Auto-adjustable Spoiler Control System

Post Mortem

Project Team:
Zhengdong Cao **CEO**
Yueying Li **COO**
Tianye Zhou **CFO**
Tianlin Yang **CTO**

Contact Person:
ZhengDong Cao
E-mail: zcao@sfu.ca
Phone: 778.317.4405

Submitted to:
Dr. Andrew Rawicz
Mr. Steve Whitemore
School of Engineering Science
Simon Fraser University

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AOA	Angle of Attack
ASCS	Auto-adjustable Spoiler Control System
CAN	Controller Area Network
FSR	Force Sensing Resistor
GPS	Global Positioning System
LCD	Liquid Crystal Display
RF	Radio Frequency

1 Introduction

When it comes to vehicles, its safety and fuel efficiency has been always the most frequent concerns of automotive customers. Studies on enhancing vehicle's fuel efficiency from aerodynamic aspect came to be increasingly important. One fact is that aerodynamic drag is the dominant resistance for vehicles at high speed therefore reducing air drag will result in significant decreases in fuel consumption [1]. Car spoiler is an effective engineering solution dealing with several undesirable aerodynamic effects applied on the vehicle. However, normal car spoiler is designed either to reduce the total aerodynamic drag with less downforce, or to offer large downforce but extra external drag onto the vehicle [2].

At Veroptimal, the project of Auto-adjustable Spoiler Control System, or ASCS, is invented to enhance both vehicle safety and fuel efficiency. The ASCS is essentially a feedback controlled mechanical system which is able to either automatically or manually change the elevation and angle of attack (AOA) of the car spoiler. When the spoiler elevation is low, or stays very close to the surface of the boot lid, the spoiler can more effectively spoil out the undesirable flows thus to reshape airflow streams around the vehicle; the major benefit would be the decrease of drag or the increase of fuel efficiency. When the spoiler elevation is high, the AOA of the spoiler plays crucial role because the angle determines how much air to be deflected upwards and thus generates downforce at the rear of the vehicle [3], [4], [5]

2 Project Design Process

2.1 System Overview

In system design stage, we modeled the high level design of the ASCS as shown in Figure 1. The ASCS can be further divided into three major sub-systems: Front Panel, Main Controller and Spoiler System. Generally, users can send commands to the system through the buttons and switches on the Front Panel; the Main Controller will then respond to user's commands by sending control signals to the Spoiler System. The output of the Spoiler System will be the change in elevation and angle of attack (AOA) of the mechanism which ties to the rear spoiler.

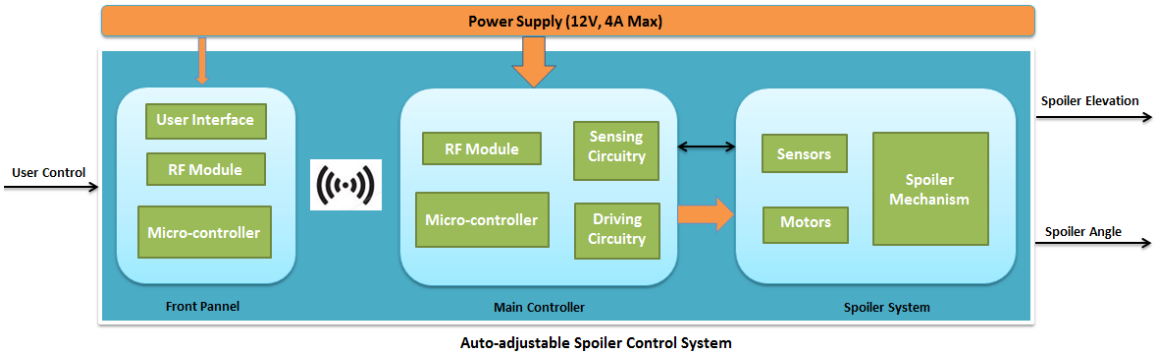

Figure 1: High level design of ASCS

2.2 Front Panel Design

The physical model of the Front Panel in the proof-of-concept stage is shown in Figure 2 (need to label for the control buttons). Users are able to select the operation mode via the Mode Selection Switch; the rotary and linear potentiometers are used to control the spoiler angle and height respectively; the green button is the Set Preference Button used to record user's preference. The LCD will display the information of the system such as the spoiler position and downforce for user's knowledge.

Figure 2: Physical Model of the Front Panel

The communication between the Front Panel and the rest of the system is wireless. We used a pair of 2.4 GHz RF transceiver module nRF24L01 to establish a transmission link that follows the half duplex manner, that is, the data transmission is bi-directional however only one party can talk at a time. In practice when we were testing the

transceiver module, we had over 50% of fail rate for data transmission. By online searching and experiment, we found that the 3.3V power rail on Arduino does not have enough current capacity to handle the inrush current of the module while transmitting. To solve for the issue, we shunted a 10uF capacitor at the power terminals of the module and used soldering for pin connections and we ended up with an acceptable fail rate less than 1%.

We also designed an enclosure for the circuit board for protection and visualization purpose. Due to the measurement error and the imperfection of the handmade circuit board, the top cover which is fabricated by 3D printer is not perfectly fitting. Nevertheless the enclosure is acceptable for this proof-of-concept model.

2.3 Main Controller Design

The circuit board of the Main Controller is prototyped using perfboard as shown in Figure 3. User's Command will be received by the RF module on the Main Controller to determine the operation mode of the system. GPS Module, Brake Detection Circuit, Force Measuring Circuit as well as Angle Measuring Circuit are able to process Sensor Output Signals sending from the Spoiler System so that the signals can be easily read by the Microcontroller. Based on the information acquired, the Microcontroller will ask Motor Driving Circuit to send control signals to the Spoiler System for further actions; meanwhile, system status will be sent back to the User Interface Panel so that the user can visualize the effects.

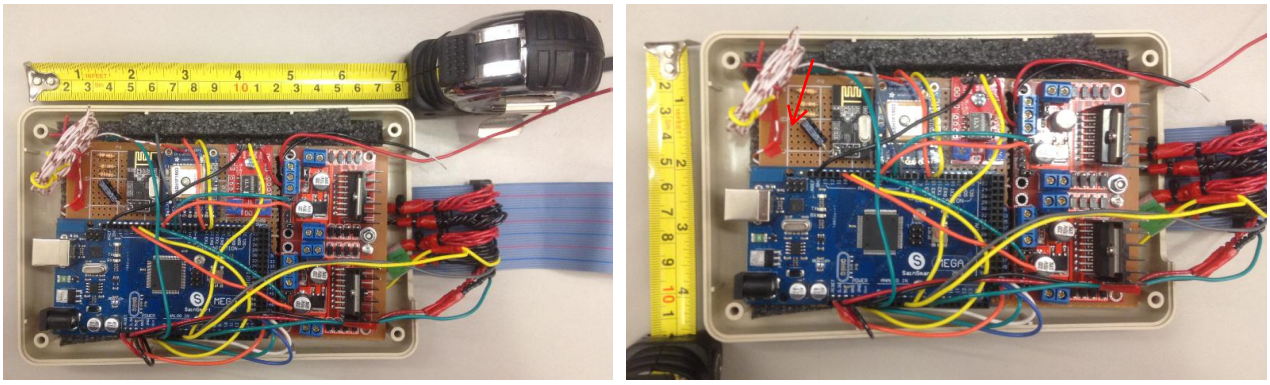

Figure 3: Main Controller Circuit Board

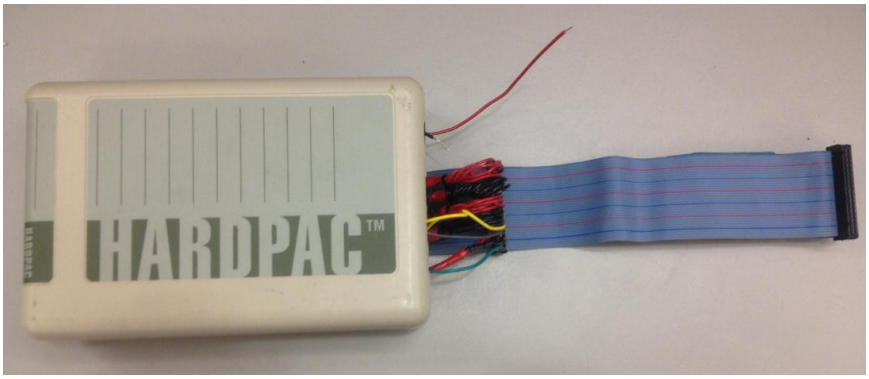

Figure 4: Enclosure for Main Controller

As Figure 4 shows, we used a box with matching dimensions of the Main Controller circuit board for enclosure. All electrical connections are connected to the Spoiler System using the Ribbon Cable.

2.4 Spoiler System Design

Spending over two months we finally turn the conceptual sketch on paper into a cool mechanical structure as shown in Figure 5. The Spoiler System is a mechanical system that consists of motors, sensors and structural elements. The motors contain a linear actuator and a DC motor. There are four force sensing resistors (FSR) and an angle sensor placed at the button of the spoiler to sense parameters such as downforce and angle of attack (AOA). Also, most structures are made using aluminum alloy or steel to improve the structural stability of the mechanical system. By connecting power from the Main Controller using the Ribbon Cable, the Spoiler System is able to adjust the spoiler height and AOA based on user's command. In the end we will mount the model onto the boot lid of a sedan car and performing road tests.

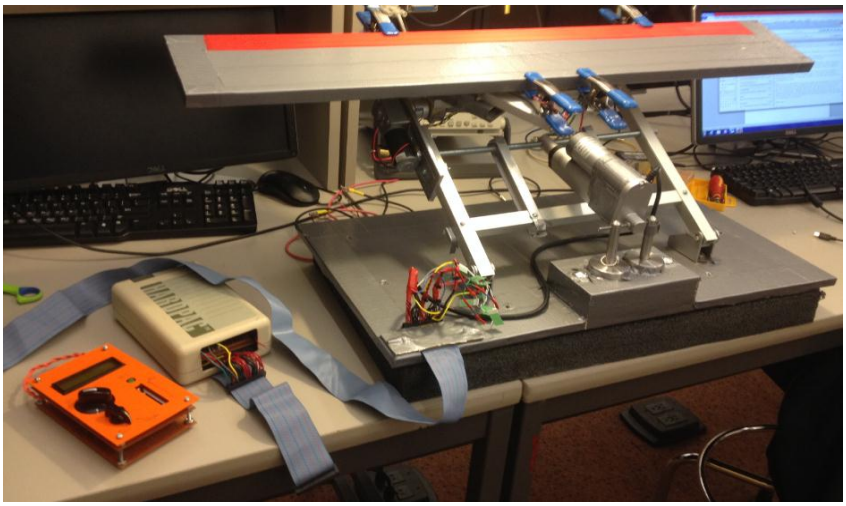

Figure 5: Spoiler System Mechanical Model

It was very difficult to make the mechanical model. The mechanical design solution for lifting the spoiler was being discussed for over 2 weeks and eventually we decided to use a linear actuator and the structural design as shown in the picture. Implementation is even tougher. We did not have enough funds to fabricate mechanical parts therefore we had to machine parts use drills, files, band saw and sanding machine. Since none of our teammates were from mechanical background, practical issues such as measurement errors and mismatching of screws and holes occurred frequently which are the major causes of our delay. Nevertheless we were glad to see a good finishing of the design in the end.

3 Budget Management

The actual cost of our entire project and the original proposed budget are compared in table 1.

Table 1: Budget Table for the Project

Item List	Estimated	Actual	Difference
Electronic Components	$200	$180	+$20
Circuit board Prototyping	$30	$50	-$20
Motors	$150	$160	-$10
Structural Elements	$220	$160	+$60
Spoiler	$120	N/A	+$120
Enclosure Materials	$50	$40	+$10
Shipping (20%)	$130	$100	+$30
Total Expenditure	**$900**	**$690**	+$210

The major change on the idea of the Spoiler System design significantly reduces our budget. In our original design, a car spoiler is a part of the system; later on we changed the idea and designed a Hand Mechanism which is able to grip a spoiler. In this manner, we no longer require an actual spoiler to complete the project. Design on structural elements is another big contribution to reduce the cost. One reason is that we just aluminum for major structural elements instead of carbon fiber; also we utilized some materials from machine shop such as plywood and metal chunks which also saved us around 40$. Overall, we control the budget under 700$ which saved us 210$ from the old plan.

4 Schedules

The schedule of project development is listed in Table 2 which includes our plan and actual finishing dates. We strictly follow the proposed schedule in the first half of the development; but the unexpected amount of work and difficulties in mechanical design and mechanical parts fabrication caused huge delays in the subsequent developments. The total amount of work required for this project is large; nevertheless we finished all technical development before demo.

Table 2: Schedule of Project Development

Technical Aspects	Expectation	Reality
Research and Planning	Week 2	Week 2
System Design	Week 3	Week 2
Hardware Development	Week 6	Week 6
Mechanical Development	Week 7	Week 10
Firmware Development	Week 9	Week 9
Integration	Week 10	Week 13
Testing and Optimization	Week 12	Week 14

5 Group Dynamics

5.1 Workload Distribution

Our group is well organized and all group members have contributed to the project. Table 3 lists the actual workload distribution on different fields of all group members. The time and efforts spent on each field is evaluated by High, Medium and Low.

Table 3: Workload Distribution

	Zhendong Cao (CEO)	Yueying Li (COO)	Tianlin Yang (CTO)	Tianye Zhou (CFO)
Documentation	High	High	Medium	Medium
Administration	High	Low	Medium	Low
Financial/Funding	Low	High	Low	Low
Parts Purchasing	Medium	Low	Medium	High
Research	High	High	Medium	High
Hardware Design and Development	High	Low	Medium	Low
Firmware Design and Development	Medium	Low	High	Medium
Mechanical Design and Development	High	Medium	High	High
Enclosure Design	Medium	High	Low	Medium
Testing	High	High	High	High

5.2 Individual Reflection

Zhendong Cao (CEO)

The capstone course is the most intensive, challenging, practical and interesting course in my undergraduate academic career at SFU Engineering Science department. Being involved in the project of designing the spoiler control system has been illuminating on both technical side and interpersonal level. Through this project not only have I enhanced my engineering skills but I have also developed my ability on project management. Also, it has been an unforgettable experience to work with a team of 4 young engineers and witness our project grows from a paper scratch to a functional prototype.

We formed the team before semester starts and all group members are friends which gave us an advantage of already having good communication. I feel grateful and lucky to be voted as the CEO of Veroptimal Solution. This experience has developed my leadership skills which keep the team progressing healthily. Through this project, I also learned how difficult it is implement the project, control the budget and design a functional, feasible and reliable product. I also

learnt the importance to document and organize the work systematically. Engineering journal is a good approach to record the development progress and remind us the future tasks. Dropbox is another medium for our group members to share results. By having all records we are able to quickly trace back when problems happen and solve the problem effectively by understanding the root cause.

Management aside, my major technical responsibility in this project is electrical system design since I just finished a one year industrial co-op doing hardware design and test. The design of the electrical system has to be based on a good overview of the entire system, for example, the maximum power of the system, the requirement memory size of the microcontroller and the number of I/O ports needed. By having a clear outline of the system requirements, I designed and implement the circuit boards and wiring for the Front Panel, Main Controller and the Spoiler System. Also, as a fourth year systems engineering student who has taken some mechanical design courses, I also contributed mechanical design proposals which also improved the progress of mechanical development. However, since the work of mechanical design in this project is much intensive than what we expected thus caused a 3 weeks delay on our schedule.

Team miscommunication has occasionally happened since each person's schedule management may not match to other group members. Still, the team has matured over the months and refined our communication tactics and overall teamwork. The project would never come into one piece without everybody's contribution and I am proud to be a member of Veroptimal Solution development team and I would like to give my thanks to all my group members.

Tianlin Yang (CTO)

As the CTO, I managed the majority part of firmware development and some mechanical design and development. As the lead designer in the firmware and is responsible for the designing of the overall control system. Throughout the development of this project our team has faced numerous challenges. However, every problem is resolved by our team works.

While designing firmware, I have learned a lot about the Arduino Micro-controller and C++ programming language. This would be a great help for possible future projects using similar hardwires. I have learned the proper way to do engineering documentation while writing all the required specifications. The rubric provided for each document showed me what to expect in a professional engineering document. This is very beneficial to me because writing proper engineering specifications is a required skill to become a real engineer.

Since I was also responsibility on mechanical part, I was required to do some designing and mounting jobs. In the beginning, I had no idea how to use tools. Fortunately, I picked it up right away. Also, I learn a lot of mechanical knowledge and some ideas to design a mechanical staff.

Although all these technical skulls are valuable the most important skills that I have gained are some other skills. Throughout these three months of development, my time management skills has greatly improved. I have learned

that in order to keep the project on schedule, aiming to finish each task few days earlier is always required. Those few days will act as a buffer zone when facing unexpected problems. We have been stuck on unexpected problems several times during our firmware development, especially automatic mode. It takes us extra days to resolve the issue and keep the project on schedule. I have also learned that RF wireless communication development skills. Our team have been spoilt into to small groups in the last few week, so we can distribute all the task more efficiently to make every single step on schedule.

Overall, this course has been an amazing experience. I met many friends. The skills I learned from this course will be the foundation for the development of my career. All of us has worked very hard to complete this project. However, some features are not complete. I love every member in our team and it would be an honor to work with those people.

Tianye Zhou (CFO)

This capstone project is truly a course which provides undergraduate students with a substantial learning opportunity to experience project planning, documenting, project building, testing, debugging and so on. From the process of completing this project, I've made great improvements in terms of engineering technical skills, team-work skills, communication skills and documentation skills. It's been an honor for me to work with a group of hard-working engineers and achieve our goal successfully at the end of this semester.

In my opinion, it is very crucial to start thinking about the capstone project prior to the course semester because the project plan varies all the time and it is very likely for people to run out of time if something unexpected happens during the designing stage. Taking our project as an example, if we didn't start off working on our project one semester prior to this semester, we would have to give up some of the functionalities such as the automatic mode of the car spoiler system to compensate the time that we wasted on fixing hardware failures. Furthermore, from the experience of working on different areas of this project, I realized that a real engineering project is a combination of a lot of aspects including designing the functionalities, controlling the budget, coordinating the teammates, meeting the deadlines, market researching and so on. Therefore, other skills are just as important as technical skills.

When it comes to the technical skills, I applied what I learned in hardware and software design to the actual project, and developed new skills in mechanical designing and Arduino programming. We spent plenty of time on figuring out solutions for a number of complex mechanisms, from which I learned and practiced to use many useful machine tools in the machine shop. For hardware designing and debugging, I become more familiar with the circuit building and circuit layout. With the help of Daniel (CEO) who is really good at hardware designing, I was able to track down and fix some hardware problems.

Although we stuck a couple of times during the designing process of the project, our team is quite efficient and we never stopped making progress. I would like to thank this course for providing me the opportunity to experience the lifecycle of a project and thank all my team members for contributing to the completion of this capstone project.

Yueying Li (COO)

The project was a wonderful journal in my university life. During these three months, I gain skills in both technical and interpersonal areas. With small teams in Veroptimal solution, four engineers are able to work on their own interests and expertise.

For the technical part, as one of the Mechanical Designer in Veroptimal solution, I was mainly responsible for parts of mechanical designs, mechanical analysis as well as the enclosure designs. Besides, I was active participant in product integration and testing. First of all, For the mechanical design part, I was able to apply theories from textbook to a workable product. However, it is a challenge process that making real product with only one theory. The fact is that taking multiple situations into consideration and analyzing parallel with be the successful steps. As a result, taking all components as a systematic analysis will be the way I should be the first and the foremost method for my future work. Next, for the product integration and testing part, with hardware, firmware and mechanical parts intersecting with each parts in this product, I was gain knowledge from mechanical part as well as the hardware tests. Integrating the whole system as a workable product requires systematic analysis in process. Being part of the integration members, I had learnt hands-on skills on hardware wirings and hardware components tests.

For interpersonal part, I was grad to be part of the Veroptimal solution because I learnt lots of interpersonal skills from my co-works. Firstly, be patient and detailed when problem occurs. Secondly, thinking systematically and analyzing problems step by step. Last but not least, teamwork and communication are one of the most important part among the group work.

In conclusion, being part of the Veroptimal solution member is a great treasure with learning technical skills, such as mechanical design and hardware tests, as well as building a finer interpersonal skill for my own. It was a great experience which leads me a better performance in my future career. I would like to thank all my group members for their help during this project.

6 Conclusion and Future Work

After 4 months intensive work we have finished the proof of concept stage of ASCS design. The diverse skill set of the Veroptimal team members enabled the group to learn from each other. The completion of our capstone project requires a combination of outstanding hardware designing, firmware programming, mechanical designing, circuit debugging, time management and teamwork. From the ASCS project, we gained tremendous knowledge, skills and experiences in both technical and interpersonal levels.

Due to the tight schedule, we did not have opportunity to perform all test cases of our product; once the demo is finished, we will be performing more serious road tests and examine the actual aerodynamic benefits of the ASCS. Modification on mechanical design is certain since the current design is not very firm. We may also consider to use CAN bus with more immunity to outside interference to replace the RF transmission; in this way, we can integrate the system onto the car. While we are modifying the design, we will also contact some spoiler manufacturers to see if they are interested in our project. We believe that spoiler manufacturers can have better sell by having a bundle sell of our project.

7 Reference

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Appendix: Meeting Agenda

A - First Half Semester Meeting Agenda and Progress Details

	Meeting Date	Location	Present	Meeting Content
Before Semester	29-Jun-15	Skype	Zhendong Cao Tianlin Yang Tianye Zhou	1. Tianlin already bought GPS module and he will begin to test the functionality 2. Abandon original plan of mading a spoiler; decided to buy a cheap one 3. Need to finalize the plan and bill for motors and linear actuators in next meeting
	21-Jul-15	Skype	Zhendong Cao Tianlin Yang Tianye Zhou	1. Zhendong has bought the motor drivers, linear actuator with position f/b and linear actuator mounts 2. Tianye and Zhendong proposed 2 mechanical design, need to test Zhendong's design in Lab on weekends
	26-Jul-15	LAB1	all members	1. Finalized the mechanical design for linear actuator height adjustment --> 1 L.A., propose 1 in PDP 214 2. Tested linear actuator with arduino code 3. Need to work on motor, spoiler, linkage and sensors
	16-Aug-15	Blenze Coffee	Zhendong Cao Tianlin Yang	1. Determined the pin mapping of the circuit design on Perf board 2. Select bracket for height adjusment mechanism 3. Working on migration of the Arduino code (from Uno to Mega board)
	22-Aug-15	Blenze Coffee	Zhendong Cao Tianlin Yang	1. Working on the system flow chart for programming
	1-Sep-15	Library	Zhendong Cao Tianlin Yang	1. Modified circuit schematic and pin mapping and updated to the network 2. Programmed and tested manual control for Linear Actuator
September	11-Sep-15	Lab1	Zhendong Cao Tianlin Yang Yueying Li	1. Proposed the new idea for mechiancal design: make an independent gripping mechanism 2. Talked to Andrew and he approved our project idea 3. Yueying will work on spoiler shape research and solidworks prototyping 4. We may want to adapt 2 Arduino Micro plan, need to decide before Sep.14 Monday and then place bill
	13-Sep-15	Skype	all members	1. Distribute work for documentation of Proposal 2. Zhendong will be designing mechanical structure of the Spoiler System 3. Tianye and Tianlin will use Solidworks to simulate aerodynamic effects on the car spoiler
	17-Sep-15	Lab4	all members	1. Distribute work for documentation of Proposal 2. Zhendong will be designing mechanical structure of the Spoiler System 3. Tianye and Tianlin will use Solidworks to simulate aerodynamic effects on the car spoiler 4. Yueying is designing company logo and documentation templates
	21-Sep-15	Lab4	all members	1. Zhendong and Tianlin are working on RF transmission; having transmission time out issues 2. By the end of the week (sep27), need to finalize the mechanism design and purchase parts
	25-Sep-15	Lab4	Zhendong Cao Tianlin Yang Tianye Zhou	1. Tianlin and Zhendong solved the RF transmission problem; able to do 2-way data transmission 2. Zhendong submitted the final paper design for the Arm Mechanism to the group; 3. Went to Homedepot, IKEA and purchase materials to build mechanical structure for Arm Mechanism 4. Need to submit the draft of Propsal before sep 27
	28-Sep-15	Machine Shop	all members	1. Submitted propsal document 2. Zhendong and Tianye built the test model for Arm Mechanism and tested; result is good 3. Need to finalize the mechanical paper design for the Hand Mechanism
October	1-Oct-15	Lab1	all members	1. Zhendong finished the hardware design on Sep 30; waiting for Nano...shipping is longger than expected 2. Zhendong and Tianye built the test model for Arm Mechanism and tested; result is good 3. Need to finalize the mechanical paper design for the Hand Mechanism 4. Need to solve the timeout issue of RF transmission
	6-Oct-15	Lab4/Lab1	all members	1. Finalized and tested the hardware design on breadboard and Arduino Uno; RF issue is solved 2. Discuss whether we need a fan for cooling down the device when fully operated 3. Distribute work for functional spec documentation
	9-Oct-15	Lab1	all members	1. In next week, build the arm set, hand set and baselink for testing 2. Complete functional spec draft version before Sep14 3. Should have the mechanical model available for testing by Sep18
	13-Oct-15	Lab1	all members	1. Produce a solidwork model for the entire deisng, also make pdf readable files 2. Discuss where and what to buy on Oct15 3. Yueying will be doing enclosure design for Front Panel and Main Controller 4. Tianye, Zhendong, Tianlin will be developing hand mechanism
	15-Oct-15	New West	Zhendong Cao Tianlin Yang	1. Bought alluminum tube and rod for building arm linkages on Friday 2. Arduino Nano boards have arrived 3. Should finish functional spec draft before Sep 18
	22-Oct-15	Lab1	all members	1. Submitted functional spec on Sep 19 2. Zhendong finished hardware perfboard layout and soldering; hardware is being tested 3. Tianye proposed mechanical design solution for Hand Mechanism; need further evaluation 4. Did oral progress report
	24-Oct-15	Lab4	Zhendong Cao Tianlin Yang Tianye Zhou	1. Tianlin and Zhendong are working on individual unit programming 2. Mechanical design for Hand Mechanism is seriously delayed; need to speed up. The linkage design for connecting Arm Mechanism, DC motor and Hand Mechanism not decided yet 3. Tianye and Tianlin asked few mechanical parts fabrication shop, but the cost for machining parts is too expensive so we decided to seek for other alternatives
	27-Oct-15	Skype	all members	1. Zhendong came up a solution for stabilizing the Arm Linkages, need to implement soon 2. Distribute work for Design Spec documentation

B - Second Half Semester Meeting Agenda and Progress Details

November	5-Nov-15	Library	all members	1. Need to solve the following issues encountered in mechanical design 1.1 where should the downforce sensor being placed? 1.2 How to stop the hand link stabilizer from axial movements 1.3 How to install the Hand Mechanism on the hand link 1.4 How to balance the weight on left and right sides 2. The progress of writing design spec is slow; need to speed up; may ask for due day extension
	10-Nov-15	Machine Shop	Zhendong Cao Tianlin Yang Tianye Zhou	1. Zhendong proposed solutions for solving 1.1, 1.2 and 1.3 listed in Nov 5, need to implement and test before Nov 16 2. Tianye's old Hand Mechanism design plan was changed; use 4 clamps instead 3. After discussion, we decide to buy an additional force sensor for measuring downforce 4. Finshing the Design Spec by Nov11
	17-Nov-15	Lab4	all members	1. The mechanical development for the Arm Mechanism and Hand Mechanism is finished; need to build a base for installation 2. Need to prepare for system integration 3. Submitted the Design Spec on Nov12
	20-Nov-15	Machine Shop	Zhendong Cao Tianye Zhou	1. Tianye and Zhendong have implemented the base
	22-Nov-15	Lab4	all members	1. Zhendong and Tianlin added two supporting mechanism to support the Arm link which is bent under heavy load condition 2. Finishing the design of final solidworks for Front Panel top cover and give deliverables to Gary Shrum on Thursday for 3D printing 3. Finsihting wiring of the Main Controller by Nov25
	24-Nov-15	Vancouver/ Lab1	Zhendong Cao Tianye Zhou	1. Purchased Ribbon cablefemale connectors 2. Tested pin connections
	26-Nov-15	Library	Zhendong Cao Tianlin Yang Yueying Li	1. Finished wiring for angle sensor on DC motor 2. Wiring for forse sensors and placed the 4 force sensors on the Hand Mechanism 3. Wiring for the power terminals of DC motor 4. Finished testing the folloiwng hardware functions 4.1 Linear actuator height adjustment using power supply 4.2 DC motor angle adjustment using power supply 4.3 Force sensor pressure test, resistance values are good 4.4 Tested angle sensors using power supply 5. Need to buy a male Ribbon Cable connector
	30-Nov-15	Lab1	Zhendong Cao Tianlin Yang Yueying Li	1. Received the Ribbon Cable Male connector from Digikey, tested connection; result is pass 2. Need to complete all wiring and hardware integration of the system
December	2-Dec-15	Lab1	all members	1. Finsihed Spoiler System wiring 2. We found that one of the Arduino Nano board is broken! Alternartive solutions: 2.1. Use Arduino Uno (available, but same memory size with Nano, bought from china, may not be good quality) 2.2. Buy another Nano (need to buy, but takes another week, too late) 2.3. Use Arduino Mega (available, larger size but bought from US, may be better quality; also larger memory size) --> prefered this option 3. Ribbon Cable male connector has arrived
	4-Dec-15	Lab1	all members	1. Hardware remodification using the Arduino Mega is finished by Zhendong by the end of Dec 3 2. Performing manual mode testing: 2.1 Spoiler heigh control is passed 2.2 Spoiler angle control has problem for two reasons: hand design is not very stable, the torque of DC motor with low duty cycle of PWM is not large enough 3. Performing preference mode testing, result is passed 4. Need to solve the DC motor issue and add limitation to the rotation angles 5. Need to have waterproof covering for water sensible parts
	Final Exams, need to pause for project development			
	10-Dec-15	Lab1	Zhendong Cao Tianlin Yang Tianye Zhou	1. Solve the DC motor power not enough issue 2. Solve the DC motor control issue in Manual Mode 3. The Hand Mechanism is too loose, Zhendong went to machine shop and stabilize it 4. Need to finish Manual Mode and Preference Mode programming on Dec 12
	11-Dec-15	Lab1	all members	1. GPS parsing is not working, it was working before; need to debug 2. Finish the manual mode programming; added limits for the rotation angles 3. Propose mounting solution on the car
	12-Dec-15	Lab1	Zhendong Cao Tianlin Yang Yueying Li	1. Yueying added water proof protection; also modified the apprance of the entire system 2. Working on documentation of Post Mortem and Demo
	13-Dec-15	Lab1	Zhendong Cao Tianlin Yang Tianye Zhou	1. Fixed and tested GPS; need a add an antenna when testing 2. Finished the first round coding for automatic mode; need real test 3. Mount the ASCS on the car boot lid; drive to 70kpm and the system is stable. Need to test on Dec14 4. Need to practice demo presentation
	14-Dec-15	ASB Parking Lot	all members	1. Testing the automatic mode code and modify the program; 2. Finishing the documentation 3. Practice for the demo presentation