SIMON FRASER UNIVERSITY
SCHOOL OF ENGINEERING SCIENCE
ENSC 305/440 – CAPSTONE PROJECT

Group Members:

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Objectives

- Team Members
- Motivation
  - Effect of Alcohol on Brain
  - BAC Limits
- Business Consideration
  - Market Potential
  - Business competition
  - Target Client
- System Overview
- System Design
  - Hardware
  - Software
- Project Details
  - Timeline
  - Budget
  - Team Dynamics
- Conclusion & Summary
- Acknowledgement and References
- Questions

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Team Members - Roles

- **Ritik Looned, Team Leader**
  - Inspire and encourage the sub-group towards its development
  - Gas sensor + Interlock implementation
  - Assisted in software implementation

- **Nima Soroudi, Electrical Designer**
  - Troubleshooting and debugging hardware components
  - Gas sensor + Interlock implementation
  - Ordering and deciding on parts
  - Minutes

Team Members – roles Cont'd

- **Mohammad Naghshineh, Project Manager**
  - Funding and Documentation
  - Deciding and purchasing on parts
  - Assisting electrical engineer
  - Packaging and integration
- **Ashraf Jerbi, Software Engineer**
  - Programming software algorithm
  - Integrating Module
  - System Testing
  - Hardware design assistance
- **Moataz Medini, Software Engineer**
  - Deciding and purchasing on parts
  - Documentation Lead
  - System Testing + software algorithm
  - Filming

Motivation

- 2,541 individuals killed in motor vehicle accidents in Canada 2010
- At least 1,082 were impairment-related
- Driving while one's ability is impeded by alcohol or drugs is a crime under the Criminal Code of Canada
- $20.62 billion financial loss by Federal Ministry of Transportation

Source: Public Health Agency of Canada

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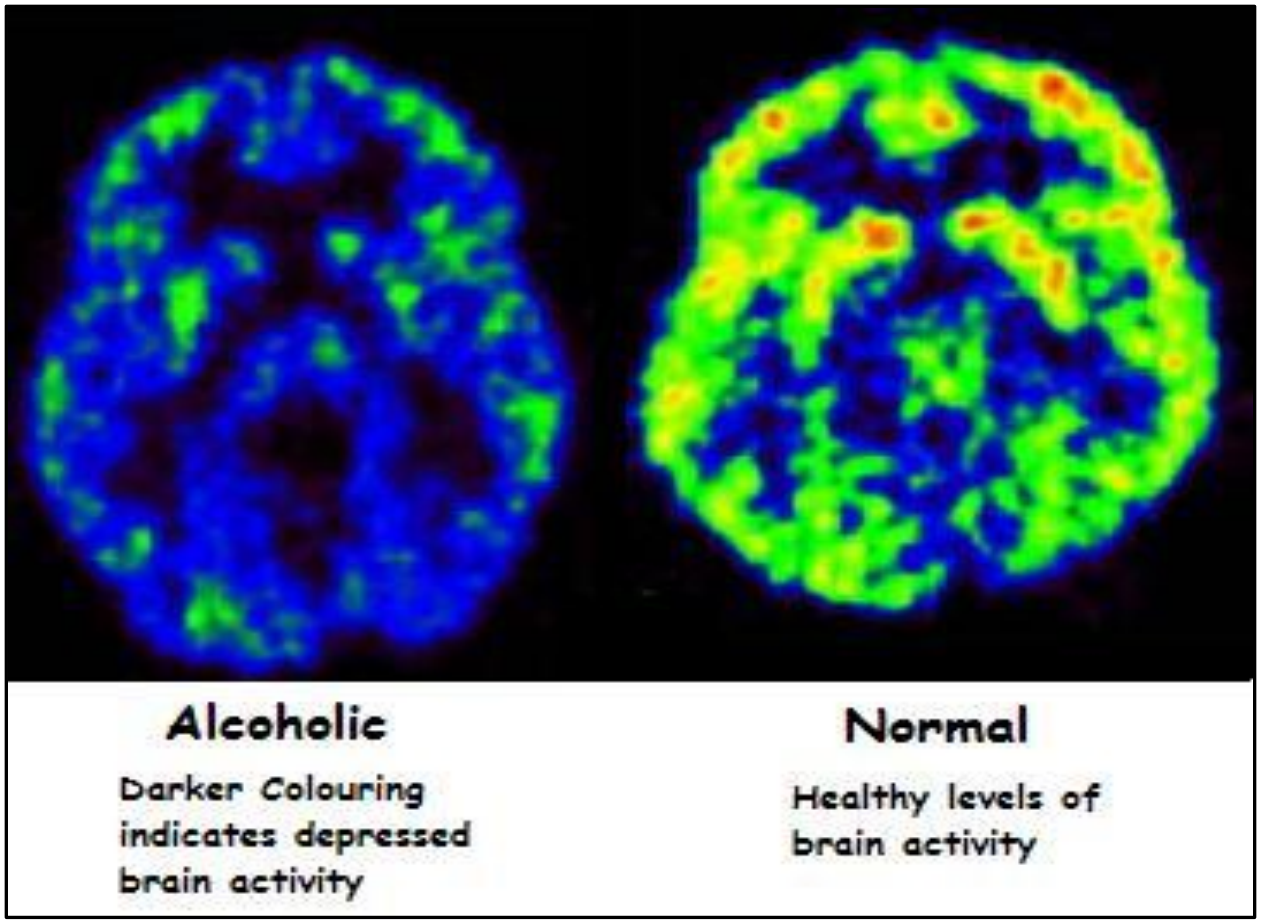
Effect of Alcohol on Brain

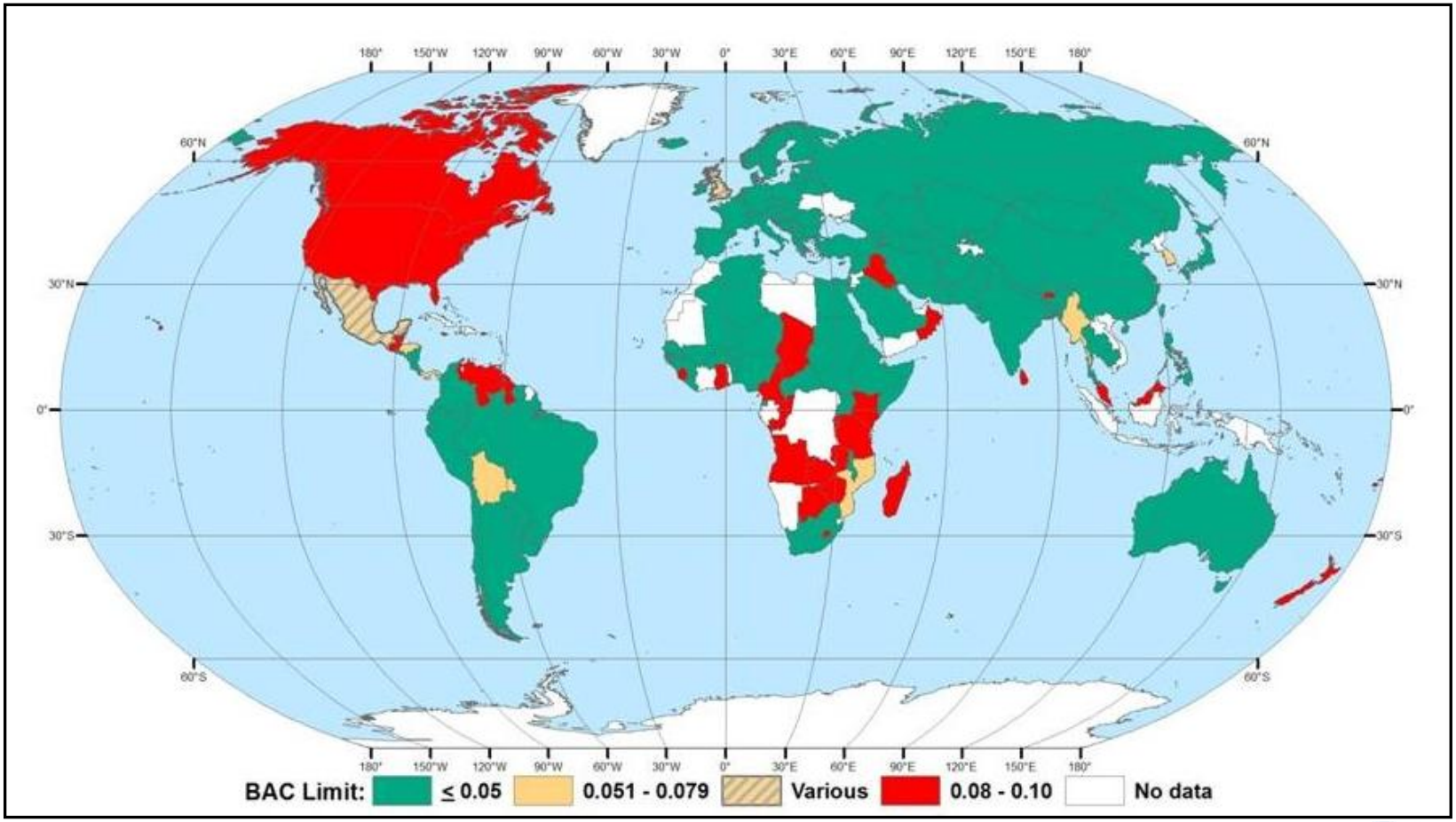
- Affects brain chemistry by altering levels of neurotransmitters.
- **Neurotransmitters** : chemical messengers that transmit the signals throughout the body that control thought processes, behaviour and emotion.
  - Excitatory: stimulate brain electrical activity.
  - Inhibitory: they decrease brain electrical activity.
- Alcohol increases the effects of the **inhibitory** neurotransmitter, GABA.
- Also increases the amount of the chemical dopamine in the brain's reward center => feeling of pleasure.
- Results: difficulty in walking, blurred vision, slurred speech, slowed reaction times, impaired memory.

Brain Activity level



Source: Australia Virtual Medical Centre 2014

BAC Limits Word Wide



Source: National Transportation Safety Board of United State of America 2013

Market Potential

- Financial Profits
  - $20.62 billion financial loss reported by Federal Ministry of Transportation in 2010 alone indicates the need for such devices.
- Social Profits
  - Research shows that alcohol interlocks reduce recidivism among both first-time and repeat offenders.
  - More than 10 evaluations of interlock applications → reduction in recidivism 35-90% (Voas and Marques 2003).
  - 15 scientific studies → while interlocks installed, the re-arrest rate of offenders decreased by median of 67% (Elder et al. 2011).
  - A Swedish study → the frequency of annual DWI offenses decreased approx. 60% among offenders who completed a 2 year interlock program.

Business Competition

- Alcoguard at Volvo Cars
  - Fuel-cell technology - accurate and reliable
  - Integrated solution for increased user-friendliness
  - Sales start in early 2008
- Toyota
  - Sweat sensors on the steering wheel to take BAC,
  - Ready for production by 2009, still under research.

Source: Mobility and Transport, European Commission

Business Competition Cont'd

- Nissan
  - Testing the system in partnership with the Japanese government
  - still under research.
- Alcolock V3, United Kingdom
  - Personal Breath Tester
  - Commercial Interlocks
  - Law Enforcement

Source: Alcolock United Kingdom

Target Clients

- Convicted DUI offenders – Government
  - Florida Department of Highway Safety & Motor Vehicles
  - Since Florida's alcohol interlock program began in 2004, over 21,000 drivers have participated in the program.
- Insurance companies
  - 5,000 interlocks used in the Swedish transport market
- Commercialized Company
  - Companies transporting passengers or dangerous goods
  - Taxi companies and driving schools

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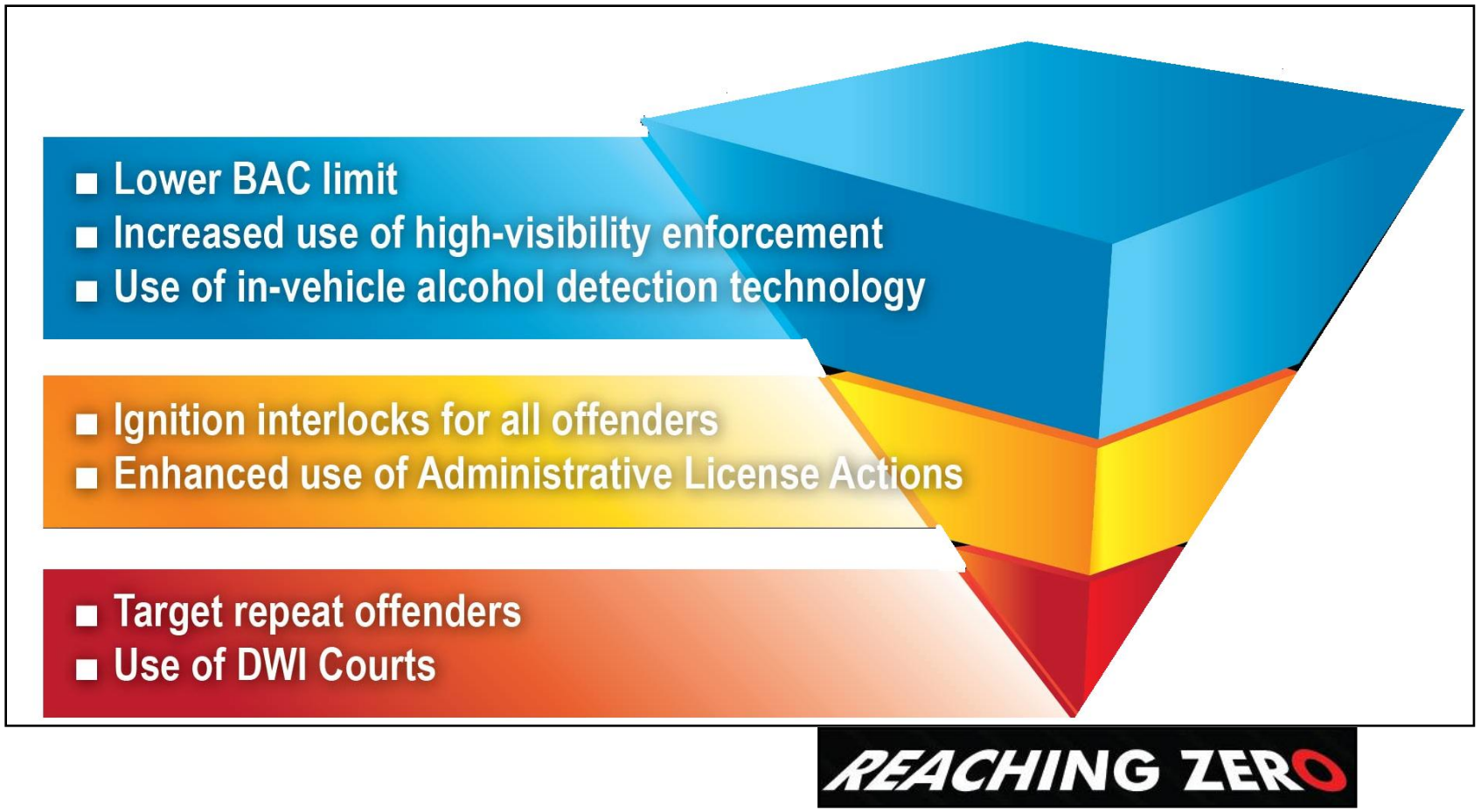
The National Transportation Safety Board



Difficulties in Industry

- Current design requires frequent breath sample
  - Disturbing
  - Annoying
- Cheating is a prevalent occurrence on current systems

What is the solution

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System Overview – 2 scenarios

1. The user is intoxicated and thus is not allowed to operate the vehicle.
   - The Blood Alcohol Content (BAC) > legal limits, the ignition kill switch is actuated to prevent operation of the vehicle.
2. The user is sober and although no immediate restrictive action is taken further authentication is required.
   - The BAC < legal limit, the driver is permitted to operate the vehicle
   - A further identity check must be performed to authenticate the driver with the breath sample.
     - Images are captured and compared with the stored database to verify a match.
     - In case of a mismatch, various notification strategies to the authorities are considered.

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System Overview cont`d

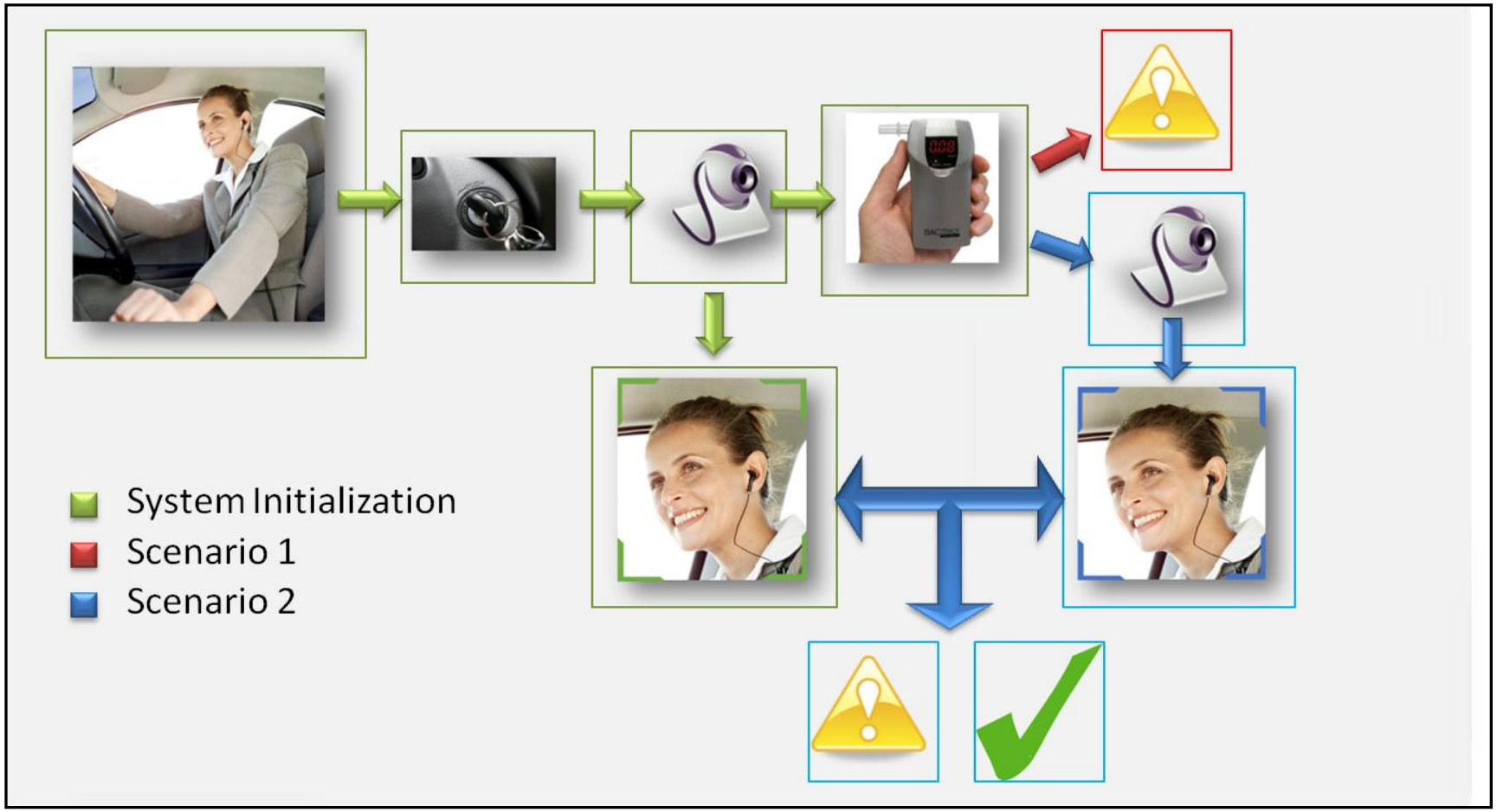
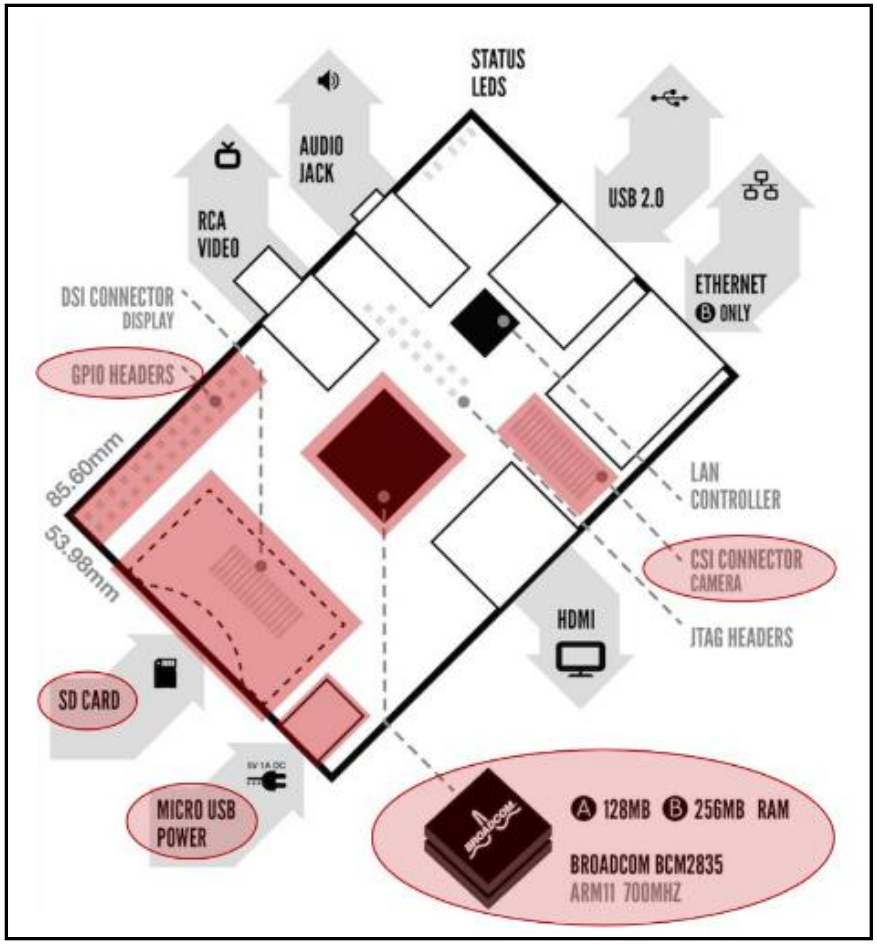


Figure 1: System overview illustrating the high level operation of the device

System Design – Processing Unit

- Raspberry Pi
  - Small, portable, low power
  - Linux-based OS
  - Ample connectivity
  - External storage



System Design - Software Algorithm

- Implemented in Python on the Raspberry Pi
  - Excellent collection of available libraries
  - OpenCV – Imaging processing
  - Numpy – Numerical calculations
  - Spidev – Serial Peripheral Interface Communication
  - AdafruitCharLCD – User interface LCD
  - GPIO – Connecting input/output components

System Design – Face Detection

- Haar cascade classifier to detect faces
  - Effective object detection for facial features

System Design – Face Comparison

- Eigenfaces to classify face comparison
  - Negative database 70 images – captures wide demographic

  - Positive database 10 images – optimized for time and accuracy

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System Design – Face Comparison

- Positive Eigenface

Ritik's Face Profile

Nima's Face Profile

- Negative Eigenface

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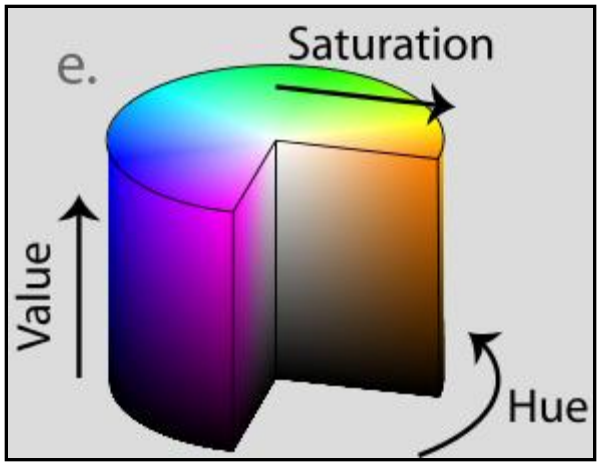
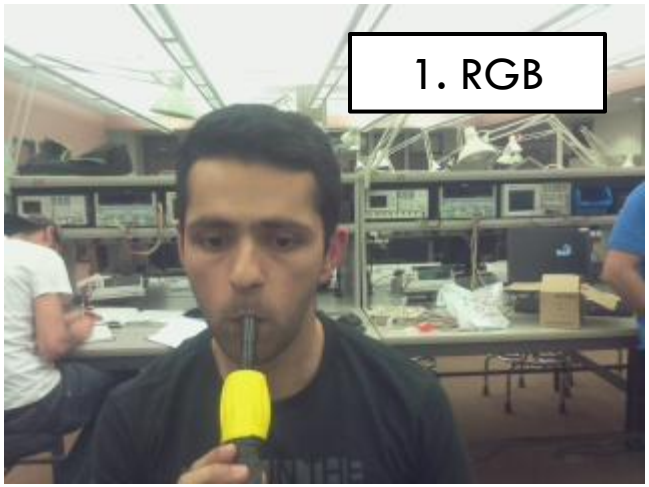
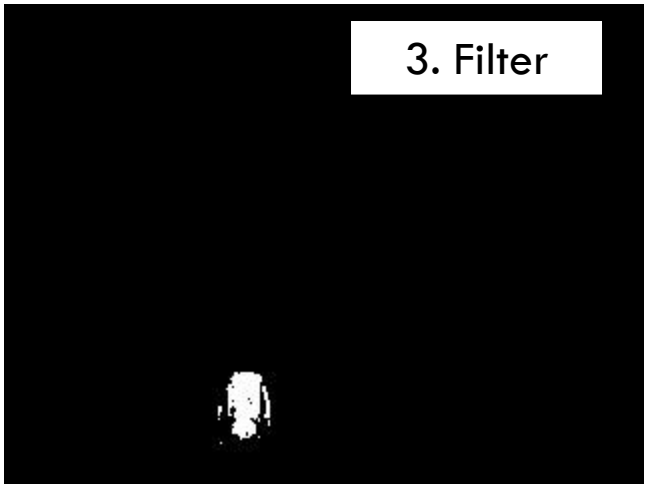
System Design – Breathalyzer Detection

- Convert RedGreenBlue (RGB) to HueSaturationValue (HSV) spectrum
- Intuitive for computer vision and image analysis
  - Hue → tint of colour
  - Saturation → amount of colour
  - Value → brightness of colour



System Design – Breathalyzer Detection





Filter:
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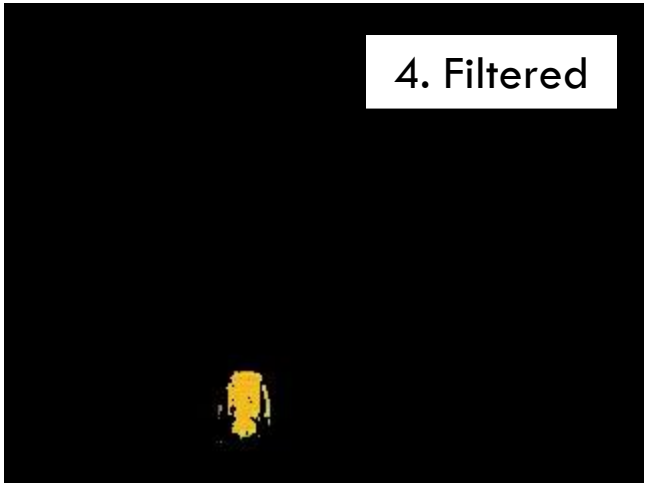
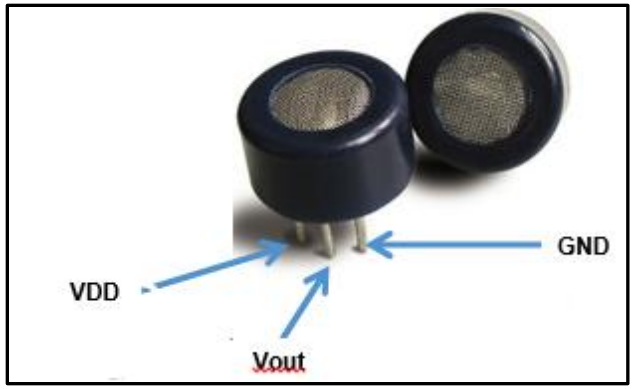
Value [100,240]



Pixel Count:
Threshold > 200 pixels

System Design - Breathalyzer



- Limitations with commercial breathalyzer
  - Inaccurate readings
  - Extensive time and drinking required to simulate drunk case
  - Law enforcement agencies often rely on blood or urine analysis regardless

- Benefits of MQ Gas Sensor
  - Fast response time
  - Reliable detection of alcohol

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System Design – Gas sensor

- Determine the Blood Alcohol Content (BAC)
- Alcohol sensor detects the ethanol vapours present
- Oxidization of ethanol vapours at anode
  - $CH_3CH_2OH(g) + H_2O(l) \rightarrow CH_3CO_2H(l) + 4H^+(aq) + 4e^-$
- Reduction of oxygen at cathode
  - $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$
- The overall reaction is the oxidation of ethanol to acetic acid and water.
  - $CH_3CH_2OH(l) + O_2(g) \rightarrow CH_3COOH(l) + H_2O(l)$
- Electrical current produced by reaction approximates BAC

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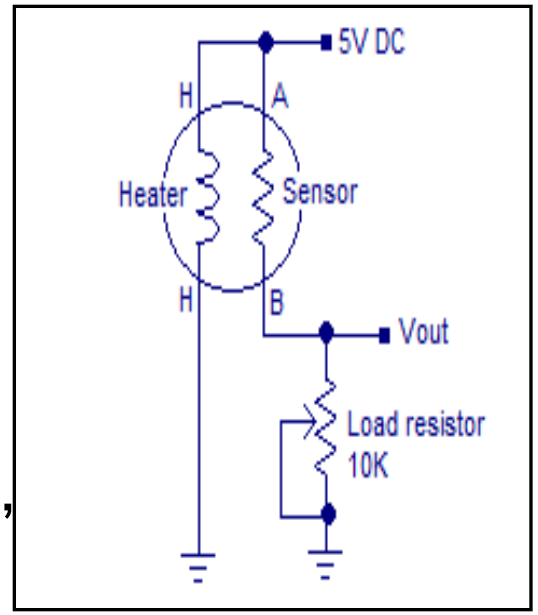
Gas Sensor cont`d

- Attempted calibration
  - Unsuccessful – sensor too sensitive
  - Settling time too slow



- Applied rate of change method
  - Large positive changes → 'Drunk sample'
  - Small changes → 'Sober sample'
  - Negligible change → 'No sample'

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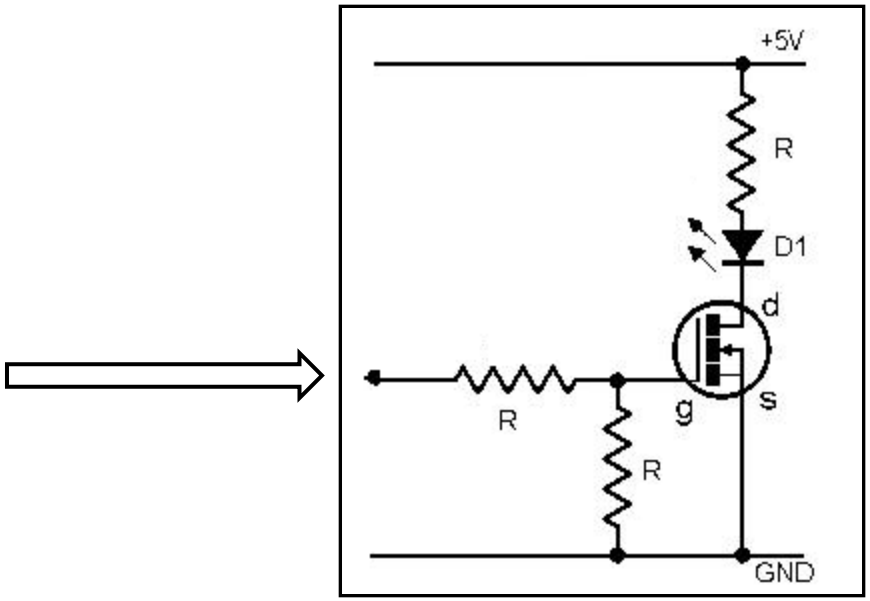
System Design – Ignition Kill Switch

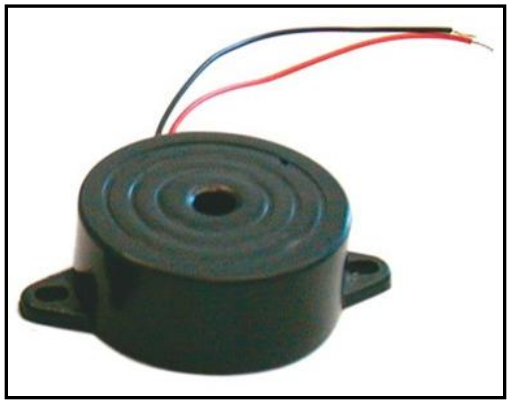
- N channel POWER MOSFET
- Enhancement Mode operation
- Turn on LED if drunk driver detected

GPIO input signal
Drunk → High (3.3V)
Sober → Low (0V)



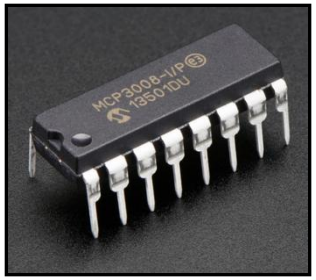
System Design - Buzzer

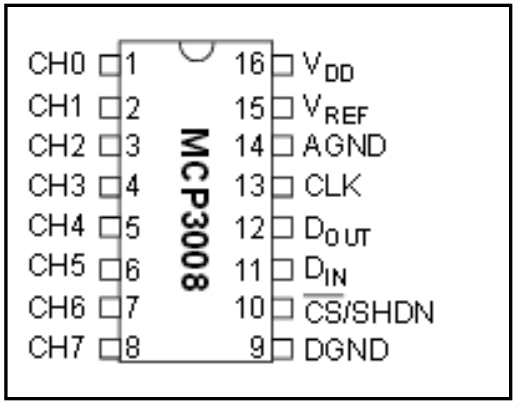
- High frequency continuous tone
- Low power operation – Input 3.3V from GPIO
- Possibly imitates alarm system of vehicle
- Illustrates notification system for failed authentication cases



System Design - ADC

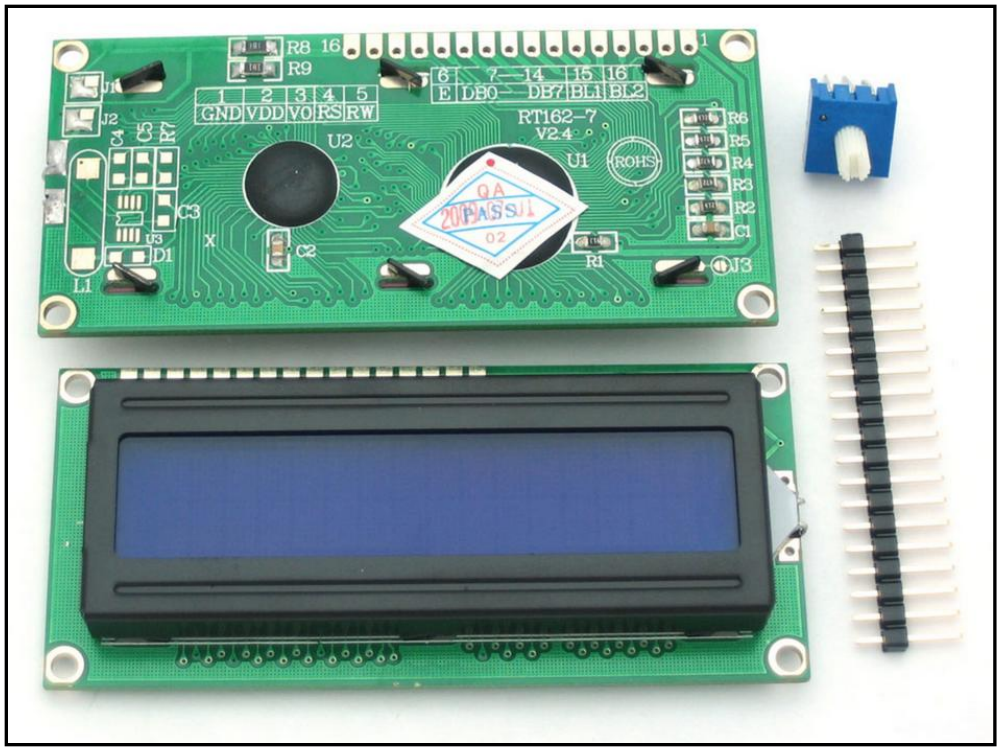
- MCP3008 – 8 Channel 10 Bit Analog to Digital Converter
- Raspberry Pi has no analog inputs
- SPI communication
- Channel 0 – Gas Sensor
- Channel 1 – Key





System Design – LCD User Interface

- Practical hardware wiring to CPU
- Well documented software library package
- Low power operation
- Adjustable backlight

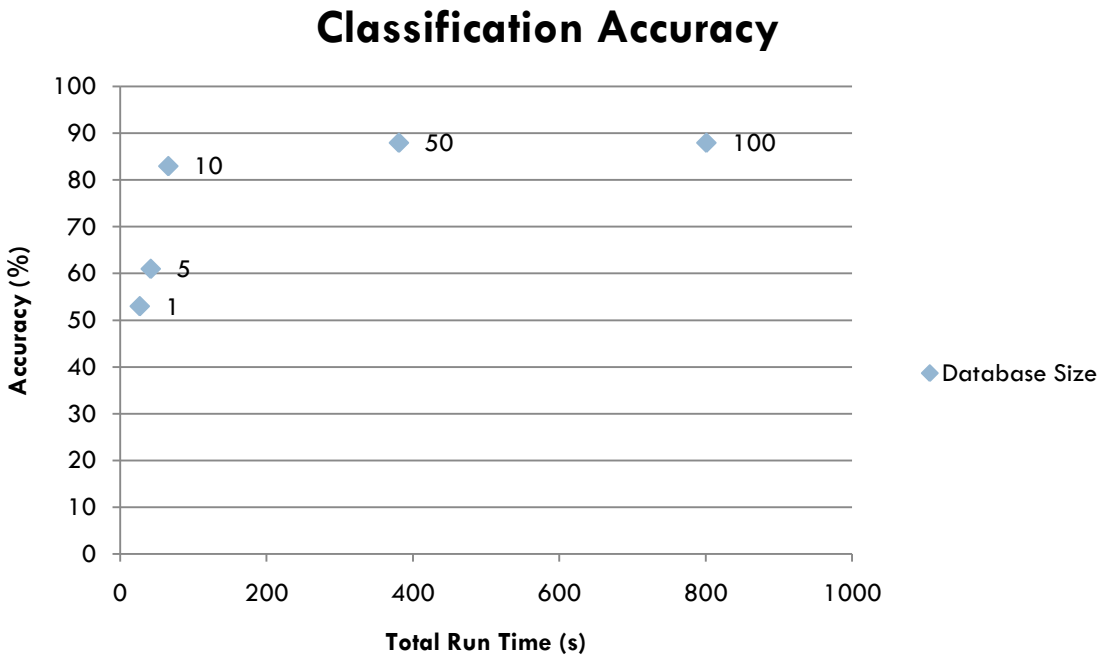


System Design – Vehicle Simulation

- Potentiometer simulates key position
  - OFF, ACC, ON
- Audio imitates vehicle operation
  - Authenticated sober driver →Vroom! Vroom!
  - Drunk driver attempted start → Eeeek!

System Limitations

- Accuracy of classification algorithm variable

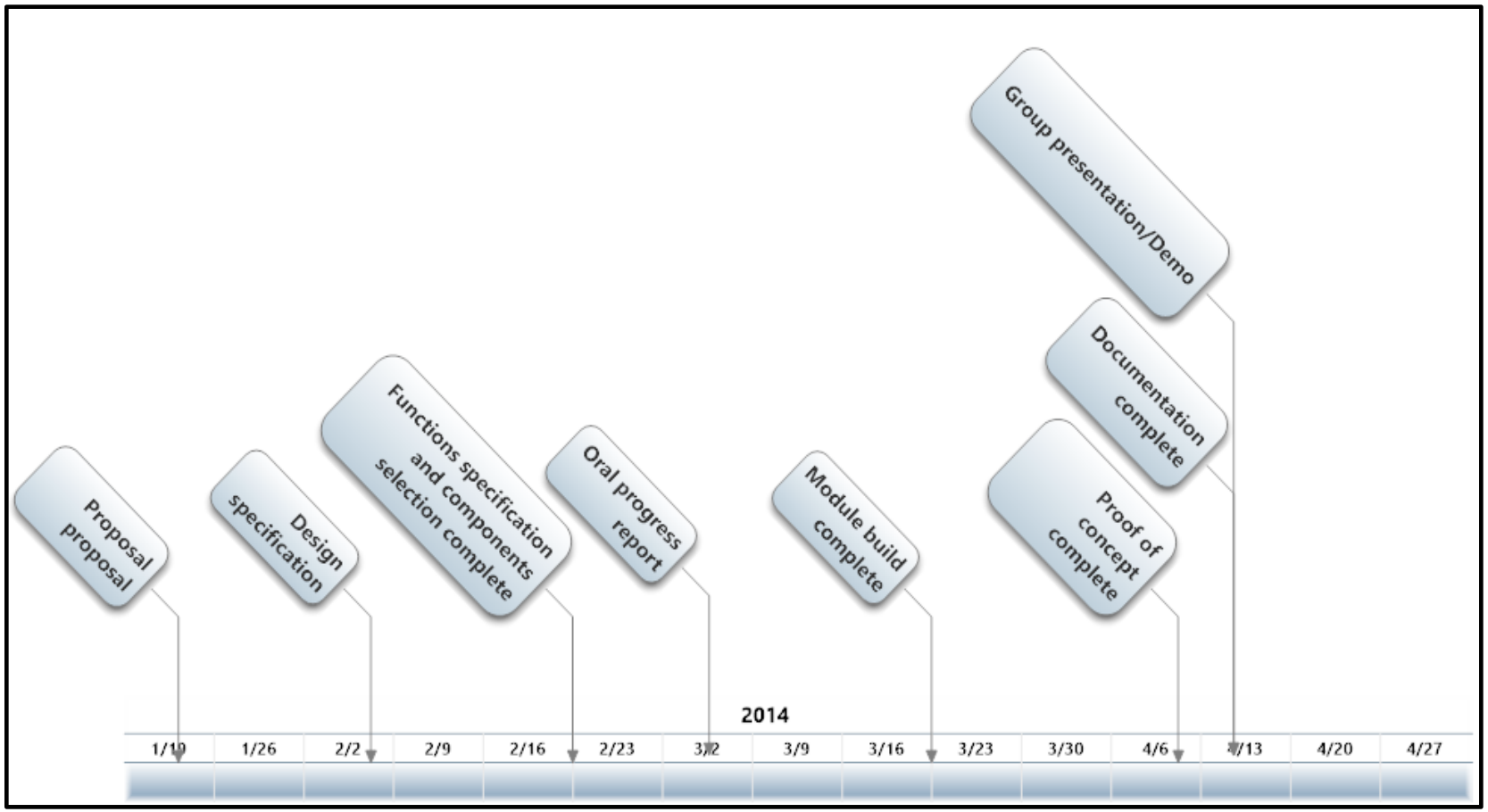


- Sensitive to lighting conditions → infrared camera
- Unstable driving conditions → built-in image stabilizers
- Facial accessories → Request removal

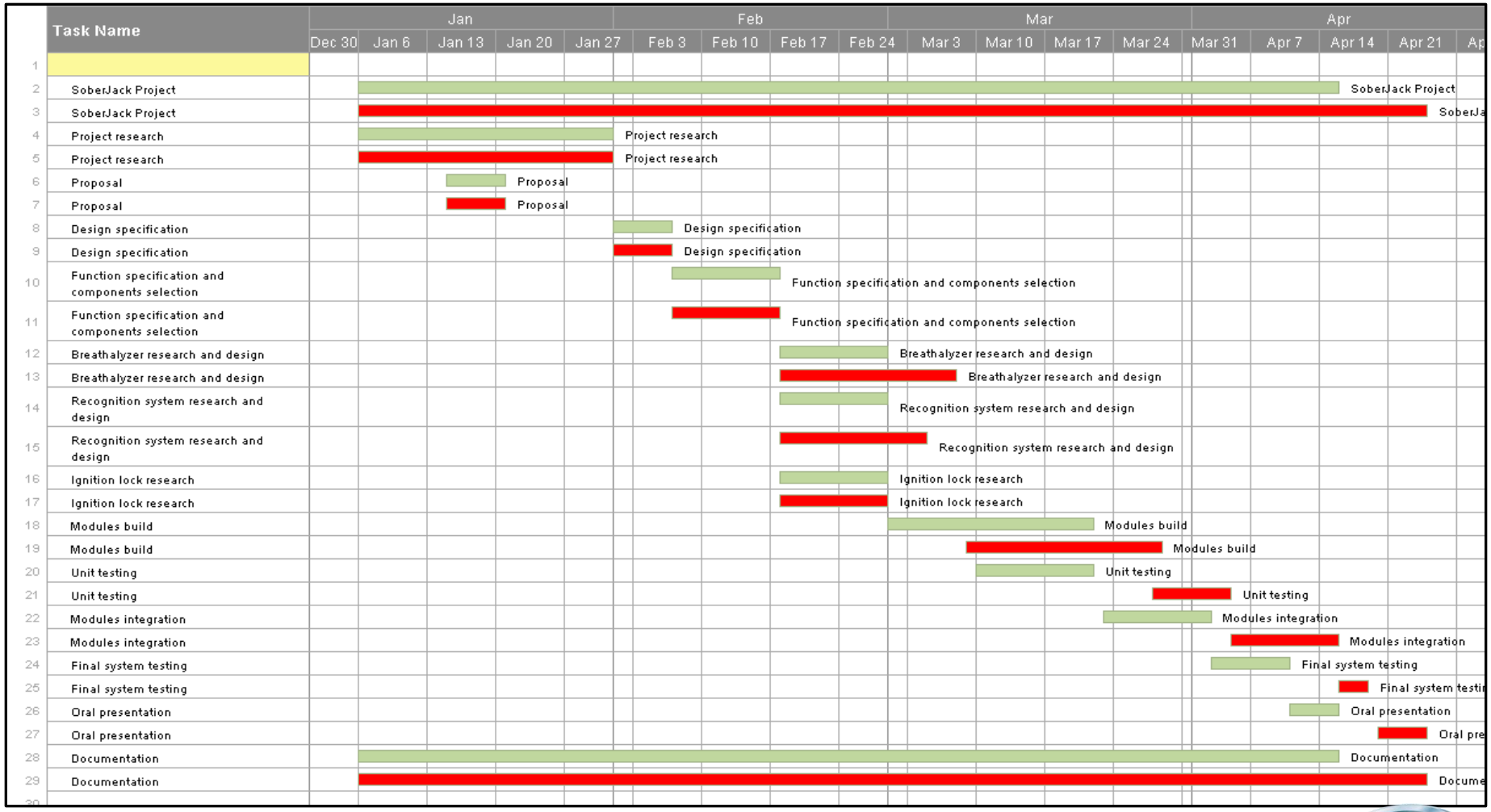
System Limitations

- Corner Cases
  - Drinking while driving
    - Frequent tests/Ambient sensor
  - Extended T-shape straw for alternate breath samples
    - Breath sample loses pressure
  - Twins/Triplets/Clones
    - We're stuck --- Suggestions?

Milestones and Tasks



Timeline – Expected vs. Actual



Budget – Expected

Component	Quantity	Price
Raspberry Pi 8 GB Microcontroller	1	$ 44.16
Raspberry Pi Camera Module	1	$ 26.00
Mini 4" PTZ Security Dome Camera Sony CCD	1	$ 186.49
Relay	2	$ 10.00
Alcomate Premium AL7000 PRO Breathalyzer	1	$ 129.99
BacTrack Blue Keychain Breathalyzer	1	$ 52.79
BeagleBone (Credit card Sized Portable computer)	1	$ 89.00
Blue LED Push Start Ignition Button	1	$ 19.99
components failure, Contingency and shipping and handling	1	$190.00
Rental car for Demo	1	$120

TOTAL: $ 868.42

Budget - Actual

Component	Quantity	Price
Buzzer-Piezo 3-28VDC	2	$7.86
PWR MOSEFET	1	$2.00
Gas Sensor	1	$7.50
LED	4	$4.00
Others (e.g. antistatic strap, tape, door stops, straws, balloons and etc)	1	$70.00
Raspberry pi camera module	3	$135
BacTrack Breathalyzer	1	$29
LCD Module	1	$12.99
PVC pipe + paint + Tank Board	1	$20.92
Electronic Components (Jumper wire, IC and etc)	1	12.69
Car module	1	$45

TOTAL: $ 346.96

Business Plan - Ignition Interlock Program

Program component	Competitor Costs
Installation of the ignition interlock device	$150
Rental fee for the device per month	$105
Application fee (does not include Registry Agent Fee)	$63
“Planning Ahead” driver program	$250
“IMPACT” driver program	$800
Removal of the ignition interlock device	$50
Total for 1 month	**$1418**

Source: Alberta Transportation : Centre of Impaired Driving 2014

Ignition Interlock Program

- **Who is required to complete the program:** Drivers who have been convicted for impaired driving under sections 253, 254, or 255 of the *Criminal Code* (Canada)
- **How to Apply:**
  - all reinstatement conditions and road test
  - payment of the reinstatement fee and the outstanding IIP condition.
- First time offender => "Planning Ahead" Driver Program before applying
- Repeat offender, => "IMPACT" Driver Program before applying
- **If cheated or bypassed the ignition interlock device:**
  - licence suspended or cancelled
  - Charged with any driving-related *Criminal Code* (Canada) offence
  - May be immediately removed from the program
  - Also result in an extension on the Ignition Interlock Program

Source: Alberta Transportation : Centre of Impaired Driving 2014

Product Selling Point

- Fool proof system – cannot be cheated like current systems
- Marketed as a voluntary add-on
- Marketed to government, and law enforcement agencies for mandatory purposes
- Competitive pricing in current market

Preliminary Finances

- Development costs
  - Components: $350
  - Employee Salaries (4 months):
    - $20 per hour per head
    - 20 hours working time per head per week
    - 5 team members
    - Total expense: $32000 x 3 = $96000 per annum
- Future projections for mass production
  - Advanced model selling price: Approx. $850
  - Market first year: 1000 units
  - Total revenue: $850,000

Future Developments – Current Design

- Implement a notification scheme to the local authorities upon detection of drunk driving.
  - Wireless transmission of the driver image and car information.
- Perform BAC checks for further restriction of the system to prevent drinking while driving.

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Future Development - Production

- Environmental Requirements
  - Operate in minimum and maximum temperature + humidity level
  - Cradle to Cradle design
- Reliability and Durability Requirements
  - Withstand all normal skills, e.g. turns, U-turns
  - Technical support – user manual, call centre, road side assistance
- Safety Requirements
  - Not cause bodily harm to the user while driving
  - Electronic components shall not cause interference with others

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Final Market Product

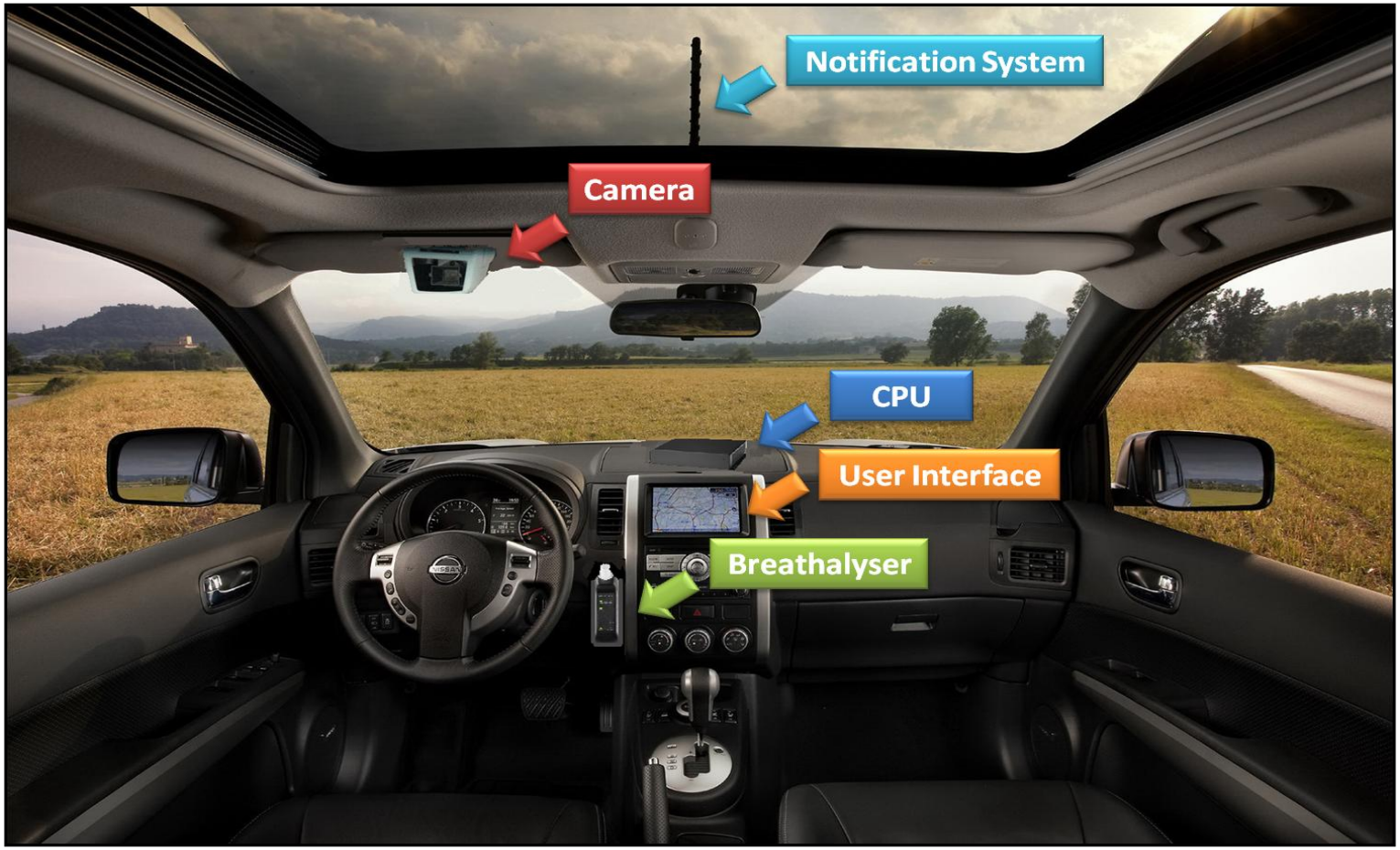


Figure 4: Envision of the final product integrated into the vehicle design

Team Dynamics

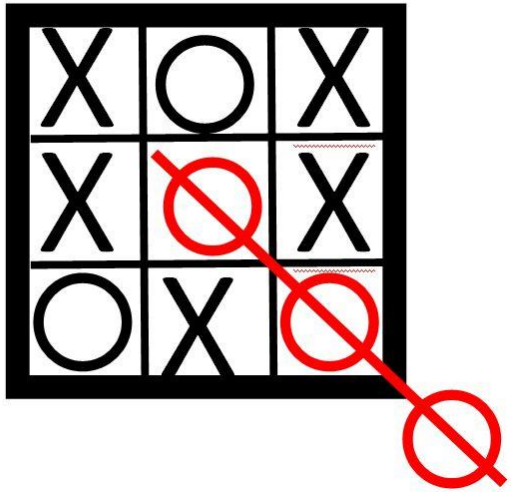
1. Forming: Pretending to get on or get along with others.
2. Storming: Letting down politeness barrier and trying to get down to the issues even if tempers flare up.
3. Norming: Getting used to each other and developing trust and productivity among each other.
4. Performing: working to a common goal on highly efficient and cooperative basis .

What We Learned - Central

- Programming in Python
- SPI Communication Protocol
- Rasbperry Pi Module
- Soldering skills and technique
- Teamwork and organization
- Commitment and sharing information
- Deadlines and short term vs. long term goals

What We Learned - Portable

- Unexpected problems occurs often
  - Budget and timeline
  - Technical: do not fully trust retail products to work as expected
  - Life problems
- Time management – other courses
- Think outside of the box →
- Attention to details
- Plan B
- Proper tools and material for measurement



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Thomas Edison, when asked why he had a team of twenty-one assistants, "If I could solve all the problems myself, I would."

Questions