Sample Project Safety Plan

Date: *04.14.2015*

Plan Completed By: *Bulldogs Racing*

Team Members and Contact Information

First Name	Last Name	Email	Phone

Background

Bulldogs Racing is the Yale University chapter of the Society of Automotive Engineers (SAE). The team designs and produces high-performance, Formula-style race cars for the annual collegiate Formula SAE race series. For 2015-2016, Bulldogs Racing is building an entirely new car. Major projects for the year 2015 include collecting data on the BR14 car in its current state, designing a new high voltage system, and designing and fabricating an optimized chassis and new carbon fiber body. The knowledge that the team acquires on BR14 will be used to refine the design of BR16 as well as to increase its durability and reliability. BR14 incorporates a 250 cc bike engine and an electric motor. The total sustained power output is around 60 kW, with a peak power output of about 100hp. BR16 will incorporate two electric motors, each capable of putting out a peak power of 108hp.

Proposed Test Description(s)

We will be driving the car on the [redacted]; at no point will we be conducting any off-road tests. The course will be pre-determined with an emphasis on durability rather than agility or speed. Course will be marked with cones to indicate both the track and the direction.

Signs that read "BRAKE" will be placed at the end of straights longer than 25m to warn drivers about when to brake. Curbs and other fixed objects will not be used as an integral part of course markings – there will be at least 1m of distance between the course marked by cones and the fixed objects.

- *Braking*
  - *Regeneration efficiency*
- *Energy Consumption*
  - *Fuel*
  - *Battery Charge*
- *Heat generation*
  - *Internal combustion engine*
  - *Batteries*
  - *Electric motor*
- *Sensor analysis and testing*
  - *GPS data*
  - *Roll, pitch, yaw data*
  - *Weight transfer calculations*
  - *Pedal travel optimization*
  - *Center of gravity optimization*
  - *Suspension adjustment and optimization*
  - *Data transmission over wireless communication*

We have removed all components of testing that would constitute "competitive driving". The purpose of the test will be to gauge the durability and reliability of the car, as such the car will not be driven to test its agility or speed.

Speed of the vehicle will not exceed 30 mph at any point on the course, and when the vehicle is being driven towards the other cars in the lot, the speed will be limited to 20 mph. Cones will be placed to ensure that the vehicle is forced to slow down when approaching the perimeter of the track. All track activities will be suspended when a pedestrian or vehicle appears to be entering

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or exiting [redacted]. Cones will be placed around the central light post as well as around harsh road imperfections to ensure a smooth operating of the vehicle in order to prevent damage to the vehicle.

Proposed Project Schedule

[redacted]

Hazard Assessment

Using the attached table for Example Hazards and Mitigation/Safety Measures as a reference, identify the hazards associated with the proposed project along with controls that will be used to mitigate them.

Potential hazards include moving parts, high voltage system on the car, internal combustion engine, on-board fuel, component failures and driving obstacles. It is understood that such hazards that are inherent to race cars can be successfully handled by incorporating safety systems in the design, operator training or control of the environment. Below is a list of potential hazards:

Hazard	Mitigation/Safety Measure(s)
Loss of control - driver	*Brake pedal has an over-travel protection switch that shuts down the internal combustion engine and the high voltage system in case of brake failure. Rear and front hydraulic brake lines have separate reservoirs and separate master cylinders. Throttle system is completely electronic, and in the unlikely case of a failure, the pedal assembly is designed to spring back to zero throttle position.* *A mechanical throttle limit will be introduced to limit the speed to about 15 mph for the test runs.* *The car will not be tested for its agility. The course will not contain sharp turns, hairpins or other challenging features. The main objective will be to familiarize people with the race car and test its reliability.*
Loss of control – fixed objects	*The cones that mark the course will be strategically placed away from any fixed objects. Signs that read "BRAKE" will be placed wherever there is a 25m or longer straight to indicate when to start braking.*
Driver Awareness	*All drivers will be required to hold a valid driver's license (US or other) or a race car license. Anyone who exhibits dangerous or on-the-limit driving or a lack of understanding of the car's operation will, at the sole discretion of the Responsible Safety Officer or the Track Safety Officer, have their driving privileges suspended for the day.*
Loss of control - bystanders	*High visibility cones will be used to mark the test track. There will be a designated `paddock` area and nobody will be allowed to leave that area when the car is in motion. There is a high-visibility LED light mounted on the main roll hoop, which flashes when the car is active and ready to be driven.*
External impact	*Race car has an external impact attenuator (11 kJ energy absorption potential) and a three-piece carbon fiber body, as well as a thick aluminum front anti-intrusion plate, front steel bulkhead and triple steel side impact protection bars. The frame is made out of chrome-moly steel, professionally welded. Two roll hoops will prevent any impact to the driver's head in the very unlikely case of a rollover.*
Drivetrain failure	*All components in the engine bay of the car, including the high voltage system, are shielded from the drivetrain and the chain by means of a chain guard.*
Driver entrapment and equipment	*Driver's seat is made out of one-piece carbon fiber, with a multi-point seat belt design. Shoulder and lap belts can withstand up to a force of 13 kN. Drivers will wear race helmets, fire suits, race gloves and will use hearing protection. Seat belts will be tightened by a crew member.*
Driver control units	*There are dedicated engine shut off, High Voltage shut off, emergency shut off buttons on the dashboard.*
Driver emergency egress	*The steering wheel and the seat belt harness employ quick release systems, enabling the driver to egress the vehicle within 5 seconds in an emergency situation.*
Components snagging driver's clothes	*All moving parts in the driver's compartments, such as the steering wheel column, are housed in protective cases to prevent snagging. All pedals are made out of steel, body panels incorporate carbon fiber and aluminum.*
Compromised hot body in the engine bay	*An aluminum firewall separates and insulates the driver from all hot bodies, high voltage system, gas tank and drivetrain*
Engine overheat	*There is a dedicated radiator to cool the engine.*

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Fuel leakage	*Gas tank (1 gal capacity) is made out of aluminum, has a sealing cap and is vented to prevent vapor buildup. There will be a designated track marshal with a fire extinguisher, ready to engage in case of an emergency.*
Vehicle visibility	*There is a high-visibility LED light mounted on the main roll hoop, which flashes when the car is active and ready to be driven. There is a dedicated brake light at the back.*
Exposure to energized equipment – hybrid high voltage system	*Battery box is made out of fire-resistant and insulating Kevlar. All high voltage connections coming out of the battery box are housed in fire-resistant and insulating conduit. All low voltage is separate from the high voltage.*
Electric potential on the frame	*Ground fault detector shuts down the high voltage system in the event of a faulty grounding of the circuit.*
Accidental activation of electrical system	*All high voltage components are marked by `High Voltage` signs. Both the low voltage and the high voltage keys need to be inserted and turned, then the high voltage system needs to be activated by a crew member, but it is live only when the driver presses the HV button on the dashboard. When the High Voltage system is activated there is a buzzer loud enough to wake the dead, and flashing LEDs that are mounted at the top of the highest roll hoop of the car.*
Electric system cooling	*One of the two radiators is dedicated to the cooling of the high voltage system.*
Big red buttons	*All around the car there are multiple emergency shut off buttons that shut down the high voltage circuit and the engine – these are wired in series with the brake over-travel switch and each other, so any one of them shuts down the entire car. They need to be manually reset before the car can be powered again.*
Complete electrical failure	*Steering, suspension and the brakes are entirely mechanical so they are fully functional regardless of the operation of the car.*
Injury	*A first aid kit designated for 25 people will be on-site. Responsible Safety Officer will maintain the communication with the medical personnel, faculty adviser and EHS.*
Safety equipment	*Race helmets, race gloves, hearing protection, fire suits, high visibility cones, safety glasses, fire extinguisher, first-aid kit and spill absorber will be brought to the testing site by the team. There will be a designated Responsible Safety Officer present throughout the event.*
Noise	*The car complies with the noise limits set forth by the Formula Hybrid committee.*
Certification	*The entire race car was scrutinized by the Formula Hybrid Committee of 2014 and is certified to be mechanically and electrically safe and track-worthy.*

Pre-Test Checklist:

- *Nut/Bolt check: One person will be responsible checking that every bolt and nut on the car is tightened to a certain torque specification*
- *Fluids Check*
  - *Fuel*
  - *Hydraulic Fluid*
  - *Engine Oil*
  - *Transmission Oil*
  - *Engine coolant*
- *Wheel check*
  - *Tire wear and pressure*
  - *Brake calipers and pads*
- *Packing list*
  - *Basic tools to be able to put the body and wheels on/off the car during testing to inspect components*
  - *Fire extinguisher*
  - *Spill absorber*
  - *Fluids mentioned above*
  - *Starter fluid*
  - *Fire suits*
  - *Race helmets, gloves and shoes*
  - *Safety glasses*
  - *Hearing protection*
  - *First aid kit*
  - *Extra 12 V batteries and charger*
  - *Jumper cables*
  - *Infrared (or Penetration) Thermometer*

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    - *Computers for data collection and transmission*
    - *High visibility cones*
    - *Marking tape*
    - *Wheel chocks*
    - *Tie-down straps*
    - *Jack stands (for inspection) and jack*
    - *Water to prevent dehydration*
    - *Radio-phones*
    - *Race flags*
    - *Cameras*
- *Transportation*
    - *Car will be strapped on a certified trailer*
    - *Only the students with valid driver's licenses will drive*
- *Communication*
    - *Assignment of the Responsible Safety Officer*
        - *Responsible Safety Officer oversees the entire event and is present on the site at all times. RSO is either a captain or the faculty adviser. If s/he has to leave, s/he will assign their duty to someone else. The RSO is the point person for the communication with the faculty adviser and EHS.*
    - *Assignment of the Track Safety Officer*
        - *Track Safety Officer oversees the safety of the driver, the car and the track. TSO is a captain, a faculty adviser or a team leader. S/he will be present throughout the entire event. If s/he has to leave, s/he will assign their duty to someone else. It is in the TSO's and RSO's sole discretion to suspend the driving privileges of anyone who exhibits a lack of understanding of the operation of the car or knowledge of the track, dangerous driving or any action that puts the driver, bystanders, the car and the environment in danger. TSO will make sure that the track is constructed such that the fixed objects are at least 1ft away from any cones, the course is clearly marked for directions and that the signage (ie BRAKE signs, flag system) are being used properly.*
    - *Assignment of the Track Marshals*
        - *Track Marshals use the flags to sign the driver what they should be doing, and they are in charge of the fire extinguishers. One will be at the paddock while the other will be on the opposite side of the track. They are to maintain the communication between the RSO, TSO and the drivers. They report to the TSO.*
    - *Coordinate with the faculty adviser about the departure/arrival time*
    - *Communicate with EHS in advance*
    - *Read the weather report*

<u>During Testing</u>

- *Marshals at entry points to course*
- *Either a captain or the faculty adviser will be present and will act as RSO. The RSO will appoint the TSO*
- *Designated marshal with fire extinguisher*
- *Course marked by cones, with indicators denoting which way to go*
- *Inspect car at every driver change*
    - *Shut down the high voltage system and the engine before the driver exits the car*
- *Driver briefing before each driver change*
    - *Emergency egress*
    - *Dashboard buttons, in particular Dashboard Emergency Stop Button*
    - *No loose clothing/hair*
- *All members except for the driver and the designated marshals must be at the paddock*
    - *Safety glasses are required*
- *At every lap the designated marshals and the paddock chief will sign the driver:*
    - *Red – stop immediately*
    - *Yellow – keep going at a slower pace*
    - *Green – keep going*
    - *Checkered flag – pull to the paddock after the current lap*
- *Strictly enforced 5mph speed limit when approaching the paddock*

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Post Testing

- *Shut down engine and high voltage system*
- *Only the Responsible Safety Officer, Track Safety Officer and the designated marshals are allowed to be in physical contact with the car*
    - *Hot bodies should be avoided*
- *Strap the car on the trailer and drive back*

Preparation and Testing Protocol

Upon obtaining appropriate approvals to perform testing and using a designated test site, the following procedure will be followed to ensure the safety measures referenced in the Risk Assessment are in place.

- □ Verify all required approvals are obtained.
    - Risk Management
    - Security
    - EHS
- □ Communicate to the EHS scheduled test dates and times to allow the option for oversight.
- □ When required, ensure appropriate supervision is available and onsite during testing procedures.
- □ When applicable, ensure nearby building occupants are informed of the event.
- □ Ensure all team members are aware of their roles and responsibilities (including emergency response procedures).
- □ Ensure the test area is cordoned off, free of personnel, and is clear of obstructions.
- □ Inspect all testing equipment and safety devices for defects and functionality.
- □ Ensure all mitigation/safety measures referenced in the Risk Assessment are in place and functioning.
- □ Ensure all participants know and understand this assessment and its requirements.
- □ When applicable, conduct a final check to ensure all personnel are clear of the defined test area.

Support requested from Yale organizations

Permission from the [redacted] to use the parking lot as a test track. We will coordinate with the [redacted] about what times would be best.

Acknowledgement

Team Leader
(Sign/Date):_____

Faculty Member/Supervisor
(Sign/Date):_____

Attachments

☐ Additional Hazards and Mitigation/Safety Measures
☐ Illustrations and other supporting documents

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Example Hazards and Mitigation/Safety Measures

Hazard	What to Look For	Mitigation/Safety Measures			
		Substitution	*Engineering*	*Administrative*	*PPE*
Physical: • Impact or vibration • Striking • Crushing or pinching • Shearing or punching • Exposure to energized equipment • Noise • Manual material handling and ergonomics • Working at heights and fall hazards • Slip and trip hazards • Hot work (fire, burns, welding hazards) • Compressed air or gas hazards • Light and laser exposure • Radiation exposure	• Sources of motion that could result in being hit by objects such as falling objects • Moving machinery and components such as grinders, drilling machines, engines, motors, pumps, etc. • Sources of sharp objects, moving machinery, or points that could pierce, catch, or pinch the body • Electrical hazards such as exposed wiring or switches, exposed receptacles, power boxes, damaged tool wiring, improper grounding, etc. • Work requiring energized electrical components • Pressurized equipment (i.e., boilers, pots, tanks, piping, hosing, etc.) • Material handling equipment components (i.e., hoists, lifts, pneumatics, etc.) • Inadequate clearance • Elevated work areas over four feet • Sources of high or low temperature that could result in burns, heat stress, hypothermia or frostbit • Sources of electromagnetic radiation such as UV welding emissions, germicidal lamps, lasers, microwaves, and magnets • Ionizing sources such as X-rays Sources of sudden release (either physical or electrically) that could harm • Uneven surfaces, slippery surfaces and outside ground conditions • Look for water depth and potential for falling into water	• Use different tools • Mechanize process	• Change the way the work is done • Use lifting aid and positioning devices • Keep things clean and uncluttered • Exhaust ventilation • Protection methods such as isolation, emergency stops, double hand starts, guarding, and cages • Shielding materials	• Lock-Out/Tag-Out • Create standard operating procedures • Hearing Conservation • Hot Work Permit • Fall Protection • Radiation badges • Electrical Safety Program • Do not wear loose clothing and tie hair back • Monitoring • Proper body position • Attend safety training • Follow safe work practices	• Safety glasses • Tinted goggles • Insulated gloves • Hearing protection • Fall protection • Safety boots • Hard hat • Leather gauntlets • Welding helmets • Cut-resistant gloves • Cut-resistant sleeves
Chemical: • Liquids, solids, gases, dusts, vapors, and mists comprised of organic or inorganic compounds • Building materials such as asbestos or lead • Toxic materials • Controlled substances • Cleaning agents • Chemotherapy drugs • Cryogenic liquids	• Chemical emissions such as smoke, gas, dusts, vapors that are not controlled • Sudden unforeseen spills or releases • Welding smoke • Pass spill history • Damaged building materials • High potential of splashing • Working with highly toxic or hazardous chemicals versus highly toxic chemicals • Working with large amounts of chemicals • Hazardous storage or materials including wastes	• Change process so chemical is not used • Substitute a less hazardous chemical in process	• Local ventilation (i.e., fume hood)	• Respirator Protection • Personal Monitoring • Attend safety training • Safety showers/eye-wash stations	• Safety glasses • Chemical resistant clothing/aprons • Chemical resistant sleeves, gloves, and respirators • Lab coats
Biological: • Blood-borne pathogens	• Working with infectious agents • DNA/RNA work	• Change process so agent or pathogen does not have to be used	• Biological safety cabinets • Contamination procedures • Proper design of work area	• Center of Disease protocols • Proper work practices • Attend safety training • Safety showers/eye-wash stations	• Safety glasses • Mask • Gloves • Proper clean-up and disposal supplies

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