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Team 513: Improving Engine Performance, Fuel Economy, and Emissions Through MIMO Engine Airpath Control

9/25/2020



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# Code of Conduct

**Mission Statement**

The members of team 513 will strive to create work that the members, the FAMU FSU College of Engineering, and the sponsor, Mathworks, will be proud to have their names on. Work will be completed with quality and timeliness.

**Ethics**

Team 513 will adhere completely to the National Society of Professional Engineers Code of Ethics. All assignments, decisions, issues, and discussions will be carried out with honesty and fairness. All commitments made will be honored and carried out with integrity. Any violations will be brought to the entire team and any repercussions will be decided as a whole.

**Team Roles**

* Austin LaFever - Controls & Simulink Engineer
  + Design the system inputs and outputs in Simulink
* Create a preliminary control system for the project
* Find a controls professor to assist in MIMO design
* Frederick Peterson - Matlab Engineer
  + Develop code for control system for the project
* Take attendance at team meetings
* Jonathan Wozny - Matlab and Thermal Fluids Engineer
  + Develop code
* Complete any necessary calculations for design involving thermal fluids
* Patrick Marlatt - Project Engineer
  + Review and turn in work, main contact with sponsor, help with code and controls
* Miscellaneous work will be assigned by the project engineer on a case-by-case basis depending on the current workload of the group members.

**Communication**

* GroupMe and Basecamp will be the main methods of communication. Github will be the main method for sharing and collaborating on the Matlab code.
* Zoom will be utilized as the main method of conducting meetings. In-person meetings may occur occasionally only for those who are okay with it and who have no COVID-19 symptoms. COVID-19 precautions will be followed at all meetings.
* Documents and assignments that will be turned in will be shared and tracked through Basecamp.
* Acknowledgement of any messages must be done within 24 hours. Failure to do so will result in team discipline and/or spontaneous combustion.

**Project Submission**

All work to be submitted must be given to the project engineer a minimum of 48 hours in advance of the due date. If any problems occur, the project engineer must be notified ASAP. If for any reason the project engineer is unable to submit the assignment, Jonathan will submit the assignment in his place.

Once the assignment has been submitted, the project engineer will notify the group via GroupMe, as well as send an image of the receipt saying it is turned in to confirm submission.

**Dress Code**

The dress code for the various meeting types are as follows:

* Group meetings: Casual attire
* Group meetings (in person): Casual attire w/ mask
* Meetings with advisors/sponsors: Collared shirts
* Presentations: Dress shirts, as uniform as possible among the team

**Attendance Policy**

* Group meetings will be held every Tuesday and Thursday during the extra time in Senior Design. There will be additional meetings on Wednesdays at a time decided that week. If needed, a Friday meeting will be called and set the same way.
* Attendance to all meetings is required unless the member lets the group know at least 24 hours in advance.
* Attendance of group meetings will be recorded by Frederick and added into an excel sheet that is available for everyone to see in Basecamp.
* Meetings with the group advisor will be held weekly on Wednesdays.
* If for any reason a team member misses more than three team meetings, the project engineer will reach out and see if there is anything that can be done to make it easier to attend team meetings, such as adjusting certain meeting times. If the offences continue, then the team will handle it as outlined in the conflict resolution section.

**Decision-Making**

All members will participate in the decision-making process. If there are any conflicts of interest, team members must state this and disqualify themselves from the decision-making process. The entire decision-making process is outlined below:

* Define the problem
* Propose solutions
* Research
* Testing
* Presenting results to the group

The solutions will then be evaluated and a vote will occur. If there is still indecision, a tie, etc., the problem will be presented to the project advisor.

**Conflict Resolution**

All conflict will be documented and signed by the project engineer and the team member(s) involved. Each member has the right to present their case to the rest of the group without any interruptions. All conflicts will be solved by majority rule. Any conflict that cannot be resolved internally will be brought to Dr. McConomy, who has the final decision.

**Amending the Code of Conduct**

If any additions or changes are required for Code of Conduct, a team meeting will be held and the changes will be discussed and administered if agreed upon by every member. The Code of Conduct document will be amended and then re-uploaded.

**Statement of Understanding**

By signing the lines below, I agree to and will abide by the above guidelines of this code of conduct.

Name:\_\_Austin LaFever\_\_\_\_\_\_ Date: \_\_9/11/2020\_\_

Name: \_\_Frederick Peterson\_\_\_ Date: \_\_9/11/2020\_\_

Name: \_\_Jonathan Wozny\_\_\_\_\_ Date: \_\_9/11/2020\_\_

Name: \_\_Patrick Marlatt\_\_\_\_\_\_ Date: \_\_9/11/2020\_\_

# Chapter One: EML 4551C

## 1.1 Project Scope

### Project Description

The goal of this project is to create a control system that corrects the air-fuel ratio by moving the throttle and wastegates to improve engine performance.

### Key Goals

The key goal of this project is to create a 2 input, 2 output Model Predictive Control System to replace the current control system Mathworks and others use. Our MPC system is to be validated with GTPower engine analytics to ensure the air-fuel ratio agrees with the simulated value. The final goal is seamlessly integrating the system into the powertrain blockset dynamometer.

### Primary Market

The first primary market for our program would be engine manufacturers trying to optimize their engines. Our control system would allow the manufacturers to optimize engine performance. We can feel confident that this is a strong market, because General Motors has already attempted to implement this Model Predictive Control.

Our second market would be emissions testing agencies, because our control system will reduce fuel usage and pollution emissions, so they can use the program to test the benchmark.

A third market for our program would be GTPower and similar engine simulation technologies. They have state of the art engine analytics and virtual dynamometers, so if they find interest in our control system, the implementation into their simulation program could improve the quality of their software.

Our final target market is students and researchers. They may be working to find ways to

reduce emissions or improve performance, and our software package is a strong start to that. It’s a relatively cheap way to improve an engine, and they could use our control system as a start to designing a new one, or use it as a better way to test their new equipment.

### Secondary Market

Our secondary market could include any pedestrians. The optimized fuel consumption and reduced emissions would improve air quality, and reduce fossil fuel use, resulting in a better environment for everyone.

### Assumptions

Our first assumption is that everything else in the powertrain blockset is perfect. This reduces the need for a physical dynamometer, which reduces cost. It also reduces the need for testing of other components in the blockset.

Our second assumption is temporary, but will be used to establish a base for our control system. We will assume the system is single input, single output, and then add the additional input and output as our system functions correctly. This will reduce the load of things we need to learn at a time, while still getting a product prepared.

Our final assumption will be that an MPC is the best possible control system we can use. This will reduce research time, and allow us to dive straight into our design.

### Stake holders

There are multiple stakeholders who will benefit from our successful completion of the project. A primary stakeholder for our project is Mathworks. Correct implementation of an MPC system would result in a more modernized and accurate model, making their Powertrain Blockset more appealing to auto manufacturers and Mathworks customers.

Secondly, Roberto Valenti and Peter Maloney are stakeholders as they are putting in their time to advise and assist us with our project. Additionally, ours is the pilot project for a new Mathworks program, headed by Valenti, that sponsors educational research projects, like ours, that are mutually beneficial to both Mathworks and students working on the projects.

Our advisors, Shayne McConomy and Koroush Shoele are stakeholders as well, since they will also be investing time into this project. Finally, FSU and FAMU are stakeholders. As a team, we represent the schools, and the schools therefore are impacted positively or negatively based on the outcome of the project. Successful completion will bring more status to the colleges. It may similarly result in continued project sponsorship by Mathworks and possibly an increase in the number of projects sponsored for the college.

## 1.2 Customer Needs

### Method

To get the needed information, we looked over the project statement and created a list of questions we felt were necessary to begin work on the project. We met our points of contact Roberto Valenti and Peter Maloney from our Mathworks, our sponsor, over Zoom for a “meet and greet.” They answered our questions, and we developed interpreted needs accordingly.

### Question-Answer-Need Table

|  |  |  |  |
| --- | --- | --- | --- |
| # | Question | Answer | Interpreted Need |
| 1 | Is it required to use model predictive control, or can we use controls that we are more familiar with, like PID, table-based, etc.? | We have been looking into MPC recently, and from our research, MPC seems to be the very best approach to solving the problem. | Use MPC control for project approach. |
| 2 | What will we be using as inputs and outputs to our control system? | A good start place to get familiar with simulink and the control system is the wastegate and throttle. If you start there, we can see what else you can add. | The control system implements the throttle and wastegate. Additional factors can be included. |
| 3 | How would we know if our control system is accurate? | Running the program produces a graph of desired intake vs actual intake. The closer the two lineup, the better your system. | The control system only demands what the system can provide. The blockset will produce a graph to ensure accuracy. |
| 4 | What is the main goal of this project? | The main goal is to integrate and simulate an MPC controller block in the powertrain block control set. The MPC should control the throttle and wastegate to get the ideal boost for the system. The new MPC controller designed by the group will replace the existing control system. | Create an MPC controller that will control the throttle and wastegate inputs to replace the existing outdated controller. |
| 5 | What is a good place to get started? | Play around with the power train blockset. Go through it, see how it all works; change the inputs and see what happens. |  |
| 6 | What can we do while we wait for the blockset? | There are apps on the market to record your car’s information [ on the throttle and wastegate], that information will help get started | Our model results can be compared to physical systems |
| 7 | What is the best way to simulate our controller within the system? | The powertrain blockset and Simulink can be used to simulate the system. We will look into getting the group access to GT Power as it has more specific engine models and GT Power is used the most in the industry for these types of simulations. | Use powertrain blockset and Simulink for simulations and perhaps GT Power later on in the project. |

### Synthesis

From our question and answer session we learned that the end-goal of this project is an MPC controller that regulates the throttle and wastegate. The controller simulation is to be done with Mathwork’s Powertrain Blockset, and the model’s results can be compared to physical systems and possibly GTPower simulations to test system efficiency.