Test model on demonstration set	1) Develop user tests: Power User Test and Normal User Test	1) Create user documentation based on previous plan	1) Beta testing with select power users	1) Beta testing with normal users to ensure that user documentation is comprehensive and easy to follow
2) Use relevant block set to create simulation with Simulink®	2) Consult with faculty advisor (Dr. Gloster) to critique the algorithm	2) Use VDHL to develop the control unit module	2) Critique and test VHDL software	2) Update VHDL code in input module if needed	2) Develop and critique plan for user documentation		2) Update user documentation accordingly	

Performance Evaluation

Expert Opinion Evaluation

Input

- *"…camera has several shortcomings and tends to be sensitive to…bad weather and abrupt maneuvers."*

Institutionen for Systemteknik: Sensor Fusion for Enhanced Lane Departure Warning by Erik Almgren, 2006

- "Auto 1" prize for innovation awarded to infra red sensor technology

III-Vs REVIEW: The advanced semiconductor magazine Vol 18-NO4-May2005: Halios based IR ELMOS chip wins Citroen "Auto 1

Control Unit

- *"FPGA mainly for programmable logic but microcontroller is mainly for hardcore processing. Choice should be informed by function."*

EETimes.com

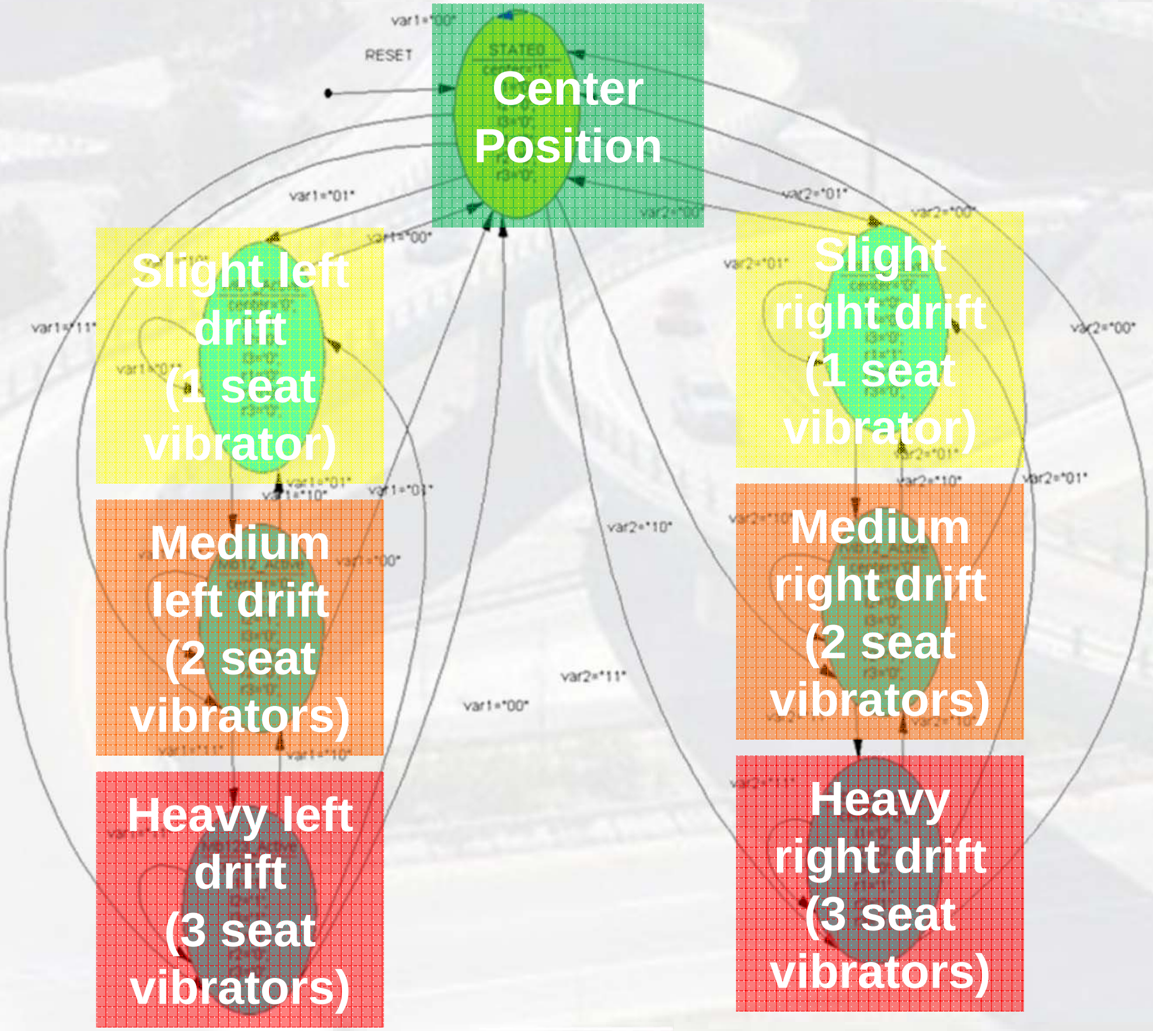
Output

- *"…better solution is to vibrate …and influence… that…will not interfere with the other occupants."*

Research Analysis: A review of tomorrow's driver assistance systems, 5 March 2007

Performance Evaluation

Simulation Evaluation



Center Position

Slight left drift (1 seat vibrator)

Slight right drift (1 seat vibrator)

Medium left drift (2 seat vibrators)

Medium right drift (2 seat vibrators)

Heavy left drift (3 seat vibrators)

Heavy right drift (3 seat vibrators)

Performance Evaluation

Simulation Evaluation

Test	**Result**	
Different types of lane markings (color and pattern)	System is activated for any light color relative to black background; Sensors allow functionality for both dashed and solid lines	✓
Different combinations of activated sensors	System allows for differing levels of alert intensity for corresponding levels of drift	✓
Functionality of LDWS considering the turn signal	System does not alert driver of drift when turn signal is active	✓
Response time of the system to input	Time from drift input signal to driver alert = 1.2 µs (ModelSIM®)	✓

Performance Evaluation

Prototype Evaluation

- Driving scenarios were based on four seasonal driving conditions
- Each trial set consisted of 25 trials in a man made driving environment

Spring weather conditions

- Wet driving condition
- 92% correct alert rate

(23 out of 25 positive alerts)

Summer weather conditions

- Dry driving condition
- 96% correct alert rate

(24 out of 25 positive alerts)

Fall weather conditions

- Debris covered driving condition
- 84% correct alert rate

(21 out of 25 positive alerts)

Winter weather conditions

- Light snow covered driving condition
- 88% correct alert rate

(22 out of 25 positive alerts)

System Functionality

Learning Experience

- Utilized knowledge from past classes to complete this lane departure warning system
- Learnt about the typical industry standard project cycle through corporate partnership
- Managed project deliverables
- Understood the relationship between group dynamics and the project progress

MATLAB SIMULINK

Acknowledgements

- Department of Electrical and Computer Engineering, Howard University
- Dr. Charles Kim and our entire Senior Design I / II class
- Corporate partner - Chrysler LLC (Tomi Igun)

Questions

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