Integrated Helmet System

Submitted by Design Team:
Allen Thomas
Dahn Vo
Francisco Valdez
Walter Madalnski

Submitted to:
Professor August Allo
University of Texas San Antonio
One UTSA Circle
San Antonio, TX 78249-1644

Submitted on:
May 2, 2008
Table of Contents

1.0 Need for Design ........................................................................................................................ 2
2.0 Background Summary/Introduction ......................................................................................... 2
3.0 Objectives .................................................................................................................................. 3
   3.1 Heads-up Visor Display ........................................................................................................ 3
   3.2 Rearview Camera ................................................................................................................. 3
   3.3 Audio Entertainment System .............................................................................................. 3
   3.4 Wireless Functionality ........................................................................................................ 3
   3.5 Turn and Brake Signal turn Indicators .............................................................................. 4
4.0 Plan ........................................................................................................................................... 4
   Phase I: Design Concept Research ............................................................................................ 4
   Phase II: Design-Hardware/Software ....................................................................................... 5
   Phase III: Implementation ........................................................................................................ 5
   Phase IV: Testing Design Performance .................................................................................... 6
   Phase V: Presentation and Report ............................................................................................. 6
5.0 Deliverables ............................................................................................................................... 6
6.0 Schedule .................................................................................................................................. 7
7.0 Staffing .................................................................................................................................... 8
   7.1 Allen Thomas .................................................................................................................... 8
   7.2 Walter Madalinski ............................................................................................................. 8
   7.3 Francisco Valdez .............................................................................................................. 8
   7.4 Danh Voe ......................................................................................................................... 9
8.0 Equipment and Materials ......................................................................................................... 9
9.0 Budget ..................................................................................................................................... 13
10.0 Conclusion ............................................................................................................................... 14
1.0 Need for Design
There are numerous motorcycle accident studies that have been conducted that prove motorcycle riders who wear helmets have fewer fatalities. Currently there is no motorcycle helmet that provides the functionality of providing safety and convenience in one integrated package. The Integrated Helmet System (IHS) will deliver both by providing Heads-Up Display (HUD), rear-view camera display, brake/turn indicators and the option to enjoy music while motorcycling.

2.0 Background Summary/Introduction
The design concept for the IHS motorcycle helmet is based on increasing the safety margin of riding motorcycles. This is accomplished by providing a real-time speed-indicator on the shield of the helmet using a HUD system. By providing a reading of the motorcycle’s speed on the shield, the rider can keep his/her eyes on the road and other drivers. Furthermore, the helmet will also be capable of energizing a small bar of LEDs on the rear of the helmet, which functions as a brake and turn indicator. The data from the motorcycle will be sent wirelessly using the XBee wireless communication package. The HUD display will occupy a small area at the corner of the face-shield so that peripheral view will not be obstructed. Based on suggestions from motorcyclists surveyed, the idea of having a rear-view camera to display the rider’s surroundings has become a goal for our design project. Prior to this point in the design the following work and research has been done:

- Literature search and patent search
- Market analysis
- Evaluation of engineering design constraints
- Development of product requirements
- Evaluation of design alternatives
- Development of a functional block diagram

The members of Design Team 1 have various employment, educational and project experience that include integrated circuit design, control circuit design, PCB design, electronic troubleshooting, software programming and circuit analysis. One of the design team members is an experienced motorcycle rider who is familiar with the risks and joys of motorcycling and therefore will provide an insight to the needs and desires of the avid motorcyclist.
3.0 Objectives
The main objective for the integrated helmet system is to supply the rider with the greatest features in safety and convenience. This main objective will be executed and achieved through five separate objectives. The key components that contribute to the functionality of the IHS are depicted in a functional block diagram. (See Appendix A: Functional Block Diagram)

3.1 Heads-up Visor Display
This objective will allow the user to view streaming video of their speed and RPM. This objective will be carried out by retrofitting the user’s motorcycle with transducers that will relay the performance data to the onboard microcontroller. The microcontroller will then convert the acquired analog signal to a digital signal and will send it to the helmet’s microcontroller. The helmet microcontroller will graphically display the input data with an LCD screen which will be optically projected on the visor. The helmet microcontroller will have the ability to toggle display screens on the LCD through an external button on the helmet.

3.2 Rearview Camera
This objective will allow the user to view real-time streaming video of what is behind them. To execute this objective a small camera will be mounted to rear side of the helmet. The camera will then be wired to the microcontroller on the helmet and the video will be shown through the heads-up display.

3.3 Audio Entertainment System
This objective is purely for adding additional luxury to our product. We are seeking to bring greater enjoyment to the customer while using our product. An additional controller will be installed on the helmet that will allow the user to upload music to the flash memory storage card. Speakers will be installed in the interior of the helmet and functionality controls will be installed on the exterior. These installations will provide input and output functionality for the audio controller.

3.4 Wireless Functionality
Safety and convenience are the motivators for this objective. Having a tether for the helmet would make the product more cumbersome and could potentially injure the user in an accident.
To link the microcontroller on the motorcycle and in the helmet, a wireless module will be integrated into each of them.

3.5 Turn and Brake Signal turn Indicators

To provide the user greater safety on the road our objective will be to make the motorcyclist more visible to motorists around them. The helmet indicators must match the indicators on the motorcycle. Therefore, sensors will be installed on the motorcycle and the data will be relayed through the microcontrollers. The relayed data is output through LEDs mounted on the rear side of the helmet.

4.0 Plan

For the IHS to become successful, a detailed method that is comprised of five phases was used to guide the design team through all crucial steps.

Phase I: Design Concept Research

This phase of the execution plan for the design is comprised of market/hardware research and overall feasibility of the design concept. These considerations are described in detail below.

- **Market Research**
  - Patent search of similar design concept is conducted to avoid patent infringement.
  - Determine need for device, as well as identify any competitors.
  - Conduct survey on desired features of a full-face helmet in order to determine design constraints.
  - Review all design constraints that include global, local, and product constraints in order to consider design alternatives.

- **Hardware/Software Research**
  - Determine data acquisition system.
  - Research wireless communication options for transmission of the data from the motorcycle to the helmet.
  - Research LCD and camera options that will work optimally in the constraints of the helmet.
  - Research display projection techniques that will place the data onto the shield.
Research microcontroller options that can handle the amount of inputs/outputs.

**Phase II: Design-Hardware/Software**

Based on the previous phase, the primary design phase can begin.

- Choose rear-view camera and LCD display. The camera will be chosen based on its size and overall performance. The LCD must be able to display text as well as real-time video.
- Choose wireless communication package. The most efficient transmission package must be chosen for the real-time data transfer of the motorcycle’s speed, engine RPM, and turn/brake signals.
- Decide on MP3 decoder and memory type for its minimum size and functionality.
- Choose microcontroller for Rx and Tx units which will be able to handle the data transfer rates, and the simultaneous functions of displaying the speed or rear-view image as well as the turn/brake signal control.
- Design power supply network for each device that can handle the load for all functions on the helmet. The transmitter power supply will also need to be designed.
- Design PCB for the transmitter module as well as the receiver module. Since the helmet PCB will be complex, the design will be extensive. The Gerber files will be sent out to PCB Express for fabrication of the custom PCB.
- Design visor reflection surface and optical focus lens for proper display on visor. This will be accomplished with the alteration of a small area on the shield for proper reflection of the display. Additionally, a special lens will be designed for the LCD screen for the purpose of making the display on the shield readable.

**Phase III: Implementation**

During this phase, all the components will be integrated together and the embedded code will be developed while waiting on parts and PCB fabrication.

- Order parts that are needed for the entire design.
- Fabricate the PCB. Once the fabricated PCB has been delivered, the PCB will be populated.
- During the time that the parts and fabrication of PCB, the embedded code will be developed.
• Retro-fit motorcycle and Helmet with embedded hardware. Once all PCB’s are populated, the transmitter modules and receiver modules will integrated onto the motorcycle and the helmet.
• Configure helmet ergonomics.

**Phase IV: Testing Design Performance**
• Testing and debugging the embedded code will perform the first initial test of wireless communications and data transfer.
• Confirmation of operation of inputs and outputs will test the function of the indicator lights, speed, RPM, and MP3 functions.
• Test power supply sustainability by applying the various loads.
• Test clarity of projected images, so that readability is confirmed.

**Phase V: Presentation and Report**
• Demo Product Prototype for Mr. Allo at the University of Texas at San Antonio.
• Submit final report and all required files.

**5.0 Deliverables**
Documents to be submitted during the course of the semester.

• Weekly Status Report Updates
• Product Specifications
• Draft of Final of Reports
• Final Report
• Programming Code
• Physical Prototype Models
• Final Presentation
• Webpage
• Project File
6.0 Schedule
The Gantt chart (Fig. 6.1) reflects the tentative schedule of the design. The Gantt chart is based on the order in which each task must be done, and the time is distributed accordingly to the length and difficulty of the task. Also, the Gantt chart does not reflect unforeseen events or occurrences, therefore it is subject to change. A cushion of time is given to certain tasks that may prove to be more of a challenge.

![Gantt chart](image)
7.0 Staffing

7.1 Allen Thomas
Allen Thomas has six years of experience in nuclear power plant operations, supervising and planning of electrical systems maintenance/repair. Areas of specialization include: power systems, autonomous controls, and digital controls. Allen’s previous planning experience Allen’s power system knowledge will prove useful in obtaining the load analysis for the Integrated Helmet System. Digital controls knowledge will allow for possible manipulation of analog and digital data. Autonomous controls may be required for camera positioning. Allen’s goals are to find a job in the power industry and attain a master degree specializing in autonomous controls.

7.2 Walter Madalinski
Walter Madalinski was hired by the Commercial Metals Company of Texas for an internship in the summer of 2007. The internship program provided hands on experience with programmable logic controllers in a manufacturing environment. This internship embedded Walter into a sensor based controller environment that allowed him to follow his design projects from the conception, to the approval process with staff electrical engineers, and finally to the installation phase allowing him to work with the technicians. Valuable lessons were learned in the design process by working with people at every level who were involved daily with the automated manufacturing systems. This provided experience in talking to people who needed a “product” to solve a problem and in product refinement based on different “consumer” needs. A development and grasp of good team working skills was required to complete these tasks and was proven to be obtained through the project results. Walter also possesses experience in assembly level programming with microcontrollers through his education at The University of Texas at San Antonio. Additional experience was also gained through a research position with autonomous underwater robotics at the university. Walter is currently pursuing a concentration in control systems and is seeking employment in the research and development field of analog design.

7.3 Francisco Valdez
Francisco Valdez has seventeen years in the automotive industry as an automotive technician. His experience includes basic maintenance, brake service, engine overhaul, A/C service, diagnosis/repair of engine control systems, and specialization in electrical trouble
shooting/repair. While working for O’bryant Automotive the last thirteen years of his automotive career, Francisco gained managerial/customer service skills as well as delegated service orders. One of the most notable projects completed was a Power-train Retro-Fit. This consisted of the redesign and implementation of a GM V-8 engine and transmission into a 1988 Toyota 4-wheel drive truck, which included a GM Engine, Engine Control Module, engine sensors, and related wiring. Francisco is currently a senior Electrical Engineering student at The University of Texas at San Antonio with a concentration in communication systems. Some of his studies include PCB design, IC design, Wireless Communications, Digital System Design, VLSI Design and circuit analysis.

7.4 Danh Voe
Danh Vo has experience in parallax microcontrollers from programming an autonomous robot to navigate through a maze. Also, Danh has experience with data acquisition, motion control, and FPGA programming, from EE 4373 embedded controls system. Danh’s experience with data acquisition will be useful in acquiring signals from the motorcycle and camera. If an FPGA is used, Danh’s knowledge can be useful to program it through lab-view. Another project that he has participated in is the inverted pendulum. Though this experience he learned how to interface with motors and PID controllers. Also, he has researched transmitters and receivers, which are a great importance to the design of the integrated helmet system.

8.0 Equipment and Materials
The materials for the Integrated Helmet System were chosen based on flexibility and ease of implementation. The Helmet system consists of seven major subsystems: microcontroller, XBee wireless communication module, camera, display, power supply, voltage regulator, and MP3 player (Figure 8.1). The motorcycle has two subsystems placed on it: microcontroller and a wireless communication package (Figure 8.2). The two microcontroller subsystems tie all the other subsystems together (Appendix A).
The Parallax microcontroller is the ideal choice for the project because it can handle analog as well as digital data. The microcontroller also has on board digital to analog converters. The microcontroller will have inputs from the camera, MP3 player, and X-BEE wireless communication package. The microcontroller will be programmed using a higher level computer language called SPIN. SPIN is a language developed by Parallax and is object oriented. The microcontroller on the bike and the microcontroller located within the helmet communicate via X-BEE communication packages.
The X-BEE module was chosen over Bluetooth technology because of its simplicity, size, power consumption, and cost. Bluetooth technology would do the trick, but it handles a lot more information than required thus making it more costly and complex. The X-BEE package is able to operate between 2mW and 120mW. The power consumption specification is perfect considering that the power to the system is limited to a battery and range of communication is only a few feet.

The camera and display subsystems are small, light weight, and use small amounts of power which makes them easy to integrate into the overall system. Both systems will be mounted within the helmet. The camera will be mounted within shell of the helmet and have 2 degrees of rotational freedom. The degrees of freedom allow the rider to lean forward or back and still have the camera view on what is behind him/her. The display will be mounted within the helmet’s
shell to the right of the rider’s right eye. The display image will be projected onto a small area located on the helmet’s visor through optical lenses. This small area will have special reflective properties which will allow the image to be directed into the motorcyclist’s eye.

The battery pack and voltage regulator will supply the necessary power to each subsystem. Figure 8.3 below shows the various voltages needed for the various subsystems. This table shows the necessity of a flexible voltage regulator due to different required voltage levels. The batteries used for this project are to be lithium cell. This will allow for longer battery life and save space over conventional nickel-cadmium batteries.

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>VOLTAGE (VDC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVELOPMENT BOARD</td>
<td>6 - 9</td>
</tr>
<tr>
<td>CAMERA</td>
<td>12</td>
</tr>
<tr>
<td>DISPLAY</td>
<td>13.3</td>
</tr>
<tr>
<td>X-BEE WIRELESS MODULE</td>
<td>2.1 – 3.6</td>
</tr>
<tr>
<td>MP3 PLAYER</td>
<td>2.5 – 3.6</td>
</tr>
</tbody>
</table>

Figure 8.3

The MP3 player will supply the rider with the luxury of listening to music while riding their favorite stretch of road. The MP3 subsystem includes: SD card input, amplifier, and speakers. The SD card can be plugged into the system with a preprogrammed play list allowing the rider to listen to their favorite songs. The music player was requested by many avid riders who wished to play tunes while riding. Figure 8.4 is a list of all major components, materials and equipment needed for the completion of the IHS.

<table>
<thead>
<tr>
<th>Part</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller Demo Board</td>
<td>1</td>
<td>$79.95</td>
</tr>
<tr>
<td>Propeller Microcontroller</td>
<td>1</td>
<td>$25.90</td>
</tr>
</tbody>
</table>
### 9.0 Budget

The total budget needed for the overall cost of building the Integrated Helmet System is estimated to be about $687.03. The itemized list in Appendix B includes all major components.
such as the microcontrollers, wireless communication package, camera and LCD display. The list also includes an estimation for passive parts and PCB fabrication.

### 10.0 Conclusion

The members of this design team are honored that you have taken the time to review this proposal and we are very grateful for the opportunity to prepare it for you. Our helmet system holds very promising potential in today’s market as well as in the future’s to come. We hope our confidence in this product and the excitement to come with it in the next phase can be shared with you. Please feel free to contact us at any time if need more clarity on any topic, or if you have any questions or comments about the product. We will be available at the contact information listed in Appendix C. Thank you once again for the privilege of your time and we look forward to our exciting future together.
Appendix A: Functional Block Diagram
# Appendix B: Budget

<table>
<thead>
<tr>
<th>Description</th>
<th>Part Number</th>
<th>Quantity</th>
<th>Unit Cost</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propeller Demo Board</td>
<td>32100</td>
<td>1</td>
<td>$79.95</td>
<td>$79.95</td>
</tr>
<tr>
<td>Propeller Microcontroller</td>
<td>P8X32A-Q44</td>
<td>2</td>
<td>$12.95</td>
<td>$25.90</td>
</tr>
<tr>
<td>Xbee Wireless Module</td>
<td>XB24-BCIT-004</td>
<td>2</td>
<td>$21.00</td>
<td>$42.00</td>
</tr>
<tr>
<td>Xbee Development Board</td>
<td>XBIB-U-DEV</td>
<td>1</td>
<td>$70.00</td>
<td>$70.00</td>
</tr>
<tr>
<td>Helmet</td>
<td>Donated</td>
<td>1</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>LCD Display (uOLED-96-Prop)</td>
<td>27307</td>
<td>1</td>
<td>$79.95</td>
<td>$79.95</td>
</tr>
<tr>
<td>Digital Camera</td>
<td>PC213XS</td>
<td>1</td>
<td>$49.95</td>
<td>$49.95</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>LT1575CN8-5-ND</td>
<td>2</td>
<td>$2.69</td>
<td>$5.38</td>
</tr>
<tr>
<td>On/Off Button</td>
<td>525PB-NM</td>
<td>3</td>
<td>$2.32</td>
<td>$6.96</td>
</tr>
<tr>
<td>Volume Control Button</td>
<td>567P-NM</td>
<td>1</td>
<td>$2.45</td>
<td>$2.45</td>
</tr>
<tr>
<td>Analog to Digital Converter</td>
<td>296-17152-2-ND</td>
<td>2</td>
<td>$7.80</td>
<td>$15.60</td>
</tr>
<tr>
<td>Display Select switch</td>
<td>401-1970-ND</td>
<td>1</td>
<td>$0.99</td>
<td>$0.99</td>
</tr>
<tr>
<td>SD Card</td>
<td>SDSDB-2048</td>
<td>1</td>
<td>$29.95</td>
<td>$29.95</td>
</tr>
<tr>
<td>MP3 Decoder</td>
<td>VS1011</td>
<td>1</td>
<td>$10.96</td>
<td>$10.96</td>
</tr>
<tr>
<td>Speakers</td>
<td></td>
<td>1</td>
<td>$16.99</td>
<td>$16.99</td>
</tr>
<tr>
<td>LED Light Array</td>
<td>3242-20</td>
<td>2</td>
<td>$25.00</td>
<td>$50.00</td>
</tr>
<tr>
<td>PCB Fabrication</td>
<td></td>
<td>2</td>
<td>$50.00</td>
<td>$100.00</td>
</tr>
<tr>
<td>General Components</td>
<td></td>
<td>1</td>
<td>$100.00</td>
<td>$100.00</td>
</tr>
</tbody>
</table>

$687.03
Appendix C: Contact Information

• Allen Thomas
  al762006@yahoo.com

• Francisco Valdez
  yrp897@my.utsa.edu

• Danh Voe
  danh@yahoo.com

• Walter Madalinski
  Walter.madalinski@utsa.edu