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## Post-Mortem for

# ATVs (All-terrain vehicles) Anti-rolling System

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## Table of Contents

<b>List of Figures and Tables.....</b>	<b>iii</b>
<b>1 Introduction .....</b>	<b>1</b>
<b>2 Current State of the System .....</b>	<b>1</b>
<b>3 Deviation of the Device .....</b>	<b>2</b>
<i>Overall System .....</i>	<i>2</i>
<i>Level Sensor and Micro controller .....</i>	<i>2</i>
<i>Protection device .....</i>	<i>2</i>
<b>4 Challenges and Modifications.....</b>	<b>2</b>
<b>5 Budget.....</b>	<b>3</b>
<b>6 Schedule.....</b>	<b>5</b>
<b>7 Workload Distribution .....</b>	<b>6</b>
<b>8 Future plan.....</b>	<b>6</b>
<i>Metal .....</i>	<i>6</i>
<i>Better UI control .....</i>	<i>6</i>
<i>Expand usage of system .....</i>	<i>7</i>
<b>9 Individual Reflection.....</b>	<b>8</b>
<i>Yigang Tao .....</i>	<i>8</i>
<i>Eric Wang.....</i>	<i>9</i>
<b>10 References.....</b>	<b>13</b>
<b>Appendix A: Meeting Minutes.....</b>	<b>14</b>

## List of Figures and Tables

Figure 1: System Overview ..... 1

Figure 2: Project Schedule ..... 5

Table 1: Financial cost..... 4

Table 2: Workload Distribution..... 6

## 1 Introduction

Anti-Rolling System for ATV is to design a system that can provide prevention and protection to the driver from rollover. The system will measure the angle of the vehicle using 4-direction level sensor. The Arduino microcontroller will process the signal from level sensor and then send the command to different devices. When a certain angle is reached, a buzzer and flash light will be triggered to alert the driver. This can allow the driver to react and drive more carefully to prevent the vehicle from rolling over. If the driver's reaction is not enough, when a steeper angle is reached, a protection bar will be ejected at the back of the seat. This can create a safe triangle around the driver to provide protection.

## 2 Current State of the System

Anti-Rolling System has three main subsystems which are logic control circuit, protection device and microcontroller. The system overview block diagram in Figure 1. Illustrates the process of whole system.

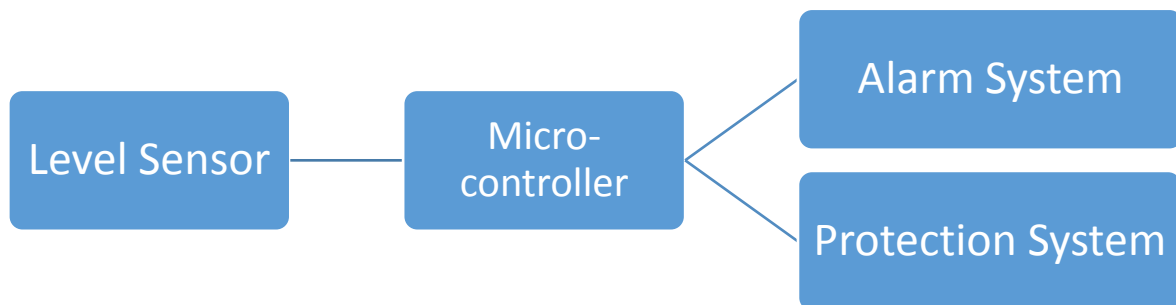


Figure 1: System Overview

Level Sensor is the detecting stage of the system. The sensor uses differential comparison circuit to determine the position of the vehicle and send the analog signal to micro-controller.

Micro controller is the calculation stage of the system. The algorithm we write in processor can decide the situation of vehicle from the signal of level sensor. The digital signal will send to control logic circuit after the processing.

The device system has alarm system and protection system. These two systems will operate under different condition. Relay logic control circuit is used in this system because the device system has different operation voltage with pervious subsystem. Once the relay received the digital signal from the control the protection system will be operated.

### 3 Deviation of the Device

#### Overall System

We achieved what we stated in function specification. Due to the time and budget constraints, we did not finish the implantation of LCD display. The screen is broken in one of our test, it take two weeks for shipping and cost extra money.

#### Level Sensor and Micro controller

The level sensor and micro-controller have not deviated very much from our original plans. The only difference is that we use Arduino UNO instead of STC12C5A60S2 as our processor. The reason for this change is that the Arduino UNO has better connection interface and programming tool.

#### Protection device

The deviation of protection device is that we cannot test the real performance of the system due to safety reason. The system design is based on the yield strength of steel and the structure strength of the screw.

### 4 Challenges and Modifications

We have decided to abandon the LCD display feature. This is because knowing the current angle does not provide better safety or experience in driver's perspective. It may however be risky because driver has more detail to pay attention to instead of the

road condition. Moreover, the trigger angle is pre-set based on the weight of the vehicle. It is not necessary for the user to modify the settings, therefore, there is no need to show the angle using LCD display. Also, the buzzer is not necessary as well because ATV is usually a team game which involves many people together. If accident happens, it is not that difficult for the driver to ask for help.

The most challenging part of the project is the hardware installation where the metal bar has to be fix on the vehicle and shoot out at the right time. The strength of the spring is hard to control and sometimes it will shoot the bar too high. We decided to add a backstop to the bar to control the length of launching. By doing that, the roll bar can be stopped at desired height and function at our expectation.

More difficulty arose when we implement the software program. Initially we ordered a microcontroller from machine shop at low price just to fit in this project. However, we found it only supports the basic function of signal control. We tried to modify its code but the program inside the microcontroller is not accessible. Therefore, we decided to change our controller to a more user-friendly board, Arduino UNO. The basic functions are easily implemented and we decided to add some more feature. One is the shockproof feature: a short time input signal will not trigger the output and the timer will reset when the signal goes off. Second is the overheat-proof feature: the output signal will be on for only two seconds to prevent the electromagnet goes overheat.

## 5 Budget

The final cost of our ATV Anti-Rolling Warning System is \$985. Since we have only received \$650 available fund from the Engineering Science Student Endowment Fund (ESSEF) office, therefore each member has to contribute \$67 in order to finish this capstone project. At the same time, we tried our best to minimize our materials cost as low as possible during the developing phase. For example, using recycled metal, second-hand electric components and eliminating some less useful parts. By this way, we are able to purchase extra low quality components for testing and backup replacing. The budget is within the range as we expected in the beginning.

Post-Mortem for ATVs (All-terrain vehicles) Anti-rolling System

Parts	Quantity	Unit Cost	Estimate Cost	Actual cost
2 axis electric level Sensor	2	\$40	\$80	\$76
Casing and wiring	-	\$25	\$25	\$18
Batteries	1	\$8	\$8	\$0
Microcontroller	1	\$45	\$45	\$55
Springs	2	\$10	\$20	\$20
Buzzers	1	\$10	\$10	\$0
LED light bulbs	10	\$1	\$10	\$18
12V DC to 5V DC power adaptor	1	\$20	\$20	\$20
LCD monitor	1	\$15	\$15	\$10
Machining cost	5.5hr	\$90/hour	\$500	\$550
Material cost(steel tube, power coated paint, drill bits wear, hardware)			\$200	\$150
Miscellaneous cost (Additional Parts, Overhead, Tax, Shipping, etc.)			\$50	\$68
<b>Total Cost</b>			\$983	\$985

Table 1: Financial cost

## 6 Schedule

The figure below illustrates a comparison between the original schedule and the actual finish time.



Figure 2: Project Schedule

Since we all have basic knowledge of design and passionate to it, we were able to finish most of the milestone ahead of time. As the figure shown above, we experienced some delay in the software test/debug, integration and documentation phase. That is because we changed our microcontroller in the middle of the development for better performance. However, we made use of our backup time, which ensured our final prototype can be delivered before deadline.



## 7 Workload Distribution

The table below illustrates the workload and responsibility distribution during our project. “XX” denotes primary responsibility and “X” the secondary.

Task	Yuchen	Eric	Yigang	Colman	Xupeng
Research	X	X	X	X	X
Financials	X				XX
Part ordering	XX				X
Protection bar mechanism design and implementation	XX	X	X		
Electric components testing			X	X	
Electric circuit design and implementation		X	XX	X	
Software design and implementation			X	XX	X
Assembly and prototype testing	XX	X	X	X	X
Documentation	X	XX	X	X	X
Administrative	XX	X			

Table 2: Workload Distribution

## 8 Future plan

Due to the limited resource and time, our project is only a prototype of our initial design. Addition features listed below should be implemented into our final product to attract more customers.

### Metal

The roll bar has to be strong enough to support the weight of the vehicle plus the weight of the driver. In our prototype, the bar is made of stainless steel. If budget allowed, we can use stronger and lighter material such as carbon fiber for special client request.

### Better UI control

The control of the ARS system for now is based on switches outside. We can implement control that can be fit into the vehicle so that the driver can configure the safety system without getting outside of the vehicle.

## Expand usage of system

This system can be modified and fit into other vehicle not just ATV. For example, there are many motorcycle accidents happen because of imbalance. We can apply our system and provide safety to reduce the chance of accident.

## 9 Individual Reflection

### Yigang Tao

During the past 4 months, I have had a great experiences of working with four young talented engineers. Every group member could share his ideas and helped each other in the project progress. The working distribution is very effective and fair, individuals can focus on the materials which he is expert in.

In this project, I put most of my efforts in hardware design. I had finished two coop work terms about power supply and control system in previous semester. The experiences from coop term help me a lot in the design of capstone project. The challenge in this project is the cooperation between software program and hardware system. The detection signal is generated in hardware and transmit to software program, the command signal sent from processor after calculation, finally the relay get the command to operate the load. The signal transfer is happen in every stage to system process, the association between hard ware design and software design is important. I was glad to work with my partner Colman who has great software skill. We had done some project before, so we have better understanding during discuss and design.

There are many knowledge I learn from this project. The most important thing I think is the team communication. For many times, I get the solution of problem in group discussion. Sometime the person who give me the hint does not even realized. The attitude is another important thing for the group project. In our group, everyone has positive attitude. The positive attitude can spread the motivation and creativity in group. In my opinion, the excellent group atmosphere is the important reason for the success of our project.

## Eric Wang

In this project I was mainly in charge of documentation and arrange group meeting. Moreover, I did help others when they need help. Most of what I have learnt from this project is project management skill and how to deal with people.

Before this project, I have wrote some reports and papers, but none of them are really formal. It was quite challenge for me to give the division of our documentation. Firstly I have read all document requirement and grading rubric. Also I have to read the old project documentations too, and then I decide the structure of our documentations. At the same time I have to keep equal work load for our team mates. As I recall, for the first documentation – project proposal, we finished it in a little rush. So after that we planned every documentation ahead and we have finished all documentations on time.

Also I got some technical experience from this project. I have never designed a product and I did not know the procedure of designing product. From mechanical design to hardware design, and from software coding and debugging to testing, now I can say I know the flow of developing a new product. And it also concerns to time management. We all have many courses during this term, especially during the final exam period. At same time, we five people have different schedule, it is very hard to find the time all people have time. Then this requires us to reschedule our other project or assignment. I have developed very good time management skill and I think this would help me a lot on my future career.

In conclusion, we did a great job. I am very thankful for working our talented teammates. I am looking forward to work together again in future.

## Xupeng He

It was a very unforgettable adventure to me in the past few months. Starting from a design concept on the scratch paper to hardware/software implementation till assembling final prototype, I finally experienced the happiness of being an engineer. This kind of fun is not coming from other people's compliment but from within which are teamwork, trust, responsibilities and self-improvement.

I was mainly being responsible for the budgeting and scheduling throughout this project. However, the skills I have learnt are more than that. Firstly, in order to come up with a persuasive budget proposal, a deeply and comprehensive market research is necessary. Every possible expenditure should be considered, as we do not want to waste our limited resource to the wrong side. Secondly, even we have abundant resources, as the CFO of the company, I have to always try to find a more competitive supplier for our parts in the developing phase, leaving more money for testing and improving. In terms of scheduling, a specific deadline for each developing step should be set in the very beginning with backup days. Try to organize a small sub-team of people in a dynamic and efficient way to work on one task at a time and let the other team to do the other task in parallel, unless one of the task deadline is approaching but still no breakthrough. And finally, same as budgeting, leaving time as much as possible for the final phase to make the design closer to a product than a prototype.

Speaking of technical gain from the project, I want to say thank you to all of our members. They all have been patient and selflessly teaching me from design to development. Now I got more experiences on solidwork and programming on embedded systems. I believe, I will put those into practice in my future work field.

## Colman Wen

ENSC 440 is definitely one of the most valuable courses in my academic years. In the last 3 months, our group can finally apply the knowledge we learnt in the past into things that we are interested in. Thanks to my talented teammates of ARS Innovation, the open-minded discussion environment and tidy management allowed us to use our expertise and combine them into a dedicated product.

My main responsibility is to configure the microcontroller to collect the digital and analog signal inputs and convert them into output control signals. Arduino UNO is the perfect tool for the project and allows me to freely set up the signals. Although this is my first time coding in Arduino, its logic is simple and the tutorial online is very straight forward for new users. As the “computer guy”, my experience gain from this project is not just software knowledge. One of the most challenging part in the project is to establish the connection between the hardware parts and software. Communication between different departments can help look at a problem in different angle. It is very important to understand the whole system before going into details of the program. A state-diagram or flow-chart can eventually speed up the implementation process because they can help programmer to sort out the conditions and steps.

Planning is a keyword why our project goes smoothly and successfully. A flexible but constrained time management is essential for making progress in any work even when situation goes out of expectation. I am very lucky to be a member of such an enthusiastic and productive team. My experience will be very helpful in my future co-op and industrial opportunity.

## Yuchen Tong

In the past four month, five of us worked on our capstone project, Anti-rolling system for ATVs. Five of us came from different primary fields bunch together for the same goal and determination. The result is positive due to our hard working and intelligent teamwork.

The balanced work load distribution is another factor that made us success. In this project the responsibility of me is mechanical design and manufacture. Since I got one year work experience at a mechanical engineering consulting company, I finished sketch drafting at first week to help us decide the work for next step before original schedule. After our overflowing ideas have been locked, we settled down and hands on this topic. Meanwhile, I finished the CAD drawing by Solidworks and sent it to shop in January. The structure of our roll bar was finished at the mid of February. After that, we discussed that our roll bar still needs more safety features such as a backstop to prevent roll bar slide back and a travel safety lock to prevent misoperation during traveling or shipping. Such safety features observably helped us build our brand. Also we met hundreds of problems during our processing, but we still keep our quality level high and work with no rush. This also helps us success at final.

The capstone project should be the most valuable course I have ever taken. Designing from draft then build to real must be tough, but we survived. This procedure tells us how to work as an engineer. We all earned numerous of experience, both technical and work flow. I hope in the near future, after we polishing our product, the ARS innovation could be one of the company standing in real market. As CEO, I want to say many thanks to all of our team members who made this project perfect.

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## Appendix A: Meeting Minutes

### Agenda

Tuesday, January 6<sup>th</sup>, 2015

12:00 – 14:00

Burnaby Campus

Purpose of meeting: To discuss topic of our project and get to know each other in our group.

Present: Scott Tong, Shayne, Eric Wang

### Minutes:

- Shayne suggested the idea of a phone case with battery and flash light.
- Scott suggested an automatic shopping cart and self-adjust ladder.
- Eric suggested an automatic faucet for bathtub and the luggage can measure the weight and with GPS location function
- Yigang missed the plane, so he did not attend the meeting
- For the topic, we will have more discuss next meeting.

## Agenda

Friday, January 9th, 2015

12:00 – 14:00

Burnaby Campus

Purpose of meeting: To discuss topic of our project

Present: Scott Tong, Shayne, Eric Wang, Yigang Tao, Colman Wen

### **Minutes:**

- Eric mentions the idea of auto grill machine
- Scott mentions the feature about steak grill
- Colman suggests that the weight sensor should be applied
- Tao draw the basic shape of the machine
- Shayne suggests that the program should have the algorithm for different kind of meat

## Agenda

Tuesday, January 13<sup>th</sup>, 2015

12:30– 14:00

Burnaby Campus

Purpose of meeting: To discuss topic of our project and get to know each other in our group.

Present: Scott Tong, Shayne, Eric Wang, Yigang Tao

### **Minutes:**

- Eric suggested another idea: a pillow can prevent snoring
- Scott suggested a protection bar for ATVs and the adjustable desk.
- We decided to do more research on all our ideas and choose an idea before next week lecture.

## Agenda

Friday, January 16<sup>th</sup>, 2015

11:00– 12:30

Burnaby Campus

Purpose of meeting: Choose one topic from our 7 ideas. Discuss about the name of the company and team organization.

Present: Scott Tong, Shayne, Eric Wang, Yigang Tao

### **Minutes:**

- After researching on our project, some of team may cost too much and some of them have already existed on the market. We decided to do ATV protection bar project.
- Discussion of our company name and logo, and also the product name: Our company name is ARS Innovation which ARS means anti-rolling system for ATVs.
- Team Organization: Yuchen Tong, our President and Chief Executive Officer (CEO), is in charge of the design process and the overall progress of the project; Eric Wang, Vice President (VP), is responsible for scheduling our group meeting and recording the meeting minutes; Yigang Tao, Chief Operating Officer (COO), is in charge of the hardware implementation to the project; Colman Wen, Technology Director, is responsible for the software design and functionality test; Xupeng He, Chief

Financial Officer (CFO), will be managing the overall budget and resolving financial issues.

## Agenda

Tuesday, January 20<sup>th</sup>, 2015

19:00–20:00

Burnaby Campus

Purpose of meeting: To prepare the presentation to ESSEF and discussion of the cost of our project. To discuss the mechanical structure of our system and list the parts that project need

Present: Shayne Wen, Eric Wang, Yigang Tao, Colman

### Minutes:

- Discussion of the cost: The total cost was estimated to be \$983.
- Prepared and finished funding presentation to ESSEF.
- Eric give the work division of Project Proposal.
- Discussion of the mechanical structure: Got the draft of the structure and Scott will draw the Solid-work structure and contact mechanical shop.
- Parts needed: Sensors and microcontroller are most important parts. Also we need Electromagnet switch. Scott will purchase those parts.
- More research on those part: We need more research on those parts before

purchasing.

## Agenda

Friday, February 6<sup>th</sup>, 2015

12:00– 13:00

Burnaby Campus

Purpose of meeting: To discuss the progress on mechanical design and review the parts we got so far

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### Minutes:

- The progress on mechanical design: Scott has finished Solidwork design, so far no problem was found, the design should be okay, nothing is needed to be changed.
- Parts we got so far: Sensors, microcontroller, buzzer and LED lights.
- Run some simple test on the parts we have so far.
- Eric give the work division of Function Specification.

## Agenda

Friday, February 13<sup>th</sup>, 2015

12:00– 13:00

Burnaby Campus

NO meeting this week (Reading Break).

## Agenda

Sunday, February 22<sup>nd</sup>, 2015

12:00– 14:00

Scott's Garage

Purpose of meeting: Update latest progress on mechanical part and circuit part

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### Minutes:

- Mechanical part: Received roll-bar from mechanical shop and nothing wrong with it.  
Our team tried to assemble the roll-bar on the ATVs, it fitted perfectly.
- Circuit part: we have received all components we need to build the circuit and we got the schematic design. We will build the circuit next week and test it.
- We need get ready for the oral progress report for next week.



## Agenda

Friday, February 27<sup>th</sup>, 2015

12:00– 13:00

Burnaby campus

Purpose of meeting: Update latest progress on circuit part and to do oral progress report.

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### **Minutes:**

- Circuit part: we have successful build the circuit. But we need 2 sec delay on the switch. We may need a better microcontroller for this.
- Colman will do the program part.
- Successful finished oral progress report
- Eric give the work division of Design Specification.

## Agenda

Friday, March 3<sup>rd</sup>, 2015

12:00– 13:00

Burnaby campus

Purpose of meeting: Update latest progress on software part

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### **Minutes:**

- We will buy a new microcontroller.
- More discussion on Design Specification Documentation.

## Agenda

Friday, March 13<sup>th</sup>, 2015

12:00– 13:00

Burnaby campus

Purpose of meeting: Update latest progress and find possible problems we may have so far.

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### **Minutes:**

- Received new microcontroller and Colman has finished coding it. We tried to connect the sensors and switch through microcontroller and it worked fine.
- Next week we will bring the all circuit part to Scott's garage and try to assemble all thing to the ATV.

## Agenda

Friday, March 20<sup>th</sup>, 2015

12:00– 13:00

Burnaby campus

Purpose of meeting: Update latest progress

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### **Minutes:**

- We tested new code, and it worked.
- We will finish assembling our system by next Friday

## Agenda

Friday, March 27<sup>th</sup>, 2015

12:00– 13:00

Burnaby campus

Purpose of meeting: Prepare for final test and prepare for demo

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### **Minutes:**

- All parts are installed on ATV.
- Eric give the work division of Post-Mortem

## Agenda

Wednesday, April 8<sup>th</sup>, 2015

12:00– 13:00

Burnaby campus

Purpose of meeting: Prepare for demo

Present: Scott Tong, Shayne Wen, Eric Wang, Yigang Tao, Colman

### **Minutes:**

- We have finished our tests on our system
- Eric did the ppt part of presentation and give the division of presentation