Activity Safety Proposal: 2.007 Electric Vehicle Section Hillclimb Race *Revision 3*

Contact name: **Charles Guan** Email: Phone:
Date: **6 May** Time: **Noon** Duration: **4 hr**
Location: **Albany St. Garage (N4)** Expected # of participants: **10 students, 4-5 staff**

MIT or Outside Organizations affiliated with this event: **Department of Mechanical Engineering**
PI: Email: Phone:
Will this be open to individuals not affiliated with MIT? **No**

Proposal Outline:

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Activity Summary:

This event is part of the Final Contest for the 2.007 Design and Manufacturing I electric vehicle building lab section. Students are tasked with designing and building small Personal Electric Vehicles of between two and four wheels capable of carrying one passenger at speeds not exceeding 20 MPH. The components of the 2.007 EV Sectional final challenge are the **drag race and hillclimb race**. They are designed to test the strength, endurance, and efficiency of the student-built vehicles. Each will be given its own separate proposal to address the specific details of the contest.

Historical Notes

In the two previous years that this section has been taught, student enrollment has been limited to 5 or 6 and the final trials have been run concurrently with the 2.007 final competition in Johnson Ice Rink. However, in the interest of establishing a framework for a larger lab section and future independent class, we are investigating methods of running these races outdoors on the MIT campus.

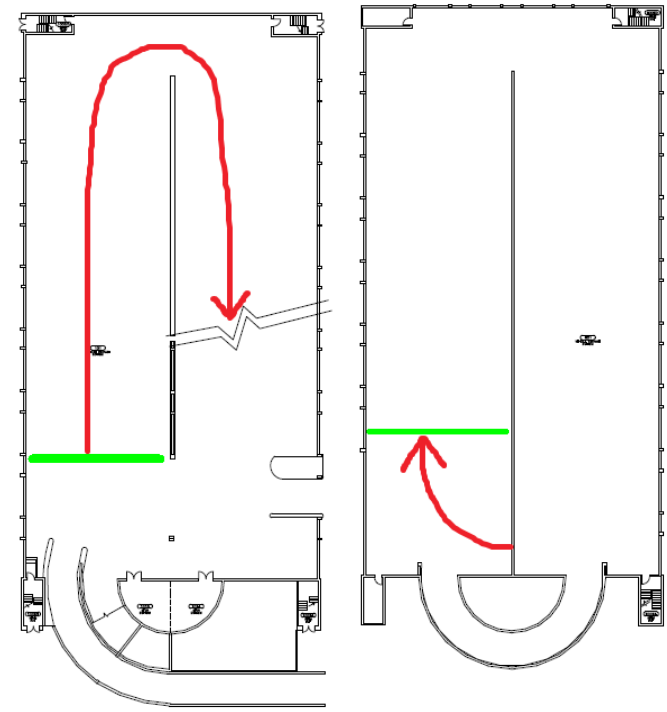
"Vehicle" in the sense used in this document should not be thought of as "car", but more along the lines of "Razor scooter" or "motorized bicycle". Typical past builds include small "personal transportation" type designs such as scooters, skateboards, bicycles, and small electric go-karts/sidewalk cars.

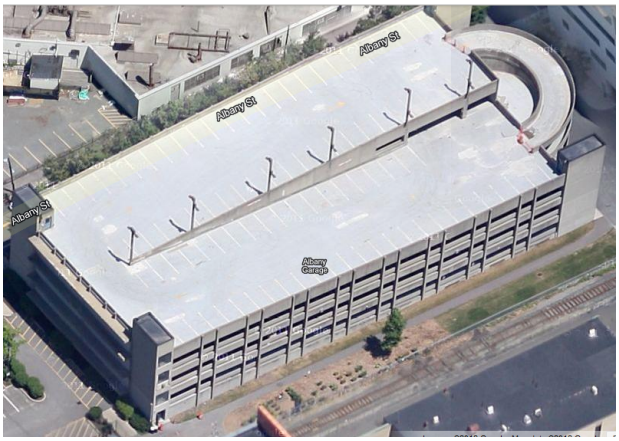
Objectives

- To let students observe the fruits of their semesters' labor in action at the final contest in front of fellow students.
- To encourage practical transportation design by letting students test their vehicles in realistic conditions.
- To observe and takes notes on the procedures and occurrences of the day in order to streamline the process for future years
- To have fun!

Venue Description

The venue selected for this event is the N4 / Albany Street parking garage, with the prospective course outlined in red:





This garage was selected as a candidate for this experimental new race because of its gently sloping parking ramps. This allows a near continuous climb from the ground level to the highest level with minimal load changes, which lets students calculate their vehicle drivetrain specifications with a fair amount of accuracy.

Additionally, very few vehicles park in the garage on weekend afternoons and evenings - scouting regularly on weekends, an average of 6 to 8 cars was noted, with the minimum being 2 on the ground level and none at higher levels. Therefore, it eases the logistics of closing the garage officially for the period of time indicated over the facility being in full use.

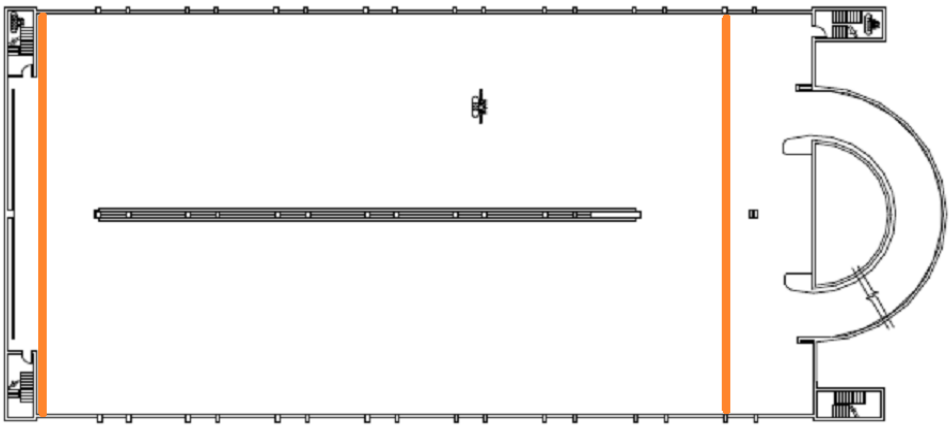
Furthermore, the N4 garage is very smooth since parts of it were recently refinished. We have not observed that any other parking structure at MIT is capable of supporting this event. For example, the West Garage does not have gently sloping ramps and is also poorly paved.

Venue Setup

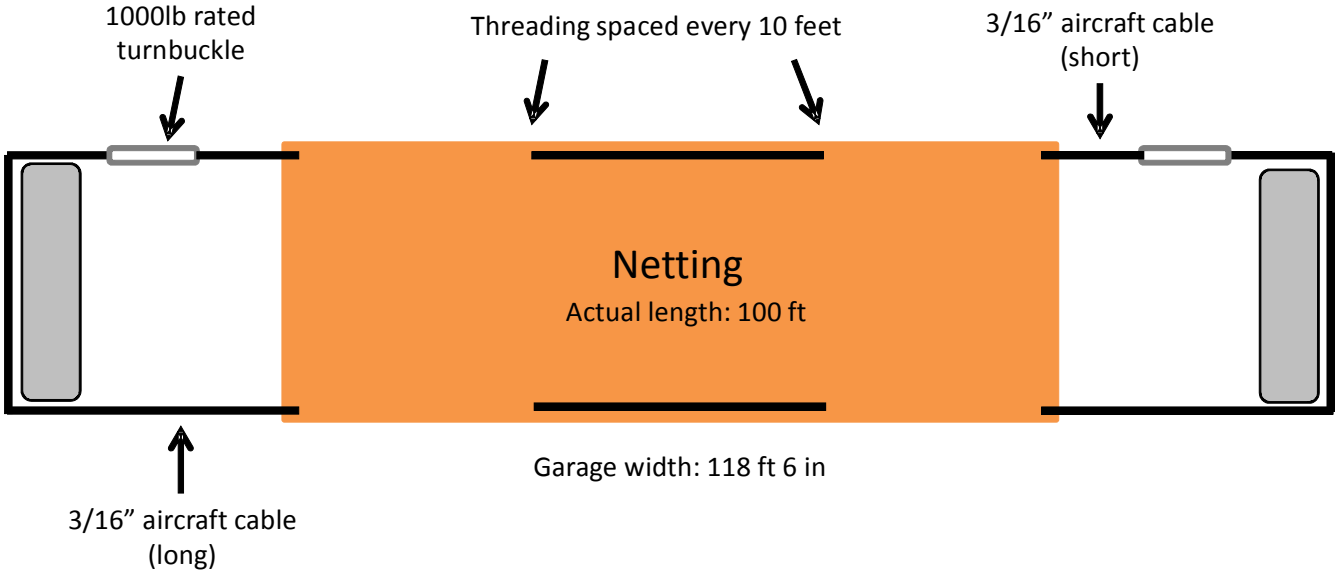
Aside from permission from MIT Parking, the three key issues surrounding use of the garage are impact prevention with the east side column (near the spiral ramp), impact prevention with the west wall (near the stairwells), and accommodating safe entry and exit of cars on the first level to prevent having to entirely close a useful MIT parking facility.

Impact Prevention

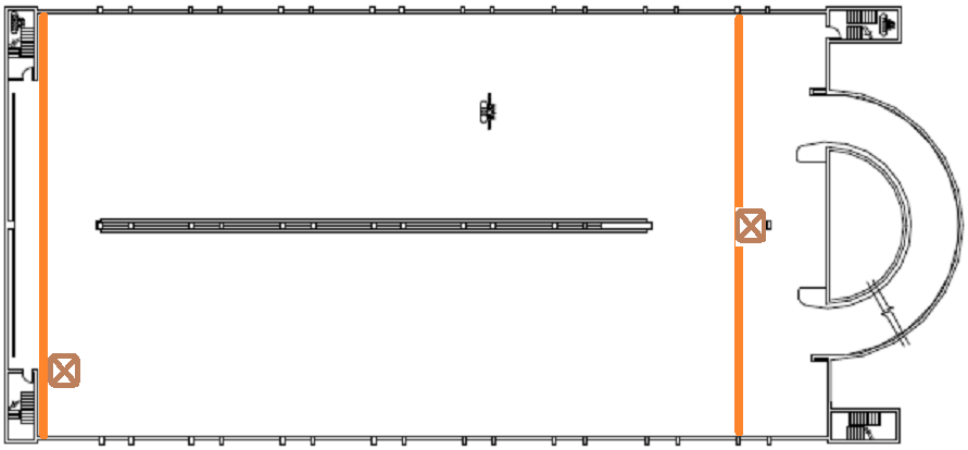
The east and west walls will be secured with a woven polyethylene debris netting similar to: http://boenonline.com/debris-netting.html. The proposed arrangement marked in orange on each intermediate level of the garage is:



We selected these locations based on the highest likelihood of a vehicle "missing the apex" of a turn *e.g.* not turning sharply enough or hypothetically losing traction in the middle of a turn. Therefore, there is open 'rebound space' in the center of both fences - about 5 feet from the west wall and 3 feet from the east support column. The construction netting will be held in tension by steel cables looped around the outer walls of the garage and tightened with turnbuckles. This ensure the fence is not "floppy" which would negate its intended function.



A stack of hay bales or similar impact dampening material will be placed in front of the column and in front of 'convex' corners, oriented in the direction of most likely approach.

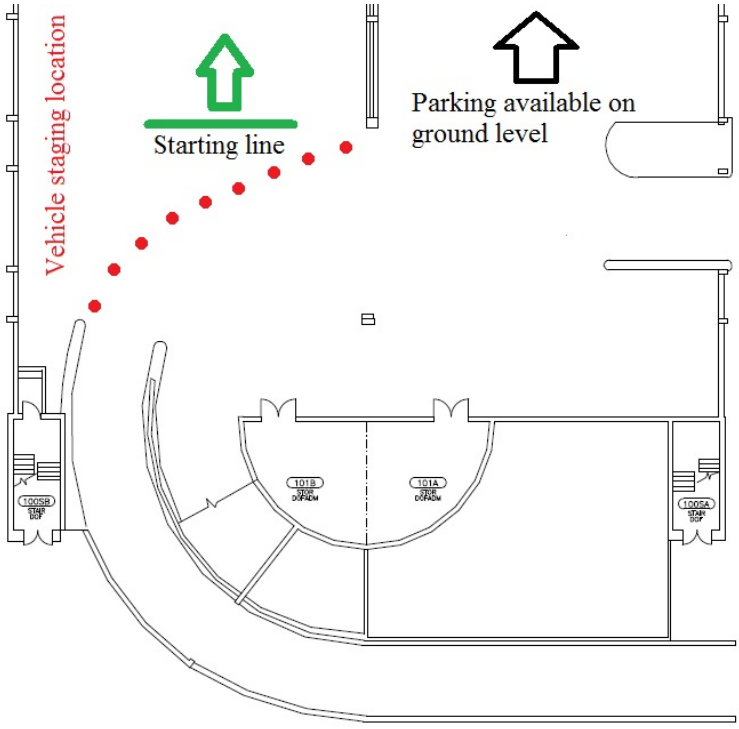


A total of six lengths of netting will be necessary: one on the west wall of the lowest level, two on each of two intermediate levels, and one final one on the east side of the second highest level.

A total of three stacks of impact absorbing material (e.g haybales) will be needed for each of the three upper levels of the garage (Each stack may consist of 2 or 3 Home Depot sized blocks). This is a manageable quantity of material.

Real Vehicle Accomodation

We intend to start the contest on the first rising ramp from the ground level. The proposed layout of the ground level, with red circles indicating cones, is:



Since the contest only uses less than half of the first level, we request only closing the south half of the first level (demarcated by cones), leaving the entry and exit ramp and ground level open for MIT parkers. People with reasons to park in the garage on the weekend may still do so, just on a different level. The amount of parking spaces on the lowest level is more than enough to accommodate all of the cars we have seen in the garage regularly on weekends (average of 6 to 8).

Safety Concerns and Mitigations

Vehicles are built by sophomores in the Department of Mechanical Engineering taking the 2.007 Design and Manufacturing I course. General safety risks associated with these vehicles are comparable to riding bicycles and scooters around campus and mitigations include the following:

- All vehicle operators must wear at least a bicycle helmet.
- Operators of vehicles which do not have handlebars or other stabilizing element, such as motorized boards, must additionally wear elbow and knee protection, as there is nothing to grip should they lose balance.
- Operators of vehicles which are fully sit-down, such as go-karts, must wear a DOT-approved motorcycle helmet (One will be provided).
- Closed-toed shoes are required.

All vehicles will undergo a full mechanical and electronic inspection before they are allowed to participate in the races. Incomplete or unsafe vehicles will not be allowed to participate. An example "inspection sheet" is provided at the end of the document.

This document will therefore only address risks particular to this event.

Safety Concern	Mitigation
Communication	Staff will communicate using 2-way radios. There will be one staff member on each level of the garage to monitor student progress.
Automobile traffic	*Ask MIT Parking and Transportation and the Campus Police to officially close the portion of the garage in use for the event* (See Procedures)
Pedestrian traffic in stairwells	Signs will be posted outside stairwell doors indicating the event is in progress. Staff will be on each level of the garage in case any pedestrian leaves the stairwell. Any staff can call an immediate stop to the vehicle under test. ***End impact barriers will prevent pedestrian intrusion.***
Risk of collision with inside or outside edge of garage lane	Garage lanes are very wide and leave time for braking or "ditching" and edge barriers are near chest height (not low) and are concrete, not fencing or wire based. Students will be allowed to take familiarization trial runs. Students are stopped at the second highest level, not the highest, to leave plenty of runoff space.
Spirally ramps	Students are forbidden from riding down the spiral ramps, since they are fairly steep. They will be marked off with cones ***or blocked by the construction netting***
Vehicle Runaway	All vehicles must be equipped with a method of cutting power, whether physical or remote (see Inspection Sheet). The garage is also uphill and has enclosed walls.
Vehicle brake failure	In the event of a brake failure not caught during inspection, vehicles are small enough to bring to a gradual stop with foot braking. The course is also entirely uphill, so coasting is less of a concern. Vehicles which experience any brake malfunction will

	not be allowed to continue.
Operator Recklessness	Recklessness such as swerving, unauthorized racing, or other horseplay will result in forfeiture from the entire contest.
Minor Injury e.g. asphalt abrasion	A first-aid kit will be available, a first-aid certified person will be present, and the student will be required to visit MIT Medical.

Battery Safety

Vehicles are electrically propelled and are limited to a 36v maximum electrical system voltage. Students are taught proper and safe handling of batteries and behavior around electrical systems as part of the class. The batteries are 12 volt lithium iron phosphate modules with built-in 40 ampere fuse, charge management, and protection circuitry donated by A123Systems, a MIT affiliated company.

A123Systems recommends the use of a dry chemical or CO2 extinguisher in the event of a true electrical fire. The A123 MSDS for the cells in use inside the battery modules is: http://web.mit.edu/charlesg/Public/SDS-1.pdf - refer to Section 5. **An ABC dry powder extinguisher will be present** (May request from Facilities or purchase)

Procedures

Due to this event requiring use of MIT parking facilities, we appreciate the input of MIT Parking and Transportation staff and the Campus Police about the feasibility of officially closing a portion of the parking facility for the duration of the event.

Preparations for the race include demarcating the start and finish lines on the ground with white gaffer's tape. Signs and cones will be posted at garage stairwell and ground level entrances forbidding pedestrian access. The impact prevention netting will be set up by staff beforehand.

A minimum of **four** staff members will be involved. Two staff members are stationed at the start and finish lines, respectively, to clear students to begin the race and time them with a stopwatch. The second staff is also responsible for checking the energy consumption instrumentation of a vehicle once the trial has been completed. Two additional staff are stationed at the intermediate levels of the garage to monitor student progress and stop the trial in case a pedestrian defies the signage or the vehicle is unable to continue. All staff will be in communication with radios so there is no delay in relaying a message.

The first staff member will clear students to begin the race after confirming with the other staff members that the garage is clear. Students proceed **one at a time** up the garage levels and are timed between starting and finishing. The vehicle energy consumption in Watt-hours is also monitored by instruments. The product of time in seconds and watt hours consumed is taken as the score.

Because this event has no alternative venue, we are willing to move it to **Saturday, May 12th** in the event of rain or inclement weather. The race will be canceled if the venue cannot be obtained for either day, as there is no practical alternative.

Other Practical Considerations

We will also work with Larry Brutti of the Parking and Transportation Office on all of these events and welcome his advice and suggestions. Additionally, we will work with the MIT Campus Police to obtain details for this event if necessary.

About the Instructor

I have been building and operating electric vehicles for six years, including several small electric vehicles that have been used around campus and at student activities events such as Orientation. I am familiar with electric vehicle power systems, safe construction and maintenance of 48-72 volt electronics, vehicle drivetrains, and electric motors. I have also constructed vehicle battery packs with battery management systems. Overall, I believe I am well qualified through experience to judge the safety of student-built electric vehicles.