# KGCOE MSD I Technical Review Agenda

P10227: FSAE Variable Intake

**Meeting Purpose**:

1. Overview of the Project
2. Overview of Engineering Specifications and Customer Needs
3. Detailed Discussion of Preliminary Testing Procedures and Results
4. Finalized Intake System Design
5. Cross-disciplinary Review: Generate Further Ideas

**Materials to be Reviewed:**

1. Project Description
2. Customer Needs
3. Engineering Specifications
4. Budget
5. Risk Assessment
6. Preliminary Testing Results
7. Finalized Intake Design Details

**Meeting Date**: February 12, 2010

**Meeting Location**: Room 09-2030

**Meeting time:** 3:00 pm – 5:00 pm

| **Meeting Timeline** | | | |
|---|---|---|---|
| **Start Time** | **Topic of Review** | **Start Time** | **Topic of Review** |
| 3:00 | Introduction for the project | 3:50 | Questions, Concerns, Ideas |
| 3:05 | Customer Needs | 3:55 | Finalized Intake Design |
| 3:10 | Customer Specifications | 4:15 | Questions, Concerns, Ideas |
| 3:15 | Questions, Concerns, Ideas | 4:25 | Next Step - Manufacturing and Assembly |
| 3:20 | Budget | 4:30 | Questions, Concerns, Ideas |
| 3:25 | Risk Assessment | 4:35 | Next Step - Dynamometer and Car Testing |
| 3:30 | Questions, Concerns, Ideas | 4:40 | Questions, Concerns, Ideas |
| 3:35 | Preliminary Testing Procedures and Results | 4:50 | Closing Comments and Concerns |

| Project # | Project Name | Project Track | Project Family |
|---|---|---|---|
| P10227 | Variable Intake | Vehicle Systems and Technologies Track | FSAE |
| **Start Term** | **Team Guide** | **Project Sponsor** | **Doc. Revision** |
| 2009-2 | Dr. Alan Nye | RIT Mechanical Engineering and FSAE | |

# Project Description

## *Project Background:*

As each competition passes, fuel efficiency and technical superiority becomes much more prevalent in competition scoring. To advance the RIT Formula SAE Racing Team in the engine subsystem, the infinitely variable intake system will prove to be innovative and technically competitive.

## *Problem Statement:*

This senior design project will develop an infinitely variable intake system for the Formula SAE race car that will allow for increased fuel efficiency, design advancements and a greener methodology to produce more engine power.

## *Objectives/Scope:*

1. Measure the fuel efficiency of the engine
2. Improve power and torque
3. Packaging the system with simplicity to allow for ease of installation and maintenance
4. Design and build for the non-professional, weekend and competition market

## *Deliverables:*

- Increased volumetric efficiency and fuel economy of the engine
- Improved power/torque
- Better drivability
- High reliability
- Manufacturability
- Servicability

## *Expected Project Benefits:*

- Allow the RIT FSAE Racing Team to flourish in competition
- Advance the engine subsystem
- Lead into other Senior Design engine projects

## *Core Team Members:*

- Dave Donohue
- Dan Swank
- Matt Smith
- Kursten O'Neill
- Tom Giuffre

# Strategy & Approach

## *Assumptions & Constraints:*

The largest constraint of this project is dependent on the status of the dyno facilities and the race car. To complete all listed deliverables specified by our customer, the intake system requires full testing and tuning.

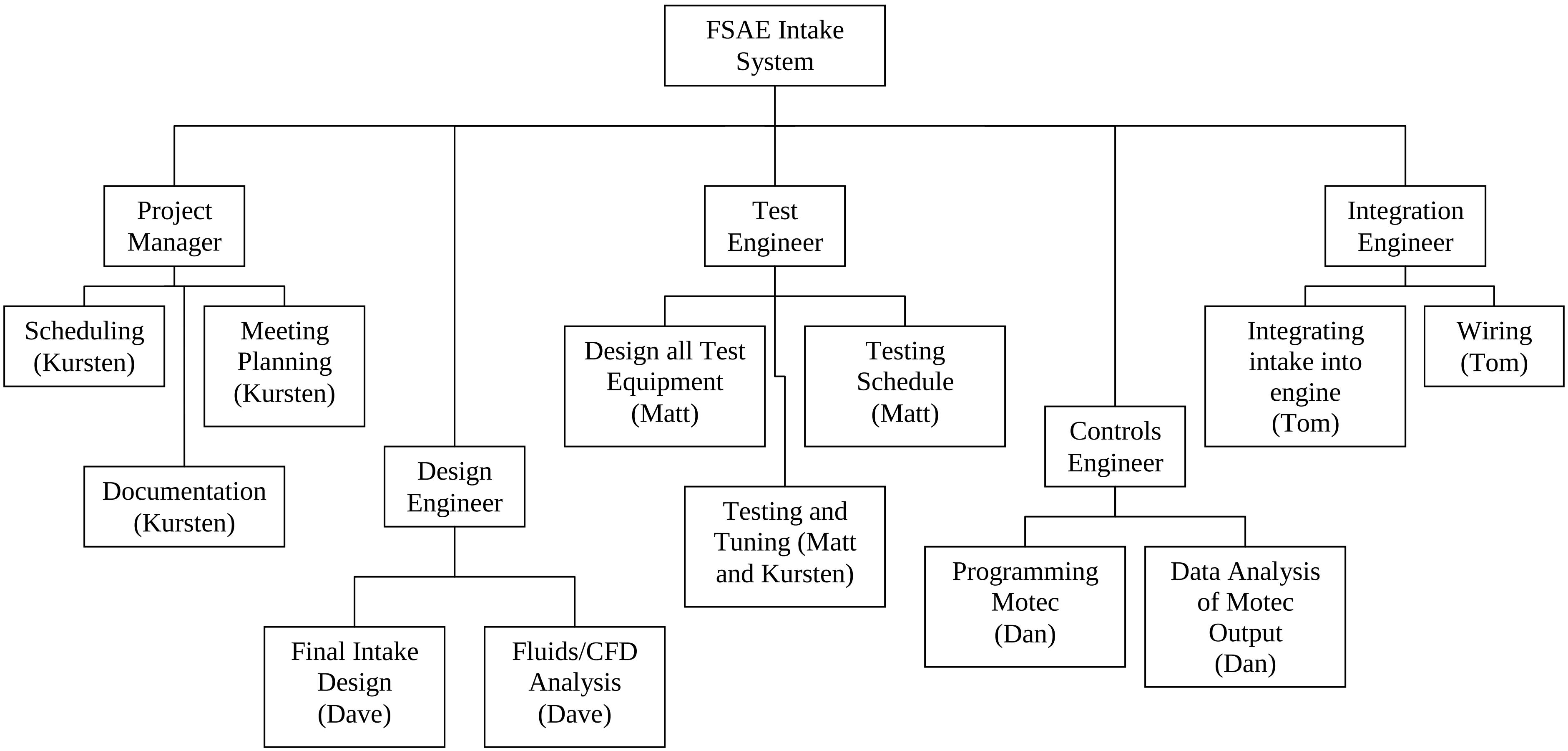
In addition, the car, as a whole, is built for high performance using lightweight designs. This trend is found in every facet of the car including the intake system.

## *Issues & Risks:*

Project Issues/Risks/Constraints

- Project Realm
  - New Project to upgrade engine package
  - New area of study for some
- Available Resources
  - Obtaining Resources
  - Order Parts/Hardware
  - Lead Time for race car completion
- Implementation Issues
  - Packaging to comply with FSAE regulations
  - Understanding the limitations of the engine package and testing resources

# P10227 Work Breakdown



# P10227 Customer Needs

| Customer Need # | Importance | Description |
|---|---|---|
| | | **Volumetric Efficiency** |
| CN1 | 4 | Increased Air Inductance |
| | | **Fuel Efficiency** |
| CN2 | 7 | Optimized usage of race fuel |
| | | **Power/Torque** |
| CN3 | 5 | Increased HP Output |
| CN4 | 5 | Increased Torque Output |
| | | **Drivability** |
| CN5 | 6 | Ease of length of change while driving |
| | | **Weight** |
| CN6 | 3 | No significant weight gain |
| | | **Reliability** |
| CN7 | 7 | Low maintenance |
| | | **Manufactuability** |
| CN8 | 1 | Simplistic |
| | | **Servicabilty** |
| CN9 | 2 | Computer programming |
| CN10 | 2 | Assembly |
| | | **Cost** |
| CN11 | 0 | Low cost |

Importance: 10 = Highest Importance; 0 = Lowest Importance

# P10227 Specifications

| Engr. Spec. # | Importance | Source | Specification (description) | Unit of Measure | Marginal Value | Ideal Value | Comments/Status |
|---|---|---|---|---|---|---|---|
| ES1 | 2 | Weight | The overall weight of the system compared to non-adjustable | lbs | 4.0 | 1.85 | Current system 1.478 lbs |
| ES2 | 1 | Performance | The reduction of lap times due to system performance | sec | 1 | 2 | Will vary depending on event |
| ES3 | 3 | Fuel Economy | The impact this system has on fuel consumption | lbs/hr | 0 | -2 | |
| ES4 | 7 | Manufacturing Time | Time required to produce a working unit | days | 20 | 10 | |
| ES5 | 6 | Current Draw | Current required by the system to operate | amps | 5 | 1 | |
| ES6 | 4 | Actuation Time | Time required to change position | milliseconds | 200 | 100 | |
| ES7 | 5 | Position Length | The accuracy of the runner position at given rpm | inches | 5% | 1% | |
| ES8 | 6 | Voltage Draw | Voltage required to produce a working system | volts | | | |

Importance: 10 = Highest Importance
0 = Lowest Importance

# P10227 Concept Selection

| Concept Screening | | |
|---|---|---|
| | 2-Stroke | Infinitely |
| **Selection Criteria** | | |
| *Volumetric Efficiency* | | |
| Increased Air Inductance | + | + |
| *Fuel Efficiency* | | |
| Optimized usage of race fuel | + | + |
| *Power/Torque* | | |
| Increased HP Output | + | + |
| Increased Torque Output | + | + |
| *Drivability* | | |
| Ease of length of change while driving | - | + |
| *Weight* | | |
| No significant weight gain | 0 | 0 |
| *Reliability* | | |
| Low maintenance | 0 | 0 |
| *Manufactuability* | | |
| Simplistic | + | - |
| *Servicabilty* | | |
| Computer programming<br>Assembly | +<br>+ | -<br>- |
| *Cost* | | |
| Low cost | 0 | 0 |
| **Sum +'s** | 7 | 5 |
| **Sum 0's** | 2 | 2 |
| **Sum -'s** | 1 | 3 |
| **Net Score** | 6 | 2 |
| **Rank** | 1 | 2 |

Based on the customer needs, the best intake system for the race car is the two-position as it allows for a greater number of benefits compared to an infinitely variable system given the time frame, tools and manufacturing capabilities available.

| Product | Manufacturer | Part Number | Unit Price | Quantity | Total Price | Comments |
|---|---|---|---|---|---|---|
| | | | ***Testing and Verification*** | | | |
| ***Testing Materials*** | | | | | | |
| 93 Octane Fuel | - | - | $ 3.00 | 20 | $ 60.00 | gallons |
| 100 Octane Fuel | - | - | $ 6.00 | 20 | $ 120.00 | gallons |
| Tires | Competition Tire East | D2696 | $ 180.00 | 4 | $ 720.00 | Goodyear Tires |
| ***Miscellaneous Dyno Materials*** | - | - | - | - | - | |
| Thermocouples | Omega | KMQSS-062U-6 | $ 26.00 | 8 | $ 208.00 | |
| | | | ***Manufacturing and Assembly*** | | | |
| ***Electric Actuation*** | | | | | | |
| Electric Solenoid | Allied Electronics | Ledex 195204-230 | $ 19.97 | 3 | $ 59.91 | 2 for testing, 1 for manufacturing |
| Extension Spring | McMaster-Carr | 9657K33 | $ 6.86 | 1 | $ 6.86 | Package of 12 |
| ***Pneumatic Actuation*** | | | | | | |
| Three Way Solenoid | Skinner | 3131BBN1EN00RRT1J1C1 | $ 57.50 | 2 | $ 115.00 | Three Way Valve |
| Pneumatic Cylinder | Bimba | 010.5-NRBNT | $ 20.15 | 2 | $ 40.30 | Single Acting .5" Stroke, non rotating, 7/16 bore |
| Pressure Regulator | Parker | 14R110C | $ 18.99 | 1 | $ 18.99 | |
| ***System Materials*** | | | | | | |
| Aluminum Plate | McMaster Carr | 8975K439 | $ 10.94 | 2 | $ 21.88 | Size: 0.25 x 6 x 12, for Base Flange |
| Aluminum Tube | McMaster Carr | 89965K123 | $ 18.18 | 1 | $ 18.18 | Size: 1.5 x 0.035 x 36, for Static Runners |
| Aluminum Sheet | McMaster Carr | 89015K14 | $ 12.63 | 1 | $ 12.63 | Size: 0.050 x 12 x 12, for Plenum Shell |
| Aluminum Sheet | McMaster Carr | 89015K18 | $ 26.29 | 1 | $ 26.29 | Size: 0.125 x 12 x 12, for Plenum Base |
| ABS Plastic Rod | McMaster Carr | 8587K52 | $ 57.57 | 1 | $ 57.57 | Size: 3 Round x 12, for Diverter |
| ABS Plastic Rod | McMaster Carr | 8587K49 | $ 22.53 | 2 | $ 45.06 | Size: 2 Round x 12, for Dynamic Runners |
| | | | | | | |
| ***Miscellaneous System Materials*** | | | | | | |
| Air Filter | K&N Filters | RU-0981 | $ 29.99 | 1 | $ 29.99 | Size: 2 Round x 12, for Dynamic Runners |
| | | | **Total** | | **$ 1,391.26** | |
| | | | **Maximum Total** | | **$ 1,500.00** | |
| | | | **Balance** | | **$ 108.74** | |

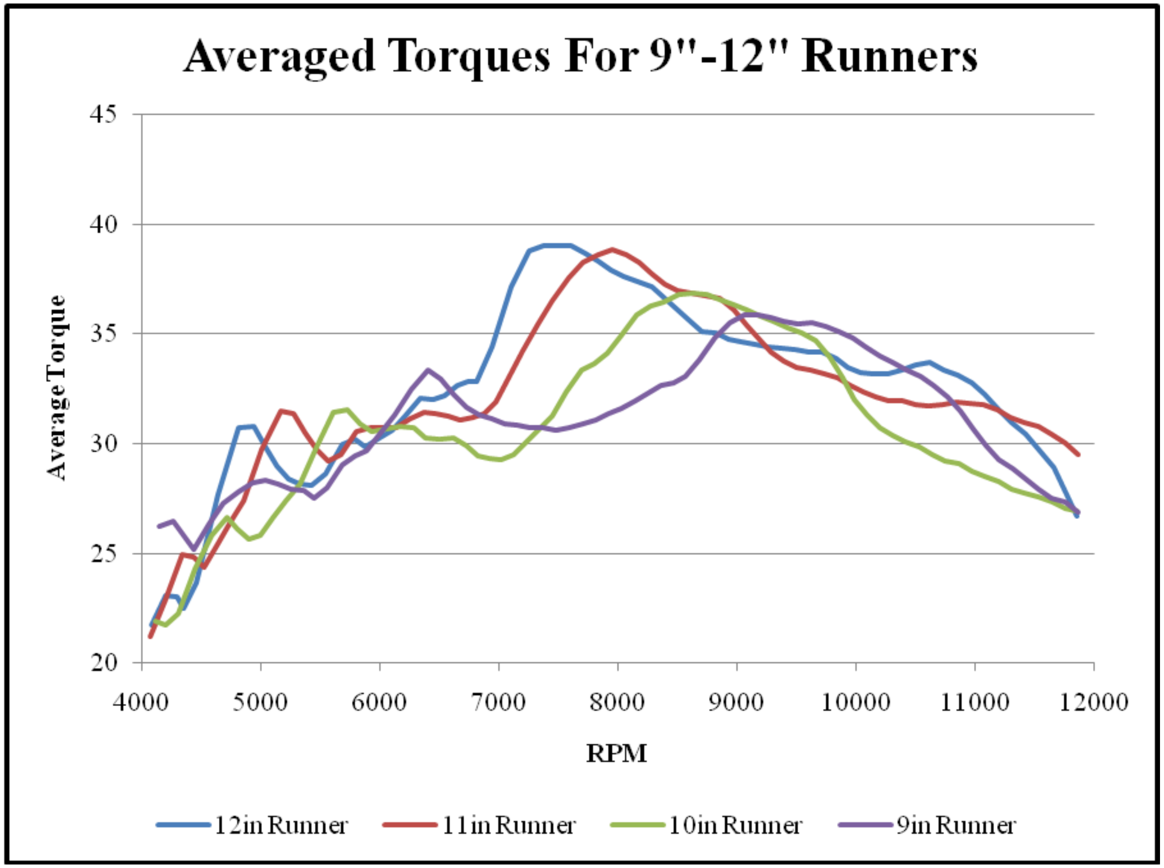
| | |
|---|---|
| (light purple) | Purchased |
| (orange) | To Be Purchased |
| (red) | To Be Returned |

# P10227 Risk Assessment

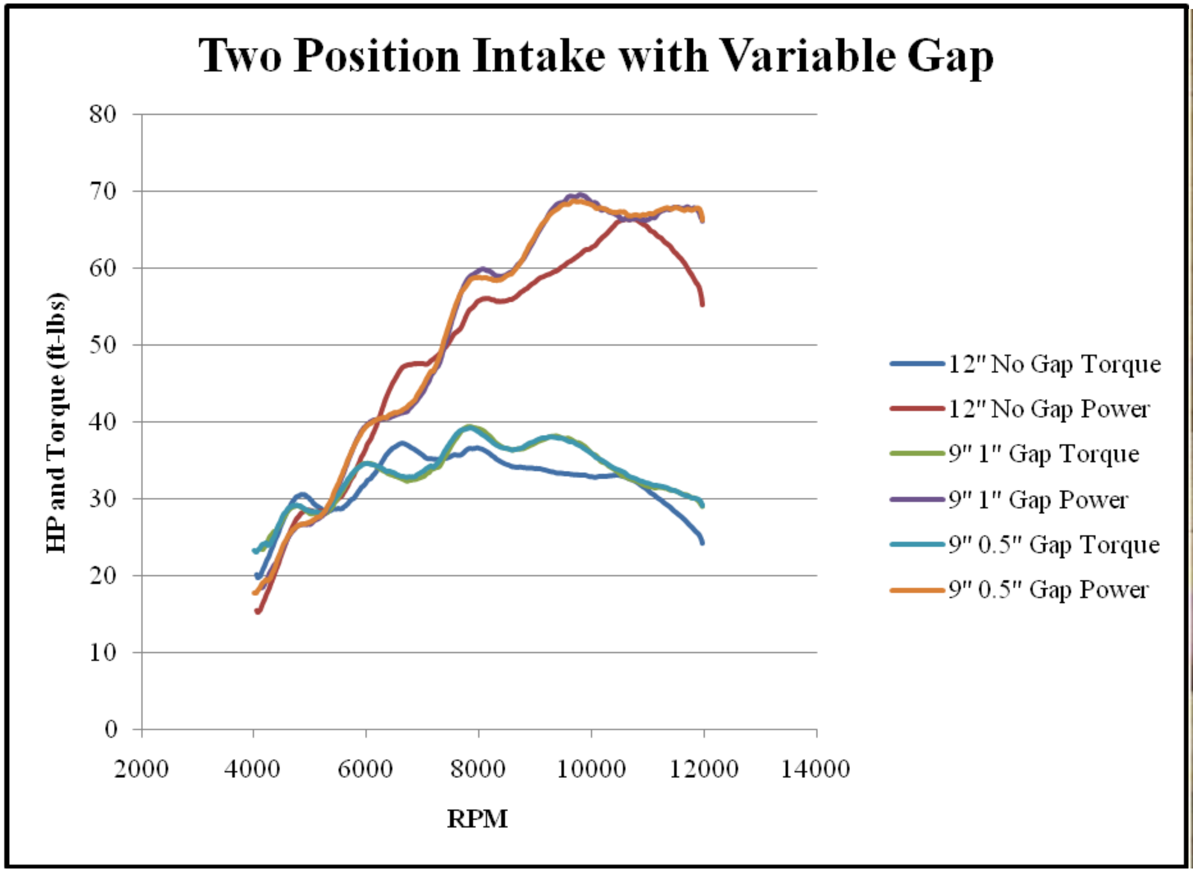
| Type | Risk | Effect | Cause | Likelihood | Severity | I.S. | Action to Minimize Risk | Owner |
|---|---|---|---|---|---|---|---|---|
| Technical | Response time is not fast enough to engage length | Intake system will not be accurate, possibly not effective | Motech cannot program to the level necessary, engine cannot meet the specified load timing | 1 | 1 | 1 | Spec the response time correctly that can be found via calculations and testing | Tom/Dan |
| Technical | Safety of Motec is Compromised | Motec could be destroyed | Not taking precautions to eliminate all potential hazards such as open live wires | 2 | 1 | 2 | Trim all potential open live wires | Tom/Dan |
| Technical | A change in runner length results in a change in plenum volume that has unknown results regarding power and functionality | Unknown and unaccountable variables in the design and testing phase | Not knowing enough about engine characteristics for different volume changes | 2 | 1 | 2 | Reading and researching in addition to consulting with our technical advisor | Dave Donohue |
| Technical | Servomotor needed are not available | Not able to run intake system | No other servos are available | 2 | 1 | 2 | Research and plan 2-3 weeks before servo will be needed | Kursten O'Neill and Matt Smith |
| Technical | Pressure Sensors not compatible with engine | Will not have a method to tune intake system | Fittings are not compatible | 2 | 1 | 2 | Design fittings that will work with the already purchased sensors | Tom/Dan |
| PM | Not have enough $ to sponsor project from ME Dept. | Not be able to purchase the materials needed to build the system | Costs are out of the range ME Dept is willing to give | 1 | 2 | 2 | Look to minimize cost in all areas | All |
| Technical | No available materials | Not able to build prototype or completed intake system | Not planning far enough in ahead on specs in order to purchase the material ahead of time | 2 | 1 | 2 | Work with FSAE and ME Dept to ensure that we have enough materials | Kursten O'Neill |
| Technical | The intake system packaging will not fit the FSAE envelope regulation | The intake system cannot be used in competition | Design constraints will not allow system to stay within envelope borders | 3 | 1 | 3 | Design for envelope borders under a given factor of safety | Dave Donohue |
| Technical | Wiring available does not work | Cannot wire the intake system to the motech computer system | Old/unreliable wire | 3 | 1 | 3 | Check all wires before assembly | Tom/Dan |
| PM/Technical | Not start manufacturing on time | Delay overall schedule to place on new car | Materials are ordered late or materials do not arrive on time | 2 | 2 | 4 | Work with Team Members and Dr. Nye to ensure materials are ordered and arrive with cushion time before manufacturing needs to begin | Kursten O'Neill |

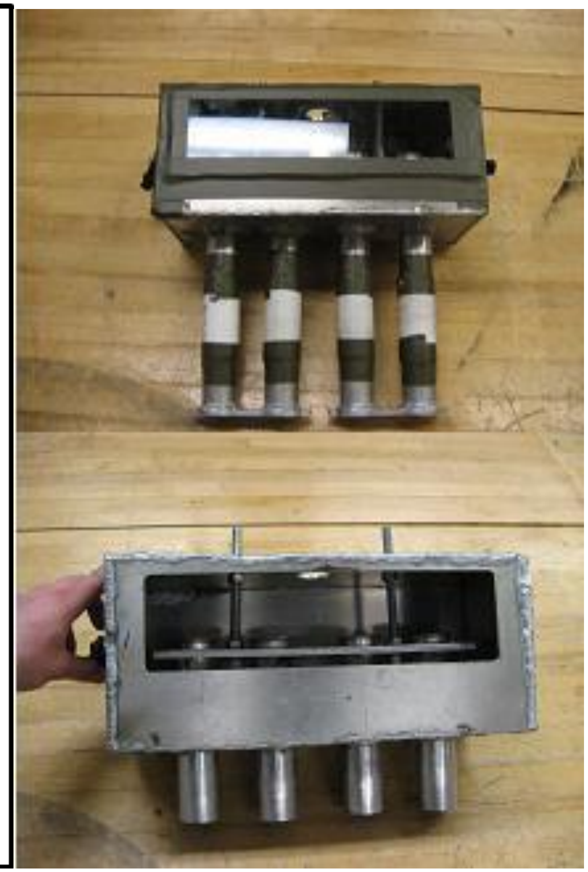
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PM/Technical | Not start testing on time | Delay data gathering to make specs | Dyno facility not working | 2 | 2 | 4 | Work with John Scanlon to schedule testing time | Matt Smith |
| Technical | The dyno facility is not up and running | Delays preliminary testing and data gathering | The dyno breaks | 2 | 2 | 4 | Work with John Scanlon | Matt Smith |
| Technical | Motec does not have the capabilities to output the necessary data to ensure specs are met | Engineering Specs can not be confirmed | Unable to program the required inputs in order for Motec to record and output the necessary data | 2 | 2 | 4 | Work with John Scanlon to program Motec and test its capabilities in order to understand its limitations | Tom/Dan |
| Technical | Not capable of measuring fuel economy | Unable to measure a deliverable | We do not have the equipment or capabilities to measure | 2 | 2 | 4 | Brainstorm and plan for the most feasible method to measure | Matt Smith |
| Technical | Machined runner's not in spec | Not compatible with intake system | Machined incorrectly | 3 | 2 | 6 | Take precautions when machining all components | Matt Smith |
| Technical | Not being able to use F17's intake system for testing | We would have to make our own testing intake system | Needed for FSAE testing and tuning on other cars | 3 | 2 | 6 | Talk with Project Manager and Chief Engineer before it is needed | Matt Smith and Dave Donohue |
| Technical | The manufacturing of the system will be outside the capabilities of the team members | Unable to machine intake system | Design constraints will not allow for a simplified machining technique | 3 | 2 | 6 | Design within machine shop capabilities | Dave Donohue |
| Technical | Car not running | Not able to test the intake system on the car | Running late on assembly in FSAE | 3 | 2 | 6 | Work with FSAE to ensure that the car is on schedule | Matt Smith and Dave Donohue |

| | | |
|---|---|---|
| Likelihood | 1 | Likely |
| | 2 | Possible |
| | 3 | Not Likely |
| Severity | 1 | Very Severe-much time lost to account for design/manufacturing changes |
| | 2 | Severe-some time will be lost to account for design/manufacturing changes |
| | 3 | Not Severe-minimal time will be lost for design/manufacturing changes |



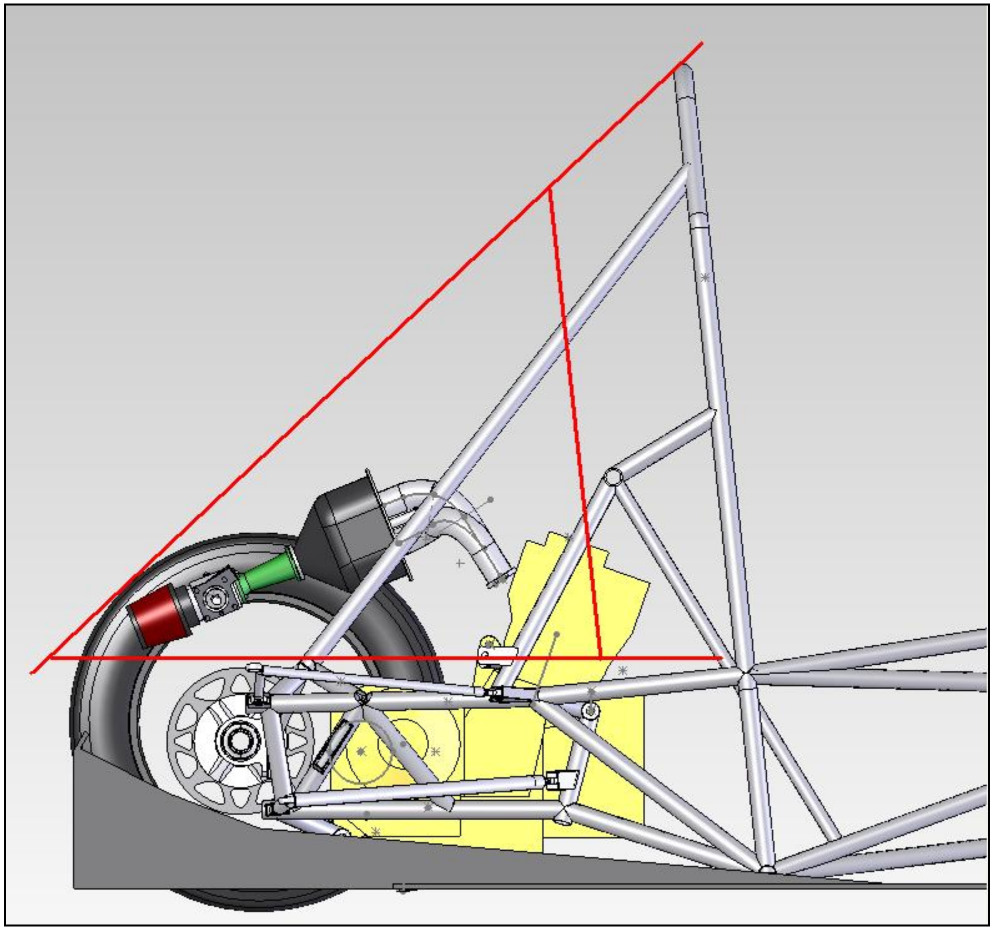

To find the runner lengths that achieved the best possible torque and horsepower, we modified a previous intake into our first prototype so that the runner length was adjustable. Testing was performed at inch increments from 6" through 12". As you can see from the graph above, the best resulting lengths are 12", 11" and 9". Using this data, a second prototype was created.



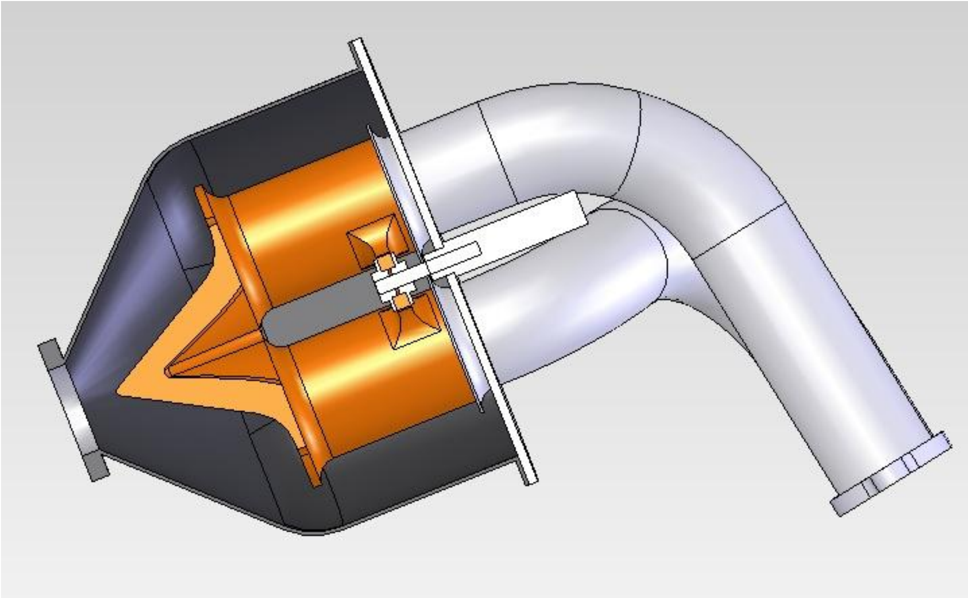



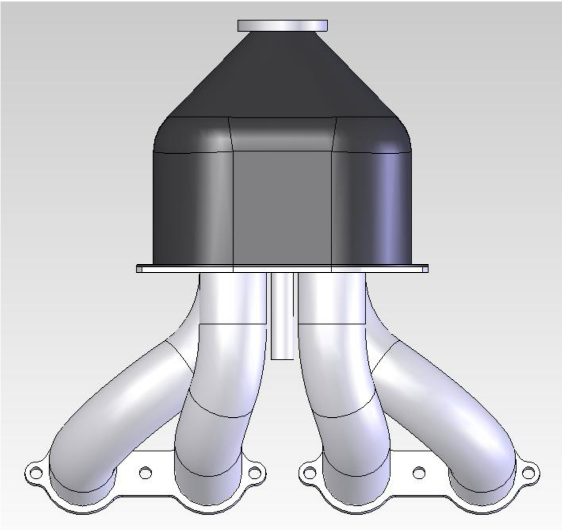
To mimic a two position system with the desired torque and horsepower peaks, we modified an existing plenum to fit the extending runners with an adjustable gap. When the intake was in long mode, the gap was closed and the total runner length was 12 inches. When the intake was in short mode, the gap was open and the total runner length was 9 inches. The open gap length was tested a multiple length in order to determine differences in yielding horsepower and torque. As a result, the optimal gap length to be used in the final design is 0.5 inches.

*Packaging Constraint*

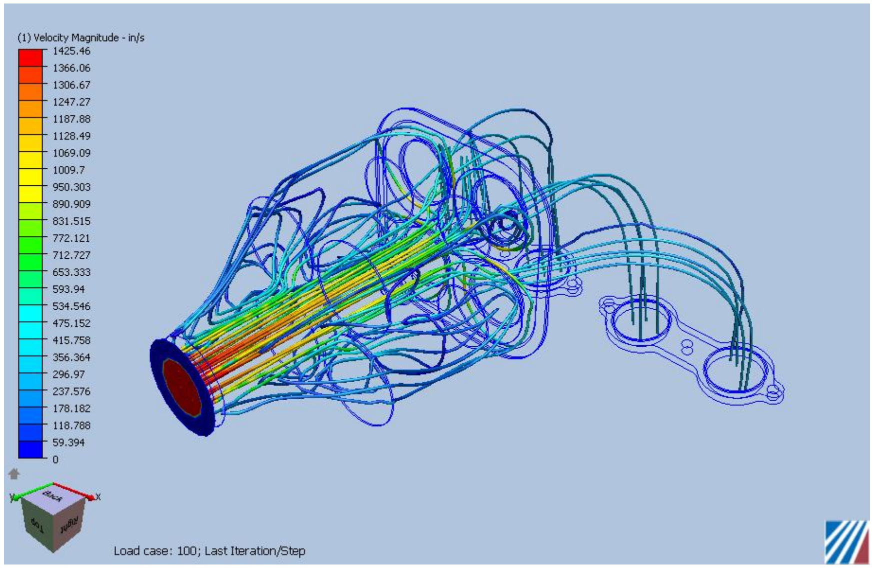


# P10227 Finalized Intake Design



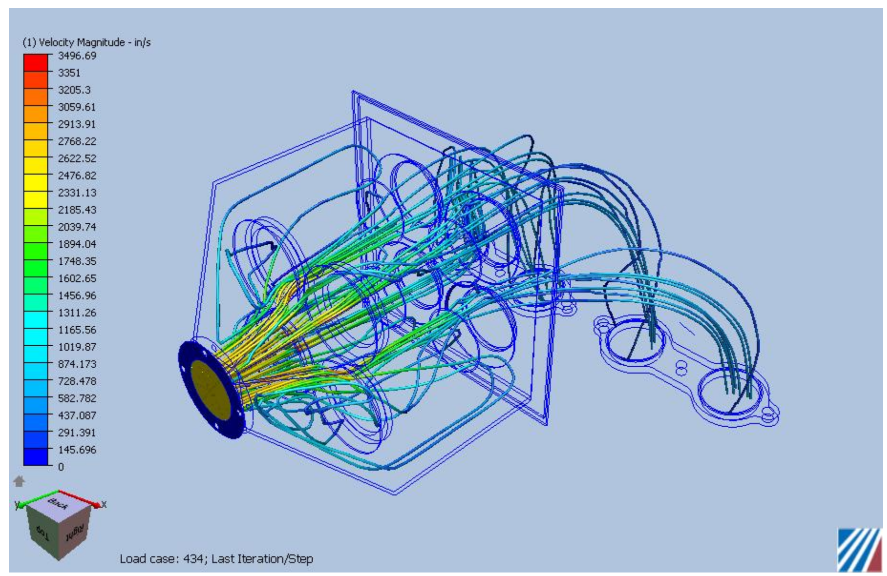


# P10227 Finalized Intake Design

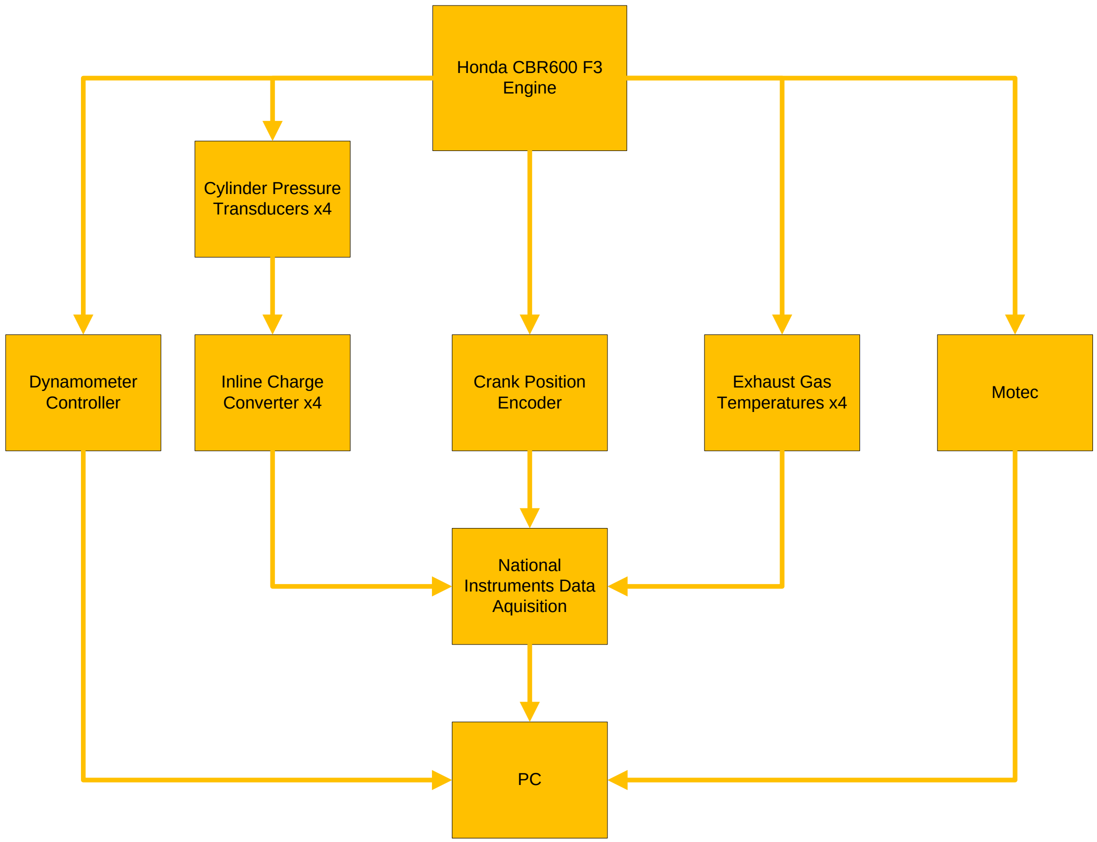



Intake System without Spike to Direct Flow into Runners

Intake System with Spike to Direct Flow into Runners



# Dynamometer Test Layout



# Intake System Design