EVADE: Emergency Vehicle Alert DEvice
Project Origination:

Have you ever:

– Heard the sirens, but not known where they were coming from?
– Been taken by surprise by an emergency vehicle and not had time to get out of the way?
– Not seen the lights or heard the siren until they are right behind you?

Then you understand the need for a more advanced warning system that can save time and lives.
Motivation:

The group was struck by the fact that more and more frequently emergency vehicles are not seen or are simply ignored by drivers on the road. This could be caused by better insulation that makes cars quieter, larger vehicles on the road creating a visual obstruction, or by increased distractions on the road like cell phones and loud music. In order to overcome these obstacles, an advanced alert system is needed that does not rely on line-of-sight or sirens and has the capability of capturing the driver’s attention.
Goals:

The objective of the emergency vehicle alert device is to surpass the current obstacles for alerting drivers by transmitting a signal from the emergency vehicle that will be picked up by cars. This signal will trigger a visual alert to inform the driver what type of vehicle is approaching and from what direction. Simultaneously, the signal will quiet the interior of the car and play an audible alert message in both English and Spanish.
Basic Objectives:

EAT - Emergency Alert Transmitter:
- Transmission begins simultaneously with lights and sirens
- Sends GPS and compass headings to determine approach direction.
- Transmission radius is large enough to provide the desired advanced alert.
- Does not inhibit normal vehicle operation or require extra work from driver.
- Does not put unusual strain on other vehicle components or battery.
EVADE: Emergency Vehicle Alert Device

Emergency Alert Transmitter Block Diagram:

- **HEC** (High-Energy Controller)
- **TOD** (Tactical Operations Device)
- **TCU** (Transport Control Unit)
- **PCM** (Power Control Module)
- **ETD** (Emergency Transmitter Device)
- **EMERGENCY VEHICLE BATTERY** (Power Supply)
- **8-BIT SIGNAL**
- **MEMORY POWER** (IF REQ'D)
- **AUTOMOBILE ANTENNA**
- **CONNECT TO EXISTING SWITCH THAT TURNS ON EMERGENCY LIGHTS.**

These components work together to transmit emergency signals and alert vehicles to potential dangers.
Basic Objectives:

**EAR - Emergency Alert Receiver:**
- Automatically detects signal and alerts driver during normal operation.
- Allows normal operation of vehicle when signal not detected.
- Shuts down stereo and plays audible alert message until vehicle is out of range, then resumes normal operation.
- Displays direction of approach to driver on a physical display screen.
- Uses low power that will not affect other systems in the car or strain battery supply levels.
Emergency Alert Receiver Block Diagram:

1. **AUTOMOBILE ANTENNA**
   - Signal from "EVADE" source
   - Power

2. **TOD**
   - Memory power (if required)

3. **RCU**
   - Control signal
   - 8-bit signal

4. **VDU**
   - Audible alert message
   - OP radio signal (bypass mode)

5. **SBU**
   - Audible alert signal

6. **PCM**
   - Power

7. **RAA**
   - Audible alert signal

8. **AUTOMOBILE SPEAKERS**

9. **AUTOMOBILE STEREO**

10. **HEC**
    - Compass signal
    - 8-bit signal

11. **POWER**

12. **IGNITION**

13. **POWER SUPPLY**

14. **SYSTEM**

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**EVADE: Emergency Vehicle Alert Device**
Project Management Flowchart:

**Beginning of Senior Design I**

- Develop Functional Requirements & Block Diagram
- Research Possible Implementations

Joshua:
- Hall Effect Compass
- GPS Sensor
- Transmitter & Receiver

Derrick:
- Audio Bypass Unit
- Power Control Unit
- Legal Restrictions

Chuck:
- Recorded Messages
- Visual Display
- PCB Diagrams

Stephen:
- Transmitter Control Unit
- Receiver Control Unit
- Programming

Proposed Design Created with Schematics

Write Complete Project Document

Build prototype

Test Prototype for Correct Functionality

- Properly Functioning
- Not Working

Present Final Design & Complete Senior Design II
Subsystem #4 - Derrick Nelson
TOD – Turn-On Device
PCM – Power Control Module
RAA – Recorded Audible Alert
SBU – Switching Bypass Unit
**EVADE: Emergency Vehicle Alert Device**

**Turn-On Device:**
- Controls power flow to components to reduce waste heat
- TOD(EAT) – simple switch connected to emergency lights, interfaces with transmitter
- TOD(EAR) – software implementation in RCU, interfaces with RAA
PCM Design Objectives:

- Operate on standard 12V vehicle power
- Provide multiple voltage levels for various components
- Provide clean source of power for transmitter and receiver: must not introduce radio frequency interference (RFI)
- Both PCMs operate whenever vehicle is running, TOD responsible for limiting power consumption
- Design Decision – linear vs. switching regulators
  - Cost, efficiency/heat, noise
## Power Specifications:

### EAT (Transmitter)

<table>
<thead>
<tr>
<th>Item</th>
<th>Voltage (V)</th>
<th>Current (mA)</th>
<th>Line</th>
<th>Total Current (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIC</td>
<td>1.8 – 3.6</td>
<td>250</td>
<td>3.3</td>
<td></td>
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<tr>
<td>Transmitter</td>
<td>1.8 – 3.6</td>
<td>12.5</td>
<td>3.3</td>
<td>322.5</td>
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<tr>
<td>GPS</td>
<td>3.3</td>
<td>50</td>
<td>3.3</td>
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<td>HEC</td>
<td>8 – 13</td>
<td>10</td>
<td>3.3</td>
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### EAR (Receiver)

<table>
<thead>
<tr>
<th>Item</th>
<th>Voltage (V)</th>
<th>Current (mA)</th>
<th>Line</th>
<th>Total Current (mA)</th>
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<td>GPS</td>
<td>3.3</td>
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<td>PIC</td>
<td>1.8 – 3.6</td>
<td>250</td>
<td>3.3</td>
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<tr>
<td>RAA</td>
<td>2.5 - 5.5</td>
<td>20</td>
<td>3.3</td>
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<tr>
<td>Receiver</td>
<td>4.8 – 5.5</td>
<td>3</td>
<td>5</td>
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<td>SBU</td>
<td>5</td>
<td>28</td>
<td>5</td>
<td></td>
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<td>VDU controller</td>
<td>2.7 – 5.5</td>
<td>2</td>
<td>5</td>
<td>433</td>
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<td>VDU display</td>
<td>5</td>
<td>400</td>
<td>5</td>
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**Voltage Regulators:**

- 3 regulators used to achieve the required voltage levels
  - All Low Drop-Out voltage for efficiency
  - Very clean output voltages
    - LD2908050 (5.0 V, 800 mA, STMicro.)
    - TPS79633 (3.3 V, 1A, TI)
    - TC1107 (3.3 V, 300 mA, Microchip)
- Vin: 12V, filtered
- Vout: 3.3 and 5V; filtered
- Current Limits: Well above spec.
SBU Design Objectives:

• Cause no distortion of stereo signal when EVADE not in use
• Completely and cleanly bypass stereo signal when in use
• Must operate whether the stereo system is in use or if it is off
Signal Bypass:

• Bypass accomplished w/ electromechanical relays (1 per speaker)
  • TX2-5 (Panasonic)
  • 4 ms switching speed
  • Max Ratings: 60 W, 2 A

• Simple interface with the vehicle’s speaker wires
Recorded Audible Alert (RAA):

The RAA alerts the driver to the presence of an emergency vehicle by playing an audio message through the vehicle’s speakers.

RAA Design Objectives:

- Generate alert messages in English and Spanish
  - Pre-recorded, or
  - Speech synthesizer
- Determine correct message to be played
- Send message to SBU and trigger bypass
Recorded Audible Alert:

• Nuvoton ISD1760 ChipCorder
  • Voice record and playback, storage on internal Flash memory
  • Stand-alone and SPI modes
  • No need for external audio amplifier

• Atmel Atmega328
  • Low-power 8-bit microcontroller
  • 32KB Programmable Flash
  • SPI interface with ISD1760
  • Programmed on Arduino Uno development board
RAA Operation:

RCU → 6-bit signal → RAA Atmega → SPI interface → RAA ISD1760

1-bit CTRL → Automobile Stereo → SBU → audible alert message

SBU → Automobile Speakers
Subsystem #2 - Joshua Guinn
HEC/GPS – Hall Effect Compass & GPS
ETD – Emergency Transmission Device
HMC 6352 Electronic Compass

Supply Voltage  =  2.7 to 5.2 V
Heading Accuracy  =  2.5 deg
Operating Temp  =  -20 to 70ºC
Size  =  6.5 x 6.5 x 1.5 mm
Weight  =  0.14 grams
I2C Serial Interface
The heading, output data, will be a value in tenths of degrees from zero to 359.9, \( N = 0 \), and provided in binary format over two bytes. These two bits will then give our eight cardinal directions.

<table>
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<tr>
<th>Direction</th>
<th>Angle Conditions</th>
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<tr>
<td>N</td>
<td>&gt; 337.5 OR &lt;= 22.5</td>
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<tr>
<td>NE</td>
<td>&gt; 22.5 AND &lt;= 67.5</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 67.5 AND &lt;= 112.5</td>
</tr>
<tr>
<td>SE</td>
<td>&gt; 112.5 AND &lt;= 157.5</td>
</tr>
<tr>
<td>S</td>
<td>&gt; 157.5 AND &lt;= 202.5</td>
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<tr>
<td>SW</td>
<td>&gt; 202.5 AND &lt;= 247.5</td>
</tr>
<tr>
<td>W</td>
<td>&gt; 247.5 AND &lt;= 292.5</td>
</tr>
<tr>
<td>NW</td>
<td>&gt; 292.5 AND &lt;= 337.5</td>
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</tbody>
</table>
## GPS Modules researched

<table>
<thead>
<tr>
<th>General Characteristics</th>
<th>GlobalSAT EM-408</th>
<th>Modulstek MG-S01SP</th>
<th>Antenova M10214-A1</th>
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<td>Receiver Architecture</td>
<td>20 channels</td>
<td>20 channels</td>
<td>20 channels</td>
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<td></td>
<td>1 satellite / channel</td>
<td>1 satellite / channel</td>
<td>1 satellite / channel</td>
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<tr>
<td></td>
<td>L1 1575.42 MHz</td>
<td>L1 1575.42 MHz</td>
<td>L1 1575.42 MHz</td>
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<tr>
<td></td>
<td>1.023 MHz chip rate</td>
<td>1.023 MHz chip rate</td>
<td>1.023 MHz chip rate</td>
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<tr>
<td>Antenna</td>
<td>Built-in or External</td>
<td>Built-in</td>
<td>Built-in</td>
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<td>Data Output Protocol</td>
<td>SiRF Binary NMEA 0183</td>
<td>NMEA 0183</td>
<td>SiRF Binary NMEA 0183</td>
</tr>
<tr>
<td>Dimensions</td>
<td>36.4 x 35.4 x 8.3mm with antenna</td>
<td>19.0 x 19.0 x 6.5mm antenna 18 x 18 x 2mm</td>
<td>43 x 9 x 4mm with antenna</td>
</tr>
</tbody>
</table>
EVADE: Emergency Vehicle Alert Device

GlobalSAT Tecnology Corporation EM-408

1: Enable/Disable
2: GND
3: RX
4: TX
5: VCC
GPS Output Protocol NMEA 0183

• NMEA “National Marine Electronics Association”
• The NMEA 0183 standard uses a simple ASCII, serial communication protocol.
• Data is transmitted at 4800 baud rate through UART.
• Data is transmitted in sentences.
• **GGA** ($GPGGA$) GPS Position, Time And Fix.

\[
$GPGGA, hh:mm:ss, ll.ll, , a, yyyy.yy, , x, xx, x.x, x.x, M, x.x, M, x.x, xxxx*hh
\]
Performance Characteristics

• Maximum altitude
  18,000 m

• Maximum velocity
  545 m/s

• Maximum acceleration
  4 g

• Position accuracy
  2.5 m

• Acquisition rate
  < 35 sec cold start
  < 1 sec hot start
Power and Environmental Specifications

• Power supply
  3.3 to 5.5 V DC

• Main supply current
  Acquiring 50 mA
  Tracking 30 mA

• Operating temperature
  -20 to 85°C

• Storage temperature
  -40 to 85 °C

• Relative humidity
  5 to 95 %
Transmitters Researched

- MICRF 113
- TXM-433-LR-S
- PD 5000
Operating Ratings

• Supply voltage
  2.1 to 3.6 V

• Output power
  -4 to 4 dBm

• Operating temperature
  -40 to 85 °C

• Transmitter frequency
  433 MHz

• Data rate
  10 kbps
EVADE: Emergency Vehicle Alert Device

TXM-433-LR-S Operating diagram

<table>
<thead>
<tr>
<th>Pin Name</th>
<th>Pin Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>Data</td>
<td>Data input</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>LADJ/VCC</td>
<td>Output power level adjust</td>
</tr>
<tr>
<td>PDN</td>
<td>Power down</td>
</tr>
<tr>
<td>VCC</td>
<td>Supply voltage</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>ANT</td>
<td>50 ohm RF output</td>
</tr>
</tbody>
</table>
Recievers researched

- MICRF002YM
- RMX-433-LR-S
- PD 5000
Operating Ratings

• Supply voltage
  2.7 to 3.6 V

• Receiver sensitivity
  -112 dBm

• Operating temperature
  -40 to 70 ºC

• Receiver frequency
  433 MHz
RXM-433-LR-S  Operating diagram

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Pin Name</th>
<th>Pin Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>GND</td>
<td>Ground</td>
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<tr>
<td>5</td>
<td>VCC</td>
<td>Supply voltage</td>
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<tr>
<td>6</td>
<td>PDN</td>
<td>Power down</td>
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<tr>
<td>7</td>
<td>RSSI</td>
<td>Received signal strength indicator</td>
</tr>
<tr>
<td>8</td>
<td>DATA</td>
<td>Data Output (Digital Output)</td>
</tr>
<tr>
<td>15</td>
<td>GND</td>
<td>Ground</td>
</tr>
<tr>
<td>16</td>
<td>ANT</td>
<td>50 ohm RF output</td>
</tr>
</tbody>
</table>
Subsystem #3 - Stephen Watson
TCU – Transmitter Control Unit
RCU – Receiver Control Unit
Function of the Transmitter Control Unit:

The transmitter control unit is essentially the brains behind the entire transmitter. It serves as the central hub that collects the information from the GPS and Hall effect compass and condenses the positional information as well as the vehicle type into a single signal which is broadcast to the receiver. The transmitter control unit is also required to create the time delays between transmissions so that signals do not overlap.
Block Diagram of Transmitter Control Unit:

EVADE: Emergency Vehicle Alert Device

GPS

Compass

PIC Controller

3 Bits

Transmitted Signal

To Transmitter for Modulation

UART
Controller Selection:

Research narrowed the choice of controller to a FPGA or PIC microcontrollers. With limited testing, PIC controllers were selected as the controller of choice.

Reasons for Choosing PIC:
• Simplified programming in C
• Very inexpensive (free samples)
• Easy to use serial protocol
• Numerous guides and sample code to assist with programming and debugging
EVADE: Emergency Vehicle Alert Device

Programming Flowchart:

Unit is turned on

Switch Flipped On?

Yes
- Read GPS Position to Memory

No
- Run Loop For Delay Between Transmissions

Combine Latitude, Longitude, Compass Bits Into Single Signal

Output Signal to Transmitter for Modulation
Transmission Delay:

- For a speed of 45 mph:
  
  45 mph => 66 ft/sec

- For a one second delay:
  
  66 ft/sec x 1 sec = 66 ft

- With the allowable test range by the FCC, this is the best delay period between transmissions.
**Transmitted Data Format:**

<table>
<thead>
<tr>
<th>Security Code</th>
<th>Compass</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Bytes</td>
<td>2 Bytes</td>
<td>8 Bytes</td>
<td>9 Bytes</td>
</tr>
</tbody>
</table>

- The total number of bytes to transmit is well below the limit of the transmitter and receiver.
Function of the Receiver Control Unit:

The receiver control unit is the most fundamental processing unit of the entire project. As the central control unit, it is required to receive the demodulated transmission signal and properly extract the information. After storing this information, the receiver control unit must compare the positional information of the emergency vehicle with its own GPS coordinates and compass heading to determine if the vehicle paths will intersect and from what direction the emergency vehicle is approaching. The receiver control unit must then initiate the visual and audible alert systems.
EVADE: Emergency Vehicle Alert Device

Block Diagram of Receiver Control Unit:

- GPS
- Compass
- Antenna & Demodulator
- UART

PIC Controller

- Transmitted Signal
- 3 Bits

- 5 Bit Alert Code
- Visual Display Unit
- Recorded Audible Alert
**Directional Calculations:**

In order to calculate the direction of the car relative to the emergency vehicle, the latitude (x value) and longitude (y value) for the emergency vehicle are subtracted from the latitude and longitude of the car.

Based on the whether the coordinates are +/-, the compass direction is used to determine if the vehicles will intersect. This is also used to determine the direction the emergency vehicle is approaching relative to the car.
Subsystem #4 - Charles Logan
VDU – Visual Display Unit
PCB Design
Visual Display Unit (VDU)

- 16x4 dot matrix LCD
- Display heading under normal operation
- Small size – mountable in dash.
EVADE: Emergency Vehicle Alert Device

**LCD Schematic**

- The LCD Display will be driven by the Hitachi HD44780

- Signal for the LED’s obtained from the RCU
EVADE: Emergency Vehicle Alert Device

- PCM
- RCU
- PIC
- Hitachi HD44780
  - Segments: SEG 1-40
  - COM: COM 1-16, COM 17-32
- Segment Driver
  - SEG 41-80
- Segment Driver
  - SEG 80-160
- LCD Screen
Visual Display Unit (VDU)

Under emergency conditions, an LED will blink to alert the motorist of the direction the emergency vehicle is approaching.
Printed Circuit Board (PCB) Design

- Created using PCB Artist software for creating the fab, pcb, and dxf files necessary to create a printed circuit board.
- Created by Advanced Circuits (4pcb.com)
EVADE: Emergency Vehicle Alert Device

Sample PCB Diagrams from RAA

.pcb File Design

Schematic Design
Final Prototypes:

Emergency Alert Transmitter

Emergency Alert Receiver
Testing:

- MPLAB Simulations
- Serial tracing
- Distance testing
- Lots of breadboards
- Even running wire down 4 floors & half-way round Engineering 1
## Budget:

<table>
<thead>
<tr>
<th>Module</th>
<th>Quantity</th>
<th>Expected Cost</th>
<th>Actual Cost</th>
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<tbody>
<tr>
<td>Antenna</td>
<td>2</td>
<td>$20</td>
<td>$20</td>
</tr>
<tr>
<td>Car Stereo &amp; Speakers</td>
<td>1</td>
<td>Donated</td>
<td>Donated</td>
</tr>
<tr>
<td>Transmitter</td>
<td>1</td>
<td>$30</td>
<td>$60</td>
</tr>
<tr>
<td>Compass &amp; GPS</td>
<td>2</td>
<td>$40</td>
<td>$165</td>
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<td>Power Supply</td>
<td>2</td>
<td>$50</td>
<td>$30</td>
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<td>Recorded Audio Chips</td>
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<td>Microcontollers</td>
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<td>PCB</td>
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<td>Display Screen and LEDs</td>
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<td>$80</td>
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<td>Incidentals</td>
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**Expected Total Cost:** $530  
**Total Expected Cost (2X Buffer):** $1060  
**Actual Cost:** $705+
## Milestones:

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Questions?